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Implementation of Scene Shadows in the Target Acquisition TDA (TARGAC)

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The performance of electro-optical weapon systems operating the visible and near-infrared (IR) spectra depend on the illumination of the target and background. Scene shadows can decrease the illumination level of the target scene and alter the contrast characteristics between the target and background. Shadows are also an important source of clutter in a target scene. The primary objective of the first year of this Phase II SBIR is to (1) develop the partly cloudy shadowing model, (2) deliver the updated TARGAC software for the PC that implements the partly cloudy shadowing model, (3) determine the relationships between target acquisition, small-scale features, shadows, and clutter, and (4) develop a design approach for the incorporation into TARGAC of the temporal and spatial characteristics of clutter.

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1. INTRODUCTION

1.1. PROJECT OVERVIEW

The performance of electro-optical weapon systems operating in the visible and near-infrared spectra depends on the illumination of the target and background. Scene shadows from clouds, large-scale features, and small-scale features can decrease the illumination level of the target scene and alter the contrast characteristics between the target and background. Thus, scene shadows can have an important effect on system performance.

Pacific-Sierra Research Corporation and Hughes STX Corporation collaborated on a Phase I Small Business Innovative Research (SBIR) project to study the feasibility of adding the effects of scene shadows to the Army's target acquisition range prediction model, TARGAC (Snapp et al., 1991). The Phase I work primarily resulted in the development of algorithms to implement scene shadow modifications in the TARGAC source code. It was assumed that actual software coding, algorithm verification, and validation would occur in a Phase II effort.

The Phase II effort is divided into a basic year and an option year. The primary objectives of the basic year were to implement the shadowing effects of partial cloud cover in the visible and near-IR sections of TARGAC and to develop a detailed approach for the implementation of small-scale feature shadows. Under this plan, the actual software implementation of small- and large-scale feature shadows and the integration of the three modules will occur in the second year.

This report focuses on the work completed by Pacific-Sierra Research Corporation and Hughes STX Corporation during the first year of the Phase II project. The work had these major objectives:

- Develop the partly cloudy shadowing model.
- Deliver the updated TARGAC software for the PC that implements the partly cloudy shadowing model. (It is assumed that updates to the UNIX version will occur in the second year of the project.)

- Determine the relationships between target acquisition, small-scale features, shadows, and clutter. (In this task we examined alternative approaches to the basic 2-d clutter and 3-d clutter caused by small-scale features and the shadows that these features produce.)
- Develop a design approach for the incorporation into TARGAC of the temporal and spatial characteristics of shadows.

The report describes the physics of the updates to TARGAC in detail, provides guidance for using the updated PC software, and provides the reader with a detailed review of the design of the planned small-scale feature shadowing implementation. PSR has included a formal software design document as appendix D of the report. A copy of the "beta" version of the software developed by Hughes STX is being shipped under separate cover to Dr. Patti Gillespie, the ARL program COTR, White Sands Missile Range, NM. For easy reference, the original version of TARGAC is referred to in this report as "TARGAC-2" and the modified version as "TARGAC-3."

1.2. BACKGROUND

Environmental conditions have played an important role in military operations throughout history. Weather can affect such wide-ranging areas as trafficability, chemical dispersion, and target acquisition. The U.S. Army uses electro-optical devices for detection and recognition of targets. These devices, which depend on the contrast between a target and its surroundings, are adversely affected by weather conditions such as rain, fog, and poor visibility.

The Army relies on tactical decision aids (TDAs) to help in understanding environmental effects on military operations. It is important that these models be as realistic as possible, while remaining easy to use. To this end, a target acquisition TDA for visual and near-infrared systems should have provisions for treating the effects of scene shadows. Shadows can decrease acquisition range by decreasing scene illumination and altering the contrast characteristics between the target and its background. Shadows cast by clouds, small-scale features, and large-scale features are important contributors to the shadowing problem.

Seagraves and Davis of the Atmospheric Sciences Laboratory (now the Army Research Laboratory) developed the TARGAC model to predict the performance of electro-optical devices for various weather conditions (1989). TARGAC includes detection and recognition range prediction models for direct view optics (DVO), image intensifiers (II), silicon television systems (SiTV), and thermal imagers (TI). This SBIR project considered only the DVO, II, and SiTV systems, which operate in the visible and near-IR wavelength region (0.4 - 1.1 μm).

In this wavelength region, TARGAC-2 accounted only for clear or overcast conditions. However, it is necessary to account for partly cloudy conditions because they cause a variance in irradiance that can play havoc with visual and near-IR sensor performance.

TARGAC-2 employed the methodology used in Hering's second Fast Atmospheric Scattering (FASCAT) model (1983) to determine downwelling illumination for clear or overcast situations. FASCAT was updated to account for partly cloudy situations (Hering and Johnson, 1984), and the update was included in the U.S. Air Force Electro-Optical Tactical Decision Aid (EOTDA) (Higgins et al., 1987). For more realistic modeling of scene shadows, this update has now been incorporated into TARGAC-3.

Under partly cloudy conditions, cloud shadows can cover a target and its background or have no effect at all. Since no person or model can predict the exact location of a cloud, the recommended approach is to calculate scene radiation for the target and background in cloud shadow and for the target and background in direct light. The acquistion range can then be bracketed by values for both cases. In addition, this approach includes an estimate of the probability that the target and background are in cloud shadow.

As with clouds, small- and large-scale features also create shadows. In addition, small-scale 3-d features (features of approximately target size or smaller) interact with the background to cause variances in the apparent 2-d clutter. Large-scale features can probably be best modeled using available Defense Mapping Agency (DMA) data such as Digital Terrain Elevation Data (DTED) and Digital Feature Analysis Data (DFAD). These products are available for most of the world with data sampled on an approximate 100 meter grid. A set of less than a dozen locations would provide representative terrain types that would meet most user needs. Large-scale feature shadows will be addressed in the second year of this effort.

One could envision extending the above referenced large-scale features approach for use with small-scale features by obtaining extremely detailed terrain/scene knowledge. However, the knowledge level required, the size of the databases, and the computational power required would be prohibitive. After examination of several approaches, we selected a statistical approach based on Schmeider et al. (1982) which will provide an output bracketed by values of acquisition ranges as a function of sensor-to-sun azimuth angle.

1.3. REPORT ORGANIZATION

This report contains information to assist TARGAC analysts, users, and maintenance programmers. The material is organized into two sections: a main report and a series of appendices.

The main body of the report should be useful to TARGAC users and analysts. Section 2 outlines the objectives of the first year of the Phase II SBIR. Section 3 describes the approach taken to implement partly cloudy situations and the design of the implementation of shadowing by small scale features. Section 4 details the impact of the implemented and planned revisions to the TARGAC code. Section 5 describes tests that were conducted to validate the revised code and planned testing of the small-scale shadowing code. Section 6 provides a summary of work completed and section 7 contains references.

The first four appendices to the report should be useful to those responsible for maintaining the PC version of the TARGAC code. Appendix A contains a tree diagram of TARGAC-3. Appendix B describes the modified FORTRAN routines and COMMON blocks. Appendix C contains the details of each change made. Each change is accompanied by an Engineering Change Report (ECR) and in-line documentation of the source code. Appendix D is a formal design document of the changes needed to implement shadowing by small-scale features. The implementation presented in appendix D is focused on the UNIX version of TARGAC; once operational in UNIX, no obstacles to porting a modified version of this software to the PC are seen.

The main report contains material generated by both PSR and Hughes STX. Hughes STX prepared appendices A, B, and C and PSR prepared appendix D.

2. TECHNICAL OBJECTIVES

The first year of the Phase II SBIR scene shadows project emphasized the incorporation of cloud shadows in the visible and near-IR sections of TARGAC and the design of the software to implement shadowing by small-scale features. Both small- and large-scale feature shadows will be incorporated during the second year. The technical objectives of the cloud shadows and small-scale feature shadows tasks are outlined below.

2.1. TASK 1: SHADOWING BY CLOUDS

The objective for Task 1 was to implement cloud shadowing effects in the TARGAC code. Since TARGAC-2 was already capable of handling overcast conditions, the work for this task centered on upgrading the software to include partial cloud cover for the 0.4 - 1.1 μm region. The upgrades recommended for this task in the Phase I effort (Snapp et al., 1991) were made to the PC version of the code. This involved the following subtasks.

2.1.1. Subtask 1.1: Incorporation of Revised FASCAT Model

This subtask involved updating TARGAC's delta-Eddington radiance model from the clear/overcast FASCAT model (Hering, 1983) to the partly cloudy FASCAT model (Hering and Johnson, 1984).

2.1.2. Subtask 1.2: Modification of Input Requirements

TARGAC-2 restricted the user to just one cloud layer for the visible devices. This subtask involved updating the input requirements to allow up to three cloud layers. For each layer, an amount, a type, and a base height may be specified. In addition, cloud inputs were made the same for the visible and thermal imager devices.

2.1.3. Subtask 1.3: Provision of Radiance in Cloud Shadow and Direct Light

This subtask involved using the revised FASCAT computations to produce two values of radiance, one for the target scene in cloud shadow and the other for the scene in direct illumination. Direct and diffuse radiance for the possible sky conditions are computed based on the cloud cover. "Bracketing" values for total radiance are then computed.

2.1.4. Subtask 1.4: Estimation of Cloud Shadow Probability

This subtask involved using the cloud cover information to estimate the probability that the target and its immediate background are in cloud shadow at any given time.

2.1.5. Subtask 1.5: Provision of Bracketing Ranges

Bracketing values of radiance at the target scene were used to provide values of sky-to-ground ratio, detection range, and recognition range for the scene in and out of cloud shadow. These bounding values can be used with the probability value to estimate sensor performance at any given time.

2.2. TASK 2: SHADOWING BY SMALL-SCALE FEATURES

The objective for Task 2 was to develop an approach to the inclusion of the effects of shadowing by small-scale features into TARGAC. Since TARGAC-2 does not handle small-scale feature shadows, the work for this task included: (1) the study and analysis of the relationship between small-scale feature shadows and target detection and recognition, (2) the development of efficient algorithmic approaches to the inclusion into TARGAC of small-scale feature shadows, and (3) the preparation of a software design document for upgrading TARGAC to include small-scale feature shadows in the 0.4 - 1.1 μm region. This involved the following subtasks.

2.2.1. Subtask 2.1: Target Acquisition Relationship: Small Scale Features, Shadows, and Clutter

Determine the relationship between small-scale features, shadows and clutter with respect to target acquisition. Perform static observer testing in order to validate the relationship between target acquisition and shadow-caused clutter.

2.2.2. Subtask 2.2: Algorithm Development and Software Design

Develop an approach to incorporate into TARGAC temporal and spatial characteristics of shadows, including diurnal, latitudinal, seasonal, terrain effects, and clutter.

3. TECHNICAL APPROACH

3.1. TASK 1: SHADOWING BY CLOUDS

A cloud shadow appears on the target scene whenever a cloud shields the scene from direct illumination. Only an estimate of cloud base height, thickness, type, and amount (fractional cloud cover for the target area) is practical in a forecast. Any approach to cloud shadow modeling must take this limitation into consideration.

TARGAC-2 constrained the user to a single cloud layer for the visible and near-IR wavelength region. If the cloud fraction was less than 0.7, clear conditions were assumed. If the cloud fraction was greater than or equal to 0.7, overcast conditions were assumed. The FASCAT model (Hering, 1983) was used to compute direct and diffuse illumination at the scene.

TARGAC-3 allows the user to enter up to three cloud layers (low, middle, and high) and accounts for partly cloudy conditions. This models the radiative effects of clouds more effectively. If the fractional cloud cover for all three cloud layers is 0.0, clear skies are assumed. The target scene is not shadowed by clouds. If the fractional cloud cover is 1.0 for at least one of the three cloud layers, overcast skies are assumed. The target scene is shadowed by clouds. In all other cases, partly cloudy skies are assumed.

For clear or overcast conditions, the decision as to whether the target scene is shadowed by clouds is straightforward. Under partly cloudy conditions, the target and its background may be in direct light or in cloud shadow at any particular time--it is impossible to predict the exact location of a cloud. These possibilities are shown in figure 1. It is desirable to predict acquisition ranges for both situations (target and background in direct light, target and background in cloud shadow) and estimate the probability that the target scene is shadowed by clouds.

The calculation of diffuse and direct illumination is key to the problem of partly cloudy conditions. The revised FASCAT model (Hering and Johnson, 1984), which extended the delta-Eddington solution to include the effects of partly cloudy conditions, has been incorporated. The basic approach is to find the average diffuse illumination from the possible cloud situations and to find "best case" and "worst case" direct illumination. The average diffuse term is then used with the two extremes of the direct term to give acquisition ranges for the target scene in and out of cloud shadow.

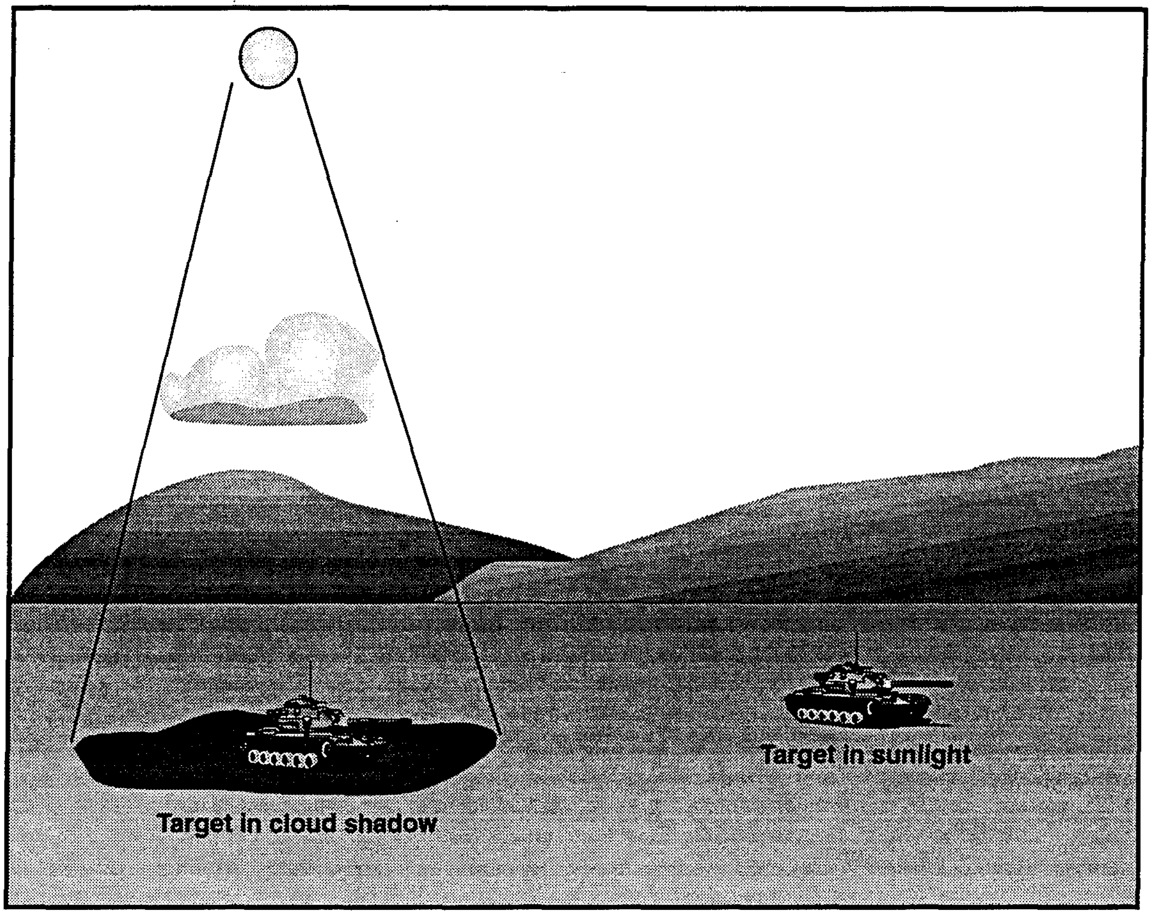


Figure 1. The shadowing problem for partly cloudy conditions.

To define the effects of shadowing by clouds, changes to TARGAC-2 were required in three areas: (1) input of up to three cloud layers; (2) incorporation of the revised FASCAT model; and (3) output of bracketing ranges for the two possible cloud situations. Each is discussed below.

3.1.1. INPUT

TARGAC-2 allowed the user to enter only the cloud base height and amount for a single layer. Cloud thickness and optical parameters were preset for an "average" cloud.

Modeling the effects of clouds on radiation has been improved in TARGAC-3 by allowing the user to enter base height, amount, and cloud type for up to three cloud layers. Cloud thickness and optical parameters are defined for each particular cloud type. The addition of cloud type to the input requirements should not present a hardship to the TARGAC user. Cloud type observations and forecasts are part of many routine civilian and military weather reports that are readily available. This additional input improves the accuracy of the model. Given a cloud type and base altitude, preset values of cloud thickness, asymmetry parameter, optical thickness, and scattering ratio are assigned. These values are described in Section 3.1.2.

In addition to adding cloud type and allowing up to three cloud layers, three other issues affected the selection of inputs for TARGAC-3. Wherever possible, we attempted to use common inputs for the visible and thermal imager sections of the code. Since the thermal imager section already included three cloud layers, we mimicked the TI inputs as closely as possible. For example, we used the same cloud types for each layer and we adopted units of kilometers (km) for cloud base height rather than feet (ft).

We attempted to harmonize inputs between TARGAC-3 and the Air Force EOTDA (Freni et al., 1993). We adopted the EOTDA limits for cloud base heights. We included the Air Force definition of ceiling height: that height at which the summation of cloud cover observed from the surface is more than 4/8 (AWSR 105-24, 1983). Because the Air Force defines cloud coverage in eighths, this means that the coverage must be at least 5/8, or approximately 0.6.

We examined the inputs for the visible and near-IR systems and tried to eliminate redundancies. We removed the significant weather input. This parameter offered choices of different levels of cloud cover (now included as cloud inputs), fog (included as an aerosol selection), and precipitation, which does not directly affect the model for visible and near-IR systems.

Section 4.1.2 describes the specific changes to the TARGAC input selection and the new inputs for interactive and batch modes

3.1.2. FASCAT CALCULATIONS

TARGAC-3 requires optical depths for the standard cloud types. However, there is a problem with defining a typical cloud for a particular cloud type. For example, the vertical extent of a cumulus cloud could range from a few hundred feet for fair weather cumulus to several thousand feet for cumulonimbus. Therefore, the optical depths used in TARGAC-3 represent an "average" cloud for each type.

Table 1 shows the optical depths used by Hering (1983) for various cloud types. Although he presented three representative thicknesses, the table below lists only the average optical depth for each cloud type.

Table 1. Average optical depths for various clouds.

Cloud Type	Optical Depth
St/Sc	22.0
Cu/Cb	15.0
As/Ac	15.9
Thick Ci/Cs	4.4
Thin Ci/Cs	1.5

According to Joseph et al. (1976), the delta-Eddington optical depth can be expressed as

$$\tau' = (1 - af)\tau$$

where

$a(t)$ = the angle scattering albedo,
f = the fractional scattering into the forward peak, and
t = the standard optical depth.

Joseph et al. states that according to previous work by van de Hulst (1968) and Hansen (1969), the relationship between the fractional scattering into the forward peak and the asymmetry parameter of the truncated phase function, g, is given by

$$f = g^2. \tag{2}$$

Thus, Equation (1) can be rewritten as

$$\tau' = \left(1 - ag^2\right)\tau. \tag{3}$$

If we assume that the single scattering albedo, a, is 1 in the visible waveband and that the asymmetry parameter for water clouds is 0.85, Equation (3) is reduced to

$$\tau' = (0.2775)\tau. \tag{4}$$

If we apply Equation (4) to the values in Table 1, we obtain the delta-Eddington optical depths for clouds used in TARGAC-3. Table 2 shows the results.

Table 2. Delta-Eddington optical depths for average clouds.

Cloud Type	Optical Depth
St/Sc	6.1
Cu/Cb	4.2
As/Ac	4.4
Thick Ci/Cs	1.2
Thin Ci/Cs	0.4

In order to determine which atmospheric layers contain clouds, TARGAC-3 uses average geometric thicknesses for the standard cloud types. Table 3 shows these values.

Table 3. Geometric thicknesses for various clouds.

Cloud Type	Geometric Thickness (km)
St/Sc	0.75
Cu/Cb	1.5
As/Ac	0.5
Thick Ci/Cs	0.5
Thin Ci/Cs	0.3

The partly cloudy FASCAT computation of average diffuse illumination was designed to handle only one or two cloud layers (Hering and Johnson, 1984). If three cloud layers are entered, then the upper two--those farthest from the ground-based sensor--need to be combined. Cloud fraction and optical depth are averaged over the two layers. Geometric thicknesses are combined. This same procedure is used in the Air Force EOTDA (Higgins et al., 1987).

TARGAC uses 17 layers to model the atmosphere from 20 km down to the surface. Each cloud layer may fill up part or all of one or more atmospheric layers. Figure 2 depicts the 17 atmospheric layers. Two example cloud layers are shown. The upper cloud layer is a combination of a middle altostratus cloud with a thickness of 0.5 km and a high thick cirrus cloud with a thickness of 0.5 km. The combined cloud fills up part of the fifth and sixth atmospheric layers, between 6 and 8 km. The lower cloud layer is a low cumulus cloud with a thickness of 1.5 km. This cloud fills up part or all of atmospheric layers 10 through 12, between 0.5 and 3 km.

We developed a weighted averaging algorithm to assign the appropriate extinction to each atmospheric layer. The cloud extinction is added to the appropriate atmospheric layers. For each atmospheric layer i, the extinction is defined as

$$\beta_i = m_{clr}\beta_{clr} + m_{cld1}\beta_{cld1} + m_{cld2}\beta_{cld2} \tag{5}$$

and the asymmetry parameter is

$$g_i = m_{clr}g_{clr} + m_{cld1}g_{cld1} + m_{cld2}g_{cld2}, \tag{6}$$

where

m_{clr} = fraction of layer i that is clear,

m_{cld1} = fraction that contains part of the upper cloud,

m_{cld2} = fraction that contains part of the lower cloud,

and the extinction coefficient, β, is related to the optical depth and the layer thickness, z, by

$$\tau = \int_0^z \beta(z')dz' . \tag{7}$$

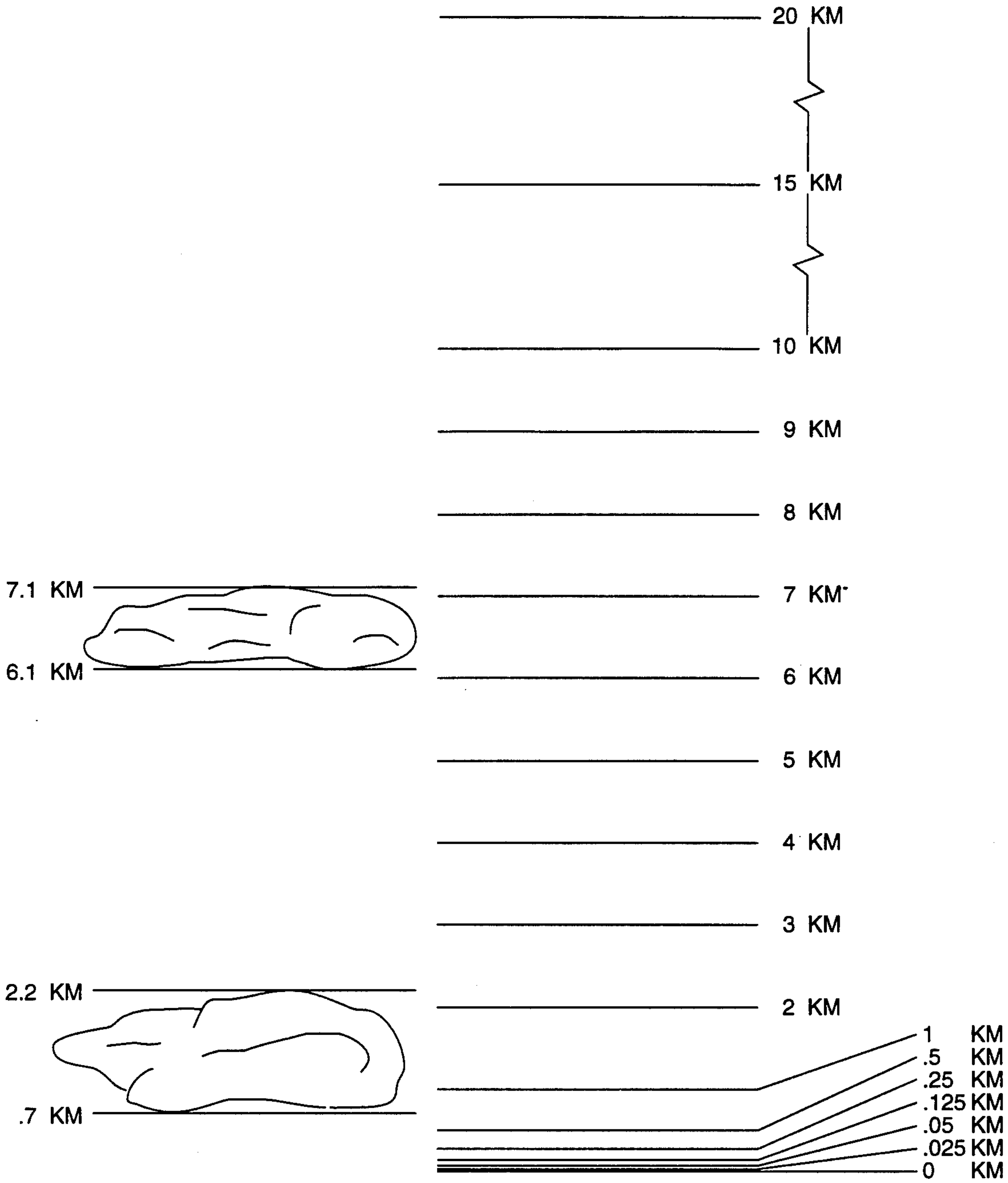


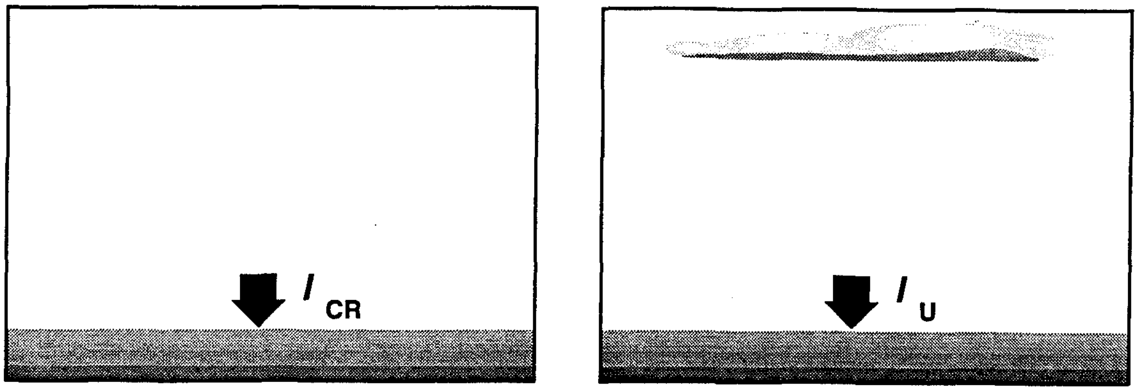
Figure 2. Assignment of clouds to atmospheric layers.

Once the appropriate optical parameters are assigned to each atmospheric layer, TARGAC-3 uses the updated FASCAT model to compute direct and diffuse radiance values. Each cloud layer is assumed to be clear (for clear skies), overcast (for overcast skies), or both (for partly cloudy skies). For partly cloudy skies, it is necessary to calculate the optical parameters and radiance values twice for the atmospheric layers containing clouds: once for a clear path and once for a cloudy path. For clear or overcast skies, these calculations need only be performed once.

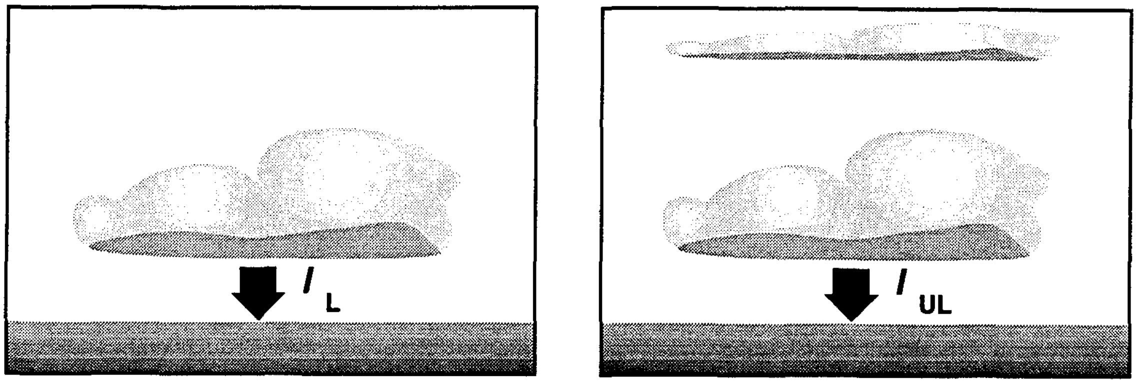
The partly cloudy FASCAT model uses a weighted averaging technique of possible cloud situations to obtain the diffuse component of illumination. The following conditions are considered:

1. For clear skies, the diffuse radiance calculation is performed once using clear layers.
2. For one overcast cloud layer (either upper or lower), the radiance is calculated once with clouds in the appropriate atmospheric layer(s).
3. For one partly cloudy layer (either upper or lower), the diffuse radiance calculation is performed twice: once with clouds in the layer(s) and once without. A weighted average of the two is then computed based on the fractional cloud cover.
4. For two overcast layers, the calculation is performed once with clouds in all applicable atmospheric layers.
5. If one of the upper or lower layers is partly cloudy (either upper of lower), the calculation is performed twice and a weighted average is computed.
6. If both layers are partly cloudy, four diffuse radiance calculations are performed: one with two clear layers (CR), one with a lower overcast (L), one with an upper overcast (U), and one with two overcast layers (UL). A weighted average of the four is then computed based on the cloud fractions.

Figure 3 shows this last situation.



Clear **Upper Cloud**



Lower Cloud **Upper and Lower Cloud**

Figure 3. Diffuse radiance calculation for two partly cloudy layers.

The direct component of illumination depends on the cloud situation. For clear skies, the direct radiance calculation is performed using clear atmospheric layers. For overcast skies, the calculation is performed using layers with clouds. For partly cloudy skies, the best case direct radiance calculation uses layers without clouds and the worst case calculation uses layers with clouds.

The average diffuse radiance, best and worst case direct radiance, and corresponding optical parameters are used to compute total radiance incident on the target and background, transmission, path radiance, sky-to-ground ratio, and acquisition ranges twice: once for a clear path and once for a cloudy path. The cloud fractions and source zenith angle are then used to estimate the probability that the target scene is in shadow.

Section 4.2. describes the specific changes to the FASCAT calculations and the effects on other parts of the TARGAC model.

3.1.3. OUTPUT

Once the diffuse and direct components of illumination are calculated, these values are used to determine the total radiance at the target, the transmitted radiance, the sky-to-ground ratio, the apparent contrast, and the detection and recognition ranges. The average diffuse radiance component is used with the best case or worst case direct component for these calculations. Output is produced for the possible situations (target and background in direct light, target and background in cloud shadow, or both). The result is a single set of output for clear or overcast cases and two sets for partly cloudy cases.

Although under partly cloudy conditions the actual cloud positions cannot be predicted with accuracy, the acquisition ranges and sky-to-ground ratio can be bracketed by providing solutions for the target scene in and out of cloud shadow. The actual values should be between these limits. The probability of being in cloud shadow provides an indicator of the most likely values.

Section 4.1.3. describes the specific changes to the TARGAC output and the values produced.

3.2. TASK 2: SHADOWING BY SMALL-SCALE FEATURES

Shadows caused by small-scale features have an important effect on target acquisition. By small-scale, we mean an object whose size, and to some degree appearance, is on the order of the target's size and/or appearance. Examples include individual trees, clumps of bushes, rock formations, boulders, dunes, or man-made target-like objects. The importance of the small-scale feature is that these objects add clutter to the scene. In most cases, target acquisition performance is inversely proportional to clutter. The higher the clutter, the lower the probability of detection or recognition.

Schmieder et al. (1982) described these clutter effects quite extensively. Although their tests focused on IR imaging systems, they stated that their methodology extended into the visible and near-IR spectrum. Their conclusion was that target scenes could be categorized in terms of the signal-to-clutter ratio (SCR) or the ratio of target contrast to clutter contrast. Higgins et al. (1989) implemented Schmieder's methodology in the Air Force EOTDA in a semi-automated form in which the user selects a scene clutter index in the TV model or scene complexity index in the IR model. Scene complexity in the EOTDA IR model was categorized into four levels (None, Low, Moderate, or High), while in the TV model only three levels are available (Low, Moderate, or High).

The major objective of task 2 is to implement a modified Schmieder methodology for the EO and near-IR parts of the spectrum. During the first year of this effort, we examined the target acquisition relationships, developed an approach to determining the clutter index over a variety of clutter and illumination conditions, and produced a software design document (appendix D).

3.2.1. Target Acquisition Relationships

Many other methods have been proposed for measuring and modeling scene or background clutter or complexity. Table 4 lists some of the better known approaches. The common factor among these methods is that they are computationally intensive.

Table 4. Background clutter/complexity modeling approaches.

Model Name	***Comment***	***References***
Auto-regressive	Although widely used, this model's power spectrum and auto correlation functions do not closely resemble those of the original image.	E. Botkin, et al, "Infrared Modeling and Analysis (IRMA), Volume I Scene Generation and Sensor/Seeker Interface," AFATL-TR-81-65, 31 August 1981, pp. 11-15. See also R. Chellapa and R. Kashyap, "Texture Synthesis Using 2-D Noncausal Autoregressive Models," IEEE Trans. Acoustics, Speech & Signal Processing, Vol. ASSP-33, No. 1, pp. 194-203, February 1985; and D. F. Strenzwilk, et al, "A Two-Dimensional ARMA Model for Simulation of IR Backgrounds," Communications in Statistics, Part B: Simulation and Computation, Vol. 18, No. 4, pp. 1539-1555, 1989.
Markov Random field	This model produces very visual textures, but its definition requires conditional probability distributions that are difficult or impossible to estimate.	R. Chellappa and S. Chatterjee, "Classification of Textures Using Gaussian Markov Random Fields," *IEEE Trans. Acoustics, Speech & Signal Processing*, Vol. ASSP-33, No. 4, pp. 959-963, August 1985. See also H. Derin and H. Elliot, "Modeling and Segmentation of Noisy and Textured Images Using Gibbs Random Fields," *IEEE Trans. Pattern Anal. Machine Intell.*, Vol. PAMI-9, No. 1, pp. 39-55, January 1987; and R. I. Kashypa and R. Chellappa, "Estimate and Choice of Neighbors Spatial-Interaction Models of Images," IEEE Trans Inform. Theo., Vol. IT-29, No. 1, pp. 60-72, January 1983.
Fractal	A fractal texture is characterized by self-similarity. However, many textures, especially man-made textures, do not exhibit self-similarity.	M. F. Barnsley, et al, "Harnessing chaos for image synthesis, " *Computer Graphics*, SIGGRAPH 1988 Conference Proceedings, 1988. See also M. F. Barnsley, *Fractals Everywhere*, Academic Press, San Diego, 1988; and R. F. Voss, "Fourier Synthesis of Gaussian Fractals: If Noise Landscapes, and Flakes," State of the Art in Image Synthesis, Tutorial No. 10, SIGGRAPH 1983, ACM, New York, 1983.

Table 4. Background clutter/complexity modeling approaches (continued).

Model Name	***Comment***	***References***
Random Mosaic	These models are mostly used to generate "cellular" textures, consisting of cells with nearly constant gray-level.	N. Ahuja and A. Rosenfeld, "Mosaic models for texture,," IEEE Trans. Pattern Anal. Machine Intell., Vol. PAMI-1. No. 1, pp. 1-11, January 1981. See also N. Ahuja and B. J. Schacter, *Pattern Models*, Wiley, New York, 1983.
Morphological	Morphological operators are used to determine size distributions of texture elements, or to enhance specific features of texture.	R. Libeskind-Handas and P. Maragos, "Application of iterated function systems and skeletonization to synthesis of fractal images," *Proc. SPIE Vol. 845, Visual Communications and Image Processing II,* 1987. See also S. Sternberg, "Gray scale Morphology," *Computer Vision, Graphics, and Image Processing*, Vol. 35, pp. 333-335, 1986.
Syntactic	These models are useful as analysis tools. They describe hierarchical geometric relationships between the elements in a texture.	R. W. Ehric and J. P. Foith, "A View of texture topology and texture grammars," *Computer Graphics and Image Processing,* Vol. 8, pp. 174-202, 1978. See also K. S. Fu, "Syntactic image modeling using stochastic tree grammars," *Computer Graphics and Image Processing,* Vol. 12, pp. 136-152, 1980; and K. S. Fu, *Syntactic Pattern Recognition and Applications,* Prentice-Hall, 1982
Moving Average	This model is driven by an excitation function, with noise added to the result, and followed by histogram modification.	J. A. Cadzow, et al, "Image Texture Synthesis-by-Analysis using Moving Average Models," Submitted to: *IEEE Trans. on Aerospace and Electronic Systems*, 1992. See also D. F. Strenzwilk, "Synthetic IR Background Imagery," *ICMG Symposium Proceedings: Targeting and Scene Modeling,* July 1992; and J. A. Cadzow, et al, "Two-dimensional models for the simulation of infrared backgrounds," Final report to U.S. Army Ballistic Research Laboratory, Aberdeen Proving Grounds, Maryland, 1990.

In 1993 in a related, classified program for the Department of Defense, we examined how the probability of detecting a target from a frame of imagery changed as a function of background clutter, solar illumination, weather conditions, and sensor collection geometries (Carroll 1993). For that effort, we implemented a simplified probability of detection estimation approach first suggested in a 1970 Rand report (Bailer, 1970). As part of that program, we implemented in software and tested three variations of the clutter/complexity modeling approaches referenced in table 4. The three approaches were auto-regressive, fractal, and moving average.

The result of that effort was a practical implementation of a software solution to the problem of estimating probability of detection from collected imagery. In this program, we have and will continue to make use of the above referenced software in performing static observer testing. The objective is to establish, validate, and quantify the relationship between target acquisition and shadow-caused clutter. Previously, we have used this software to estimate the complexity of classified images. In this program, we will use this software in establishing the complexity of sample images being supplied to us by NVESD, formally the Army Night Vision Laboratory. The following section presents an overview of the Rand approach, which was adapted by Rand for the *RCA Electro-Optics Handbook* and originally published in 1974.

3.2.1.1 Theory of Detection Overview

Imaging sensor performance may be estimated and/or evaluated by application of a target detection/recognition model such as that suggested by Rand, namely

$$Pid = P_1 \bullet P_2 \bullet P_3 \bullet h \tag{8}$$

and

$$Pd = P_1 \bullet P_2 \bullet h \tag{9}$$

where Pid is the probability that a target will be identified (recognition in TARGAC terminology) on a display or piece of film and Pd is the probability of detection; P_1 is the probability that the observer, searching an area that is known to contain a target, looks with his foveal vision for a specific glimpse time in the direction of the target; P_2 is the probability that if the displayed target image is viewed foveally for one glimpse period, it will, in the absence of noise, have sufficient contrast and size to be detected; P_3 is the probability that if a target is detected, there will be enough detail shown for it to be recognized (again during a single glimpse and in the absence of noise); and h is the overall degradation factor arising from noise.

The probability P_1 is difficult to estimate because it is affected by

1. the solid angle presented to the eye of the search field,
2. the time available to search the image,
3. the number of confusion elements within the scene, and
4. any availability of "cues" or a priori information as to where to look on the image.

The model employs the relation

$$P_1 = 1 - \exp\left[- (700 / G) \bullet (At / As) \bullet t \right] \qquad (10)$$

where

At = area of target
As = area to be searched
t = search time
G = congestion factor, usually between 1 and 10, for most real imagery of interest.

The probability of detection, P_2, at a contrast ratio (C) of $C = 1$, is by definition 50 percent. A useful approximation for P_2 at other contrasts available at the eye is given by

$$P_2 \approx 1/2 \pm 1/2 \bullet \{ 1 - \exp\left[- 4.2 \bullet C^2 \right] \}^{0.5} \qquad (11)$$

where a minus sign is used when $C < 0$. This equation is plotted in figure 4.

The other two factors in the basic equation (P_3 & h) are also plotted in figure 4 and can be calculated respectively from

$$Nr \geq 2 \qquad P_3 = 1 - \exp\left[- (Nr / 2 - 1)^2 \right] \qquad (12)$$

$$Nr < 2 \qquad P_3 = 0, \tag{13}$$

where

$$Nr = Lmin / \sin \alpha\, r \tag{14}$$

is the number of resolution cells contained in the minimum projected target dimension, Lmin, α is the angular resolution of the sensor, r is the target range, and h is a function the displayed signal-to-noise (SNR) ratio.

$$SNR \geq 1 \qquad h = 1 - \exp\left[- (SNR - 1)^2 \right] \tag{15}$$

$$SNR < 0 \qquad h = 0 \tag{16}$$

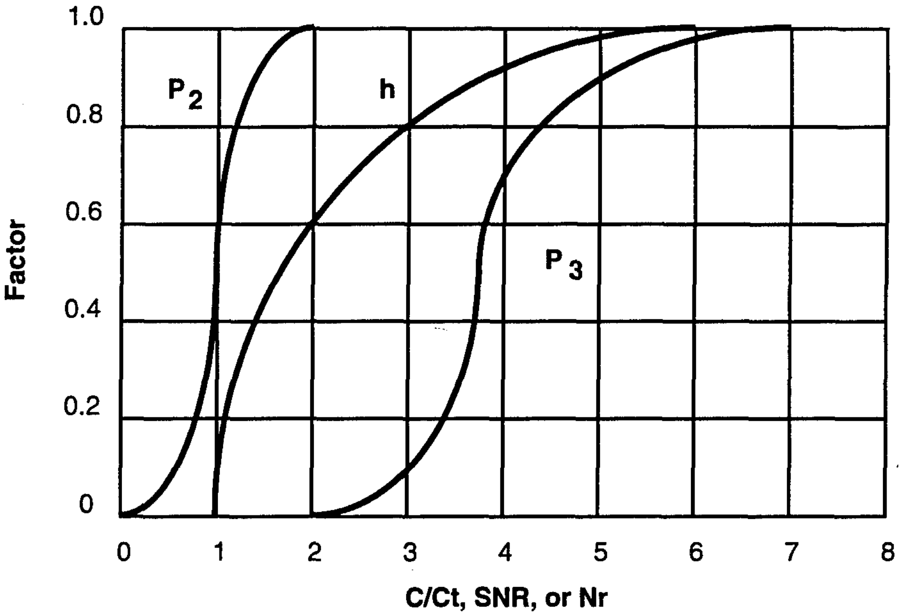


Figure 4. Probability factors.

3.2.1.2 The Congestion/Complexity Factor

The Rand approach refers to G as the congestion factor of the image. One can think of the congestion of an image as its complexity or "busyness" with an empty parking lot being very homogeneous and having a very low complexity, and a mixed forest area being very rough and random and having a high complexity. Alternatively (Freni, 1993), one can describe the clutter of a "TV" system as, "The busyness of the target area, including both the number of objects comparable in size and shape to the target and the magnitude of the contrast between scene features". Thus, G maps to what we are calling the scene or background clutter (EO) or complexity (IR). In our implementation of this approach, we found that the use of a fractal dimension estimator provided the best results when compared to experimental studies using real imagery and imagery analysts. The fractal dimension estimator we used was the Hurst dimension (Feders, 1988). The Hurst dimension is a form of fractal dimension that for most real imagery has a value of between 0 and 2. In the above referenced implementation, after calculating the Hurst dimension of an image, we scaled it from the range of (1 to 2) to the desired range (1 to 10). It is our plan in this effort to use a mapping of the Hurst dimension as an approximation of the clutter and complexity. In the later discussion of our approach to 2-d and 3-D clutter, the relationship of this work to the current effort will be evident.

3.2.2. Algorithm Development and Software Design Approach

Our algorithm and software design approach to the problem of predicting the effects of small-scale feature shadows (features about the same size as the target) on the probability of detection and recognition has focused on five goals: algorithm simplicity, software modularity, clear and simple user inputs, flexible fidelity, and speed of execution. In this section, we discuss our overall design approach. Appendix D presents a detailed technical review of the software design.

At the simplest level, one can think of this package as one group of software routines that examines the scene clutter and another group of software routines that examines the target. These two groups pass their output to a third group of routines that calculates the signal-to-clutter ratio. A last group of software calculates the probability of detection and recognition of the target. Let us look at each of these software groups separately.

3.2.2.1 Calculating the Clutter Index

In the PSR approach, the largest group of software is dedicated to calculating the clutter index. Figure 5 presents a graphical overview of the functions performed in this group. Clutter is initially represented as 2-d clutter or 3-d clutter. Clutter is only considered for a small region within the scene. The size of this region must be big enough to provide accurate statistics, yet as small as possible so that it will not clog the computational process. For ease of use, the analyst will be able to select from a set of photographs the 2-d clutter desired: None, Low, Medium, or High. The Air Force EOTDA handles clutter/complexity in a similar manner.

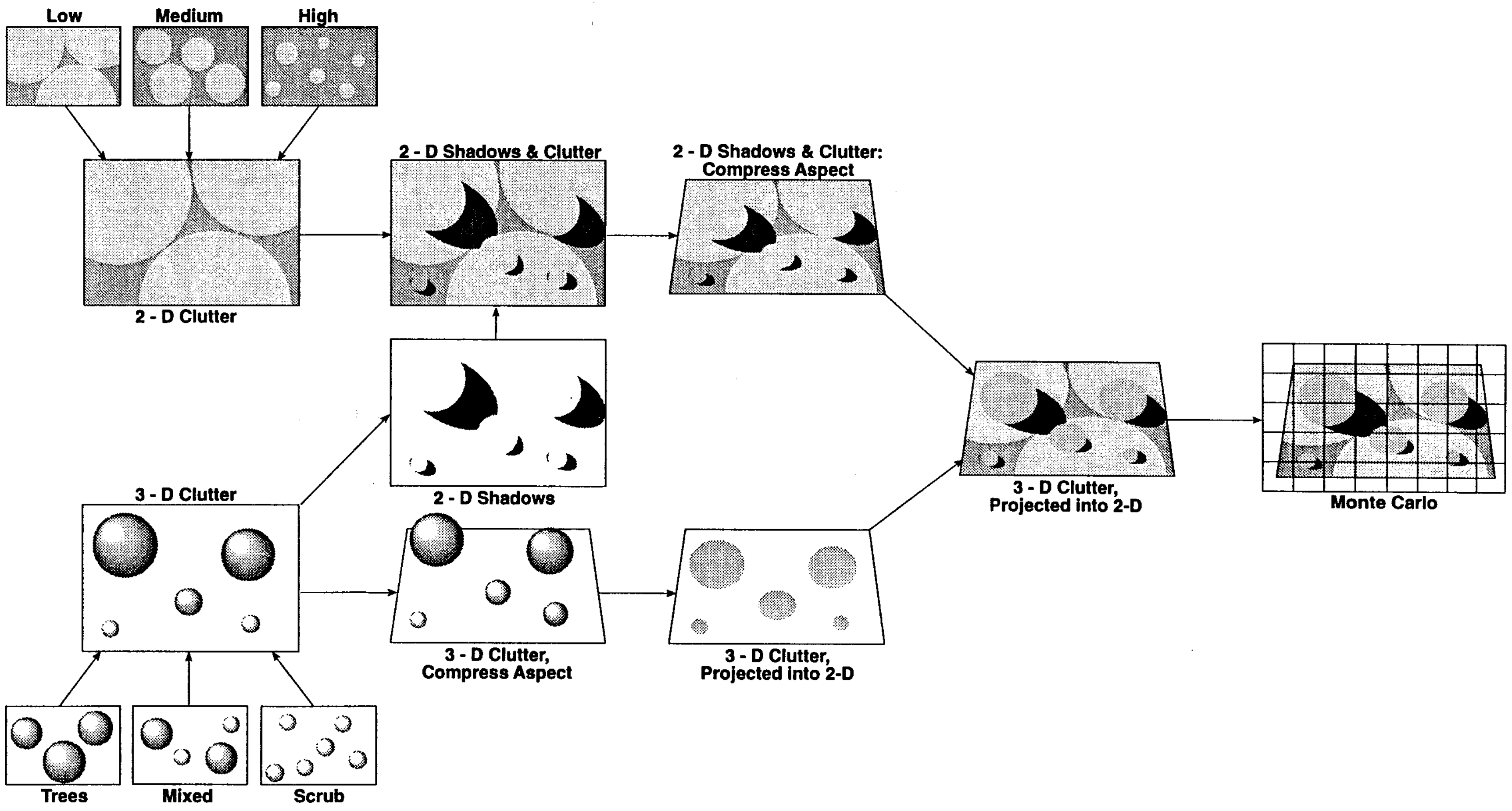


Figure 5. Clutter Index Overview.

However, to maximize fidelity and flexibility when required, the advanced user can input the statistics of the 2-d region. 3-d clutter is handled in a similar manner: either select a clutter type from a set of photos (see table 5) or input a set of statistics for the region. Note: for 3-d clutter we will provide a matrix of photos that combine man-made and natural clutter.

Table 5. Man-made and natural clutter matrix.

Man-Made	***Natural***			
	None	***Trees***	***Scrubs***	***Mixed***
None	None-None	None-Trees	None-Scrubs	None-Mixed
Light	Light-None	Light-Trees	Light-Scrubs	Light-Mixed
Average	Average-None	Average-Trees	Average-Scrubs	Average-Mixed
High	High-None	High-Trees	High-Scrubs	High-Mixed

Based on the photos selected or the inputs provided by the user, synthetic regions (with the same fractal/Hurst dimension discussed in section 3.2.1.2.) of 2-d and 3-d clutter are generated based on an approximation using circles (2-d) and spheres (3-d).

We have chosen to use spheres as 3-d objects (see plate 1). This choice greatly simplifies the computations, because spheres are rotationally invariant both in azimuth and elevation. We added a SCUD missile resupply vehicle to provide a size reference in the plate. As shown in plate 2, future versions of TARGAC could use combinations of spheres to represent trees, shrubs, and even man-made objects without drastically increasing the complexity of the code.

Based on the location and time-of-day information provided by the user, sun and/or moon 2-d shadows are generated from the 3-d region. These shadows are then added to the 2-d clutter region as shown in figure 5. Both the 2-d and 3-d regions are aspect compressed to the perspective of the observing sensor. Remember that in most cases the observer will be at or near the plane of the ground. The 3-d clutter region will be projected into a 2-d region from the point-of-view of the sensor and will be added to the 2-d plus shadow region.

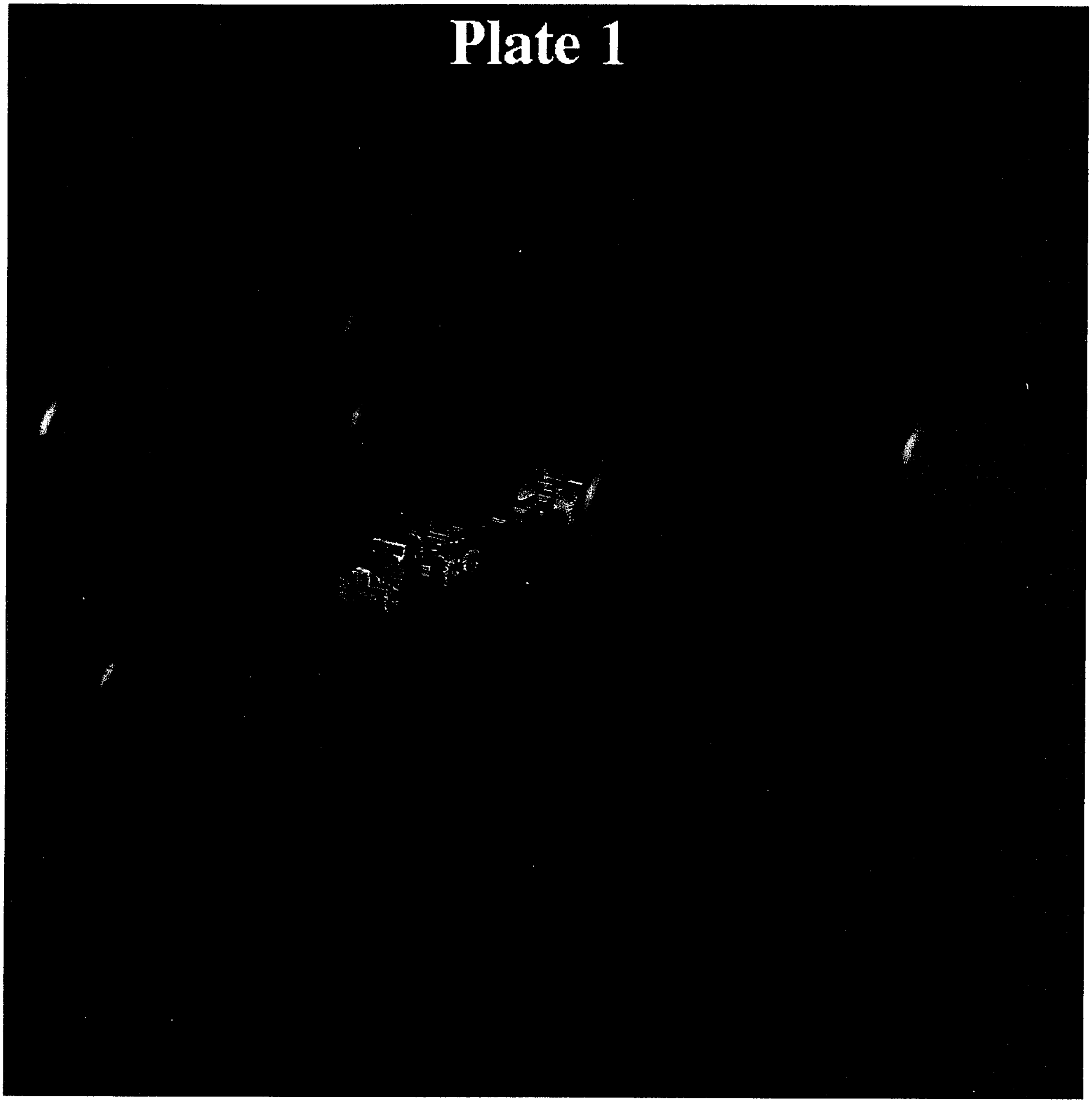


Figure 6. Plate 1.

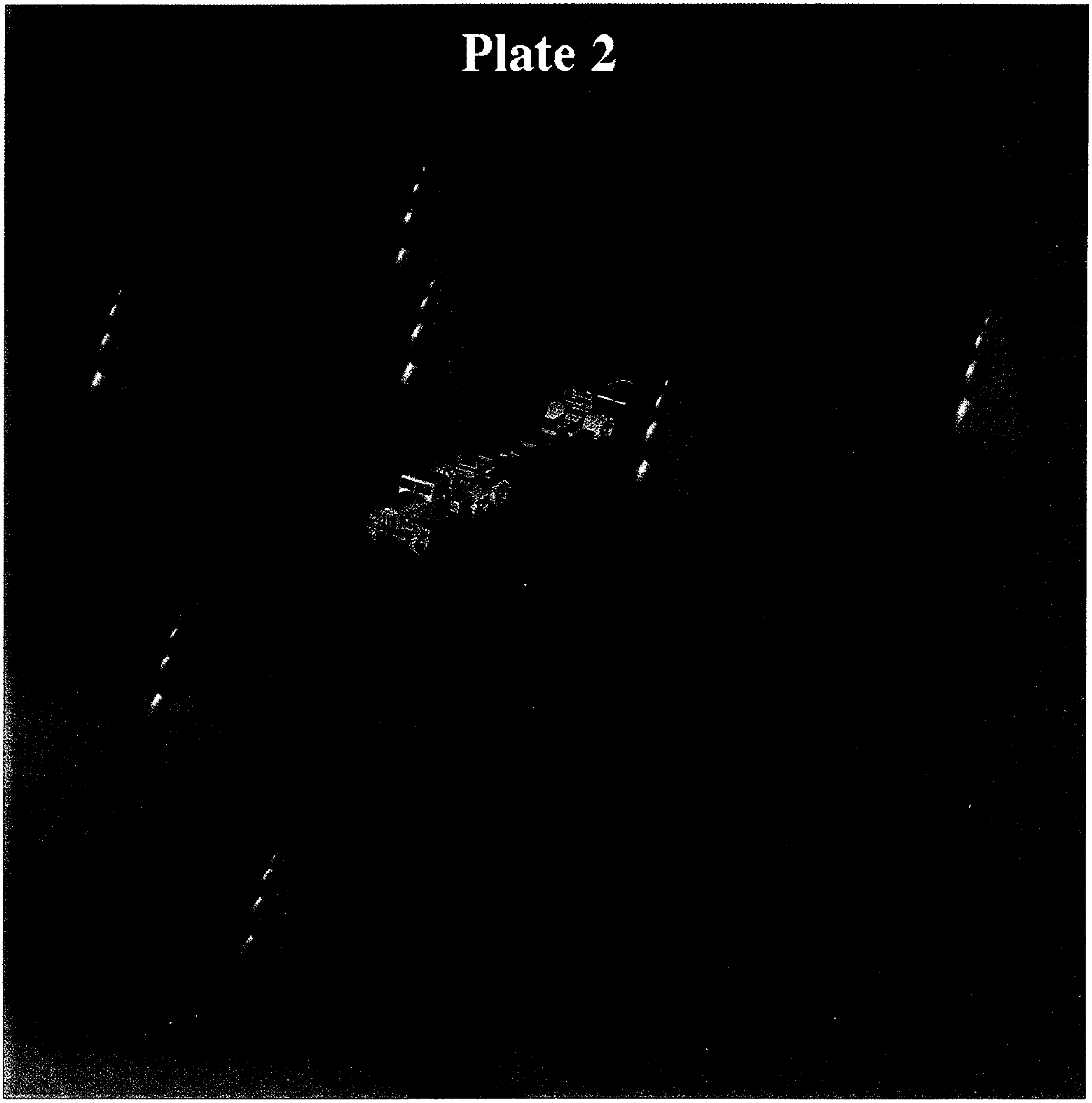


Figure 7. Plate 2.

The clutter index *CI* as defined below is then computed. Conceptually, a sample region as shown in figure 5 is broken into cells roughly the size of the target, and the background radiance is computed for each cell. The clutter index is the root-mean-square of variations in radiance between adjacent cells as depicted in equation (17).

$$CI = \sqrt{\frac{\sum_i \sigma_i^2}{N}} \tag{17}$$

Here the summation of variance is taken over adjacent cells and divided by the total number of adjacent components in the sum.

The CI computation can be performed in one of two ways. The first is to use the statistical information on scene objects and perform a closed form solution assuming independence between the various components. Such a closed form solution although possible is extremely complicated and very inflexible. The second is to perform a fast Monte-Carlo computation on a small, synthetically generated scene. This second approach was adopted for the research effort because of its simplicity and flexibility.

3.2.2.2. Calculating the Signal-to-Clutter Ratio

Once the clutter index has been computed, the signal-to-clutter ratio (SCR) can readily be determined. In the Schmieder approach the pixel with the highest radiance is assigned a count value of 255 and the pixel with the lowest value is assigned a count value of 0. SCR is defined as the maximum difference between the target and background divided by the rms clutter for positive contrast targets

$$\text{SCR} = \frac{|\text{ Max Target Value (counts) - Bkgrd Mean (counts) }|}{\text{rms clutter (counts)}} \tag{18}$$

while for negative contrast targets

$$\text{SCR} = \frac{|\text{ Min Target Value (counts) - Bkgrd Mean (counts) }|}{\text{rms clutter (counts)}} \tag{19}$$

However, as shown below, the problem becomes more complicated when one has to deal with both shadow and non-shadow backgrounds.

3.2.2.3 Calculating the Probability of Detection & Recognition

TARGAC currently considers targets to have at most length and width (some modules of the code only deal with a minimum target dimension), so in essence targets are cylinders and often only spheres. As long as one limits the use of TARGAC to horizontal and near horizontal line-of-sight (LOS) situations, cylinders provide an excellent form because they are rotationally invariant in azimuth. However, they are not rotationally invariant in elevation. Errors will be introduced as elevation differences increase. With the introduction of small-scale feature shadows, especially the shadow of the target itself, the calculation of the probability of detection becomes complicated. The increased complexity stems from the fact that with the introduction of shadow, the target no longer resides on a single background type. When calculating probability from a statistical basis, even highly complex backgrounds can be represented on average as a single background type. In the general case (with or without shadow), the probability of detecting a target is a function of its size (cycles on target) and the contrast with its surroundings.

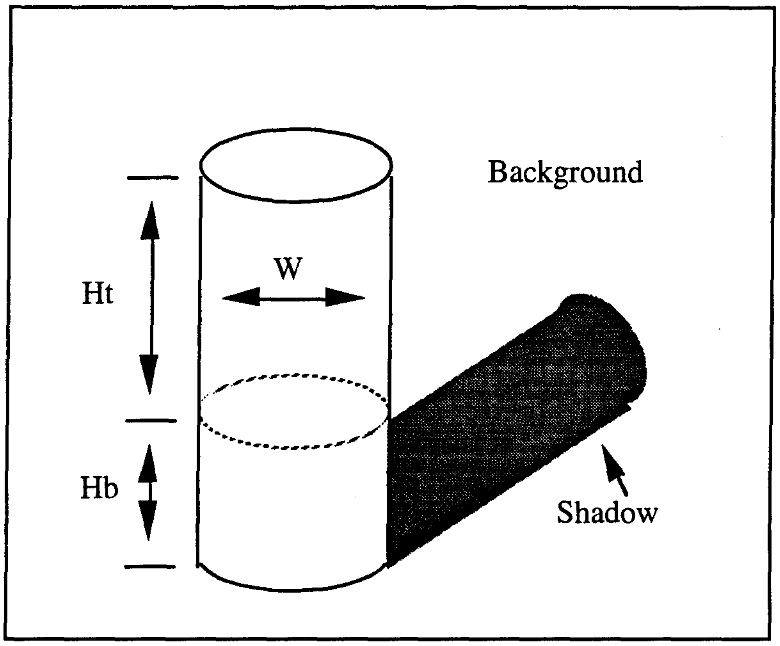


Figure 8. Targets and target shadow.

Figure 8 depicts a cylindrical shaped target and its shadow. For this target, the probability of detection with shadows can be written as:

$$P(d_w|w) = P(d_t|w) + P(d_b|w)\ (1 - P(d_t|w)) \tag{20}$$

where we have used the rotational invariance of the cylinder to divide its height into two target parts. One target part with only clutter as a background (Ht) and one target part with both clutter and shadowed clutter as a background (Hb).

The above equation states that the probability of detecting the whole target $P(d_w|w)$ is equal to the probability of detecting the top part $P(d_t|w)$ of the target (the part of the target bounded by only clutter and target) given the whole target, plus the probability of detecting the bottom part $P(d_b|w)$ of the target (the part of the target bounded by clutter, target, and shadowed clutter) given the whole target, times the quantity one minus the probability of detecting the top of the target given the whole target $(1 - P(d_t|w))$. This equation accounts for the interaction of the top and bottom parts of the cylinder.

The problem is that accounting for this interaction between the top and bottom parts of the target is difficult. One would like to use $P(d_t|t)$ and $P(d_b|b)$ respectively as the probability of detecting the top part of the target given only the top part of the target and the probability of detecting the bottom part of the target given only the bottom part of the target. Using these two probabilities derives the equation

$$P(d_w|w) = P(d_t|t) + P(d_b|b)\ (1-P(d_t|t)) + g(b) \tag{21}$$

Combining the equations (20) and (21) derives

$$g(b) = [P(d_t|w) + P(d_b|w)\ (1 - P(d_t|w))] - [P(d_t|t) + P(d_b|b)\ (1 - P(d_t))] \tag{22}$$

where g(b) is a non-zero variable dependent on the relationship between the contrast of target with the clutter background and the shadowed clutter background. One would normally expect the value of g(b) to be quite small. However, during the option year of this effort, we need to either establish a methodology for estimating g(b) or develop an evidentiary base for ignoring it.

4. IMPACT OF THE REVISIONS

4.1. TASK 1: IMPACTS ON USERS

This section is designed to assist the TARGAC user by describing how to load and compile the new software (the software written during the basic phase of this contract), how to run the software with appropriate inputs, and how to analyze the output. With the exception of some additional cloud inputs and expanded output, the code operates much as it did before. As mentioned above, TARGAC-3 has been implemented for the PC only; the UNIX version will be completed next year. There are no new hardware requirements for the PC version of TARGAC-3.

4.1.1. LOADING AND COMPILING

The TARGAC-3 code was developed using the Microsoft FORTRAN Compiler, Version 5.1. The following instructions anticipate the use of the Microsoft compiler, but the code can be compiled with other compilers. Note that compilation warning messages will appear because of unused and undefined variables that were present in TARGAC-2. The suggested way for loading and compiling the PC version of TARGAC-3 is as follows:

1. Create a working directory with two subdirectories named TARGAC and TCM2. Copy the source code for the TARGAC-3 model into the TARGAC subdirectory. Copy the source code for TCM2 into the TCM2 subdirectory. Copy all batch files and TCM2 target files into the working directory.

2. To create the TARGAC-3 executable file, enter the TARGAC subdirectory. Use the following command to compile with the Microsoft compiler:

   ```
   FL /c /Gt0 /AH *.FOR.
   ```

   Type the following Microsoft link command with the accompanying switches:

   ```
   FL /FeTARGAC3 *.OBJ /link /NOE /E/SE:1024.
   ```

Copy the newly created executable file, TARGAC3.EXE, to the working directory.

3. To create the TCM2 executable file, enter the TCM2 subdirectory. Use the following commands to compile with the Microsoft compiler:

```
FL /c *.FOR
FL /c /Od FT3B*.FOR.
```

Note that the superfile FT3b*.FOR cannot be compiled with the Microsoft FORTRAN optimization option; this causes the program to fail with a run-time error. Type the following Microsoft link command with the accompanying switches:

```
FL /FeTCM2 *.OBJ /link /NOE /E /SE:200.
```

Copy the newly created executable file, TCM2.EXE, to the working directory.

4. Move to the working directory and type in the command TARGAC-3 to run the model. The batch file TARGAC-3.BAT controls execution.

The Microsoft command line switches are defined as follows:

/c	compile without linking
/GT0	allocate all data items to a new data segment
/Fe	give the executable file the name that follows
/AH	select the huge library
/Od	disable optimization
/link	link the object files listed
/NOE	prevent link from searching for extended dictionaries in the libraries
/E	pack the executable
/SE	set the maximum number of segments.

Note that Microsoft FORTRAN Version 5.1 by default selects the large library (/AL), uses full optimization (/Ox), generates in-line instructions, and selects coprocessor commands (/FPi87). For more details on the command line switches, see the references provided with the Microsoft FORTRAN Compiler.

4.1.2. INPUT

TARGAC input has undergone several changes. Cloud data are now entered for up to three layers: low, medium, and high. Cloud type is a new input for all cloud layers. Cloud base height limits have changed, along with the unit system for entering cloud base heights. The significant weather input was removed. Inputs have changed for both interactive and batch modes. Note: some of the changes will affect thermal imager runs. Specific changes are described below.

4.1.2.1. Interactive Mode

In interactive mode, cloud information may be specified by the user or read in from a climatological database. If the user chooses to enter cloud information, the cloud fractional amount is required for all three cloud layers. If the cloud fraction is greater than zero for a cloud layer, a cloud base height must be entered for that layer. If it is a low or high cloud, a cloud type must be entered. Since there is only one type of middle cloud supported, a middle cloud type does not have to be entered. Cloud types for the visible and near-IR systems are the same as those for thermal imager systems. The following is a list of cloud types used in TARGAC-3.

High Cloud Types

1	Thin Cirrus
2	Thick Cirrus

Middle Cloud Type

3	Altostratus/Altocumulus

Low Cloud Types

4	Stratus/Stratocumulus
5	Cumulus/Cumulonimbus

The cloud base height limits have changed to match those in the Air Force EOTDA. The new base height limits apply for the visible, near-IR, and thermal imager systems. Cloud base heights are always entered in kilometers, regardless of the sensor system used. The following is a list of the cloud base height limits.

High Clouds
6.1 - 13.7 km

Middle Clouds
2.0 - 6.1 km

Low Clouds
0.1 - 2.0 km

For the visible and near-IR systems, the user is allowed to have a low cloud on the ground. If the visibility is less than 0.55 km, a cloud is assumed to be on the ground. The user is asked to enter a cloud top height, rather than a cloud base height. The cloud fraction is automatically set to 1.0, and the cloud type is set to stratus.

If the user chooses to read in cloud information from a climatological database, only one value of cloud cover and the corresponding base height is available. If the base height is between 6.1 and 13.7 km and the cloud cover is greater than 62.5 percent, the thick cirrus type is used. The thin cirrus type is used for any smaller cloud cover. If the base height is between 2.0 and 6.1 km, the altocumulus type is used. If the base height is between 0.1 and 1.2 km and the cloud cover is greater than 50 percent, the stratus type is used. Otherwise, the cumulus type is used. These types are assigned automatically. The decision process is shown in table 6.

Cloud geometric thickness is automatically assigned based on cloud type, unless there is a low cloud on the ground. The thickness values that are used by TARGAC-3 are given in table 3, section 3.1.2. If there is a low cloud on the ground, the user specifies the cloud thickness by entering a cloud top height. A default value of 0.2 km is used.

The user is not required to specify a ceiling height. Instead, ceiling height is calculated from the cloud inputs for any of the sensor types. The ceiling is defined as that height at which the cloud cover observed from the surface is more than 60%. This definition is based on the definition used by the Air Force (AWSR 105-24, 1983).

Table 6. Assignment of cloud type for climatology data.

Base Height	**Cloud Cover**	**Cloud Type**
6.1 - 13.7 km	> 62.5%	Thick Cirrus
6.1 - 13.7 km	< 62.5%	Thin Cirrus
2.0 - 6.1 km	any	Altocumulus
1.2 - 2.0	any	Cumulus
0.1 - 1.2	>50%	Stratus
0.1 - 1.2	<50%	Cumulus

The significant weather input was removed, since this information was covered elsewhere. The input options for significant weather included cloud cover, blowing snow or sand, fog, drizzle, rain, snow, or thunderstorm. Cloud cover is entered separately. Fog can be entered as an aerosol type or as a low cloud on the ground. Precipitation is entered as precipitation type.

The minimum value for the user-supplied background reflectance was changed from 0.0 to 0.01. As specified in the *TARGAC Users Guide* (Gillespie, 1993), a value slightly greater than 0.0 was necessary to prevent a divide-by-zero error.

4.1.2.2. Batch Mode

In batch mode, all inputs are entered in records in the TAC.DAT file. This section describes the changes made to specific records.

Since the thermal imager section of TARGAC already required three cloud layers, we decided to use the same batch records to implement three cloud layers in the visible and near-IR sections: the LCLD, MCLD, and HCLD records. Note that the cloud base height limits for these records have been changed. In TARGAC-2, the cloud information for these systems was entered in the METD record. Data must still be entered in all fields of the METD record, but the cloud data can be any dummy value.

As explained in section 4.1.2.1, the significant weather input was removed. This input was part of the ILUM record. As with the METD record, the data must still be entered in all fields of the record, but the data for the significant weather can be any dummy value.

The background reflectance value was moved from the METD record to the second field of the CONTEXTL record, after the CNTRST field. This value was never saved to the TAC.SAV file after an interactive mode run, causing a problem when TAC.SAV was used for a batch mode run. The minimum value for the field was changed from 0.0 to 0.01 to prevent a divide-by-zero error in the model.

The next few paragraphs describe the records that have been changed either in content or usage: CONT, HCLD, MCLD, LCLD, ILUM, and METD. These descriptions are meant to make updates to the *TARGAC Users Guide* (Gillespie, 1993) easier.

The CONT (Contrast) Record

This record is used with the DVO, II, and SiTV sensor types. The record described here designates that contrast shall be calculated from external input values.

```
CNTRST - Value of inherent contrast.
         Range: 0.1 - 1.0.

BKREF - Surface reflectance.
        Range: 0.1 - 1.0

         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
CONTEXTL  CNTRST    BKREF

Sample of CONTEXTL Record:
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
CONTEXTL  0.5       0.15
```

The HCLD Record

This record is used with any sensor type. The WTME parameter is not used for the DVO, II, and SiTV types.

```
WTME - Time.
       Range: 0000.0 - 2400.0 (HHMM) (GMT)
       Default: 1200.0 Hr.

IWX(I,4) - Cloud indicator.
           Range: 0.0 - None.
                  1.0 - Thin
                  2.0 - Thick
           Default: 0.0

WX(I,9) - Cloud fraction.
          Range: 0.0 - 1.0
          Default: 0.0

WX(I,12) - Cloud base height.
           Range: 6.1 - 13.7 km.
           Default: 9.0 km.

         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
HCLD      WTME      IWX(I,4)  WX(I,9)   WX(I,12)


Sample of HCLD Record:
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
HCLD      1200.0    0.0       0.0       0.0
```

The MCLD Record

This record is used with any sensor type. The WTME parameter is not used for the DVO, II, and SiTV types.

```
WTME - Time.
       Range: 0000.0 - 2400.0 (HHMM) (GMT)
       Default: 1200.0 Hr.

IWX(I,5) - Cloud indicator.
           Range: 0.0 - None.
                  3.0 - Any middle cloud.
           Default: 0.0

WX(I,10) - Cloud fraction.
           Range: 0.0 - 1.0
           Default: 0.0

WX(I,13) - Cloud base height.
           Range: 2.0 - 6.1 km.
           Default: 4.0 km.
```

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
MCLD      WTME      IWX(I,5)  WX(I,10)  WX(I,13)
```

Sample of MCLD Record:

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
MCLD      1200.0    3.0       0.5       4.0
```

The LCLD Record

This record is used with any sensor type. The WTME parameter is not used for the DVO, II, and SiTV types.

```
WTME - Time.
       Range: 0000.0 - 2400.0 (HHMM) (GMT)
       Default: 1200.0 Hr.

IWX(I,6) - Cloud indicator.
           Range: 0.0 - None.
                  4.0 - Stratus
                  5.0 - Convective
           Default: 0.0

WX(I,11) - Cloud fraction.
           Range: 0.0 - 1.0
           Default: 0.0

WX(I,14) - Cloud base height.
           Range: 0.1 - 2.0 km.
           Default: 1.0 km.

         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
LCLD      WTME      IWX(I,6)  WX(I,11)  WX(I,14)

Sample of LCLD Record:
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
LCLD      1200.0    0.0       0.0       0.0
```

The ILUM Record

This record is used with the DVO, II, and SiTV sensor types. The first record described here designates that the user will input an illumination level in footcandles. The second record indicates that the user will choose a phase of the moon to determine the illumination level. The third record described here designates that TARGAC will have ILUMA calculate the illumination level based on the day and the weather.

```
AL - Value of the illuminance in footcandles (fc).
     Default: 1000.0 fc
     For DVO and SiTV devices the allowed values are 1.0 - 10,000 fc.
     For II devices the allowed values are 0.0001 - 0.01 fc.

SIGWX - Significant weather ID.  No longer used.

OBSURF - Observed state of ground, choices 1-10.
          1 - Dry
          2 - Moist
          3 - Wet
          4 - Frozen
          5 - Ice
          6 - Snow < 0.5 in
          7 - 0.5 in < Snow < all
          8 - Snow (all)
          9 - 0.5 in < Loose, dry snow, dust, sand < all
         10 - Loose, dry snow, dust, sand (all)
         Default: 1.0

PRTYPE - Precipitation type, choices 1-5.
          1 - None
          2 - Drizzle
          3 - Rain
          4 - Snow
          5 - Hail
         Default: 1.0

IMOON - The phase of the moon.
        Range: -1.0 - Clear sky, full moon conditions.
               -2.0 - Clear sky, quarter moon conditions.
               -3.0 - Clear sky, no moon conditions.
        Default: -1.0
```

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
ILUMEXTL  AL        NOT USED  OBSURF    PRTYPE
```

Sample of ILUMEXTL Record:

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
ILUMEXTL  100.0     0.0       1.0       1.0
```

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
ILUMEXTL  IMOON
```

Sample of ILUMEXTL Record:

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
ILUMEXTL  -2.0
```

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
ILUMINTL            NOT USED  OBSURF    PRTYPE
```

Sample of ILUMINTL Record:

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
ILUMINTL            0.0       1.0       1.0
```

The METD Record

This record is used with the DVO, II, and SiTV sensor types.

VIS - Visibility
Range: 0.10 - 200.0 (km).
Default: 7.0 km.

CF1 - Cloud fraction. No longer used.

ZC1 - Cloud base height. No longer used.

THICK - Cloud thickness.
Range: 0.1 - 5.0 (km).
Default: None.

TMP - Temperature.
Range: -60.0 - 60.0 (degrees Celcius).
Default: 10.0 degrees.

TDEW - Dewpoint temperature.
Range: -60.0 - TMP above (degrees Celcius).
Default: 8.0 degrees.

BKREF - Surface reflectance. No longer used.

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
METD      VIS       NOT USED  NOT USED  THICK     TMP       TDEW
```

Sample of METD Record:

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
METD      7.0       0.0       0.0       1.0       10.0      8.0
```

4.1.3. OUTPUT

The output for TARGAC-3 is in the same basic format as for TARGAC-2. The sky-to-ground ratio has been changed to include values for both in and out of cloud shadow cases when the appropriate conditions exist. The detection and recognition ranges have also been expanded to include clear sky values, in cloud shadow values, or both depending on the cloud conditions. Each condition provides a complete set of detection and recognition ranges for each sensor. No change has been made to the format previously used to report ranges.

The probability of the target scene in cloud shadow has been added. This value is given as a percentage. In addition, information about the cloud situation has been added to the output. Layers are reported as clear, partly cloudy, or overcast. Below is an example of the TARGAC-3 output block.

```
    ************************OUTPUTS ************************

    SOLAR ELEVATION ANGLE =   25.60 DEGREES.
    SOLAR AZIMUTH  ANGLE  =   82.45 DEGREES.
    LUNAR ELEVATION ANGLE =  -64.34 DEGREES.
    LUNAR AZIMUTH  ANGLE  =    5.48 DEGREES.
    LUNAR PHASE  ANGLE    =  -72.32 DEGREES.

    SOLAR ILLUMINANCE =     27198.26 LUMENS/SQ-METER.
    LUNAR ILLUMINANCE =        .0000 LUMENS/SQ-METER.
    NET  ILLUMINANCE  =   27198.2600 LUMENS/SQ-METER.

    INTEGRATED TOTAL FLUX =    292.45 WATTS/SQ-METER.

*** ILLUMINATION VALUE OUT OF RANGE
    DEFAULT VALUE WILL BE USED

SKY TO GROUND RATIO (NO CLOUD) IS        1.212847
SKY TO GROUND RATIO (IN CLOUD) IS        7.182998

PROBABILITY OF TARGET IN CLOUD SHADOW:      60.769370
TWO PARTLY CLOUDY LAYERS.
```

```
DEVICE TYPE IS I I
CLEAR SKY CASE:

DETECTION   RANGE (KM)
PROBABILITY LEVEL = .10             .50             .90
SENSOR ID
     1              2.0              1.2              .7
     2              1.4               .8              .5
     3              2.2              1.3              .8
     4               .5               .3              .1

DEVICE TYPE IS I I
CLEAR SKY CASE:

RECOGNITION RANGE (KM)
PROBABILITY LEVEL = .10             .50             .90
SENSOR ID
     1               .9               .4              .3
     2               .6               .3              .1
     3              1.0               .5              .3
     4               .2               .1              .1


DEVICE TYPE IS I I
CLOUD SHADOW CASE:

DETECTION   RANGE (KM)
PROBABILITY LEVEL = .10             .50             .90
SENSOR ID
     1              1.2               .8              .5
     2               .9               .6              .4
     3              1.3               .9              .6
     4               .4               .2              .1

DEVICE TYPE IS I I
CLOUD SHADOW CASE:

RECOGNITION RANGE (KM)
PROBABILITY LEVEL = .10             .50             .90
SENSOR ID
     1               .6               .4              .2
     2               .4               .2              .1
     3               .7               .4              .2
     4               .2               .1              .1
```

4.2. TASK 1: IMPACTS ON ANALYSTS

This section describes the equations used in TARGAC-3 to predict, direct, and diffuse radiance incident on the target and background, the inherent contrast, and the contrast transmittance. The resulting sky-to-ground ratios and detection/recognition ranges are also described.

4.2.1. DELTA-EDDINGTON RADIATIVE TRANSFER MODEL

The partly cloudy FASCAT model (Hering and Johnson, 1984) has been incorporated into TARGAC-3. This model uses the delta-Eddington approximation to the radiative transfer equation to determine direct and diffuse radiance on a target scene. As described in section 3.1.2, the direct radiance is computed for "best case" and "worst case" cloud conditions. The diffuse radiance is computed as an average over all possible conditions. The total radiance is the sum of the direct and diffuse terms. This section describes the equations used in TARGAC-3 to predict direct, diffuse, and total radiance on the target scene.

TARGAC-3 uses the standard definition of direct radiance:

$$D(\tau) = F_0 e^{-\frac{\tau}{\mu_0}}, \tag{23}$$

where

μ_0 = cos θ,
θ = zenith angle,
τ = optical depth from the top of the atmosphere down to the elevation of interest,

and

πF_0 = solar irradiance.

Shettle and Weinman (1970) give the equation of transfer defining the diffuse radiance $I(\tau,\mu,\phi)$ as

$$\mu \frac{dI}{d\tau}(\tau,\mu,\phi) = -I(\tau,\mu,\phi) + \frac{a}{4\pi}\int_{0}^{2\pi}\int_{+1}^{+1} P(\mu,\phi;\mu',\phi')I(\tau,\mu',\phi')d\mu'\,d\phi' + \frac{1}{4}aF_0P(\mu,\phi;\mu_0,\phi_0)e^{-\frac{\tau}{\mu_0}} \tag{24}$$

where

ϕ = azimuth angle,
$a(\tau)$ = single scattering albedo,

and

$P(\mu,\phi;\mu',\phi')$ = phase function for light incident at angle (μ',ϕ') and scattered in the direction (μ,ϕ).

They use Eddington's approximation to express diffuse radiance as a sum of two terms, a directionally independent term, I_0, and a directionally dependent term, I_1:

$$I(\tau,\mu) = I_0(\tau) + I_1(\tau)\mu . \tag{25}$$

Shettle and Weinman substitute this expression into the equation of transfer, expand the phase function using a simple cosine dependence, and integrate to obtain a pair of linear differential equations:

$$\frac{dI_1}{d\tau} = -3[1 - a(\tau)]I_0 + \frac{3}{4}a(\tau)F_0e^{-\frac{\tau}{\mu_0}} \tag{26}$$

$$\frac{dI_0}{d\tau} = -[1 - a(\tau)g(\tau)]I_1 + \frac{3}{4}a(\tau)g(\tau)\mu_0F_0e^{-\frac{\tau}{\mu_0}}, \tag{27}$$

where

$g(\tau)$= phase function asymmetry parameter.

For turbid atmospheres, the assumption that there is no absorption of the scattered component,

$$a(\tau) = 1, \tag{28}$$

is a good approximation in most cases (Wachtmann et al., 1985). This assumption simplifies the solution of equations (26) and (27) and leads to the following conservative solution to the equation of transfer:

$$I_0(\tau) = B_1 - \frac{3}{4}\mu_0^2 F_0 e^{-\frac{\tau}{\mu_0}} - B_2 T(\tau) \tag{29}$$

$$I_1(\tau) = B_2 - \frac{3}{4}\mu_0 F_0 e^{-\frac{\tau}{\mu_0}}, \tag{30}$$

where

$$B_2 = \frac{3\mu_0 F_0 (1-A)\left[2 + 3\mu_0 + (2 - 3\mu_0) e^{-\frac{\tau^*}{\mu_0}}\right]}{4\left[4 + 3(1-A)T(\tau^*)\right]}, \tag{31}$$

$$B_1 = \left(\frac{3\mu_0^2}{4} + \frac{\mu_0}{2}\right) F_0 - \frac{2B_2}{3}, \tag{32}$$

the effective optical depth is

$$T(\tau) = \int_0^{\tau} [1 - g(\tau')] d\tau', \tag{33}$$

τ^* = optical thickness of the entire atmosphere,

and

A = ground albedo.

Diffuse irradiance is then computed from I_0 and I_1:

$$F(\tau) = 2\pi \int_0^{\pm 1} (I_0 + \mu I_1)\mu d\mu = \pi \left[I_0(\tau) \pm \frac{2}{3} I_1(\tau) \right] \tag{34}$$

where

$\mu>0$ corresponds to downwelling diffuse irradiance, $F\downarrow(\tau)$,

and

$\mu<0$ corresponds to upwelling diffuse irradiance, $F\uparrow(\tau)$.

Joseph et al. (1976) modified the Eddington approximation to better account for the highly asymmetric phase functions associated with particulate scattering. The delta-Eddington approximation uses a truncated forward scatter peak and a two-term expansion of the phase function. The delta-Eddington approximation is equivalent to the Eddington approximation except the transformed parameters τ', a', and g' are substituted for τ, a, and g. The delta-Eddington parameters are defined as follows:

$$\tau' = (1 - af)\tau \tag{35}$$

$$g' = \frac{g}{1+g} \tag{36}$$

$$a' = \frac{(1-f)a}{1-af}, \tag{37}$$

where the fractional scattering into the forward peak is defined as

$$f = g^2. \tag{38}$$

The delta-Eddington parameters result in modified values for the components of diffuse radiance, $I_0(\tau')$ and $I_1(\tau')$, and for direct radiance, $D(\tau')$.

Hering used the delta-Eddington approximation in his development of the FASCAT model. This model was developed in three stages. FASCAT computes radiances under clear (1981), overcast (1983), and partly cloudy (1984) meteorological conditions.

Hering's method solves for diffuse radiance for a partly cloudy sky as a weighted average of clear-sky and overcast-sky values. The method allows up to two cloud layers. For two cloud layers, the following situations are possible:

1. Two clear layers. The diffuse radiance components, I_0 and I_1, are calculated just once using clear layers.

2. Upper layer overcast, lower layer clear. I_0 and I_1 are computed once with the appropriate cloud optical depth added to the optical depth from the top of the atmosphere down to the level of interest. We are mainly interested in targets at or near ground level, so we assume that the level of interest is below any cloud layers.

3. Lower layer overcast, upper layer clear. I_0 and I_1 are computed once with the appropriate cloud optical depth added to the optical depth from the top of the atmosphere down to the level of interest.

4. Two overcast layers. I_0 and I_1 are computed once with both cloud optical depths added to the atmospheric optical depth.

5. Upper layer partly cloudy, lower layer clear. I_0 and I_1 are calculated twice: once with both layers clear and once with the appropriate cloud optical depth included. Weighted averages of the two values for I_0 and I_1 are then computed.

6. Upper layer partly cloudy, lower layer overcast. I_0 and I_1 are calculated twice: once with both cloud optical depths included and once with just one cloud optical depth included (from the overcast layer). Weighted averages are then computed.

7. Lower layer partly cloudy, upper layer clear. I_0 and I_1 are calculated twice: once with both layers clear and once with the appropriate cloud optical depth

included. Weighted averages of the two values for I_0 and I_1 are then computed.

8. Lower layer partly cloudy, upper layer overcast. I_0 and I_1 are calculated twice: once with both cloud optical depths included and once with just one cloud optical depth included (from the overcast layer). Weighted averages are then computed.

9. Two partly cloudy layers. I_0 and I_1 are calculated four times: once using clear layers, once with the lower cloud optical depth included, once with the upper cloud optical depth included, and once with both cloud optical depths included. This scenario is depicted in figure 3 in section 3.1.2. Weighted averages of the four values for I_0 and I_1 are then computed.

Hering developed generalized equations to perform the weighted averages:

$$\overline{I_0} = (1-F_U)(1-F_L)I_{0,CR} + F_U(1-F_L)I_{0,U} + F_L(1-F_U)I_{0,L} + F_U F_L I_{0,UL} \tag{39}$$

$$\overline{I_1} = (1-F_U)(1-F_L)I_{1,CR} + F_U(1-F_L)I_{1,U} + F_L(1-F_U)I_{1,L} + F_U F_L I_{1,UL}, \tag{40}$$

where

$$F_U(n_U,\mu) = n_U(1.43 - 1.21\mu - 2.00n_U + 1.21n_U\mu + 1.57n_U^2), \tag{41}$$

$$F_L(n_L,\mu) = n_L(1.43 - 1.21\mu - 2.00n_L + 1.21n_L\mu + 1.57n_L^2), \tag{42}$$

n_{U} = upper cloud fraction,

n_{L} = lower cloud fraction,

$I_{0,\mathrm{CR}} = I_0$ with no clouds,

$I_{0,\mathrm{U}} = I_0$ with upper overcast cloud,

$I_{0,\mathrm{L}} = I_0$ with lower overcast cloud,

$I_{0,\mathrm{UL}} = I_0$ with upper and lower overcast clouds,

$I_{1,\mathrm{CR}} = I_1$ with no clouds,

$I_{1,\mathrm{U}} = I_1$ with upper overcast cloud,

$I_{1,\mathrm{L}} = I_1$ with lower overcast cloud,

and

$I_{1,\mathrm{UL}} = I_1$ with upper and lower overcast clouds.

Hering's weighting factors F_U and F_L are based on work done by Shapiro (1982) to fit SOLMET data. Note that F_U is zero for a clear upper cloud layer and one for an overcast layer; F_L is zero for a clear lower cloud layer and one for an overcast layer. Equations (39) and (40), then, can be used to compute $\overline{I_0}$ and $\overline{I_1}$ values for any of the nine possible cloud situations. Any inapplicable terms cancel out.

According to Hering and Johnson (1984), the downward diffuse radiance below cloud layers has an additional term, which we will denote I_COR, to account for forward scattering of direct radiance through the cloud layers:

$$\begin{aligned} I_{COR} = {} & \left[(1-F_U)(1-F_L) - G_U G_L\right] D_{CR}(\tau') + \left[F_U(1-F_L) - G_L(1-G_U)\right] D_U(\tau') + \\ & \left[F_L(1-F_U) - G_U(1-G_L)\right] D_L(\tau') + \left[F_U F_L - (1-G_U)(1-G_L)\right] D_{UL}(\tau') \end{aligned} , \tag{43}$$

where

$D_\mathrm{CR}(\tau') = D(\tau')$ with no clouds,

$D_\mathrm{U}(\tau') = D(\tau')$ with upper overcast cloud,

$D_\mathrm{L}(\tau') = D(\tau')$ with lower overcast cloud, and

$D_{\mathrm{UL}}(\tau') = D(\tau')$ with upper and lower overcast clouds.

The factors G_{U} and G_{L} are the probabilities of a cloud-free solar path through the upper and lower cloud layers. These values are derived by Allen and Malick (1983) as follows:

$$G(n,\theta) = p_n^{1+c_n \tan\theta}, \tag{44}$$

where the average height-to-width ratio for a cubical cloud, c_n, is given as

$$c_n = 0.55 - \frac{n}{2}, \tag{45}$$

the probability of a cloud-free path from the zenith, p_n, is

$$p_n = 1 - n\frac{1+3n}{4}, \tag{46}$$

and n is the upper or lower cloud fraction. Note that G_U is one for a clear upper cloud layer and zero for an overcast layer; G_L is one for a clear lower cloud layer and zero for an overcast layer.

We can now calculate the total radiance incident on the target scene as a sum of direct and diffuse components. For a downward line-of-sight, the average diffuse radiance is

$$\overline{I} = \overline{I_0} + \frac{2}{3}\overline{I_1} + I_{COR}. \tag{47}$$

For an upward line-of-sight, the average diffuse radiance is

$$\overline{I} = \overline{I_0} - \frac{2}{3}\overline{I_1}. \tag{48}$$

For a horizontal line-of-sight, we take the average of the upward and downward values:

$$\bar{I} = \overline{I_0} + \frac{I_{COR}}{2}. \tag{49}$$

To this average diffuse radiance value, we add the best case direct radiance value to obtain the higher bracketing value of total radiance. We add the worst case direct radiance value to obtain the lower bracketing value. For situation 1, with two clear layers, a single value of total radiance is computed:

$$R = \bar{I} + D_{CR}(\tau'). \tag{50}$$

For cloud situations 2 or 3, with one overcast layer, a single value is computed:

$$R = \bar{I} + D_{U}(\tau') \tag{51}$$

or

$$R = \bar{I} + D_{L}(\tau'). \tag{52}$$

For situation 4, with two overcast layers, a single value is computed:

$$R = \bar{I} + D_{UL}(\tau'). \tag{53}$$

For cloud situations 5 and 7, with one partly cloudy layer, two bracketing values of total radiance are computed:

$$R_1 = \bar{I} + D_{CR}(\tau') \tag{54}$$

and

$$R_2 = \bar{I} + D_{U}(\tau') \tag{55}$$

or

$$R_2 = \bar{I} + D_{L}(\tau'). \tag{56}$$

Here, R_1 is the "best case" radiance and R_2 is the "worst case" radiance. For situations 6 and 8, with one partly cloudy layer and one overcast layer, two bracketing values of total radiance are again computed:

$$R_1 = \bar{I} + D_L(\tau') \tag{57}$$

or

$$R_1 = \bar{I} + D_U(\tau') \tag{58}$$

and

$$R_2 = \bar{I} + D_{UL}(\tau'). \tag{59}$$

Finally, for cloud situation 9, with two partly cloudy layers, two bracketing values of total radiance are computed:

$$R_1 = \bar{I} + D_{CR}(\tau') \tag{60}$$

and

$$R_2 = \bar{I} + D_{UL}(\tau'). \tag{61}$$

The other two possibilities (using D_U and D_L) are ignored.

Finally, the FASCAT model allows computation of the probability that the target scene is in cloud shadow. This value depends on the probability of a cloud-free path through each cloud layer:

$$P = 1 - G_U G_L, \tag{62}$$

where G_U and G_L are defined by Equation (29).

4.2.2. INHERENT CONTRAST

The inherent contrast between the target and the background is computed once for clear or overcast conditions and twice for partly cloudy conditions. The bracketing values of total radiance are used for these computations:

$$C_{0,1} = \frac{{}_tR_{0,1} - {}_bR_{0,1}}{{}_bR_{0,1}} \tag{63}$$

and

$$C_{0,2} = \frac{{}_tR_{0,2} - {}_bR_{0,2}}{{}_bR_{0,2}}, \tag{64}$$

where the presubscripts designate the target or background, and the postsubscript 0 indicates that the scene is observed at zero distance. Note that the radiance values ${}_tR_0$ and ${}_bR_0$ include a multiplicative factor for the target or background viewing angle and reflectivity. For example, ${}_tR_{0,1}$ refers to the inherent (zero distance), "best case" radiance reflected off the target.

The radiance reflected off the target is multiplied by the transmittance and added to the path radiance between the target and sensor to obtain the apparent radiance:

$${}_tR_{r,1} = {}_tR_{0,1}T(r) + N^* \tag{65}$$

and

$${}_tR_{r,2} = {}_tR_{0,2}T(r) + N^*, \tag{66}$$

where r is the distance between the target and sensor,

${}_tR_{r,1}$ = the best case apparent radiance,

${}_tR_{r,2}$ = the worst case apparent radiance,

$T(r)$ = transmission along the distance r, and

N^* = path radiance between the target and sensor.

Similar equations are used to compute ${}_bR_{r,1}$ and ${}_bR_{r,2}$.

4.2.3. CONTRAST TRANSMITTANCE

The apparent radiance values can then be used to compute apparent contrast. The bracketing values of apparent radiance are used for these computations:

$$C_{r,1} = \frac{{}_tR_{r,1} - {}_bR_{r,1}}{{}_bR_{r,1}} \tag{67}$$

and

$$C_{r,2} = \frac{{}_tR_{r,2} - {}_bR_{r,2}}{{}_bR_{r,2}}. \tag{68}$$

The bracketing values of inherent and apparent contrast can then be used to compute contrast transmittance:

$$\frac{C_{r,1}}{C_{0,1}} = \frac{1}{1 + \dfrac{N^*}{{}_bR_{0,1}T(r)}} \tag{69}$$

and

$$\frac{C_{r,2}}{C_{0,2}} = \frac{1}{1 + \dfrac{N^*}{{}_bR_{0,2}T(r)}}. \tag{70}$$

The contrast transmittance can also be written as a function of sky-to-ground ratio, S_{gr}:

$$C_{r,1} = C_{0,1}\frac{1}{1+S_{gr,1}e^{\beta r-1}} \tag{71}$$

and

$$C_{r,2} = C_{0,2}\frac{1}{1+S_{gr,2}e^{\beta r-1}}, \tag{72}$$

where the postsubscripts 1 and 2 again refer to best and worst case values.

4.2.4. SENSOR PERFORMANCE MODEL

The sensor performance model was updated only to include detection and acquisition range prediction for up to two bracketing conditions. No other changes to this model were made.

4.3. TASK 2: ANTICIPATED IMPACTS

This section covers the planned new inputs and modified outputs to TARGAC that will support the addition of small-scale feature shadowing.

4.3.1. INPUTS

Two new types of operator inputs will be needed to support the small-scale scene shadow modifications to TARGAC. The first group consists of inputs related to 2-d and 3-d clutter and the second includes those related to the viewing geometry. Figure 9 may help in the visualization of these geometric inputs. The new inputs are as follows:

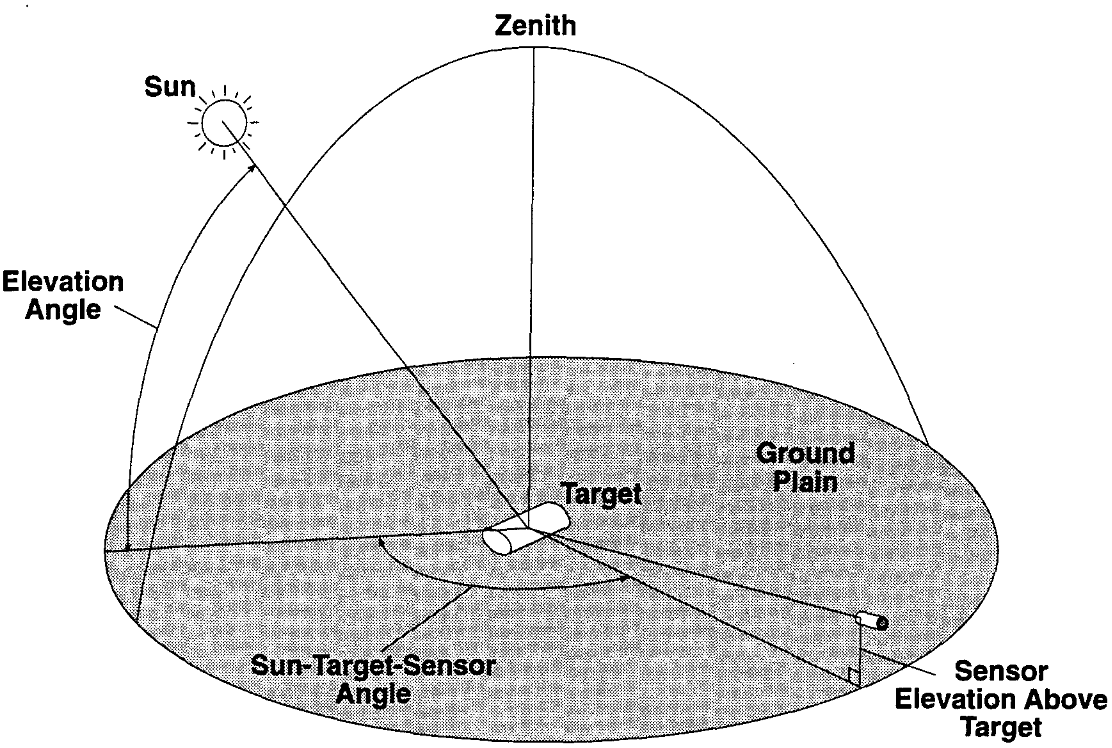


Figure 9. Sensor-target geometry.

- 2-d clutter type or statistics - as stated previously, the operator will be required to either select the desired 2-d clutter type from a set of supplied images or to input a set of 2-d clutter statistics.

- 3-d clutter type or statistics - as with 2-d clutter, the operator will be required to either select the desired 3-d clutter type from a set of supplied images, or to input a set of 3-d clutter statistics.

- Range of SUN-TARGET-SENSOR angles - Unless the sensor is headed directly at the target, this angle will change as a function of sensor-to-target distance. Thus it is important to calculate detection ranges for various sun-target-sensor angles. Here the operator may input the starting angle, the stopping angle, and the value of each step, or accept the default values.

- Sensor-target elevation difference - Unlike the EOTDA, TARGAC was designed as an LOS code, which means that in most cases the target and the observer are at approximately the same elevation. However, since the clutter index will change with large changes in the observer-target-ground angle, we use the difference between sensor and target elevations as an input in determining how many clutter indexes we must calculate for a specific run.

- Slope angles for the target - these inputs are the elevation angle and rotation angle of the target about the observer-to-target line of sight as projected into the ground plane. Although TARGAC currently considers the earth as flat, the large-scale feature shadowing modifications being performed as part of this effort will be incorporating DTED and ground slope into the code. By adding these two parameters to our calculations, we are facilitating the future incorporation of DTED into the small scale feature shadowing module.

4.3.2. OUTPUTS

The output for TARGAC with the small-scale scene shadowing modifications will be basically in the same format as TARGAC-3. The output will be changed to include the values of the SUN-TARGET-SENSOR AZIMUTH angle. For each angle computed, an array of user defined probability levels (with the defaults set equals to 25, 50, and 75 percent) versus sensor ID number will be calculated for both the detection and recognition cases.

```
     *****************SAMPLE*OUTPUTS***********************

     SOLAR ELEVATION ANGLE =   25.60 DEGREES.
     SOLAR AZIMUTH   ANGLE  =   82.45 DEGREES.
     LUNAR ELEVATION ANGLE = -64.34 DEGREES.
     LUNAR AZIMUTH   ANGLE  =    5.48 DEGREES.
     LUNAR PHASE   ANGLE    =  -72.32 DEGREES.

     SOLAR ILLUMINANCE =    27198.26 LUMENS/SQ-METER.
     LUNAR ILLUMINANCE =       .0000 LUMENS/SQ-METER.
     NET  ILLUMINANCE  =  27198.2600 LUMENS/SQ-METER.

     INTEGRATED TOTAL FLUX =    292.45 WATTS/SQ-METER.

 *** ILLUMINATION VALUE OUT OF RANGE
     DEFAULT VALUE WILL BE USED

 SKY TO GROUND RATIO IS        7.182998


 DEVICE TYPE IS I I
 SUN-TARGET-SENSOR AZIMUTH = 10 DEGREES:

 DETECTION   RANGE (KM)
 PROBABILITY LEVEL = .10              .50              .90
 SENSOR ID
       1             2.0              1.2               .7
       2             1.4               .8               .5
       3             2.2              1.3               .8
       4              .5               .3               .1

 DEVICE TYPE IS I I
 SUN-TARGET-SENSOR AZIMUTH = 10 DEGREES:

 RECOGNITION RANGE (KM)
 PROBABILITY LEVEL = .10              .50              .90
 SENSOR ID
       1              .9               .4               .3
       2              .6               .3               .1
       3             1.0               .5               .3
       4              .2               .1               .1


 DEVICE TYPE IS I I
 SUN-TARGET-SENSOR AZIMUTH = 20 DEGREES:

 DETECTION   RANGE (KM)
 PROBABILITY LEVEL = .10              .50              .90
 SENSOR ID
       1             1.2               .8               .5
       2              .9               .6               .4
       3             1.3               .9               .6
       4              .4               .2               .1
```

```
DEVICE TYPE IS I I
SUN-TARGET-SENSOR AZIMUTH = 20 DEGREES:

RECOGNITION RANGE (KM)
PROBABILITY LEVEL = .10              .50              .90
SENSOR ID
      1               .6               .4               .2
      2               .4               .2               .1
      3               .7               .4               .2
      4               .2               .1               .1
```

5. TESTING

Although part of the Electro-Optical Systems Atmospheric Effects Library (EOSAEL), TARGAC is a self-contained module. TARGAC has been under development for a number of years by a number of contractors as a multi-year, incremental research and development program. Each cycle of TARGAC development builds on the previous effort and provides an increasing degree of capability and sophistication. However, as the sophistication increases, the testing requirements for a new module also increase. This fact is exacerbated by the lack of comprehensive documentation and configuration control. PSR and Hughes STX are taking a small step towards the resolution of this problem through the use of formalized Engineering Change Reports (ECRs) as part of our development process and through the use of highly modular code which will facilitate future software modifications.

In this section, we will first examine the testing of the PC version of the shadowing by clouds module and then examine the test planning that has been accomplished for the shadowing by small-scale features module. In addition to the testing and test planning reported here, during the second year of this phase II SBIR, the shadowing by large-scale features module will be tested, as will the intergration of all three modules within both the PC and UNIX versions of TARGAC.

5.1. TASK 1: SHADOWING BY CLOUDS MODULE TESTING

Software tests were conducted to analyze the performance of scene shadowing modifications to TARGAC. Whenever feasible, individual routines were tested during the course of modification. For formal testing, three distinct series of tests were conducted to evaluate the model differently: functionality tests, tests against TARGAC-2 sample runs, and comparison tests against the EOTDA. The tests ensured complete program execution, validated system default values, and looked to see that radiance values (both direct and diffuse), the probability that the target scene is in cloud shadow, sky-to-ground ratios, and bracketing range values were within acceptable ranges. Tests were carried out under a pass/fail system. For each failure, appropriate modifications were made to TARGAC-3 to correct the problem.

5.1.1. FUNCTIONALITY TESTS

5.1.1.1. Overview

The first group of tests focused on evaluating the serviceability of the scene shadowing modifications to the TARGAC code. This required that every possible combination of low, middle, and high clouds be reviewed.

5.1.1.2. Cloud Type/Amount/Base Height

This section involved the most extensive testing. Cloud type and base height were varied randomly. Base height extremes were tested. In addition, each cloud level was tested in a clear, partly cloudy, and overcast state. The partly cloudy amounts were varied to encompass a broad spectrum of configurations.

5.1.1.3. Sensor Type

All of the sensor types available in TARGAC were utilized. Direct View Optics, Image Intensifiers, and Silicon Television Systems were extensively tested since they are now sensitive to variable cloud conditions. Thermal Imagers were looked at only to ensure that the modifications did not alter the outputs.

5.1.1.4. Interactive/Batch Mode

Two modes of input were used. All the interactive options were exercised. The batch format was employed to ensure correctness. Default and extreme values affecting modifications to TARGAC inputs were tested.

5.1.1.5. Climatology/User-Specified Data

The climatology information utilized by TARGAC-3 can be specified by the user or obtained from an existing database. Both methods were tested to ensure that reasonable data was entered into the system. Two climatological databases were used: North Atlantic States (73) and Southwestern States (53). A random sampling of user-specified inputs was examined.

5.1.1.6. Results

The total number of possible cloud combination tests that exist are 432. This number was reduced to 66 tests for three reasons:

1. Cloud shadows do not influence thermal imaging systems; therefore, only a limited number of thermal imaging tests were conducted to ensure functionality.

2. The climatology database provides cloud information for only one layer, thereby eliminating an entire series of cloud combination tests.

3. Each cloud combination was tested just once to validate the output. As a result, the many combinations were equally distributed among the possible input selections.

After appropriate code modification, all tests ran naturally to completion. No functionality errors were detected.

5.1.2. TESTS AGAINST TARGAC SAMPLE RUNS

5.1.2.1. Overview

This series of tests simply repeated the tests that were conducted on TARGAC-2. These tests, in addition to the outputs they produced, are listed in the *TARGAC Users Manual* (Gillespie, 1993). The sample tests were run to verify that the output from TARGAC-3 correlates favorably with the output from TARGAC-2 for clear and overcast sky conditions and improves the output for partly cloudy cases.

We created new batch input files for the TARGAC-3 sample runs. These files contain the same information as those used for the TARGAC-2 sample runs, but some of the records have been changed to correspond to the changes described in section 4.1.2.2. The old and new batch file names for each sample test are shown in table 7.

Table 7. Input files for TARGAC sample runs.

Sample #	Old Input File	New Input File
1A	TACDVO1.DAT	TACDVO1N.DAT
1B	TACDVO2.DAT	TACDVO2N.DAT
2	TACDVO3.DAT	TACDVO3N.DAT
3	TACDVO4.DAT	TACDVO4N.DAT
4	TACDVO5.DAT	TACDVO5N.DAT
5A	TACII3.DAT	TACII3N.DAT
5B	TACII2.DAT	TACII2N.DAT
6	TACII1.DAT	TACII1N.DAT
7A	TACSTV1.DAT	TACSTV1N.DAT
7B	TACSTV2.DAT	TACSTV2N.DAT
8	TACTI1.DAT	TACTI1N.DAT
9	TACTI2.DAT	TACTI2N.DAT
10	TACUSR1.DAT	TACUSR1N.DAT
11	TACUSR2.DAT	TACUSR2N.DAT
12	TACUSR3.DAT	TACUSR3N.DAT

5.1.2.2. Results

After appropriate code modification, all the batch mode tests ran to completion. Comparisons of the output files for TARGAC-2 and TARGAC-3 indicated some differences, as expected. The TARGAC-3 sky-to-ground ratio values for in and out of cloud shadow typically bracketed the TARGAC-2 values, although in several cases both of the TARGAC-3 values were lower than the TARGAC-2 values. Detection and recognition ranges showed smaller variation than the sky-to-ground ratios. Changes in the net illuminance value for sample 1A and the sky-to-ground ratio values for sample 4 require further investigation.

5.1.3. COMPARISON TESTS BETWEEN TARGAC AND THE AIR FORCE EOTDA

5.1.3.1. Overview

In a similar manner to the functionality tests, each sensor type was scrutinized under a number of different cloud conditions using the TARGAC-3 model and Version 3.0 of the Air Force EOTDA. An attempt was made to closely duplicate the input data used in both the TARGAC-3 and EOTDA runs in order to generate similar output ranges. Debug versions of both models were employed so that intermediate radiance values could be monitored.

These tests were deemed useful because the scene shadow modules that were written into the TARGAC-3 program were patterned directly after the code developed for the EOTDA model. They are believed to provide the best program verification available.

One limitation in using the EOTDA model for comparison is the restricted number of sensors that both models have in common. No direct view optical device is currently available on both systems.

5.1.3.2. Results

Limitations were discovered in relating the outputs of the two models. Different units for illumination and radiance values made it difficult to make exact comparisons. The EOTDA assumes a downward line-of-sight, while TARGAC-3 uses a horizontal line-of-sight. In general, illuminance, the probability of the target scene being in cloud shadow, and detection range appeared to vary in a similar manner as cloud conditions were changed. Further investigation is required.

5.2. Task 2: SHADOWING BY SMALL-SCALE FEATURES MODULE TESTING.

5.2.1. Overview

This section describes the plans for testing the small-scale feature shadowing enhancement to the TARGAC code. TARGAC is a complex system designed to operate on IBM-compatible PCs and UNIX-based workstations. Our TARGAC testing goal is to ensure that the initial implementation of small-scale feature shadowing performs as designed, presents predictable and understandable results, and is able to respond rapidly in both the PC and UNIX environments. Data collected during testing will be used in the evaluation of the software design and to identify high payoff research and development areas for future TARGAC improvements.

5.2.2. Scope

This plan covers software verification and validation testing for the small-scale feature shadowing enhancement to the TARGAC code at PSR, but does not include a discussion of integration testing of the various modules (enhancements) under independent development at PSR and Hughes STX. This and related TARGAC improvements are part of a multi-phase SBIR effort that will incorporate many new concepts and capabilities over the SBIR program life cycle. This test plan provides a general framework and guide for TARGAC module testing in the future, but is specifically tailored to address the testing and validation of the small-scale feature shadowing enhancement to the TARGAC code.

This section is organized in two parts. The first part discusses PSR's testing approach as it pertains to the testing of these modifications to the TARGAC code. This includes the approach, constraints, test team, test system configuration, test procedures, test data, and evaluation recording. The second part describes the schedule that will be followed during this testing.

5.2.3. Approach

TARGAC must be able to calculate detection and recognition ranges for a sensor-target combination as a function of user selected probabilities of detection. Thus, the criterion that must apply to the testing and evaluation of this new TARGAC module should be fidelity to reproduce selected experimental and theoretical results.

5.2.3.1. Software Verification and Validation Tests

These software verification and validation tests are designed to answer two important questions: (1) do individual small-scale feature shadowing software component functions compute correct results and (2) do these software components (function aggregates) work together as designed? Both quantitative and qualitative results will be examined during testing.

5.2.3.2. System Integrity Tests

PSR will perform system integrity tests to determine if the small-scale feature shadowing module is producing results that are predictable and explainable. These tests will qualitatively reproduce results expected by analysts that will verify operational correctness given the various constraints.

5.2.3.3. System Fidelity and Performance Tests

PSR will perform system fidelity and performance tests. These tests are designed to measure the utility of TARGAC's small-scale feature shadows model under various scenarios. PSR will test TARGAC results for various sensors at various contrast levels in the following types of scenarios:

- High, medium, and low 2-d clutter with no 3-d clutter. This is the best scenario for comparison of TARGAC against the Air Force EOTDA.

- High, medium, and low 3-d clutter with no 2-d clutter. This scenario will permit comparison of the effects of 3-d object masking/shadows from scattered objects to the effects of 3-d object masking/shadows from tree lines and terrain being developed in the large-scale feature shadowing task.

- High, medium, and low 2-d clutter versus high, medium, and low 3-d clutter. This scenario will produce nine cells per contrast level per sensor type for comparison to real and synthetic imagery.

5.2.4. Test Team

PSR will test TARGAC using the experience of both software engineers and experienced analysts. The objective of the test team will be to evaluate the new TARGAC module's accuracy, functionality, and to a limited extent its utility.

5.2.5. System Configurations

The following system configurations will be used during testing:

- Compaq PC 486/33 w/4 M-Byte of RAM & MS-DOS 6.0

- Sun SPARC-2 Workstation w/32 M-Byte of RAM & SunOS Release 4.1.3
- SGI Workstation w/64 M-Byte of RAM & IRIX 4.0.5
- HP 9000 Workstation (via Internet).

It should be noted that these configurations may be updated before the end of testing. New versions of MS-DOS, SunOS, and SGI OS occur on approximately a six month cycle. For example, MS-DOS 6.2 has just been released by Microsoft.

5.2.6. Test Procedures

TARGAC will be tested against a specific set of test procedures. Each test procedure will include the following items as applicable:

- Background - information to indicate how the function/model is used and any other pertinent information not contained in the body of the test procedure.
- Purpose of test - description of the capabilities to be tested and the criteria the function/model must meet.
- Data requirements - description of data necessary for testing TARGAC capabilities.
- Software requirements - the name and identifier of the software component to be tested.
- Preparation - any setup or preparation required to conduct the test.
- Test procedure - the actual steps required to perform the test.
- Expected results - the outcome required for the test to be considered successful.

5.2.7. Test Data

PSR will work with three distinct types of data in the testing of the small-scale feature shadows module of TARGAC:

- Synthetic data generated by PSR using BRL-CAD, ACAD, and/or EUCLID. (These programs are target modeling codes that run on various work stations to include Sun and SGI. Plates 1 and 2 at the back of this report were generated by PSR using BRL-CAD.)
- Real imagery which is being provided to us (at no cost) by NVESD, formally the Army Night Vision Laboratory.
- Calculated data and the results of other codes such as the Air Force EOTDA and PSR's Probability of Detection Code. All of these codes have problems such as lack of common sensors, different spectral bands of interest, etc.

5.2.8. Evaluation

TARGAC testing will be evaluated quantitatively and qualitatively based on the level of testing as discussed in section 5.2.3. Specifically, software verification and validation tests will be evaluated through quantitative methods that rely on synthesized, idealized data to support test procedures. Results from software verification and validation tests will be documented in test procedures developed for individual software components. Errors encountered during these tests will be captured and documented in discrepancy reports (see figure 10). The Discrepancy Report Form that will be used during testing is a standard PSR form and all items contained within it may not be pertinent to this program.

TEST DISCREPANCY REPORT FORM DR # ____________

To be completed by originator

Date: ___________

Originator: ___________

Problem Impact: 0 1 2 3 4 5

Key to Impact

0 Enhancement
1 Aesthetics only
2 Inconvenient: Impacts ease of use
3 Important: feature does not work
4 Very Important: Multiple impacts
5 Critical: immediate solution required

To be completed by originator

Brief Description of Problem:

Detailed Problem Description (include activity on progress):

To be completed by originator, program manager, or developer

Module of files affected:

To be completed by developer

Description of Changes Made/Solution:

Date Completed At PSR: _________
Date Completed On Site: _________

To be completed by developers

Assigned at PSR: _____________ Date: _________

Assigned on Site: _____________ Date: _________

To be completed by CCB and/or Project Leader

Date: _________ Project Leader Signature: ______________________
Date: _________ CCB Signature: ______________________

Figure 10. The PSR Test Discrepancy Report Form.

System integrity tests will be evaluated using qualitative methods that rely on analyst experts to evaluate output results generated by the TARGAC system. Discrepancy reports that describe inconsistencies in expected processing results will be filed if required.

System fidelity and performance tests will be evaluated using both quantitative and qualitative methods that exploit system performance statistics and domain model fidelity characteristics. Discrepancy reports that describe inconsistencies in expected processing results will be filed if required. In addition, model fidelity and performance measurements will be made to help identify system requirements and track performance statistics. These measurements could be used in future development to ensure optimal system performance. During system fidelity and performance testing, comparisons will be made between the PC and UNIX versions of the software.

5.2.9. Schedule

The draft test schedule shown in figure 11 addresses only the testing of the PC and UNIX versions of the small-scale feature shadowing components of TARGAC. This schedule will be integrated with the schedules for the various other activities to be performed by PSR and Hughes STX during the option year of this contract. We must remember that during this same time frame integration testing of the cloud shadowing, small-scale feature shadowing, and large-scale feature shadowing will be taking place. This parallel development approach necessitates close coordination and configuration control between PSR and Hughes STX.

TARGAC small-scale feature shadows testing will take place over a four month period starting May 1, 1994. Software verification and validation tests will be performed May 1 through July 1. System integrity tests will be performed June 1 through August 1, and fidelity tests will be performed July 1 through September 1.

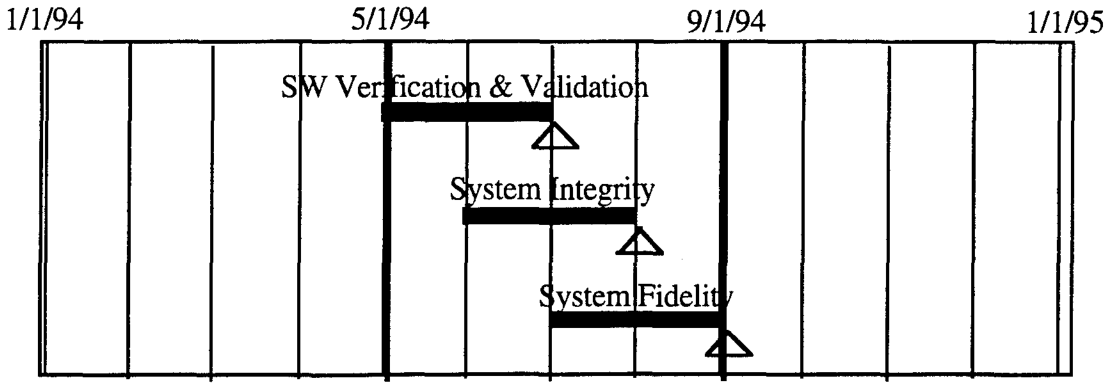


Figure 11. TARGAC small-scale feature shadowing testing schedule.

6. SUMMARY

The goals of this first year of the Phase II SBIR Scene Shadows project were to develop the partly cloudy shadowing model, deliver updated TARGAC software for the PC, determine the relationship between small-scale feature shadows and clutter, and develop an approach to incorporating the temporal and spatial characteristics of small-scale feature shadows into TARGAC. This report describes the Hughes STX revised delta-Eddington model in TARGAC-3. The report also describes software changes that have been implemented and tested. The report describes and discusses the foundations underlying the PSR approach to modeling small-scale scene shadows and provides an overview of the implementation and testing plan PSR has developed.

During the first year of the Phase II SBIR, PSR's accomplishments included:

1. Examination of target acquisition relationships, solving many of the problems facing year two of this effort.

2. Development of an approach to the determining of the clutter index over a variety of clutter and illumination conditions.

3. Production of a software design document for the inclusion of small-scale feature shadows into TARGAC.

During the first year of the Phase II SBIR, Hughes STX's accomplishments included:

1. Development of the partly cloudy shadowing model.

2. Incorporation of the partly cloudy shadowing model into the TARGAC code for the PC and delivery of the updated software.

While PSR was designing the software for the inclusion of small-scale feature shadows into TARGAC, it achieved several corollary objectives in support of the large-scale feature shadowing task:

1. Implemented β software to access DMA DTED data stored on CD ROMs and 9-track tapes.

2. Implemented β software to access DMA DFAD data on 9-track tapes (DFAD is not yet available on CD ROMs).

While Hughes STX was implementing the partly cloudy shadowing model, it achieved several corollary objectives:

1. Cloud inputs were made the same between the visible and thermal imager sections of TARGAC-3.

2. TARGAC-3 cloud inputs were modified to conform to inputs used by the Air Force EOTDA.

3. Several pre-existing errors in TARGAC-2 were fixed. These included faulty COMMON block names in the ELIMIN and STG subroutines, an incorrect lower limit for the background reflectivity input, and incorrect passing of constants to the XSCALE subroutine.

In the second year of the Phase II SBIR, PSR will implement the small-scale feature shadowing changes to both the PC and UNIX versions of TARGAC. PSR will also validate through testing the relationships between small-scale feature shadowing and clutter that were developed during the first year of this effort, and we will perform the final integration and test of the Hughes STX- and PSR-developed modules in the TARGAC code. Hughes STX will implement the cloud shadowing changes to the UNIX version of TARGAC. A study will be conducted to investigate the differences between and applicability of the conservative and non-conservative solutions to the delta-Eddington approximation. PSR and Hughes STX will also implement large-scale feature shadows in TARGAC.

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APPENDIX A: TREE DIAGRAM

This appendix provides a tree diagram of the TARGAC program. The following notation is used before routine names in the tree:

P	Program
S	Subroutine
F	Function
B	Block Data.

This tree diagram is accurate for DVO, II, and SiTV systems. However, for thermal imager systems the PC version breaks after the call to THERML to execute TCM2, a separate program. When TCM2 is done executing, the flow returns to the call to THERMB. The tree diagram for the TCM2 program is unchanged; the diagram is provided by Touart and DeBenedictis (1991).

```
Program: TARGAC

└─P.TARGAC
   ├─D.CLYMBD
   ├─D.CONSBD
   ├─D.FCONBD
   ├─D.FRMTBD
   ├─D.GEOMBD
   ├─D.IOUNBD
   ├─D.SAVEBD
   ├─D.SPOTBD
   ├─D.TAR1BD
   ├─D.TAR2BD
   ├─D.RHDATA
   ├─S.REDCOM
   ├─S.RDTCM2
   ├─S.CARDRD
   │  ├─S.SORT
   │  └─S.HOURLY
   └─S.FINDR
      ├─S.INTCHK
      ├─S.REALCK
      ├─S.CNTRAS
      │  ├─S.REALCK
      │  └─S.INTCHK
      ├─S.THERML
      │  ├─S.INTCHK
      │  ├─S.REALCK
      │  ├─F.VAPOR
      │  └─S.TCONVR
      ├─S.THERMB
      │  └─S.TCONVR
      ├─S.SGR
      │  ├─S.GETDAT
      │  ├─S.INTCHK
      │  ├─S.REALCK
      │  ├─S.CVRTJD
      │  ├─S.CLIMAT
      │  ├─S.IOOPEN
      │  ├─S.XSCALE
      │  │  ├─S.TRPCTL
      │  │  │  └─S.INTERP
      │  │  ├─S.SLANT
      │  │  │  ├─S.TRPCTL
      │  │  │  │  └─S.INTERP
      │  │  │  └─S.CASE
      │  │  ├─F.EXPCHK
      │  │  ├─S.SNOSLN
      │  │  ├─S.ICEFOG
      │  │  │  └─S.NDXRFR
      │  │  └─F.RESFN
      │  ├─S.ILMDAT
      │  │  ├─S.ILUMA
      │  │  │
```

```
│  │  │  ├─S.UCA
│  │  │  ├─S.ILLUM
│  │  │  │  ├─F.SUNFAC
│  │  │  │  └─F.PHFACT
│  │  │  ├─S.FRATRN
│  │  │  │  ├─F.X3
│  │  │  │  ├─S.LOCATE
│  │  │  │  └─S.BILINR
│  │  │  └─S.DIRDIF
│  │  ├─S.INTCHK
│  │  └─S.REALCK
│  └─F.STG
│     ├─S.GETCLD
│     │ └─S.COMBIN
│     ├─F.CUBINT
│     │  ├─S.SPLINE
│     │  └─S.SPLINT
│     ├─S.LAYERS
│     ├─S.INITI
│     │  └─F.SIGRAY
│     ├─S.DELTED
│     │  ├─S.ELIMIN
│     │  └─F.CUBINT
│     │     ├─S.SPLINE
│     │     └─S.SPLINT
│     └─S.CONTST
│        ├─F.SIMPNE
│        │  └─F.X3
│        └─S.DIFUSE
│           └─S.PCDIF
├─S.SMINFO
│  ├─S.INTCHK
│  ├─S.REALCK
│  ├─S.KWEXT
│  └─F.SMOSGR
├─S.GETSND
├─S.IOOPEN
├─S.XSCALE
│  ├─S.TRPCTL
│  │  └─S.INTERP
│  ├─S.SLANT
│  │  ├─S.TRPCTL
│  │  │ └─S.INTERP
│  │  └─S.CASE
│  ├─F.EXPCHK
│  ├─S.SNOSLN
│  ├─S.ICEFOG
│  │  └─S.NDXRFR
│  └─F.RESFN
├─S.SLNCOF
│  ├─F.CUBINT
│  │  ├─S.SPLINE
│  │  └─S.SPLINT
│  └─F.VAPOR
│
```

```
├─S.EXTIC
│  ├─F.CUBINT
│  │  ├─S.SPLINE
│  │  └─S.SPLINT
│  └─S.EXTCOF
├─F.UNILIN
├─F.RCF
│  ├─F.CUBINT
│  │  ├─S.SPLINE
│  │  └─S.SPLINT
│  └─F.USRFUN
└─S.ACQUIR
```

APPENDIX B: DESCRIPTIONS OF MODIFIED AND NEW ROUTINES

This appendix contains lists of modified TARGAC routines, new routines, and modified COMMON blocks. Descriptions of the modified routines are also included. Note that no new COMMON blocks have been added.

B.1. LIST OF MODIFIED ROUTINES

The following table lists the TARGAC subroutines and functions that have been modified for the new TARGAC-3 code.

Subroutines	Functions
CNTRAS	STG
CONTST	
DELTED	
ELIMIN	
FINDR	
GETDAT	
ILMDAT	
ILUMA	
INITI	
SGR	
THERMB	
THERML	

B.2. LIST OF NEW ROUTINES

The following table lists the subroutines that have been added for the new TARGAC-3 code.

Subroutines

COMBIN
DIFUSE
GETCLD
LAYERS
PCDIF

B.3. LIST OF MODIFIED COMMON BLOCKS

The following table lists the TARGAC COMMON blocks that have been modified for the new TARGAC-3 code.

<u>**COMMON Blocks**</u>

/CLOUD/
/GAUSS/
/RADIA/

B.4. FUNCTIONAL DESCRIPTIONS OF MODIFIED AND NEW ROUTINES

This section provides a brief description of each of the added or modified routines (subroutines or functions). The listing is arranged in alphabetical order. The name of the file containing each routine is shown in parentheses beside the name of the routine.

SUBROUTINE CNTRAS (TARGAC.FOR)

Calculates the target-background contrast for direct view optics, image intensifiers, silicon TVs, or thermal imagers.

SUBROUTINE COMBIN (COMBIN.FOR)

Combines the cloud properties of two cloud layers into a single "representative" layer.

SUBROUTINE CONTST (CONTRAST.FOR)

Calculates the path radiance, the transmission, the direct and diffuse radiance components, the inherent target and background radiances, and the apparent spectral contrast along the given line-of-sight.

SUBROUTINE DELTED (CONTRAST.FOR)

Calculates the direct and diffuse radiance components at each level using the delta-Eddington approximation.

SUBROUTINE DIFUSE (DIFUSE.FOR)

Computes the components of diffuse radiance at the target level.

SUBROUTINE ELIMIN (CONTRAST.FOR)

Solves a system of equations using Gaussian elimination.

SUBROUTINE FINDR (FINDR.FOR)

Calculates acquisition ranges for image intensifiers, direct view optics, silicon TVs, and thermal imagers for specified probability levels.

SUBROUTINE GETCLD (GETCLD.FOR)

Sets atmospheric data for layers containing clouds.

SUBROUTINE GETDAT (FINDR.FOR)

Initializes atmospheric data.

SUBROUTINE ILMDAT (ILMDAT.FOR)

Reads illumination or calls ILUMA to compute it as a function of geographical location, date, time, and meteorological conditions.

SUBROUTINE ILUMA (ILUMA.FOR)

Computes total solar/lunar illumination received at the ground as a function of geographical location, date, time, and meteorological conditions.

SUBROUTINE INITI (ILMDAT.FOR)

Initializes radiometric data.

SUBROUTINE LAYERS (LAYERS.FOR)

Computes the extinction coefficients and asymmetry parameters for the atmospheric layers that contain clouds.

SUBROUTINE PCDIF (PCDIF.FOR)

Computes average partly cloudy diffuse radiance component according to the sky condition.

SUBROUTINE SGR (SGR.FOR)

Determines sky-to-ground ratio for visible wavelengths based on illumination and meteorological conditions.

FUNCTION STG (SLNCOF.FOR)

Calculates the sky-to-ground ratio using a delta-Eddington radiative transfer algorithm.

SUBROUTINE THERMB (THERMB.FOR)

Assigns input data and displays inputs for thermal imager systems.

SUBROUTINE THERML (THERML.FOR)

Reads input data for thermal imager systems

APPENDIX C: ENGINEERING CHANGE REPORTS

This appendix contains Engineering Change Reports (ECRs) for each change made to TARGAC. ECRs are used by Hughes STX to maintain an audit trail of code evolution. An ECR is generated each time an existing routine is modified or a new routine is added. ECRs are numbered sequentially, first by routine number and second by change number. In-line documentation referencing the appropriate ECR number is also provided for each change.

Appendix B gives a functional description for each of the 18 routines that were changed or added. Here, we include the ECRs with code listings. For each changed or added routine, the complete code listing is provided. Our intent is to make it as easy as possible for the TARGAC maintenance programmer to locate each change.

The table below provides a list of all ECRs for the implementation of cloud shadows. The following pages provide all ECRs for each routine, followed by the code listing for that routine.

TABLE C-1
Engineering Change Reports

ECR Numbers	Routine Name	File Name
1-1 through 1-9	SGR	SGR.FOR
2-1 through 2-6	STG	SLNCOF.FOR
3-1	ELIMIN	CONTRAST.FOR
4-1 and 4-2	ILUMA	ILUMA.FOR
5-1	COMBIN	COMBIN.FOR
6-1	INITI	ILMDAT.FOR
7-1 and 7-2	DELTED	CONTRAST.FOR
8-1 through 8-5	CONTST	CONTRAST.FOR
9-1 through 9-6	GETCLD	GETCLD.FOR
10-1 and 10-2	PCDIF	PCDIF.FOR
11-1	GETDAT	FINDR.FOR
12-1 through 12-3	FINDR	FINDR.FOR
13-1	THERML	THERML.FOR
14-1 and 14-2	THERMB	THERMB.FOR
15-1	LAYERS	LAYERS.FOR
16-1	CNTRAS	TARGAC.FOR
17-1	DIFUSE	DIFUSE.FOR
18-1	ILMDAT	ILMDAT.FOR

ECR # HSTX - 1 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: SGR

Old Date: 5/18/93

File Name: SGR.FOR

New Date: 8/11/93

Implemented By: Michael Oberlatz

Reason for Revision: Added code necessary to implement the input of the three cloud layers.

Description of Revision: Added variables, CF2, CF3, ZC2, and ZC3, to contain fractional cloud cover and base height for two additional cloud layers. Added these variables to the CLOUD COMMON block. Added necessary code to input the middle and high cloud data.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 1 - 2

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: SGR

Old Date: 8/11/93

File Name: SGR.FOR

New Date: 8/23/93

Implemented By: Don Hamann

Reason for Revision: Expanded CLOUD COMMON block to maintain information on multiple cloud layers. Added loop to count the number of cloud layers in order to determine if cloud layers need to be combined.

Description of Revision: Added variables NUMCLD, MLOOP, CLDG(2), CLDBTA(2), LYRCLD(2), THK1, THK2, THK3, ITY1, ITY2, and ITY3 to CLOUD COMMON block. NUMCLD incremented for each layer containing some cloud fraction.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 1 - 3

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: SGR Old Date: 8/23/93

File Name: SGR.FOR New Date: 9/14/93

Implemented By: Michael Oberlatz

Reason for Revision: Updated the batch mode for the three cloud layers; added cloud type input; changed the rules for ceiling height, inversion height and cloud thickness.

Description of Revision: Changed the records that the SGR routine uses for the cloud inputs from METD to the records LCLD, MCLD, and HCLD. Added new inputs for the cloud type. The ceiling height rule was changed to be the height of the lowest layer with cloud fraction greater than 0.7. The inversion height rule was changed so that all three cloud layers are checked before it is asked for. Added cloud thickness for each cloud type. Left total THICK the same.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 1 - 4

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: SGR

Old Date: 9/14/93

File Name: SGR.FOR

New Date: 9/14/93

Implemented By: Don Hamann

Reason for Revision: To maintain information on the probability of a cloud-free path through each cloud layer and on the probability of the target scene in direct light.

Description of Revision: Added variable PSCLD and array PCF(2) to CLOUD COMMON block to maintain information for each cloud layer.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 1 - 5

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: SGR

Old Date: 9/14/93

File Name: SGR.FOR

New Date: 9/14/93

Implemented By: Don Hamann

Reason for Revision: To save information on the sky to ground (SOG) ratio for both clear and in cloud shadow bracketing conditions.

Description of Revision: Converted the variable SOG into an array containing the clear and cloud shadow sky to ground ratio.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 1 - 6

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: SGR

Old Date: 9/14/93

File Name: SGR.FOR

New Date: 9/17/93

Implemented By: Melanie J. Gouveia

Reason for Revision: Fix the error that cloud base heights were out of range for batch mode inputs. Also, add cloud situation flag.

Description of Revision: For batch mode, check the cloud base height inputs only if the appropriate cloud fractions are greater than zero. Add the variable ICLDF to the /CLOUD/ COMMON block.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 1 - 7

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: SGR

Old Date: 9/17/93

File Name: SGR.FOR

New Date: 10/7/93

Implemented By: Michael Oberlatz

Reason for Revision: Several constant values sent to the XSCALE routine were being changed in XSCALE. This caused a run-time error for the second cycle of a multiple cycle run.

Description of Revision: Variables set to the constant values were substituted for the constant values in the calls to the XSCALE routine.

Notes: Using temporary variables to store the constant values eliminated the run-time error.

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 1 - 8

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: SGR

Old Date: 10/7/93

File Name: SGR.FOR

New Date: 10/7/93

Implemented By: Dan DeBenedictis

Reason for Revision: The background reflectance (BKREF) was not being saved to TAC.SAV when climate data was being used. BKREF is now being saved with record CONTEXTL. Saving RECVAL(8,7) (BKREF) on the METD record is no longer necessary.

Description of Revision: Omitted RECVAL(8,7) from the WRITE statement for writing the record METD to TAC.SAV.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 1 - 9

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: SGR

Old Date: 10/7/93

File Name: SGR.FOR

New Date: 10/20/93

Implemented By: Dan DeBenedictis

Reason for Revision: All of the conditions included in the significant weather input are now included as part of other inputs. Also, the ceiling height assignment was changed to match the Air Force definition.

Description of Revision: Eliminate the SIGWX input for interactive mode and from the ILUM record for batch mode. The ceiling height is now assigned to that height at which clouds at and below the height cover more than 4/8 of the sky. Since the Air Force defines cloud coverage in eighths, this means that the coverage must be at least 5/8, or approximately 0.6.

Notes: This definition of ceiling height was taken from AWSR 105-24, Vol. 1, 1 March 1983.

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C
C***********************************************************************
      SUBROUTINE SGR ( BKGREF, XLAMB, VIS, SOG, TMP, TDEW, ICLIM, IDEV )
C***********************************************************************
      COMMON /IOUNIT/ IOIN, IOOUT, IPHFUN, LOUNIT, NDIRTU, NCLIMT,
     +                IRELH, KSTOR, NPLOTU, STDERR
      COMMON /INOUT/ INTER, IRPT, EFLAG
      COMMON /IBLOCK/ RECVAL(111,7), RECUSE(21), IPTR(21), IBEGIN(22)
CRF17APR92COMMON /XSCL/ ZZZ(999), BETA(999), RELH(999), NNZPTS, SLNFLG
CRF   REMOVE SLNFLG FROM XSCL COMMON BLOCK FOR UPGRADE TO XSCALE92
      COMMON/XSCL/ZZZ(999),BETA(999),RELH(999),NNZPTS
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-1-----------------------------------
C ADDED THE VARIABLES ZC2, ZC3, CF2, AND CF3 TO THE CLOUD COMMON BLOCK
C TO ACCOMODATE 3 CLOUD LAYERS
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-2-----------------------------------
C ADDED VARIABLES NUMCLD, MLOOP, CLDBTA(2), CLDG(2), LYRCLD(2), THK, ITY
C TO CLOUD COMMON BLOCK TO MAINTAIN INFORMATION ON MULTIPLE CLOUD LAYERS.
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-4----------------------------------
C ADDED VARIABLE PSCLD AND ARRAY PCF(2) TO CLOUD COMMON BLOCK TO MAINTAIN
C INFORMATION ON PROBABILITY OF CLOUD-FREE PATH THROUGH EACH CLOUD LAYER
C AND THE PROBABILITY OF THE TARGET IN DIRECT LIGHT.
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-6----------------------------------
C ADDED VARIABLE ICLDF TO CLOUD COMMON BLOCK TO MAINTAIN INFORMATION ABOUT
C CLOUD SITUATION.
C     COMMON /CLOUD/ ZC1, CF1
C     COMMON /CLOUD/ ZC1, ZC2, ZC3, CF1, CF2, CF3
C     COMMON /CLOUD/ NUMCLD, MLOOP, CLDBTA(2), CLDG(2), LYRCLD(2),
C    +            THK1, THK2, THK3, ITY1, ITY2, ITY3,
C    +               ZC1, ZC2, ZC3, CF1, CF2, CF3
      COMMON /CLOUD/ICLDF, NUMCLD, MLOOP, CLDBTA(2), CLDG(2), LYRCLD(2),
     +               THK1, THK2, THK3, ITY1, ITY2, ITY3,
     +               ZC1, ZC2, ZC3, CF1, CF2, CF3, PCF(2), PSCLD
C-HSTX---SCENE SHADOWS----------------------------------------------------
C
      COMMON /SOUND/ NZLEV, ZLEV(20), PRESR(20), TMPER(20), DENS(20)
CRF      COMMON /SCALEX/ TEMP, RD, AINVHT  17 APR 92
CRF   REMOVE SCALEX COMMON BLOCK FOR UPGRADE TO XSCALE92
C
C***REV 1/91
      COMMON /ILDATA/ FMONTH, DAY, YEAR, GTIME, SLAT, SLON, ILR1, ILR2,
     +                ILR3, RG, FR1, FR2, FR3, SIGWX, OBSURF, CEILHT,
     +             PRTYP, FRC, ITARG
      COMMON /ILUMCM/ ALTS, AZIS, ALTMN, AZIM, DPHASE, ELUMI, SUNLIT,
     +                MOOLIT, TCLSUN, TCLLUN, RCLSUN, RCDSUN, RCLLUN,
     +                RCDLUN
      COMMON /ILLUMI/ AL, ILLUM, L22, ACK, IL1, IL2
      COMMON /IOFILE/IOFILE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-5----------------------------------
C CHANGE SKY-TO-GROUND RATIO VARIABLE TO AN ARRAY IN ORDER TO SAVE
C INFORMATION FOR TARGET IN AND OUT OF CLOUD SHADOW.
      REAL SOG(2)
C-HSTX---SCENE SHADOWS----------------------------------------------------
C
      INTEGER DATE, IOIN, IOOUT, IPHFUN, LOUNIT, NDIRTU, NCLIMT
      INTEGER IRELH, KSTOR, NPLOTU, STDERR, IOFILE
      LOGICAL ICLMAT , INTER, EFLAG, RECUSE
      REAL LUNAZ,MOOLIT,COSZ
CRF   XSCALE92 DEFAULT VALUES START   17 APR 92
      DIMENSION Q(3,2), QAVE(2), DECPER(3), XMEAN(3), XMODE(3),
     +    WAVRFN(20), RESPFN(20)
      COMPLEX UM
CRF   XSCALE92 DEFAULT VALUES STOP   17 APR 92
CUV   CHARACTER*15 NMSND
```

```
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-3---------------------------------
C GEOMETRIC THICKNESSES FOR THE FIVE CLOUD TYPES
      DIMENSION CTHICK(5)
      DATA CTHICK /0.3, 0.5, 0.5, 0.75, 1.5/
C-HSTX---SCENE SHADOWS-------------------------------------------------
C
C***REV 1/91
      DATA RAD / 57.29578 /
CRF   XSCALE92 DEFAULT VALUES START    17 APR 92
      DO 701 IX = 1,3
   DECPER(IX) = 0.0
   XMEAN(IX) = 0.0
   XMODE(IX) = 0.0
 701  CONTINUE
      IWATER = 0
      NBR = 0
      DO 702 IX = 1,20
   WAVRFN(IX) = 0.0
   RESPFN(IX) = 0.0
 702  CONTINUE
      ALT = 0.0
CP   ALT IS NEVER USED, BUT IT COULD BE IN CALL TO XSCALE.
CP   NUMBER 0.0 IS USED TO CALL XSCALE INSTEAD. NOV 92 PSG.
CRF   XSCALE92 DEFAULT VALUES STOP   17 APR 92
C
C
C *** THIS SUBROUTINE CALCULATES SKY-TO-GROUND RATIO FOR VISIBLE
C     WAVELENGTHS BASED ON VISIBILITY, SURFACE ALBEDO, SUN ANGLE, ETC.
C
CUV   DIMENSION ALBEDO(4)
C
C  SET DEFAULT AEROSOL STRUCTURE THIS SETS THE VALUE OF
C  BETAA AT 18 LEVELS UP TO 20 KM.
C
      CALL GETDAT
C
C     INPUT DATA FOR SKY TO GROUND RATIO CALCULATIONS
C     PROMPT FOR OPTION TO CALL EOSAEL ROUTINE CLIMAT
C
      RD = 0.002
      RDTEMP = RD
      IF (INTER) THEN
 50     CONTINUE
   WRITE(IOOUT,*)
     +        'YOU WILL BE ASKED NOW TO PROVIDE INPUT RELATING TO'
   WRITE(IOOUT,*)
     +        'THE TIME AND PLACE OF INTEREST AND VARIOUS WEATHER'
   WRITE(IOOUT,*)'RELATED PARAMETERS.  SOME OF THIS DATA MAY BE'
   WRITE(IOOUT,*)'SUPPLIED BY THE EOSAEL ROUTINE CLIMAT.  IN'
   WRITE(IOOUT,*)'ORDER TO USE CLIMAT YOU WILL NEED TO BE AWARE'
   WRITE(IOOUT,*)'OF THE VARIOUS INPUT PARAMETERS, WHICH ARE'
   WRITE(IOOUT,*)'DESCRIBED IN VOLUME 8 OF THE EOSAEL REPORTS.'
   WRITE(IOOUT,*)'ADDITIONALLY, INPUT DATA FILES FROM THE CLIMAT'
   WRITE(IOOUT,*)'DIRECTORY ARE NECESSARY.  IF YOU WISH TO'
   WRITE(IOOUT,*)'USE CLIMATOLOGICAL DATA WHENEVER POSSIBLE'
   WRITE(IOOUT,*)'IN THIS ROUTINE, ENTER 1. '
   WRITE(IOOUT,*)'IF YOU WISH TO INPUT YOUR OWN INFORMATION,'
   WRITE(IOOUT,*)'ENTER 0.'
   READ(IOIN,*) ICLIM
   WRITE(IOOUT,*)ICLIM
   WRITE(IOOUT,*)
   IF (ICLIM .NE. 1 .AND. ICLIM .NE. 0) THEN
      WRITE(IOOUT,*)'YOU MUST ENTER 0 OR 1; TRY AGAIN'
      GOTO 50
```

```
    ENDIF
      ELSE
    IF (RECUSE(2)) THEN
      ICLIM = 1
    ELSE
      ICLIM = 0
    ENDIF
      ENDIF
      ICLMAT = (ICLIM .EQ. 1)
CP   BEGIN WRITTEN INFORMATION ABOUT THE CLIMAT OPTION (C.BACA JULY 92)
      IF (ICLMAT) THEN
    IF (INTER) THEN
 51     CONTINUE
     WRITE(IOOUT,*)'CHOOSE A GENERAL LOCATION FROM THE LIST BELOW'
     WRITE(IOOUT,*)'  '
     WRITE(IOOUT,*)'  1 - FOR CENTRAL EUROPE              (1-4)'
     WRITE(IOOUT,*)'  2 - FOR MID-EAST                    (5-10)'
     WRITE(IOOUT,*)'  3 - FOR KOREA                      (11-13)'
     WRITE(IOOUT,*)'  4 - FOR ALASKA                     (14-16)'
     WRITE(IOOUT,*)'  5 - FOR SCANDINAVIA                (17-18)'
     WRITE(IOOUT,*)'  6 - FOR CENTRAL AMERICA            (19-21)'
     WRITE(IOOUT,*)'  7 - FOR MEXICO                     (22-25)'
     WRITE(IOOUT,*)'  8 - FOR SOUTH AMERICA              (26-31)'
     WRITE(IOOUT,*)'  9 - FOR INDIA                      (32-34)'
     WRITE(IOOUT,*)' 10 - FOR SOUTHEAST ASIA               (35)'
     WRITE(IOOUT,*)' 11 - FOR SOUTHERN EUROPE            (36-47)'
     WRITE(IOOUT,*)' 12 - FOR CANADA AND USA             (48-74)'
     READ(IOIN,*) IGENRL
     IF(IGENRL .LT. 1 .OR. IGENRL .GT. 12) THEN
       WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM 1 TO 12'
       GOTO 51
     ENDIF
     IF(IGENRL .EQ. 1) THEN
 21       WRITE(IOOUT,*)'INPUT THE REGION CODE NUMBER FOR '
     +        ,'CENTRAL EUROPE'
       WRITE(IOOUT,*)'  '
       WRITE(IOOUT,*)'  REGION  1 - EUROPEAN LOWLANDS'
       WRITE(IOOUT,*)'  REGION  2 - EUROPEAN RHINE VALLEY'
       WRITE(IOOUT,*)'  REGION  3 - EUROPEAN HIGHLANDS'
       WRITE(IOOUT,*)'  REGION  4 - EUROPEAN ALPINE'
       READ(IOIN,*) LOCAT
       IF(LOCAT .LT. 1 .OR. LOCAT .GT. 4) THEN
         WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM THIS LIST'
         GOTO 21
       ENDIF
     ELSE IF(IGENRL .EQ. 2) THEN
 22       WRITE(IOOUT,*)'INPUT THE REGION CODE NUMBER FOR MID-EAST'
       WRITE(IOOUT,*)'  '
       WRITE(IOOUT,*)'  REGION  5 - MIDEAST DESERTS'
       WRITE(IOOUT,*)'  REGION  6 - MIDEAST COASTAL'
       WRITE(IOOUT,*)'  REGION  7 - MIDEAST PERSIAN GULF'
       WRITE(IOOUT,*)'  REGION  8 - MIDEAST RED SEA'
       WRITE(IOOUT,*)'  REGION  9 - MIDEAST EASTERN MOUNTAINS'
       WRITE(IOOUT,*)'  REGION 10 - MIDEAST INDUS VALLEY'
       READ(IOIN,*) LOCAT
       IF(LOCAT .LT. 5 .OR. LOCAT .GT. 10) THEN
         WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM THIS LIST'
         GOTO 22
       ENDIF
     ELSE IF(IGENRL .EQ. 3) THEN
 23       WRITE(IOOUT,*)'INPUT THE REGION CODE NUMBER FOR KOREA'
       WRITE(IOOUT,*)'  '
       WRITE(IOOUT,*)'  REGION 11 - KOREAN EAST COAST'
       WRITE(IOOUT,*)'  REGION 12 - SOUTH KOREA'
       WRITE(IOOUT,*)'  REGION 13 - WEST KOREA'
```

```
      READ(IOIN,*) LOCAT
      IF(LOCAT .LT. 11 .OR. LOCAT .GT. 13) THEN
        WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM THIS LIST'
        GOTO 23
      ENDIF
    ELSE IF(IGENRL .EQ. 4) THEN
24       WRITE(IOOUT,*)'INPUT THE REGION CODE NUMBER FOR ALASKA'
      WRITE(IOOUT,*)'  '
      WRITE(IOOUT,*)'  REGION 14 - ALASKAN TUNDRA'
      WRITE(IOOUT,*)'  REGION 15 - ALASKAN SUBARCTIC CONTINENTAL'
      WRITE(IOOUT,*)'  REGION 16 - ALASKAN SOUTHERN COAST'
      READ(IOIN,*) LOCAT
      IF(LOCAT .LT. 14 .OR. LOCAT .GT. 16) THEN
        WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM THIS LIST'
        GOTO 24
      ENDIF
    ELSE IF(IGENRL .EQ. 5) THEN
25       WRITE(IOOUT,*)'INPUT THE REGION CODE NUMBER FOR SCANDINAVIA'
      WRITE(IOOUT,*)'  '
      WRITE(IOOUT,*)'  REGION 17 - WESTERN SCANDINAVIA'
      WRITE(IOOUT,*)'  REGION 18 - EASTERN SCANDINAVIA'
      READ(IOIN,*) LOCAT
      IF(LOCAT .LT. 17 .OR. LOCAT .GT. 18) THEN
        WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM THIS LIST'
        GOTO 25
      ENDIF
    ELSE IF(IGENRL .EQ. 6) THEN
26       WRITE(IOOUT,*)'INPUT THE REGION CODE NUMBER FOR '
    +        ,'CENTRAL AMERICA'
      WRITE(IOOUT,*)'  '
      WRITE(IOOUT,*)'  REGION 19 - CENTRAL AMERICA PACIFIC SIDE'
      WRITE(IOOUT,*)'  REGION 20 - CENTRAL AMERICAN INTERIOR'
      WRITE(IOOUT,*)'  REGION 21 - CENTRAL AMERICA ATLANTIC SIDE'
      READ(IOIN,*) LOCAT
      IF(LOCAT .LT. 19 .OR. LOCAT .GT. 21) THEN
        WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM THIS LIST'
        GOTO 26
      ENDIF
    ELSE IF(IGENRL .EQ. 7) THEN
27       WRITE(IOOUT,*)'INPUT THE REGION CODE NUMBER FOR MEXICO'
      WRITE(IOOUT,*)'  '
      WRITE(IOOUT,*)'  REGION 22 - MEXICO SUBTROPICAL'
      WRITE(IOOUT,*)'  REGION 23 - MEXICO PACIFIC'
      WRITE(IOOUT,*)'  REGION 24 - MEXICO HIGHLANDS'
      WRITE(IOOUT,*)'  REGION 25 - MEXICO TROPICAL'
      READ(IOIN,*) LOCAT
      IF(LOCAT .LT. 22 .OR. LOCAT .GT. 25) THEN
        WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM THIS LIST'
        GOTO 27
      ENDIF
    ELSE IF(IGENRL .EQ. 8) THEN
28       WRITE(IOOUT,*)'INPUT THE REGION CODE NUMBER FOR '
    +        ,'SOUTH AMERICA'
      WRITE(IOOUT,*)'  '
      WRITE(IOOUT,*)'  REGION 26 - SOUTH AMERICA TROPICS'
      WRITE(IOOUT,*)'  REGION 27 - SOUTH AMERICA DESERT WEST'
      WRITE(IOOUT,*)'  REGION 28 - SOUTH AMERICA DESERT CENTRAL'
      WRITE(IOOUT,*)'  REGION 29 - SOUTH AMERICA SUBTROPICS'
      WRITE(IOOUT,*)'  REGION 30 - SOUTH AMERICA SUBPOLAR'
      WRITE(IOOUT,*)'  REGION 31 - SOUTH AMERICA HIGHLANDS'
      READ(IOIN,*) LOCAT
      IF(LOCAT .LT. 26 .OR. LOCAT .GT. 31) THEN
        WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM THIS LIST'
        GOTO 28
      ENDIF
```

```
    ELSE IF(IGENRL .EQ. 9) THEN
29       WRITE(IOOUT,*)'INPUT THE REGION CODE NUMBER FOR INDIA'
      WRITE(IOOUT,*)'  '
      WRITE(IOOUT,*)'  REGION 32 - INDIA WEST/CENTRAL REGION'
      WRITE(IOOUT,*)'  REGION 33 - INDIA NORTHERN VALLEYS'
      WRITE(IOOUT,*)'  REGION 34 - INDIA TROPICAL AREA'
      READ(IOIN,*) LOCAT
      IF(LOCAT .LT. 32 .OR. LOCAT .GT. 34) THEN
        WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM THIS LIST'
        GOTO 29
      ENDIF
    ELSE IF(IGENRL .EQ. 10) THEN
30       WRITE(IOOUT,*)'INPUT THE REGION CODE NUMBER FOR '
    +        ,'SOUTHEAST ASIA'
      WRITE(IOOUT,*)'  '
      WRITE(IOOUT,*)'  REGION 35 - SOUTHEAST ASIA'
      READ(IOIN,*) LOCAT
      IF(LOCAT .LT. 35 .OR. LOCAT .GT. 35) THEN
        WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM THIS LIST'
        GOTO 30
      ENDIF
    ELSE IF(IGENRL .EQ. 11) THEN
31       WRITE(IOOUT,*)'INPUT THE REGION CODE NUMBER FOR '
    +        ,'SOUTHERN EUROPE'
      WRITE(IOOUT,*)'  '
      WRITE(IOOUT,*)'  REGION 36 - EUROPEAN ADRIATIC'
      WRITE(IOOUT,*)'  REGION 37 - EUROPEAN AGEAN'
      WRITE(IOOUT,*)'  REGION 38 - EUROPEAN BALKAN HIGHLANDS'
      WRITE(IOOUT,*)'  REGION 39 - EUROPEAN BALKAN PLAINS'
      WRITE(IOOUT,*)'  REGION 40 - EUROPEAN DINARIC ALPS'
      WRITE(IOOUT,*)'  REGION 41 - EUROPEAN PO VALLEY'
      WRITE(IOOUT,*)'  REGION 42 - EUROPEAN CENT. MEDITERRANEAN'
      WRITE(IOOUT,*)'  REGION 43 - EUROPEAN RHONE VALLEY'
      WRITE(IOOUT,*)'  REGION 44 - EUROPEAN FRENCH PLATEAU'
      WRITE(IOOUT,*)'  REGION 45 - EUROPEAN NW. MEDITERRANEAN'
      WRITE(IOOUT,*)'  REGION 46 - EUROPEAN SPANISH PLATEAU'
      WRITE(IOOUT,*)'  REGION 47 - EUROPEAN ATLANTIC COAST'
      READ(IOIN,*) LOCAT
      IF(LOCAT .LT. 36 .OR. LOCAT .GT. 47) THEN
        WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM THIS LIST'
        GOTO 31
      ENDIF
    ELSE
32       WRITE(IOOUT,*)'INPUT THE REGION CODE NUMBER FOR '
    +        ,'CANADA AND USA'
      WRITE(IOOUT,*)'  '
      WRITE(IOOUT,*)'   48 - WESTERN CANADA             '
    +                 ,'   62 - LOWER MISSISSIPPI VALLEY'
      WRITE(IOOUT,*)'   49 - SACRAMENTO VALLEY          '
    +                 ,'   63 - MIDDLE ATLANTIC COAST'
      WRITE(IOOUT,*)'   50 - NORTHERN ROCKY MOUNTAINS   '
    +                 ,'   64 - SOUTHERN ATLANTIC COAST'
      WRITE(IOOUT,*)'   51 - CENTRAL ROCKY MOUNTAINS    '
    +                 ,'   65 - GULF COAST'
      WRITE(IOOUT,*)'   52 - SOUTHERN ROCKY MOUNTAINS   '
    +                 ,'   66 - SOUTHERN PACIFIC COAST'
      WRITE(IOOUT,*)'   53 - SOUTHWESTERN DESERT        '
    +                 ,'   67 - CENTRAL PACIFIC COAST'
      WRITE(IOOUT,*)'   54 - NORTHERN INTER-MOUNTAIN    '
    +                 ,'   68 - NORTHERN PACIFIC COAST'
      WRITE(IOOUT,*)'   55 - SOUTHERN INTER-MOUNTAIN    '
    +                 ,'   69 - TENNESSEE VALLEY'
      WRITE(IOOUT,*)'   56 - CANADIAN PRAIRIE           '
    +                 ,'   70 - OHIO VALLEY'
      WRITE(IOOUT,*)'   57 - NORTHERN GREAT PLAINS      '
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      +                 ,'   71 - GREAT LAKES'
        WRITE(IOOUT,*)'   58 - CENTRAL GREAT PLAINS        '
      +                 ,'   72 - EASTERN GREAT LAKES'
        WRITE(IOOUT,*)'   59 - SOUTHERN GREAT PLAINS       '
      +                 ,'   73 - NORTHERN ATLANTIC COAST'
        WRITE(IOOUT,*)'   60 - UPPER MISSISSIPPI VALLEY  '
      +                 ,'   74 - CANADIAN ATLANTIC REGION'
        WRITE(IOOUT,*)'   61 - MIDDLE MISSISSIPPI VALLEY '
        READ(IOIN,*) LOCAT
        IF(LOCAT .LT. 48 .OR. LOCAT .GT. 74) THEN
          WRITE(IOOUT,*)'YOU MUST CHOOSE A NUMBER FROM THIS LIST'
          GOTO 32
        ENDIF
      ENDIF
  52     CONTINUE
      WRITE(IOOUT,*)'INPUT THE MONTH OF INTEREST FROM 1 TO 12'
      READ(IOIN,*) MONTH
      IF (MONTH .LT. 1 .OR. MONTH .GT. 12) THEN
        WRITE(IOOUT,*)'THE MONTH MUST BE BETWEEN 1 AND 12'
        GOTO 52
      ENDIF
  53     WRITE(IOOUT,*)
      +' INPUT THE CLIMATOLOGY CLASS NUMBER FROM 1 TO 22'
      WRITE(IOOUT,*)'  1 - FOG, HAZE AND MIST WITH VIS LT 1 KM'
      WRITE(IOOUT,*)
      +'  2 - FOG, HAZE AND MIST WITH VIS GE 1, LT 3 KM'
      WRITE(IOOUT,*)
      +'  3 - FOG, HAZE AND MIST WITH VIS GE 3, LT 7 KM'
      WRITE(IOOUT,*)'  4 - FOG, HAZE AND MIST WITH VIS GE 7 KM'
      WRITE(IOOUT,*)'  5 - DUST WITH VIS LT 3 KM'
      WRITE(IOOUT,*)'  6 - DUST WITH VIS GE 3 KM'
      WRITE(IOOUT,*)'  7 - DRIZZLE, RAIN AND TSTMS WITH VIS LT 1 KM'
      WRITE(IOOUT,*)
      +'  8 - DRIZZLE, RAIN AND TSTMS WITH VIS GE 1, LT 3KM'
      WRITE(IOOUT,*)
      +'  9 - DRIZZLE, RAIN AND TSTMS WITH VIS GE 3, LT 7KM'
      WRITE(IOOUT,*)' 10 - DRIZZLE, RAIN AND TSTMS WITH VIS GE 7 KM'
      WRITE(IOOUT,*)' 11 - SNOW WITH VIS LT 1 KM'
      WRITE(IOOUT,*)' 12 - SNOW WITH VIS GE 1, LT 3 KM'
      WRITE(IOOUT,*)' 13 - SNOW WITH VIS GE 3, LT 7 KM'
      WRITE(IOOUT,*)' 14 - SNOW WITH VIS GE 7 KM'
      WRITE(IOOUT,*)
      +' 15 - NO WEATHER AND ABSOLUTE HUMIDITY LT 10 GM/CU M'
      WRITE(IOOUT,*)
      +' 16 - NO WEATHER AND ABSOLUTE HUMIDITY GE 10 GM/CU M'
      WRITE(IOOUT,*)
      +' 17 - VIS LT 1 KM AND CEILING HEIGHT LT 300 M'
      WRITE(IOOUT,*)
      +' 18 - VIS LT 3 KM AND CEILING HEIGHT LT 1000 M'
      WRITE(IOOUT,*)' 19 - CEILING HEIGHT LT 300 M'
      WRITE(IOOUT,*)' 20 - CEILING HEIGHT LT 1000 M'
      WRITE(IOOUT,*)' 21 - NO CEILING'
      WRITE(IOOUT,*)' 22 - ALL CONDITIONS COMBINED'
      READ(IOIN,*) ICLASS
      WRITE(IOOUT,*)
      IF(ICLASS .LT. 1 .OR. ICLASS .GT. 22) THEN
        WRITE(IOOUT,*)'THE CLASS NUMBER MUST BE BETWEEN 1 AND 22'
        WRITE(IOOUT,*)'HIT RETURN TO CONTINUE'
        READ(IOIN,300) IDUM
CP    IDUM WILL SHOW UP AS SET BUT NEVER USED IN CODE CHECKERS.
CP    IT IS BEING USED TO STOP SCREEN IN THIS FORTRAN CONFIGURATION.
 300    FORMAT(I1)
        GOTO 53
      ENDIF
CP   END INFORMATION ABOUT CLIMAT OPTION (C.BACA JULY 92)
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```
CD  REV 8/18/89
       WRITE(21,54)'CLIM',FLOAT(LOCAT),FLOAT(MONTH),FLOAT(ICLASS)
   54 FORMAT(A4,6X,3E10.4)
CP 54 FORMAT(A4,6X,3I10)
CD  REV 8/18/89
    ELSE
       LOCAT = NINT(RECVAL(2,1))
       MONTH = NINT(RECVAL(2,2))
       ICLASS = NINT(RECVAL(2,3))
       CALL INTCHK(47,1,LOCAT,'CLIM','1ST',1)
       CALL INTCHK(12,1,MONTH,'CLIM','2ND',1)
       CALL INTCHK(22,1,ICLASS,'CLIM','3RD',1)
    ENDIF
      ENDIF
      IF (INTER) THEN
  100  WRITE(IOOUT,*)'INPUT THE JULIAN DAY NUMBER 1 TO 366'
    READ(IOIN,*) DATE
    WRITE(IOOUT,*)DATE
    WRITE(IOOUT,*)
    IF (DATE .LT. 1 .OR. DATE .GT. 366) THEN
       WRITE(IOOUT,*)'YOU MUST ENTER A DATE FROM 1 TO 366'
       WRITE(IOOUT,*)
       GOTO 100
    ENDIF
C***REV 1/91    NEW INTERACTIVE INPUT--REQUESTING YEAR OF INTEREST
C               AS REQUIRED BY ILUMA MODULE
  104  WRITE(IOOUT,*)'INPUT THE YEAR, FROM 1977 TO 1999'
    READ(IOIN,*) YEAR
    WRITE(IOOUT,*)YEAR
    WRITE(IOOUT,*)
    IF (YEAR .LT. 1977.0 .OR. YEAR .GT. 1999.0) THEN
       WRITE(IOOUT,*)'YOU MUST ENTER A YEAR FROM 1977 TO 1999'
       WRITE(IOOUT,*)
       GOTO 104
    ENDIF
  110  WRITE(IOOUT,*)'INPUT THE TIME IN HH.MM ZULU                '
    READ(IOIN,*) TIME
    WRITE(IOOUT,*)TIME
    WRITE(IOOUT,*)
    IF (TIME .LT. 0.00 .OR. TIME .GT. 24.00) THEN
       WRITE(IOOUT,*)'YOU MUST ENTER A TIME FROM 00.00 TO 24.00'
       WRITE(IOOUT,*)
       GOTO 110
    ENDIF
  120  WRITE(IOOUT,*)'ENTER THE LATITUDE IN DEGREES + FOR NORTH,'
    WRITE(IOOUT,*)'- FOR SOUTH.'
    WRITE(IOOUT,*)'THE LATITUDE MUST BE BETWEEN -90 AND +90 DEG.'
    READ(IOIN,*) ALAT
    WRITE(IOOUT,*)ALAT
    WRITE(IOOUT,*)
    IF (ALAT .LT. -90.0 .OR. ALAT .GT. 90.0) THEN
       WRITE(IOOUT,*)'YOU HAVE ENTERED AN ILLEGAL VALUE OF '
     +                   ,'LATITUDE -- TRY AGAIN'
       WRITE(IOOUT,*)
       GOTO 120
    ENDIF
  130  WRITE(IOOUT,*)'ENTER THE LONGITUDE IN DEGREES + FOR WEST'
    WRITE(IOOUT,*)'- FOR EAST'
    WRITE(IOOUT,*)'THE LONGITUDE MUST BE BETWEEN -180 AND +180'
    READ(IOIN,*) ALONG
    WRITE(IOOUT,*)ALONG
    WRITE(IOOUT,*)
    IF (ALONG .LT. -180.0 .OR. ALONG .GT. 180.0) THEN
       WRITE(IOOUT,*)'YOU HAVE ENTERED AN ILLEGAL VALUE OF ',
     +                    'LONGITUDE -- TRY AGAIN'
```

```
       WRITE(IOOUT,*)
       GOTO 130
    ENDIF
      ELSE
    DATE = NINT(RECVAL(5,1))
    TIME = RECVAL(5,2)
    ALAT = RECVAL(5,3)
    ALONG = RECVAL(5,4)
C***REV 1/91   NEW BATCH INPUT--YEAR OF INTEREST REQUIRED BY ILUMA MODULE
    YEAR = RECVAL(5,6)
    CALL INTCHK (366,1,DATE,'GEOM','1ST',188)
    CALL REALCK (24.0,0.0,TIME,'GEOM','2ND',12.0)
    CALL REALCK (90.0,-90.0,ALAT,'GEOM','3RD',55.0)
    CALL REALCK (180.0,-180.0,ALONG,'GEOM','4TH',9.0)
C***REV 1/91
    CALL REALCK (1999.0,1977.0,YEAR,'GEOM','6TH',1991.0)
      ENDIF
C***REV 1/91   CALLS CVRTJD TO CONVERT JULIAN DATE TO MONTH AND YEAR,
C              CONVERTS TIME TO HUNDREDS HOURS (HHMM) FORMAT, AND
C              STORES LATITUDE AND LONGITUDE AS REQUIRED INPUT
C              TO THE ILUMA MODULE
      CALL CVRTJD ( DATE, YEAR, FMONTH, DAY )
      GTIME = TIME * 100.0
      SLAT = ALAT
      SLON = -ALONG
C
C  CALL EOSAEL ROUTINE CLIMAT TO OBTAIN CLIMATOLOGICAL DATA
C
      IF (ICLMAT) THEN
    TIMLOC = (TIME - ALONG / 15.0)
    IF (TIMLOC .GT. 23.0) TIMLOC = 24. - TIMLOC
    NHOUR = NINT(TIMLOC)
    CALL CLIMAT ( LOCAT, MONTH, NHOUR, ICLASS, 0, TEMP, PRESS, RH,
     +        AH, DP, VIS, WNDVEL, WINDIR, IPASCT, CLDHT, CLDCVR)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-3-------------------------------
C ASSIGN APPROPRIATE CLQUD LAYER:  CLOUD BASE HEIGHT, FRACTION, AND TYPE.
C THE UNIT CONVERSIONS WERE REMOVED SINCE ALL CLOUD BASE HEIGHTS ARE NOW
C ENTERED IN KILOMETERS INSTEAD OF FEET.
C   CF1 = CLDCVR / 100.0
C   ZC1 = CLDHT * 3281.0
         IF (CLDHT .LE. 2.0) THEN
            CF3 = CLDCVR / 100.0
            ZC3 = CLDHT
            IF (CLDHT .LE. 1.2 .OR. CLDCVR .GT. 50.0) THEN
               ITY3 = 4
            ELSE
               ITY3 = 5
            ENDIF
         ELSE IF (CLDHT .LE. 6.1) THEN
            CF2 = CLDCVR / 100.0
            ZC2 = CLDHT
            ITY2 = 3
         ELSE IF (CLDHT. LE. 20.0) THEN
            CF1 = CLDCVR / 100.0
            ZC1 = CLDHT
            IF (CLDCVR .GT. 67.5) THEN
               ITY1 = 2
            ELSE
               ITY1 = 1
            ENDIF
         ENDIF
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
    TMP = TEMP + 273.2
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```
      ENDIF
      IF (INTER) THEN
  140  WRITE(IOOUT,*)'ENTER THE TARGET HEADING BETWEEN 0 AND 360 DEG'
    READ(IOIN,*) TARGAZ
    WRITE(IOOUT,*)TARGAZ
    WRITE(IOOUT,*)
    IF (TARGAZ .LT. 0.0 .OR. TARGAZ .GT. 360.0) THEN
       WRITE(IOOUT,*)'THE TARGET HEADING MUST BE BETWEEN'
       WRITE(IOOUT,*)'0 AND 360 DEG --- TRY AGAIN'
       GOTO 140
    ENDIF
CCB THESE LINES ARE MOVED INTO THE INTERACTIVE BLOCK FROM BELOW ENDIF
CD  REV 8/18/89
  152 FORMAT(A4,6X,6E10.4)
CP152 FORMAT(A4,6X,1I10,4E10.4)
      WRITE(21,152)'GEOM',FLOAT(DATE),TIME,ALAT,ALONG,TARGAZ,YEAR
CD  REV 8/18/89
CCB (11/26/91) END MOVED BLOCK
      ELSE
    TARGAZ = RECVAL(5,5)
    CALL REALCK(360.0,0.0,TARGAZ,'GEOM','5TH',90.0)
      ENDIF
      IF (.NOT. ICLMAT) THEN
    IF (INTER) THEN
700       WRITE(IOOUT,*)'INPUT THE VISIBILITY IN KILOMETERS     '
       READ(IOIN,*) VIS
       WRITE(IOOUT,*)VIS
       WRITE(IOOUT,*)
       IF (VIS .EQ. 0.0) VIS = 0.01

       IF (VIS .LT. 0.0) THEN

          WRITE(IOOUT,*)'NEGATIVE VISIBILTY IS NOT POSSIBLE.'
          WRITE(IOOUT,*)'PLEASE CHECK.'
          GOTO 700
       ENDIF
       DVIS = 3.912/VIS
       CONTINUE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-1-------------------------------
C CHANGED THE WORDING OF THE FIRST CLOUD COVER INPUT TO READ "LOW
C CLOUDS" INSTEAD OF JUST CLOUDS; CHANGED THE VARIABLE FROM CF1 TO
C CF3; ALLOW BASE HEIGHT ENTRY FOR ANY FRACTION GREATER THAN ZERO;
C CHANGED THE BASE HEIGHT LIMIT TO BE LOW CLOUDS BETWEEN 0.1 AND
C 2.0 KM; THIS LIMIT IS THE SAME AS THE EOTDA VERSION 2.0
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-3-------------------------------
C ADD INPUTS FOR A LOW CLOUD TYPE; ASSIGN CLOUD THICKNESS BASED ON TYPE
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-9-------------------------------
C FOR A CLOUD ON THE GROUND, USE TYPE STRATUS.  REARRANGE SOME LINES TO
C MAKE MORE SENSE WITH DVIS IF STATEMENTS.
       IF (DVIS .LT. 7.0) THEN
  149        WRITE(IOOUT,*)'ENTER THE FRACTIONAL LOW CLOUD COVER'
          WRITE(IOOUT,*)'BETWEEN 0 AND 1'
          READ(IOIN,*) CF3
          WRITE(IOOUT,*)CF3
          WRITE(IOOUT,*)
             IF (CF3 .LT. 0.0 .OR. CF3 .GT. 1.0) THEN
                WRITE(IOOUT,*)'THE LOW CLOUD COVER MUST BE BETWEEN'
             WRITE(IOOUT,*)'0 AND 1 TRY AGAIN'
             GOTO 149
          ENDIF
       ELSE
          CF3 = 1.0
       ENDIF
       IF (CF3 .GT. 0.0) THEN
```

```
          IF (DVIS .LT. 7.0) THEN
  150           WRITE(IOOUT,*)'ENTER THE LOW CLOUD BASE HEIGHT'
                WRITE(IOOUT,*)'BETWEEN 0.1 AND 2.0 KM'
            READ(IOIN,*) ZC3
            WRITE(IOOUT,*)ZC3
            WRITE(IOOUT,*)
                IF (ZC3 .LT. 0.1 .OR. ZC3 .GT. 2.0) THEN
                   WRITE(IOOUT,*)'THE LOW CLOUD BASE HEIGHT MUST BE'
                   WRITE(IOOUT,*)'BETWEEN 0.1 AND 2.0 KM'
               WRITE(IOOUT,*)'TRY AGAIN'
               GOTO 150
            ENDIF
  164           WRITE(IOOUT,*)'ENTER THE LOW CLOUD TYPE'
                WRITE(IOOUT,*)'4 STRATUS/STRATOCUMULUS'
                WRITE(IOOUT,*)'5 CUMULUS/CUMULONIMBUS'
                READ(IOIN,*) ITY3
                WRITE(IOOUT,*) ITY3
                WRITE(IOOUT,*)
             IF (ITY3 .LT. 4 .OR. ITY3 .GT. 5) THEN
                   WRITE(IOOUT,*)'THE LOW CLOUD TYPE MUST BE'
               WRITE(IOOUT,*)'4 OR 5 TRY AGAIN'
               GOTO 164
            ENDIF
                THK3 = CTHICK(ITY3)
         ELSE
           WRITE(IOOUT,*)'VISIBILITY IS LOW, A CLOUD IS ON THE ',
     +                         'GROUND'
  167          WRITE(IOOUT,*)'ENTER THE HEIGHT OF THE LOW CLOUD TOP'
           WRITE(IOOUT,*)'OR -1 IF IT IS UNKNOWN'
           READ(IOIN,*) ZH3
           WRITE(IOOUT,*)ZH3
           WRITE(IOOUT,*)
               IF (ZH3 .EQ. -1.0) ZH3 = 0.2
               IF (ZH3 .LT. 0.1 .OR. ZH3 .GT. 2.0) THEN
                  WRITE(IOOUT,*)'THE LOW CLOUD TOP HEIGHT MUST BE'
                 WRITE(IOOUT,*)'BETWEEN 0.1 AND 2.0 KM'
             WRITE(IOOUT,*)'TRY AGAIN'
             GOTO 167
          ENDIF
              ZC3 = 0.0
              THK3 = ZH3
              ITY3 = 4
         ENDIF
      ENDIF
C-HSTX---SCENE SHADOWS---------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-1----------------------------
C ADDED MIDDLE AND HIGH CLOUD INPUTS -- THE CLOUD BASE HEIGHT LIMIT
C IS THE SAME AS THE EOTDA VERSION 2.0 FOR EACH CLOUD TYPE
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-3----------------------------------
C ASSIGN TYPE ALTOSTRATUS/ALTOCUMULUS FOR MIDDLE CLOUD; ASSIGN THICKNESS;
C ADD INPUTS FOR A HIGH CLOUD TYPE; ASSIGN CLOUD THICKNESS BASED ON TYPE;
C SAVE CLOUD INFORMATION TO BATCH MODE RECORDS LCLD, MCLD, AND HCLD
      WRITE(IOOUT,*)'ENTER THE FRACTIONAL MIDDLE CLOUD COVER'
      WRITE(IOOUT,*)'BETWEEN 0 AND 1'
      READ(IOIN,*) CF2
      WRITE(IOOUT,*)CF2
      WRITE(IOOUT,*)
      IF (CF2 .LT. 0.0 .OR. CF2 .GT. 1.0) THEN
  159       WRITE(IOOUT,*)'THE MIDDLE CLOUD COVER MUST BE BETWEEN'
         WRITE(IOOUT,*)'0 AND 1 TRY AGAIN'
         WRITE(IOOUT,*)'ENTER THE FRACTIONAL MIDDLE CLOUD COVER'
         WRITE(IOOUT,*)'BETWEEN 0 AND 1'
         READ(IOIN,*) CF2
         WRITE(IOOUT,*)CF2
```

```
         WRITE(IOOUT,*)
         IF (CF2 .LT. 0.0 .OR. CF2 .GT. 1.0) GOTO 159
      ENDIF
      IF (CF2 .GT. 0.0) THEN
         ITY2 = 3
            THK2 = CTHICK(ITY2)
151         CONTINUE
         WRITE(IOOUT,*)'ENTER THE MIDDLE CLOUD BASE HEIGHT'
            WRITE(IOOUT,*)'BETWEEN 2.0 AND 6.1 KM'
         READ(IOIN,*) ZC2
         WRITE(IOOUT,*)ZC2
         WRITE(IOOUT,*)
            IF (ZC2 .LT. 2.0 .OR. ZC2 .GT. 6.1) THEN
               WRITE(IOOUT,*)'THE MIDDLE CLOUD BASE HEIGHT MUST BE'
               WRITE(IOOUT,*)'BETWEEN 2.0 AND 6.1 KM'
           WRITE(IOOUT,*)'TRY AGAIN'
           GOTO 151
         ENDIF
      ENDIF
      WRITE(IOOUT,*)'ENTER THE FRACTIONAL HIGH CLOUD COVER'
      WRITE(IOOUT,*)'BETWEEN 0 AND 1'
      READ(IOIN,*) CF1
      WRITE(IOOUT,*)CF1
      WRITE(IOOUT,*)
      IF (CF1 .LT. 0.0 .OR. CF1 .GT. 1.0) THEN
169         WRITE(IOOUT,*)'THE HIGH CLOUD COVER MUST BE BETWEEN'
         WRITE(IOOUT,*)'0 AND 1 TRY AGAIN'
         WRITE(IOOUT,*)'ENTER THE FRACTIONAL HIGH CLOUD COVER'
         WRITE(IOOUT,*)'BETWEEN 0 AND 1'
         READ(IOIN,*) CF1
         WRITE(IOOUT,*)CF1
         WRITE(IOOUT,*)
         IF (CF1 .LT. 0.0 .OR. CF1 .GT. 1.0) GOTO 169
      ENDIF
      IF (CF1 .GT. 0.0) THEN
156         CONTINUE
         WRITE(IOOUT,*)'ENTER THE HIGH CLOUD BASE HEIGHT'
            WRITE(IOOUT,*)'BETWEEN 6.1 AND 13.7 KM'
         READ(IOIN,*) ZC1
         WRITE(IOOUT,*)ZC1
         WRITE(IOOUT,*)
            IF (ZC1 .LT. 6.1 .OR. ZC1 .GT. 13.7) THEN
               WRITE(IOOUT,*)'THE HIGH CLOUD BASE HEIGHT MUST BE'
               WRITE(IOOUT,*)'BETWEEN 6.1 AND 13.7 KM'
           WRITE(IOOUT,*)'TRY AGAIN'
           GOTO 156
         ENDIF
         WRITE(IOOUT,*)'ENTER THE HIGH CLOUD TYPE'
         WRITE(IOOUT,*)'1 THIN CIRRUS'
         WRITE(IOOUT,*)'2 THICK CIRRUS'
         READ(IOIN,*) ITY1
         WRITE(IOOUT,*) ITY1
         WRITE(IOOUT,*)
         IF (ITY1 .LT. 1 .OR. ITY1 .GT. 2) THEN
174            WRITE(IOOUT,*)'THE HIGH CLOUD TYPE MUST BE'
           WRITE(IOOUT,*)'1 OR 2 TRY AGAIN'
           WRITE(IOOUT,*)'ENTER THE HIGH CLOUD TYPE'
           WRITE(IOOUT,*)'1 THIN CIRRUS'
           WRITE(IOOUT,*)'2 THICK CIRRUS'
           READ(IOIN,*) ITY1
           WRITE(IOOUT,*) ITY1
           WRITE(IOOUT,*)
           IF (ITY1 .LT. 1 .OR. ITY1 .GT. 2) GOTO 174
         ENDIF
            THK1 = CTHICK(ITY1)
```

```
       ENDIF
          DUM = 0.0
       WRITE(21,399)'HCLD',DUM,FLOAT(ITY1),CF1,ZC1
       WRITE(21,399)'MCLD',DUM,FLOAT(ITY2),CF2,ZC2
       WRITE(21,399)'LCLD',DUM,FLOAT(ITY3),CF3,ZC3
  399       FORMAT(A4,6X,4E10.4)
C-HSTX---SCENE SHADOWS---------------------------------------------
C
    ELSE
       VIS = RECVAL(8,1)
       CALL REALCK(200.0,0.1,VIS,'METD','1ST',7.0)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-3----------------------------------
C UPDATED THE BATCH INPUTS TO USE THE LCLD, MCLD, AND HCLD RECORDS
C FOR CLOUD INPUTS, RATHER THAN METD.  THE UNIT CONVERSIONS WERE
C REMOVED SINCE THE CLOUD BASE HEIGHTS ARE ENTERED IN KILOMETERS
C INSTEAD OF FEET.
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-6----------------------------------
C CHECK CLOUD BASE HEIGHT INPUTS ONLY IF CLOUD FRACTION IS GREATER THAN 0.
C             CF1 = RECVAL(8,2)
C             ZC1 = RECVAL(8,3)
       ITY1 = NINT(RECVAL(15,2))
       CF1 = RECVAL(15,3)
       ZC1 = RECVAL(15,4)
       ITY2 = NINT(RECVAL(49,2))
       CF2 = RECVAL(49,3)
       ZC2 = RECVAL(49,4)
       ITY3 = RECVAL(32,2)
       CF3 = RECVAL(32,3)
       ZC3 = RECVAL(32,4)
       CALL INTCHK(2,0,ITY1,'HCLD','2ND',0)
       CALL INTCHK(3,3,ITY2,'MCLD','2ND',0)
       CALL INTCHK(5,4,ITY3,'LCLD','2ND',0)
       CALL REALCK(1.0,0.0,CF1,'HCLD','3RD',0.0)
       CALL REALCK(1.0,0.0,CF2,'MCLD','3RD',0.0)
       CALL REALCK(1.0,0.0,CF3,'LCLD','3RD',0.0)
       IF (CF1.GT.0.) CALL REALCK(13.7,6.1,ZC1,'HCLD','4TH',8.0)
       IF (CF2.GT.0.) CALL REALCK(6.1,2.0,ZC2,'MCLD','4TH',4.0)
       IF (CF3.GT.0.) CALL REALCK(2.0,0.1,ZC3,'LCLD','4TH',1.0)
          IF (ITY3 .GT. 0) THK3 = CTHICK(ITY3)
       IF (ITY2 .GT. 0) THK2 = CTHICK(ITY2)
          IF (ITY1 .GT. 0) THK1 = CTHICK(ITY1)
       DVIS = 3.912/VIS
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-1------------------------------
C USE THE VARIABLES ZH3, CF3, AND ZC3 INSTEAD OF ZH1, CF1, AND ZC1
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-3------------------------------
C THE CEILING HEIGHT IS CHANGED TO BE THE HEIGHT OF THE LOWEST CLOUD
C LAYER WITH A CLOUD FRACTION OF GREATER THAN 0.7.  REMOVE UNIT
C CONVERSION BECAUSE CLOUD HEIGHTS ARE NOW IN KM, RATHER THAN FEET.
C CLOUD THICKNESS IS SET TO 0.2 KM IF ANY CLOUD LAYER IS PRESENT.
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-9------------------------------
C CHANGE THE CEILING HEIGHT TO MATCH THE AIR FORCE DEFINITION: THE
C HEIGHT AT WHICH CLOUDS AT AND BELOW THAT HEIGHT COVER MORE THAN 4/8
C OF THE SKY (FROM AWSR 105-24).  5/8 (0.625) IS THE NEXT INCREMENT.
       ZH3 = 300.0
    ENDIF
      ENDIF
C      IF (CF3 .GT. 0.7) THEN
C         IF (DVIS .LE. 7.0) THEN
C            CEILHT=ZC3*0.0003048
C            THICK = 0.20
C         ELSE
C            CEILHT = 0.0
```

```
C            THICK = ZH3*0.0003048
C         ENDIF
C      ELSE
C         CEILHT = -1.0
C         THICK = 0.0
C      ENDIF
       CEILHT = -1.0
       FRAC = CF3
       IF (FRAC.GT.0.6) THEN
          CEILHT = ZC3
       ELSE
          FRAC = FRAC + CF2
          IF (FRAC.GT.0.6) THEN
             CEILHT = ZC2
          ELSE
             FRAC = FRAC + CF1
             IF (FRAC.GT.0.6) CEILHT = ZC1
          ENDIF
       ENDIF
       IF ((CF3.GT.0.0) .OR. (CF2.GT.0.0) .OR. (CF1.GT.0.0)) THEN
          THICK = 0.20
       ELSE
          THICK = 0.0
       ENDIF
C-HSTX---SCENE SHADOWS---------------------------------------------
C
C***REV 1/91   STORES FRACTIONAL CLOUD COVER FOR USE BY ILUMA MODULE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-1----------------------------
C CHANGED THE CLOUD FRACTION INPUTS FOR THE ILUMA VARIABLES -- FR1,
C FR2, AND FR3 TO HANDLE THE NEW 3 CLOUD LAYER INPUTS INSTEAD OF THE
C PREVIOUS 1 CLOUD LAYER INPUT
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-3----------------------------
C SET ILUMA VARIABLES ILR1, ILR2, AND ILR3 TO CLOUD TYPE INPUTS
C     FRC = CF1
      FR1 = CF1
      FR2 = CF2
      FR3 = CF3
      ILR1 = ITY1
      ILR2 = ITY2
      ILR3 = ITY3
C-HSTX---SCENE SHADOWS---------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-2----------------------------
C DETERMINE THE NUMBER OF CLOUDS BY COUNTING CLOUD LEVELS THAT
C CONTAIN A CLOUD.
      NUMCLD = 0
      IF ( CF1 .GT. 0.0 ) NUMCLD = NUMCLD + 1
      IF ( CF2 .GT. 0.0 ) NUMCLD = NUMCLD + 1
      IF ( CF3 .GT. 0.0 ) NUMCLD = NUMCLD + 1
C-HSTX---SCENE SHADOWS---------------------------------------------
C
      IF (INTER) THEN
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-3----------------------------
C THE RULE FOR ASKING FOR THE INVERSION HEIGHT WAS CHANGED TO ACCOUNT
C FOR THE THREE CLOUD LAYERS
C      IF (CF1 .LT. 0.001) THEN
       IF (CF1 .LT. 0.001 .AND. CF2 .LT. 0.001 .AND.
     1     CF3 .LT. 0.001) THEN
C-HSTX---SCENE SHADOWS---------------------------------------------
C
    WRITE(IOOUT,*)'INPUT RADIATION FOG OR INVERSION HEIGHT IN KM'
    WRITE(IOOUT,*)'IF ONE IS PRESENT (OTHERWISE INPUT -1.0)'
    READ(IOIN,*) AINVHT
```

```
     WRITE(IOOUT,*)AINVHT
     WRITE(IOOUT,*)
        END IF
       ELSE
     AINVHT = RECVAL(14,2)
     CALL REALCK(10.0,-1.0,AINVHT,'XSCL','2ND',-1.0)
       ENDIF
  115 CONTINUE
       IF (.NOT. ICLMAT) THEN
     IF (INTER) THEN
        WRITE(IOOUT,*)
        WRITE(IOOUT,*)'ENTER THE TEMPERATURE IN DEG C '
        READ(IOIN,*) TMP
        WRITE(IOOUT,*)TMP
        WRITE(IOOUT,*)
        IF (ABS(TMP) .GT. 60.0) THEN
           WRITE(IOOUT,*)
     +               'YOU HAVE ENTERED AN EXTREME TEMPERATURE READING'
           WRITE(IOOUT,*)'PLEASE CHECK YOUR READINGS AND REENTER'
           WRITE(IOOUT,*)'THE TEMPERATURE INFORMATION.'
           GOTO 115
        ENDIF
  111      CONTINUE
        WRITE(IOOUT,*)'ENTER THE DEWPOINT TEMPERATURE IN DEG C '
        READ(IOIN,*) TDEW
        WRITE(IOOUT,*)TDEW
        WRITE(IOOUT,*)
        IF (TDEW .GT. TMP) THEN
           WRITE(IOOUT,*)
     +               'YOUR DEWPOINT TEMPERATURE INDICATES MORE THAN'
           WRITE(IOOUT,*)
     +               '100% HUMIDITY. PLEASE CHECK YOUR READINGS AND'
           WRITE(IOOUT,*)
     +               'REENTER THE DEWPOINT TEMPERATURE INFORMATION.'
           GOTO 111
        ENDIF
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-3-----------------------------
C OMIT CLOUD FRACTION AND BASE HEIGHT FROM METD RECORD; THIS
C INFORMATION IS NOW STORED IN LCLD, MCLD, AND HCLD RECORDS FOR
C THREE CLOUD LAYERS
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-8-----------------------------
C OMIT RECVAL(8,7) (BACKGROUND REFLECTANCE, BKREF) FROM METD RECORD.
C THIS INFORMATION IS NOW STORED IN THE CONTEXTL RECORD.
CD  REV 8/18/89
C           WRITE(21,112)'METD',VIS,CF1,(ZC1/1000),THICK,TMP,TDEW,
C    +            RECVAL(8,7)
C      WRITE(21,112)'METD',VIS,DUM,DUM,THICK,TMP,TDEW,
C     +            RECVAL(8,7)
          DUM = 0.0
       WRITE(21,112)'METD',VIS,DUM,DUM,THICK,TMP,TDEW,DUM
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
  112 FORMAT(A4,6X,7E10.4)
CD  REV 8/18/89
    ELSE
       TMP = RECVAL(8,5)
       TDEW = RECVAL(8,6)
       CALL REALCK(60.0,-60.0,TMP,'METD','5TH',10.0)
       CALL REALCK(TMP,-60.0,TDEW,'METD','6TH',8.0)
    ENDIF
    TMP = TMP + 273.2
    RH = 100.0*EXP(6885.06*(1.0/TMP-1.0/(TDEW+273.2))+5.31*
     +        ALOG(TMP/(TDEW+273.2)))
      ENDIF
```

```
CP      SIGVIS = 3.912 / VIS   USED IN CALL TO OLD XSCALE. PSG NOV 92.
      IF (INTER) THEN
    WRITE(IOOUT,*)
    WRITE(IOOUT,*)'SELECT AEROSOL TYPE'
    WRITE(IOOUT,*)' 1-MARITIME AIR MASS'
    WRITE(IOOUT,*)' 2-URBAN'
    WRITE(IOOUT,*)' 3-RURAL (CONTINENTAL POLAR)'
    WRITE(IOOUT,*)' 4-FOG (HEAVY ADVECTION)'
    WRITE(IOOUT,*)' 5-FOG (MODERATE RADIATION)'
CRF         WRITE(IOOUT,*)' 6-RAIN (DRIZZLE)'
CRF         WRITE(IOOUT,*)' 7-RAIN (WIDESPREAD)'
CRF         WRITE(IOOUT,*)' 8-RAIN (THUNDERSTORM)'
CRF         WRITE(IOOUT,*)' 9-SNOW'
CRF   17 APR 92   CHANGE AEROSOLS FOR XSCALE92
    WRITE(IOOUT,*)' 6-DESERT AIR MASS'
    WRITE(IOOUT,*)' 7-RAIN (DRIZZLE)'
    WRITE(IOOUT,*)' 8-RAIN (WIDESPREAD)'
    WRITE(IOOUT,*)' 9-RAIN (THUNDERSTORM)'
    WRITE(IOOUT,*)' 10-SNOW'
    WRITE(IOOUT,*)' 11-ICEFOG'
    READ(IOIN,*)IAERO
    WRITE(IOOUT,*)IAERO
    WRITE(IOOUT,*)
      ELSE
    IAERO = NINT(RECVAL(14,1))
CRF      CALL INTCHK(9,1,IAERO,'XSCL','1ST',3)  17 APR 92
CRF   REPLACE THE PREVIOUS LINE WITH THE FOLLOWING FOR XSCALE92
   CALL INTCHK(11,1,IAERO,'XSCL','1ST',3)
      ENDIF
      TEMP = TMP - 273.2
      ISLT = 1
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-9---------------------------
C SIGWX IS NO LONGER USED; IF FOG AEROSOL SET ILR3 FOR ILUMA HERE.
      IF ((IAERO.EQ.4 .OR. IAERO.EQ.5 .OR. IAERO.EQ.11) .AND.
     1    (CF3 .LE. 0.1)) ILR3 = 2
C-HSTX---SCENE SHADOWS--------------------------------------------
C
CRF   IF (IAERO .GE. 6 .AND. IAERO .LE. 8) THEN  17 APR 92
CRF   REPLACE THE PREVIOUS LINE WITH THE FOLLOWING FOR XSCALE92
      IF (IAERO .GE. 7 .AND. IAERO .LE. 9) THEN
    IF (INTER) THEN
       WRITE(IOOUT,103)
  103 FORMAT(' ENTER RAIN RATE (MM/HR)')
       READ(*,*)RNRT
       WRITE(IOOUT,*) RNRT
       WRITE(IOOUT,*)
    ELSE
       RNRT = RECVAL(14,3)
       CALL REALCK(254.0,0.0,RNRT,'XSCL','3RD',0.0)
    ENDIF
C        IOTEMP = IOIN
C        IOIN = IPHFUN
    CALL IOOPEN(KSTOR,'SCTH.UNT','SCRATCH',0,'FORMATTED',
     +        'TARGAC','SGR',LUNERR,*105)
    RANGE = 5
    IF (RANGE .GT. CEILHT .AND. CEILHT .GT. 0.0 ) RANGE = CEILHT
CRF      CALL XSCAIL(0.45,0.7,-20.,SIGVIS,XSTRN,IERR,ISLT,3,
CRF  +        RANGE,90.,CEILHT,0,RNRT,THICK,RH,WNDVEL)
CRF   REMOVE THE PREVIOUS 2 LINES AND REPLACE WITH . . .
    DUM1 = 90.0
    DUM2 = 0.0
CP    DUM1 AND DUM2 WERE DEFINED ABOVE TO SEND TO XSCALE BECAUSE
CP    THEY ARE MODIFIED IN XSCALE.
CRF   THE FOLLOWING 6 LINES FOR XSCALE92.   17 APR 92.
```

```
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-7----------------------------
C CHANGED THE CONSTANTS SENT TO XSCALE TO VARIABLES.  THESE VALUES
C MAY BE CHANGED IN XSCALE.  THIS CAUSED PROBLEMS WHEN XSCALE ENDED,
C SINCE THE CONSTANTS WERE NO LONGER THE VALUES THAT THEY WERE
C SUPPOSED TO BE.
C           CALL XSCALE(0.45,0.7,VIS,3,2,ISLT,NBR,
C     1                 RD,DECPER,XMEAN,XMODE,IWATER,
C     2                 WAVRFN,RESPFN,
C     3                 RANGE,90.0,0.0,CEILHT,THICK,AINVHT,
C     4                 RNRT,TEMP,WNDVEL,RH,XSTRN,IERR,
C     5                 Q,UM,EXT55I,QAVE)
    DUM45 = 0.45
    DUM7 = 0.7
    IDUM3 = 3
    IDUM2 = 2
    DUM90 = 90.0
    DUM0 = 0.0
    CALL XSCALE(DUM45,DUM7,VIS,IDUM3,IDUM2,ISLT,NBR,
     1                 RD,DECPER,XMEAN,XMODE,IWATER,
     2                 WAVRFN,RESPFN,
     3                 RANGE,DUM90,DUM0,CEILHT,THICK,AINVHT,
     4                 RNRT,TEMP,WNDVEL,RH,XSTRN,IERR,
     5                 Q,UM,EXT55I,QAVE)
C-HSTX---SCENE SHADOWS------------------------------------------
C
C         REWIND IPHFUN
C         IOIN = IOTEMP
    GOTO 106
  105     IERR = 1
  106     CONTINUE
CP106     CLOSE(KSTOR)
    IF (IERR .EQ. 1) THEN
       EFLAG = .TRUE.
       RETURN
    ENDIF
    ISLT = 0
CRF   ELSE IF (IAERO .EQ. 9) THEN   17 APR 92
CRF   REPLACE THE PREVIOUS LINE WITH THE FOLLOWING FOR XSCALE92
      ELSE IF (IAERO .EQ. 6 .OR. IAERO .EQ. 10) THEN
CUV        TEMP2=TMP-273.2
    RD=.002
    IF (INTER) THEN
  999      WRITE(IOOUT,*) 'INPUT WINDSPEED IN KNOTS'
       READ(IOIN,*) WIND
       WRITE(IOOUT,*)WIND
       WRITE(IOOUT,*)
       IF (WIND .LT. 0.0) THEN
       WRITE(IOOUT,*)'NEGATIVE WINDSPEED IS NOT POSSIBLE.'
       WRITE(IOOUT,*)'REENTER WINDSPEED. '
       GOTO  999
    ENDIF
    IF (WIND .GT. 75.0) THEN
       WRITE(IOOUT,*)'YOU HAVE ENTERED AN EXTREMELY HIGH'
       WRITE(IOOUT,*)'WINDSPEED.'
       WRITE(IOOUT,*)'REENTER WINDSPEED.'
       GOTO  999
    ENDIF
    ELSE
       WIND = RECVAL(14,3)
       CALL REALCK(75.0,0.0,WIND,'XSCL','3RD',0.0)
    ENDIF
    WNDVEL=WIND*0.5144
C         IOTEMP = IOIN
C         IOIN = IPHFUN
```

```
CP         CALL IOOPEN(NPLOTU,'SCTH.UNT','SCRATCH',0,'FORMATTED',
CP    +         'TARGAC','SGR',LUNERR,*1000)
      RANGE = 5
      IF (RANGE .GT. CEILHT .AND. CEILHT .GT. 0.0 ) RANGE = CEILHT
CRF        CALL XSCAIL(0.45,0.7,-20.,SIGVIS,XSTRN,IERR,ISLT,3,
CRF   +         RANGE,90.,CEILHT,0,RNRT,THICK,RH,WNDVEL)
CRF   REMOVE THE PREVIOUS 2 LINES AND REPLACE WITH . . .
      DUM1 = 90.0
      DUM2 = 0.0
CP    DUM1 AND DUM2 WERE DEFINED ABOVE TO SEND TO XSCALE BECAUSE
CP    THEY ARE MODIFIED IN XSCALE.
CRF   THE FOLLOWING 6 LINES FOR XSCALE92.   17 APR 92.
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-7---------------------------
C CHANGED THE CONSTANTS SENT TO XSCALE TO VARIABLES.  THESE VALUES
C MAY BE CHANGED IN XSCALE.  THIS CAUSED PROBLEMS WHEN XSCALE ENDED,
C SINCE THE CONSTANTS WERE NO LONGER THE VALUES THAT THEY WERE
C SUPPOSED TO BE.
C          CALL XSCALE(0.45,0.7,VIS,3,2,ISLT,NBR,
C     1                RD,DECPER,XMEAN,XMODE,IWATER,
C     2                WAVRFN,RESPFN,
C     3                RANGE,90.0,0.0,CEILHT,THICK,AINVHT,
C     4                RNRT,TEMP,WNDVEL,RH,XSTRN,IERR,
C     5                Q,UM,EXT55I,QAVE)
      DUM45 = 0.45
      DUM7 = 0.7
      IDUM3 = 3
      IDUM2 = 2
      DUM90 = 90.0
      DUM0 = 0.0
      CALL XSCALE(DUM45,DUM7,VIS,IDUM3,IDUM2,ISLT,NBR,
     1                RD,DECPER,XMEAN,XMODE,IWATER,
     2                WAVRFN,RESPFN,
     3                RANGE,DUM90,DUM0,CEILHT,THICK,AINVHT,
     4                RNRT,TEMP,WNDVEL,RH,XSTRN,IERR,
     5                Q,UM,EXT55I,QAVE)
C-HSTX---SCENE SHADOWS--------------------------------------------
C
C         REWIND IPHFUN
C         IOIN = IOTEMP
      GOTO 1002
CUV 1000 IERR = 1
 1002    CONTINUE
CP1002   CLOSE(NPLOTU)
      IF (IERR .EQ. 1) THEN
         EFLAG = .TRUE.
         RETURN
      ENDIF
      ISLT = 0
        ENDIF
        IF(INTER)THEN
CD  REV 8/18/89
 1001 FORMAT(A4,6X,3E10.4)
CP1001 FORMAT(A4,6X,1I10,2E10.4)
CRF   IF (IAERO .EQ. 9) THEN   17 APR 92
CRF   REPLACE THE PREVIOUS LINE WITH THE FOLLOWING FOR XSCALE92
        IF (IAERO .EQ. 6 .OR. IAERO .EQ. 10) THEN
      WRITE(21,1001)'XSCL',FLOAT(IAERO),AINVHT,WIND
CRF   ELSE IF (IAERO .LE. 8 .AND. IAERO .GE. 6) THEN   17 APR 92
CRF REPLACE THE PREVIOUS LINE WITH THE FOLLOWING FOR XSCALE92
        ELSE IF (IAERO .LE. 9 .AND. IAERO .GE. 7) THEN
      WRITE(21,1001)'XSCL',FLOAT(IAERO),AINVHT,RNRT
        ELSE IF (IAERO .LE. 5 .AND. IAERO .GE. 1) THEN
      WRITE(21,1003)'XSCL',FLOAT(IAERO),AINVHT
CRF  ADD THE FOLLOWING LINE FOR XSCALE92
```

```
      ELSE IF (IAERO .EQ. 11) THEN
    WRITE(21,1003)'XSCL',FLOAT(IAERO),AINVHT
      ENDIF
 1003 FORMAT(A4,6X,2E10.4)
CP1003 FORMAT(A4,6X,1I10,1E10.4)
CD  REV 8/18/89
      END IF
C     IOTEMP = IOIN
C     IOIN = IPHFUN
CP    CALL IOOPEN(NPLOTU,'SCTH.UNT','SCRATCH',0,'FORMATTED',
CP   +     'TARGAC','SGR',LUNERR,*1010)
      RANGE = 5
      IF (RANGE .GT. CEILHT .AND. CEILHT .GT. 0.0 ) RANGE = CEILHT
      MAERO = IAERO
CRF   IF (IAERO .GE. 4 .AND. IAERO .LE. 9) MAERO=3   17 APR 92
CRF  REPLACE THE PREVIOUS LINE WITH THE FOLLOWING LINE FOR XSCALE92
      IF (IAERO .GE. 4 .AND. IAERO .LE. 11) MAERO = 3
CRF   CALL XSCAIL(0.45,0.7,-20.,SIGVIS,XSTRN,IERR,ISLT,MAERO,
CRF  +     RANGE,90.,CEILHT,0,RNRT,THICK,RH,WNDVEL)
CRF   REMOVE THE PREVIOUS 2 LINES AND REPLACE WITH . . .
    DUM1 = 90.0
    DUM2 = 0.0
CP    DUM1 AND DUM2 WERE DEFINED ABOVE TO SEND TO XSCALE BECAUSE
CP    THEY ARE MODIFIED IN XSCALE.
CRF   THE FOLLOWING 6 LINES FOR XSCALE92.   17 APR 92.
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-7----------------------------
C CHANGED THE CONSTANTS SENT TO XSCALE TO VARIABLES.  THESE VALUES
C MAY BE CHANGED IN XSCALE.  THIS CAUSED PROBLEMS WHEN XSCALE ENDED,
C SINCE THE CONSTANTS WERE NO LONGER THE VALUES THAT THEY WERE
C SUPPOSED TO BE.
C      CALL XSCALE(0.45,0.7,VIS,MAERO,2,ISLT,NBR,
C     1            RD,DECPER,XMEAN,XMODE,IWATER,
C     2            WAVRFN,RESPFN,
C     3            RANGE,90.0,0.0,CEILHT,THICK,AINVHT,
C     4            0.0,TEMP,0.0,RH,XSTRN,IERR,
C     5            Q,UM,EXT55I,QAVE)
    DUM45 = 0.45
    DUM7 = 0.7
    IDUM2 = 2
    DUM90 = 90.0
    DUM0 = 0.0
      CALL XSCALE(DUM45,DUM7,VIS,MAERO,IDUM2,ISLT,NBR,
     1            RD,DECPER,XMEAN,XMODE,IWATER,
     2            WAVRFN,RESPFN,
     3            RANGE,DUM90,DUM0,CEILHT,THICK,AINVHT,
     4            DUM0,TEMP,DUM0,RH,XSTRN,IERR,
     5            Q,UM,EXT55I,QAVE)
C-HSTX---SCENE SHADOWS---------------------------------------------
C
C     REWIND IPHFUN
C     IOIN = IPHFUN
      GOTO 1012
CUV 1010 IERR = 1
 1012 CONTINUE
CP1012 CLOSE(NPLOTU)
      IF (IERR .EQ. 1) THEN
    EFLAG = .TRUE.
    RETURN
      ENDIF
C
      IF (INTER) THEN
C
C***REV 1/91    ADDED SIGNIFICANT WEATHER ID TO INTERACTIVE PART AS
C               NEEDED BY ILUMA MODULE
```

```
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-9---------------------------
C ELIMINATE SIGWX; CONDITIONS ARE COVERED BY OTHER INPUTS.
C  990   WRITE(IOOUT,*)'SELECT SIGNIFICANT WEATHER ID:'
C   WRITE(IOOUT,*)'  1 - SKY COVER < 50%'
C   WRITE(IOOUT,*)'  2 - SKY COVER = 50%'
C   WRITE(IOOUT,*)'  3 - SKY COVER > 50%'
C   WRITE(IOOUT,*)'  4 - BLOWING SNOW OR SAND'
C   WRITE(IOOUT,*)'  5 - FOG/HAZE (NON-OBSCURING)'
C   WRITE(IOOUT,*)'  6 - DRIZZLE'
C   WRITE(IOOUT,*)'  7 - RAIN'
C   WRITE(IOOUT,*)'  8 - SNOW/RAIN (NO SHOWER)'
C   WRITE(IOOUT,*)'  9 - RAIN/SNOW/HAIL SHOWER'
C   WRITE(IOOUT,*)' 10 - THUNDERSTORM'
C   READ(IOIN,*)SIGWX
C   WRITE(IOOUT,*)SIGWX
C   WRITE(IOOUT,*)
C   IF (NINT(SIGWX) .LT. 0 .OR. NINT(SIGWX) .GT. 10) THEN
C      WRITE(IOOUT,*)'THE SIGNIGICANT WEATHER ID MUST BE BETWEEN',
C     +           ' 1 AND 10'
C      WRITE(IOOUT,*)'TRY AGAIN'
C      WRITE(IOOUT,*)
C      GOTO  990
C   ENDIF
C-HSTX---SCENE SHADOWS--------------------------------------------
C
C***REV 1/91   ADDED OBSERVED STATE OF GROUND TO INTERACTIVE PART AS
C              NEEDED BY ILUMA MODULE
  991  WRITE(IOOUT,*)'SELECT OBSERVED STATE OF GROUND:'
    WRITE(IOOUT,*)'  1 - DRY'
    WRITE(IOOUT,*)'  2 - MOIST'
    WRITE(IOOUT,*)'  3 - WET'
    WRITE(IOOUT,*)'  4 - FROZEN'
    WRITE(IOOUT,*)'  5 - ICE'
    WRITE(IOOUT,*)'  6 - SNOW -- < 0.5'
    WRITE(IOOUT,*)'  7 - SNOW -- > 0.5 & < ALL'
    WRITE(IOOUT,*)'  8 - SNOW --  ALL'
    WRITE(IOOUT,*)'  9 - LOOSE DRY SNOW/DUST/SAND -- >0.5 & <ALL'
    WRITE(IOOUT,*)' 10 - LOOSE DRY SNOW/DUST/SAND -- ALL'
    READ(IOIN,*) OBSURF
    WRITE(IOOUT,*)OBSURF
    WRITE(IOOUT,*)
    IF (NINT(OBSURF) .LT. 0 .OR. NINT(OBSURF) .GT. 10) THEN
       WRITE(IOOUT,*)'THE OBSERVED STATE OF GROUND MUST BE',
     +                    ' BETWEEN 1 AND 10'
       WRITE(IOOUT,*)'TRY AGAIN'
       WRITE(IOOUT,*)
       GOTO  991
    ENDIF
C***REV 1/91   ADDED PRECIPITATION TYPE TO INTERACTIVE PART
C              AS NEEDED BY ILUMA MODULE
  992  WRITE(IOOUT,*)'SELECT PRECIPITATION TYPE:'
    WRITE(IOOUT,*)'  1 - NONE'
    WRITE(IOOUT,*)'  2 - DRIZZLE'
    WRITE(IOOUT,*)'  3 - RAIN'
    WRITE(IOOUT,*)'  4 - SNOW'
    WRITE(IOOUT,*)'  5 - HAIL'
    READ(IOIN,*)PRTYP
    WRITE(IOOUT,*)PRTYP
    WRITE(IOOUT,*)
    IF (NINT(PRTYP) .LT. 0 .OR. NINT(PRTYP) .GT. 5) THEN
       WRITE(IOOUT,*)'THE PRECIPITATION TYPE BETWEEN',
     +                    ' BETWEEN 1 AND 5'
       WRITE(IOOUT,*)'TRY AGAIN'
       WRITE(IOOUT,*)
```

```
          GOTO  992
       ENDIF
         ELSE
C***REV 1/91   ADDED SIGNIFICANT WEATHER ID, OBSERVED STATE OF GROUND,
C              AND PRECIPITATION TYPE TO BATCH PORTION AS NEEDED BY
C              ILUMA MODULE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-9--------------------------
C ELIMINATE SIGWX; CONDITIONS ARE COVERED BY OTHER INPUTS.
C    SIGWX  = RECVAL(7,2)
C    CALL REALCK(10.0,1.0,SIGWX ,'ILUM','2ND',1.0)
C-HSTX---SCENE SHADOWS-------------------------------------------
C
     OBSURF = RECVAL(7,3)
     PRTYP = RECVAL(7,4)
     CALL REALCK(10.0,0.0,OBSURF,'ILUM','3RD',1.0)
     CALL REALCK( 5.0,0.0,PRTYP,'ILUM','4TH',1.0)
       ENDIF
C
C
       RD = RDTEMP
       TARGAZ = TARGAZ + 180.0
       IHOUR = NINT(TIME)
       ZTIME = TIME * 100.0
       IMIN = NINT(ZTIME) - IHOUR * 100
       XMIN = FLOAT(IMIN) / 60.0
       TIME = FLOAT(IHOUR) + XMIN
C
C  SUBROUTINE ZEN TO OBTAIN THE SOLAR ZENITH AND
C  AZIMUTH ANGLES
C
C      CALL ZEN(DATE,TIME,ALAT,ALONG,COSZ,SUNAZ)
C
C***REV 1/91   CALL TO SOLUN COMMENTED OUT--REPLACED BY CALL TO ILUMA
C      CALL SOLUN(DATE,TIME,ALAT,ALONG,COSZ,SUNAZ,COSM,LUNAZ)
C
C***REV 1/91   CALLS ILUMA FOR SOLAR AND LUNAR ELEVATIONS AND AZIMUTHS.
C              ELEVATIONS CONVERTED TO ZENITHS
       CALL ILMDAT ( IDEV )
       ZENSUN = (90.0 - ALTS)/RAD
       COSZ = COS(ZENSUN)
       SUNAZ = AZIS
C      SUNAZ = AZIS + 180.0
C      IF (SUNAZ .GT. 360.0) SUNAZ = SUNAZ - 360.0
C
       ZENLUN = (90.0 - ALTMN)/RAD
       COSM = COS(ZENLUN)
       LUNAZ = AZIM
C      LUNAZ = AZIM + 180.0
C      IF (LUNAZ .GT. 360.0) LUNAZ = LUNAZ - 360.0
C
CP     THE PARAMETER FLIP IS USED TO TEST AGAINST BECAUSE THERE ARE
CP     PROBLEMS WITH MICROSOFT FORTRAN 5.0 IN TESTING AGAINST THIS
CP     PARAMETER. PSG 26 MARCH 1993. MICROSOFT FORTRAN THINKS THAT
CP     COSZ IS LESS THAN 0.0, GREATER THAN .972, LESS THAN 9.72,
CP     AND LESS THAN 1.0. CONFUSING N'EST PAS?????
       FLIP = 0.0
       IF (COSZ .LE. FLIP) THEN
   IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
     WRITE(IOOUT,*)
     WRITE(IOOUT,*)'  CAUTION, SUN IS BELOW THE HORIZON.'
     WRITE(IOOUT,*)'  VALUES FOR THE SKY TO GROUND RATIO'
     WRITE(IOOUT,*)'  MAY BE ERRONEOUS.  LUNAR AZIMUTH'
     WRITE(IOOUT,*)'  AND ZENITH ANGLE USED INSTEAD OF'
     WRITE(IOOUT,*)'  SOLAR AZIMUTH AND ZENITH ANGLE.'
```

```
   ENDIF
   IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
     WRITE(NDIRTU,*)
     WRITE(NDIRTU,*)'  CAUTION, SUN IS BELOW THE HORIZON.'
     WRITE(NDIRTU,*)'  VALUES FOR THE SKY TO GROUND RATIO'
     WRITE(NDIRTU,*)'  MAY BE ERRONEOUS.  LUNAR AZIMUTH'
     WRITE(NDIRTU,*)'  AND ZENITH ANGLE USED INSTEAD OF'
     WRITE(NDIRTU,*)'  SOLAR AZIMUTH AND ZENITH ANGLE.'
   ENDIF
    COSZ = COSM
    SUNAZ = LUNAZ
      ENDIF
      RHO = BKGREF
C
C  USE STG TO FIND THE SKY TO GROUND RATIO
C
CPUSB  STG2 WILL LOOK LIKE IT IS USED BEFORE SET TO CODE CHECKERS.
CPUSB  STG2 IS A VALUE RETURNED BY FUNCTION STG. 18 NOV 92.
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-1-5---------------------------------
C CHANGE SKY-TO-GROUND RATIO VARIABLE TO AN ARRAY IN ORDER TO SAVE
C INFORMATION FOR PARTLY CLOUDY SITUATIONS.  ADD LOOP AND OUTPUT
C STATEMENTS TO REPORT BOTH SKY-TO-GROUND RATIOS.
C     SOG=STG(XLAMB,COSZ,SUNAZ,VIS,TARGAZ,RHO,STG2)
      SOG(1)=STG(XLAMB,COSZ,SUNAZ,VIS,TARGAZ,RHO,STG2)
      SOG(2) = STG2
C
      IF ( MLOOP .EQ. 1 ) THEN
   JSTOP = 1
      ELSE
   JSTOP = 2
      END IF
      DO 500 JCLOUD=1,JSTOP
        IF (SOG(JCLOUD) .LT. 0.5) THEN
     IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
            IF ((JCLOUD.EQ.2).OR.((MLOOP.EQ.1).AND.(NUMCLD.GT.0))) THEN
              WRITE(IOOUT,*)
     1          'SKY TO GROUND RATIO (IN CLOUD) IS LESS THAN 0.5'
            ELSE
              WRITE(IOOUT,*)
     1          'SKY TO GROUND RATIO (NO CLOUD) IS LESS THAN 0.5'
            ENDIF
       WRITE(IOOUT,*)'THE VALUE HAS BEEN RESET TO 0.5'
          ENDIF
          IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
            IF ((JCLOUD.EQ.2).OR.((MLOOP.EQ.1).AND.(NUMCLD.GT.0))) THEN
              WRITE(NDIRTU,*)
     1          'SKY TO GROUND RATIO (IN CLOUD) IS LESS THAN 0.5'
            ELSE
              WRITE(NDIRTU,*)
     1          'SKY TO GROUND RATIO (NO CLOUD) IS LESS THAN 0.5'
            ENDIF
            WRITE(NDIRTU,*)'THE VALUE HAS BEEN RESET TO 0.5'
          ENDIF
          SOG(JCLOUD) = 0.5
        END IF
        IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
          WRITE(IOOUT,*)'   '
          IF ((JCLOUD.EQ.2).OR.((MLOOP.EQ.1).AND.(NUMCLD.GT.0))) THEN
            WRITE(IOOUT,*)
     1        'SKY TO GROUND RATIO (IN CLOUD) IS ',SOG(JCLOUD)
          ELSE
            WRITE(IOOUT,*)
     1        'SKY TO GROUND RATIO (NO CLOUD) IS ',SOG(JCLOUD)
          ENDIF
```

```
          WRITE(IOOUT,*)'  '
        ENDIF
        IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
          WRITE(NDIRTU,*)'    '
          IF ((JCLOUD.EQ.2).OR.((MLOOP.EQ.1).AND.(NUMCLD.GT.0))) THEN
            WRITE(NDIRTU,*)
     1         'SKY TO GROUND RATIO (IN CLOUD) IS ',SOG(JCLOUD)
          ELSE
            WRITE(NDIRTU,*)
     1         'SKY TO GROUND RATIO (NO CLOUD) IS ',SOG(JCLOUD)
          ENDIF
          WRITE(NDIRTU,*)'  '
        ENDIF
 500  CONTINUE
C-HSTX---SCENE SHADOWS----------------------------------------------------
C
      RETURN
      END
C
```

ECR # HSTX - 2 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: STG

Old Date: 1/14/93

File Name: SLNCOF.FOR

New Date: 8/11/93

Implemented By: Michael Oberlatz

Reason for Revision: Corrects an error in naming of the CLOUD COMMON block and adds three cloud layers to the model.

Description of Revision: Changed the name of the CLOUDS COMMON block to CLOUD to match the SGR function. Added the variables ZC2, ZC3, CF2, and CF3 to the CLOUD COMMON block to implement the three cloud layers.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 2 - 2

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: STG

Old Date: 8/11/93

File Name: SLNCOF.FOR

New Date: 8/23/93

Implemented By: Dan DeBenedictis

Reason for Revision: Set atmospheric data for layers with and/or without clouds. Add loop structure for possible cloud situations.

Description of Revision: 1) Re-dimension the variables I0, I1, SURF, SURF0, F, PTHRD, and ISTAR to support partly cloudy situations. 2) Add the variables NUMCLD, MLOOP, CLDBTA, CLDG, LYRCLD, THK, and ITY to the COMMON block CLOUD. 3) Call GETCLD. 4) Loop through the number of cloud situations. (See code for more details.) Pass the loop counter to the subroutine DELTED; pass the counter and SZA to CONTST. Assign STG and STG2 as bracketing values, depending on MLOOP.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 2 - 3

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: STG Old Date: 8/23/93

File Name: SLNCOF.FOR New Date: 8/27/93

Implemented By: Don Hamann

Reason for Revision: To maintain information on the probability of a cloud-free path through each cloud layer and on the probability of the target scene in direct light.

Description of Revision: Added variable PSCLD and array PCF(2) to CLOUD COMMON block to maintain probability information.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 2 - 4

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: STG　　Old Date: 8/27/93

File Name: SLNCOF.FOR　　New Date: 9/15/93

Implemented By: Melanie J. Gouveia

Reason for Revision: Fix the error that, for clear sky cases, gave 100.0 for the probability that the target is in cloud shadow.

Description of Revision: Initialize the probability that the target is in direct light to 100.0, before any clouds are accounted for.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 2 - 5

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: STG

Old Date: 9/15/93

File Name: SLNCOF.FOR

New Date: 9/17/93

Implemented By: Don Hamann

Reason for Revision: Probability of cloud free path through layer requires initialization for clear sky situation. Added flag to keep track of the cloud situation.

Description of Revision: Added variable ICLDF to CLOUD COMMON block to maintain information on cloud situation. ICLDF is initialized to 1, PCF is initialized to 1, and PSCLD is initialized to 100.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 2 - 6

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: STG

Old Date: 9/17/93

File Name: SLNCOF.FOR

New Date: 10/20/93

Implemented By: Dan DeBenedictis

Reason for Revision: To find a weighted average of the extinction coefficient (BETAA) and the asymmetry parameter (G) for all atmospheric layers that contain some or all of a cloud layer.

Description of Revision: Call the routine LAYERS inside the DO loop controlled by MLOOP.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C
C***********************************************************************
C<BEGIN>
C<IDENTIFICATION>         NAME:  STG
C                         TYPE:  FORTRAN FUNCTION (REAL)
C                     FILENAME:  SACB.F
C=======================================================================
C<DESCRIPTION>
C    CALCULATES THE SKY TO GROUND RATIO USING A DELTA-EDDINGTON RADIATIV
C    TRANSFER ALGORITHM
C=======================================================================
C<INPUT>
C    COMMON BLOCK VARIABLES:
C        / ATMOS / Z
C        / CLOUDS / CF1, ZC1
C        / RADIA / PTHRD
C        / XSCALE / BBETA, NNZPTS, ZZZ
C=======================================================================
C<OUTPUT>
C    COMMON BLOCK VARIABLES:
C        / ATMOS / NLAY, NLEV
C        / GEOM / NOBS, PHIOB, PHI0, THETOB, THET0, XLAM, XOB, YOB, ZOB
C        / RADIA / A, ALBEDO, BETAA, G, VIS
C        / TARGS / AZTARG, NTARG, RTARG, THTARG, XTARG, YTARG, ZTARG
C=======================================================================
C<CALLED ROUTINES>
C    CONTRAST    -    (SUBR)    CALCULATES THE BACKGROUND REFLECTANCE
C    DELTED      -    (SUBR)    INITIALIZES THE DELTA-EDDINGTON VARIABLE
C    INITI       -    (SUBR)    INITIALIZES RADIOMETRIC VALUES
C=======================================================================
C<PARAMETER>
C    CALLING SEQUENCE:
C        STG (XLAMB, SZA, SUNAZ, TARGAZ, VIS, ALBE)
C    INPUT:
C        XLAMB    (REAL)    WAVELENGTH OF INTEREST IN MICRONS
C        SZA      (REAL)    SOLAR ZENITH ANGLE
C        SUNAZ    (REAL)    SOLAR AZIMUTH ANGLE MEASURED POSITIVE WEST O
C        TARGAZ   (REAL)    TARGET HEADING MEASURED POSITIVE EAST OF NOR
C        VIS      (REAL)    VISIBILITY IN KM
C        ALBE     (REAL)    ALBEDO OF THE SURFACE
C    OUTPUT:
C        STG      (REAL)    FUNCTION VALUE OF SKY TO GROUND RATIO
C=======================================================================
C<HISTORY>
C  UPDATED FALL 1988
C=======================================================================
C<END>
      FUNCTION STG(XLAMB,SZA,SUNAZ,VS,TARGAZ,ALBE,STG2)
      COMMON/ATMOS/PRES(21),Z(21),RHO(21),NLEV,NLAY
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-2-------------------------------
C RE-DIMENSIONED THE FOLLOWING VARIABLES TO SUPPORT PARTLY CLOUDY
C COMPUTATION:
C   I0(20), I1(20)       ===> I0(20,4), I1(20,4)
C   SURF(30), SURF0(30) ===> SURF(30,4), SURF0(30,2)
C   F(20), PTHRD(30)     ===> F(20,4), PTHRD(30,2)
C   ISTAR(20,30)        ===> ISTAR(20,30,2)
C
      COMMON/RADIA/A(20),G(20),GP(20),BETAA(20),BETAR(20),
     1          BETA(20),K(20),P(20),ALPHA(20),BET(20),
     2          TAU(0:20),I0(20,4),I1(20,4),F(20,4),TF(20),FNOT,
     3          NANG,PF(180,20),ANG(180,20),I2(20),TAUP(0:20),
     4          ISTAR(20,30,2),PTHRD(30,2),SING(30),AP(20),PHF(30),
     5          ALBEDO,SURF(30,4),SURF0(30,2),TAUSTR,VIS,CAPTP(20),
     6               B1,B2
```

```
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
       COMMON/GEOM/THETO,PHIO,UNOT,XLAM,NOBS,PHI(30),BTA(30),NLOS,
     1              XOB(30),YOB(30),ZOB(30),THETOB(30),PHIOB(30)
       COMMON/TARGS/NTARG,XTARG(29),YTARG(29),ZTARG(29),THTARG(29)
     1              ,AZTARG(29),RTARG(29),CTARG(29)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-1-----------------------------------
C CHANGED THE CLOUDS COMMON BLOCK NAME TO CLOUD TO MATCH UP WITH
C THE SGR FUNCTION.  THIS CORRECTS AN ERROR IN TARGAC AND ADDS THE
C THREE CLOUD LAYERS TO THE MODEL.
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-2-----------------------------------
C ADDED VARIABLES NUMCLD, MLOOP, CLDBTA(2), CLDG(2), LYRCLD(2), THK, ITY
C TO CLOUD COMMON BLOCK TO MAINTAIN INFORMATION ON MULTIPLE CLOUD LAYERS.
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-3-----------------------------------
C ADDED VARIABLE PSCLD AND ARRAY PCF(2) TO CLOUD COMMON BLOCK TO MAINTAIN
C INFORMATION ON PROBABILITY OF CLOUD-FREE PATH THROUGH EACH CLOUD LAYER
C AND THE PROBABILITY OF THE TARGET IN DIRECT LIGHT.
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-5-----------------------------------
C ADDED VARIABLE ICLDF TO CLOUD COMMON BLOCK TO MAINTAIN INFORMATION ABOUT
C CLOUD SITUATION.
CUV       COMMON /CLOUDS/ZC1,CF1
C      COMMON /CLOUDS/ZC1,ZC2,ZC3,CF1,CF2,CF3
C      COMMON /CLOUD/ZC1,ZC2,ZC3,CF1,CF2,CF3
C      COMMON /CLOUD/NUMCLD, MLOOP, CLDBTA(2),CLDG(2), LYRCLD(2),
C    +            THK1, THK2, THK3, ITY1, ITY2, ITY3,
C    +            ZC1,ZC2,ZC3,CF1,CF2,CF3
       COMMON /CLOUD/ICLDF, NUMCLD, MLOOP, CLDBTA(2),CLDG(2), LYRCLD(2),
     +            THK1, THK2, THK3, ITY1, ITY2, ITY3,
     +            ZC1,ZC2,ZC3,CF1,CF2,CF3,PCF(2),PSCLD
C-HSTX---SCENE SHADOWS-----------------------------------------------------
C
      COMMON/BCONST/DGTRD,LUOUT,LUIN
      COMMON /CONST/PI,PI2,PIRAD,TWOPI,TORRMB,CDEGK
CRF   COMMON/XSCL/ZZZ(999),BBETA(999),RELH(999),NNZPTS,SLNFLG
CRF   REMOVE SLNFLG FROM XSCL COMMON BLOCK FOR UPGRADE TO XSCALE92
CRF   17 APR 92
      COMMON/XSCL/ZZZ(999),BBETA(999),RELH(999),NNZPTS
      REAL I0,I1,I2,ISTAR,K
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-6-----------------------------------
C ADD TEMPORARY VARIABLE TO STORE ATMOSPHERIC LAYER EXTINCTION, WITHOUT
C CLOUDS.
      REAL BETAAI(20)
C-HSTX---SCENE SHADOWS-----------------------------------------------------
C
CRF   LOGICAL SLNFLG
CUV       CHARACTER*1 ANSW
C
C***********************************************************
C
C   VARIABLES
C
C***********************************************************
C
C   PRES  REAL VECTOR OF ATMOSPHERIC PRESSURES IN MB.
C   Z     REAL VECTOR OF ATMOSPHERIC LEVELS IN KM.
C   A     REAL VECTOR OF SINGLE SCATTERING ALBEDOS
C   RHO   REAL VECTOR OF ATMOSPHERIC DENSITY IN GM**M-3
C   G     REAL VECTOR OF ASYMMETRY PARAMETERS
C   GP    REAL VECTOR OF MODIFIED ASYMMETRY PARAMETERS
C   BETAA REAL VECTOR OF AEROSOL EXTINCTION COEFS IN KM**-1
C   BETAR REAL VECTOR OF RAYLEIGH SCATTERING COEFS IN KM**-1
C   BETA  REAL VECTOR OF TOTAL EXTINCTION COEFS IN KM**-1
C   K     REAL VECTOR OF PARAMETER USED IN DELTAED SOLUTION
```

```
C   P     REAL VECTOR OF PARAMETER USED IN DELTAED SOLUTION
C   ALPHA REAL VECTOR OF PARAMETER USED IN DELTAED SOLUTION
C   BET   REAL VECTOR OF PARAMETER USED IN DELTAED SOLUTION
C   TAU   REAL VECTOR OF LAYER OPTICAL THICKNESSES
C   NLEV  INTEGER OF THE NUMBER OF ATMOSPHERIC LAYERS
C   XLAM  REAL OF THE WAVELENGTH USED IN MICRO METERS
C   THETO REAL OF THE SOLAR ZENITH ANGLE IN DEGREES
C   PHIO  REAL OF THE SOLAR AZIMUTH IN DEGREES WEST OF SOUTH
C   UNOT  REAL VALUE OF THE COSINE OF THE SOLAR ZENITH ANGLE
C   PHNOT REAL VALUE OF THE SOLAR AZIMUTH ANGLE IN DEGREES
C   THETOBREAL VALUE OF THE OBSERVATION ZENITH ANGLE IN DEGREES
C   PHIOB REAL VALUE OF THE OBSERVATION AZIMUTH ANGLE IN DEGREES
C   ZOB   REAL VALUE OF THE OBSERVER HEIGHT IN KM.
C   ALBEDO REAL VALUE OF THE SURFACE ALBEDO
C   NANG  INTEGER VALUE OF THE NUMBER OF ANGLES FOR EXACT PHASE FUNCTION
C   PF    MATRIX(NANG,NLAY) OF EXACT PHASE FUNCION INFORMATION
C   NOBS  NUMBER OF OBSERVATION COORDINATES EQUAL TO UNITY IN THIS CASE
C   XOB   X COORDINATE OF THE OBSERVER
C   YOB   Y COORDINATE OF THE OBSERVER
C   ZOB   Z COORDINATE OF THE OBSERVER
C   THETOB ZENITH ANGLE OF THE LINE OF SIGHT
C   PHIOB  AZIMUTH ANGLE OF THE LINE OF SIGHT
C
C**********************************************************************
C
      NLAY = 17
      NLEV = 18
      ALBEDO = ALBE
      XLAM = XLAMB
      THETO = ACOS(SZA) / 3.14159 * 180.0
      PHIO = SUNAZ / 3.14159 * 180.0
      VIS = VS
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-6-----------------------------------
C STORE INITIAL VALUES OF LAYER EXTINCTION, WITHOUT CLOUDS.
      DO 51 I = 1,17
      BETAAI(I) = BETAA(I)
   51 CONTINUE
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
C     *** SET EXTINCTION COEFFICIENTS ACCORDING TO THE FOLLOWING SCHEME
C         1ST -- DEFAULT COEFFICIENTS HAVE ALREADY BEEN ASSIGNED BY
C                CALLING GETDATA IN THE SUBROUTINE SGR
C         2ND -- USE A SCALING HEIGHT ACCORDING TO ELTERMAN FOR THE
C                LAYER BETWEEN 5 KM AND 2 KM
C         3RD -- USE XSCALE TO SET THE EXTINCTION COEFFICIENTS IN THE
C                LOWEST TWO KILOMETERS -- VALUES OF EXTINTION COEFFICIENT
C                HAVE ALREADY BEEN ASSIGNED IN THE BBETA ARRAY FROM THE
C                CALL TO XSCALE IN THE SUBROUTINE SGR
C         4TH -- PRESENCE OF A CLOUD SUPERCEDES ALL OTHER RULES IN
C                THE LAYER ICLOUD
C
      BETAV = 3.912 / VIS
      SCHT = - 5.0 / LOG( 0.005 / BETAV )
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-2----------------------------------
C DEFINE THE NUMBER OF CLOUD SITUATIONS AND LOOP THROUGH.  IF THERE ARE
C CLOUDS, GET CLOUD OPTICAL PARAMETERS.
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-4----------------------------------
C INITIALIZE PROBABILITY THAT TARGET IS IN DIRECT LIGHT (NO CLOUDS).
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-5----------------------------------
C INITIALIZE PROBABILITY OF CLOUD-FREE PATH THROUGH LAYER.  INITIALIZE
C THE CLOUD SITUATION FLAG (NO CLOUDS).
C  MLOOP = 1
C      One iteration of the loop for the conditions:
```

```
C       both layers clear
C       one layer overcast, one layer clear
C       both layers overcast
C  MLOOP = 2
C      Two iterations of the loop for the conditons:
C       one partly cloudy layer, one clear layer
C       one partly cloudy layer, one overcast layer
C           First iteration for:
C           two clear layers
C           one overcast layer, one clear layer
C           Second iteration for:
C           one clear layer, one overcast layer
C           two overcast layers
C  MLOOP = 4
C      Four iterations of the loop for the conditon:
C       two partly cloudy layers
C           First iteration for:
C           two clear layers
C           Second iteration for:
C           high cloud layer only
C           Third iteration for:
C           low cloud layer only
C           Fourth iteration for:
C           both cloud layers
      PSCLD = 100.
      PCF(1) = 1.0
      PCF(2) = 1.0
      IF (NUMCLD.GT.0) THEN
         CALL GETCLD
      ELSE
    MLOOP = 1
    ICLDF = 1
      ENDIF
      DO 200 I = 1, MLOOP
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C     *** SET THE LAYER VALUES FOR THE SINGLE PARTICLE SCATTERING ALBEDO
C         AND THE ASYMMETRY PARAMETER.  THE ASYMMETRY PARMETER WILL BE L
C         ADJUSTED SO THAT LAYERS WITHOUT AEROSOL WILL HAVE PARAMETERS O
C
    DO 30 N =1,NLEV-1
       A(N) = 0.99999
       G(N) = 0.8045
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-6-------------------------------------
C RESET EXTINCTION VALUES FOR THE ATMOSPHERIC LAYERS, NOT INCLUDING CLOUDS.
       BETAA(N) = BETAAI(N)
C-HSTX---SCENE SHADOWS------------------------------------------------------
C
   30    CONTINUE
C
C     *** SCALE THE EXTINCTION COEFFICIENT BETWEEN 2 AND 5 KM
C
    DO 50 N = 1, NLAY
       IF(Z(N+1) .LT. 5.0 .AND. Z(N+1) .GT. 2.0) THEN
          BETAA(N) = BETAV * EXP( -(Z(N) + Z(N+1)) / 2.0 / SCHT )
       ELSE IF(Z(N+1) .LE. 2.0) THEN
          ZHOLD = (Z(N) + Z(N+1)) / 2.0
CJ   CHANGE INTERPOLATION FROM BESSEL TO CUBIC SPLINE
CJ   AUGUST 1992  J.FITZGERREL, P.GILLESPIE
CJ             BETAA(N) = BSL1F(ZHOLD,ZZZ,BBETA,NNZPTS)
          BETAA(N) = CUBINT(ZHOLD,ZZZ,BBETA,NNZPTS)
       ENDIF
C   WRITE(*,*) 'BETAA(',N,') = ',BETAA(N)
   50    CONTINUE
```

```
C
C     *** SET THE ASYMMETRY FACTOR AND EXT. COEF. FOR CLOUD IN THIS LAYER
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-2-----------------------------------
C GETCLD FINDS THE LEVEL OF CLOUD BASE AND THE CLOUD LAYERS; CODE HAS
C BEEN REMOVED FROM STG.  ASYMMETRY FACTOR AND EXT. COEF. FOR CLOUD LAYERS
C DEPEND ON ITERATION.
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-6-----------------------------------
C CALL LAYERS TO FIND WHICH ATMOSPHERIC LAYERS CONTAIN CLOUDS AND COMPUTE
C A WEIGHTED AVERAGE FOR THE ASYMMETRY FACTOR AND EXTINCTION COEFFICIENT.
C THIS ECR OVERRIDES ECR # HSTX 2-2 AT THIS JUNCTION OF THE CODE.
    IF (NUMCLD.NE.0) THEN
       IF (MLOOP.EQ.1) THEN
          CALL LAYERS(ZC1,THK1,ZC2,THK2,CLDBTA,CLDG)
       ENDIF
       IF (MLOOP.EQ.2.AND.NUMCLD.EQ.1.AND.I.EQ.2) THEN
          CALL LAYERS(ZC1,THK1,0.0,0.0,CLDBTA,CLDG)
       ELSEIF (MLOOP.EQ.2.AND.NUMCLD.EQ.2.AND.I.EQ.1) THEN
          IF (CF1.EQ.1.) THEN
            CALL LAYERS(ZC1,THK1,0.0,0.0,CLDBTA,CLDG)
          ELSEIF (CF2.EQ.1.) THEN
            CALL LAYERS(0.0,0.0,ZC2,THK2,CLDBTA,CLDG)
          ENDIF
       ELSEIF (MLOOP.EQ.2.AND.NUMCLD.EQ.2.AND.I.EQ.2) THEN
             CALL LAYERS(ZC1,THK1,ZC2,THK2,CLDBTA,CLDG)
       ENDIF
       IF (MLOOP.EQ.4) THEN
          IF (I.EQ.2) THEN
            CALL LAYERS(ZC1,THK1,0.0,0.0,CLDBTA,CLDG)
          ELSEIF (I.EQ.3) THEN
            CALL LAYERS(0.0,0.0,ZC2,THK2,CLDBTA,CLDG)
          ELSEIF (I.EQ.4) THEN
            CALL LAYERS(ZC1,THK1,ZC2,THK2,CLDBTA,CLDG)
          ENDIF
       ENDIF
    ENDIF
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
CP    WRITE(*,*)'G AND BETAA ARE ',G(1),BETAA(1)
C
C     *** SET THE VIEWING GEOMETRY
C
    NOBS = 1
CP  NTARG = 1
    NTARG = 2
    RTARG(1) = 0.10
    XOB(1) = 0.0
    YOB(1) = 0.0
CP  ZOB(1) = 0.002
    ZOB(1) = 0.0
    XTARG(1) = 0.0
    YTARG(1) = 100.0
CP  ZTARG(1) = 10.0
    ZTARG(1) = 0.0
CP  THTARG(1) = 180.00000
    THTARG(1) = 90.00000
    AZTARG(1) = TARGAZ
CP  THETOB(1) = 84.289407
    THETOB(1) = 90.0
    PHIOB(1) = TARGAZ
    XOB(2) = 0.0
    YOB(2) = 0.0
CP  ZOB(2) = 0.002
    ZOB(2) = 0.0
    XTARG(2) = 0.0
```

```
    YTARG(2) = 100.0
    ZTARG(2) = 0.0
CP  THTARG(2) = 180.0000
    THTARG(2) = 0.0000
    AZTARG(2) = TARGAZ
CP  THETOB(2) = 90.000000
    THETOB(2) = 90.000000
    PHIOB(2) = TARGAZ
CP    RTARG(2) = .33
CP    WRITE(*,*)'WHAT IS THE VALUE OF THE GROUND RTARG?'
CP    READ(*,*)RTARG(2)
    RTARG(2) = ALBEDO
CP    WRITE(*,*)'PHIOB IS ',PHIOB(1),PHIOB(2)
C
C     *** CALL MAIN ROUTINES
C
    CALL INITI
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-2----------------------------------
C ADDED ARGUMENT I TO DELTED AND CONTST; ALSO SZA TO CONTST
    CALL DELTED (I)
CP       WRITE(*,*)'BEFORE CALL TO CONTRAST '
CP       CALL CONTRAST
    CALL CONTST (I, SZA)
 200  CONTINUE
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
CP    WRITE(*,*)'AFTER CALL TO CONTRAST '
CP    WRITE(*,*)'USE THE ACTUAL SURFACE ALBEDO?'
CP    WRITE(*,*)'FIRST THE UPGRADED SURFACE REFLECTANCE,...'
CP    READ(*,100)ANSW
100   FORMAT(A)
CP    IF((ANSW.EQ.'N').OR.(ANSW.EQ.'N'))THEN
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-2----------------------------------
C COMPUTE SKY-TO-GROUND RATIO FOR TARGET IN AND OUT OF CLOUD SHADOW
      IF (MLOOP.EQ.1) THEN
      STG = PTHRD(1,1) / SURFO(2,1)
      ELSE
      STG = PTHRD(1,1) / SURFO(2,1)
      STG2 = PTHRD(1,2) / SURFO(2,2)
      ENDIF
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
CP WRITE(*,*)'THE SKY TO GROUND RATIO IS ',STG
CP WRITE(*,*)'PTHRD AND SURFO IN STG ',PTHRD(1,1),SURFO(1,1)
CP      STG = PTHRD(1) / SURFO(1)
CP WRITE(*,*)'SURF AFTER THE SGR CALC IS ',SURFO(1,1)
CP    ELSE
CP      WRITE(*,*)'OLD SGR CALC, NLAY, TF ',NLAY,TF(NLAY)
CP WRITE(*,*)'ALBEDO & PTHRD ',ALBEDO,PTHRD(1,1)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-2-2----------------------------
C COMMENT OUT PREVIOUS VALUE OF STG2
C  STG2 = PTHRD(1) / (TF(NLAY) * ALBEDO / 3.1416)
C-HSTX---SCENE SHADOWS---------------------------------------------
C
CP WRITE(*,*)'TF AND ALBEDO AT THE SGR CALC ARE ',TF(NLAY),ALBEDO
CP    END IF
      RETURN
      END
C
C                                 <END OF UNIT: STG>
```

ECR # HSTX - 3 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: ELIMIN

Old Date: 2/25/93

File Name: CONTRAST.FOR

New Date: 8/11/93

Implemented By: Dan DeBenedictis

Reason for Revision: An error in TARGAC was discovered: the COMMON block AGAUSS should be named GAUSS. GAUSS is used in the routine DELTED, which fills in the arrays stored in GAUSS.

Description of Revision: The COMMON block AGAUSS is renamed GAUSS.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C
      SUBROUTINE ELIMIN(N,ERR)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-3-1---------------------------
C CHANGED THE AGAUSS COMMON BLOCK NAME TO GAUSS TO MATCH UP WITH
C THE DELTED ROUTINE.  THIS CORRECTS AN ERROR IN TARGAC.
C     COMMON/AGAUSS/ AA(40,40),BB(40),X(40)
      COMMON/GAUSS/ AA(40,40),BB(40),X(40)
C-HSTX---SCENE SHADOWS--------------------------------------------
C
      COMMON/IOUNIT/IOIN,IOOUT,IPHFUN,LOUNIT,NDIRTU,NCLIMT,IRELH,
     1              KSTOR,NPLOTU,STDERR
      COMMON /CONST/PI,PI2,PIRAD,TWOPI,TORRMB,CDEGK
      COMMON /IOFILE/IOFILE
      INTEGER IOIN,IOOUT,IPHFUN,LOUNIT,NDIRTU,NCLIMT
      INTEGER IRELH,KSTOR,NPLOTU,STDERR,IOFILE
      DIMENSION A(40,41),Y(40),ID(40)
      NN = N + 1
      DO 200 I = 1, N
      A(I,NN) = BB(I)
      DO 200 J = 1,N
  200 A(I,J) = AA(I,J)
      K = 1
    1 CONTINUE
      DO 21 I = 1,N
   21   ID(I) = I
    2 CONTINUE
      KK = K + 1
      IS = K
      IT = K
      B = ABS(A(K,K))
      DO 3 I = K, N
        DO 3 J = K, N
          IF(ABS(A(I,J)) - B) 3,3,31
   31     IS = I
          IT = J
          B = ABS(A(I,J))
    3 CONTINUE
      IF(IS - K) 4,4,41
   41 DO 42 J = K, NN
        C = A(IS,J)
        A(IS,J) = A(K,J)
   42 A(K,J) = C
    4 CONTINUE
      IF(IT - K) 5,5,51
   51 IC = ID(K)
      ID(K) = ID(IT)
      ID(IT) = IC
      DO 52 I = 1, N
      C = A(I,IT)
      A(I,IT) = A(I,K)
   52 A(I,K) = C
    5 CONTINUE
      IF(A(K,K))6,102,6
    6 CONTINUE
      DO 7 J = KK,NN
      A(K,J) = A(K,J)/A(K,K)
      DO 7 I = KK,N
      W = A(I,K)*A(K,J)
      A(I,J) = A(I,J) - W
      IF(ABS(A(I,J)) - .0001 * ABS(W))71,7,7
   71 A(I,J) = 0.
    7 CONTINUE
      K = KK
      IF(K - N)2,81,102
```

```
   81 IF(A(N,N))8,102,8
    8 CONTINUE
      Y(N) = A(N,NN)/A(N,N)
      NM = N - 1
      DO 9 I = 1,NM
      K = N -I
      KK = K + 1
      Y(K) = A(K,NN)
      DO 9 J = KK,N
      Y(K) = Y(K) -A(K,J) * Y(J)
    9 CONTINUE
      DO 10 I = 1, N
      DO 10 J = 1,N
      IF(ID(J)-I)10,101,10
  101 X(I) = Y(J)
   10 CONTINUE
      RETURN
  102 IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
   WRITE(NDIRTU,1000)
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
   WRITE(IOOUT,1000)
      ENDIF
      RETURN
 1000 FORMAT('  ')
C     THE COMMENT BELOW HAS TO DO WITH THE DELTA EDDINGTON SOLN
 1001 FORMAT(' NO UNIQUE SOLUTION')
      END
```

ECR # HSTX - 4 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: ILUMA

Old Date: 3/23/93

File Name: ILUMA.FOR

New Date: 8/11/93

Implemented By: Dan DeBenedictis

Reason for Revision: Cloud fraction (FR1, FR2, & FR3) and cloud type (ILR1, ILR2, & ILR3) for each layer are now user inputs.

Description of Revision: Removed all initialization and setting of the variables FR1, FR2, FR3, ILR1, ILR2, and ILR3. Also ID2 is set to 1 for clear or 2 for cloudy. This eliminates the algorithm to set ID2 to a value from 1 to 8 based on cloud fraction and ceiling height. ILR1, ILR2, and ILR3 are input with the Thermal model cloud index. ILUMA converts these numbers to the ILUMA cloud index.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 4 - 2

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: ILUMA

Old Date: 8/11/93

File Name: ILUMA.FOR

New Date: 10/18/93

Implemented By: Dan DeBenedictis

Reason for Revision: Remove references to and use of the variable SIGWX. All cloud information (type, fraction, and height) and fog are input elsewhere.

Description of Revision: Commented out any code that referenced SIGWX.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C***********************************************************************
      SUBROUTINE ILUMA ( IPRFLG, IERR )
C***********************************************************************
C       12-FEB-1990 18:25 (DPS)
C ----------------------------------------------------------------------
C      THIS SUBROUTINE READS ALL INPUT DATA EXCEPT FLAG IPRFLG FROM
C      THE STANDARD EOSAEL INPUT UNIT IOIN. THE CALLING PROGRAM SHOULD
C      SET IPRFLG = 0 TO SUPPRESS NORMAL OUTPUTS TO LUN IOOUT, OR TO
C      NON-ZERO VALUE TO ACTIVATE NORMAL OUTPUT LISTINGS
C ----------------------------------------------------------------------
C
C    THIS PROGRAM COMPUTES TOTAL SOLAR/LUNAR ILLUMINATION (WATT/M**2)
C    RECEIVED AT THE GROUND AS A FUNCTION OF GEOGRAPHICAL LOCATION,
C    DATE, GREENWICH MEAN TIME GMT), AND METEOROLOGICAL CONDITIONS.
C    THE ALBEDO OPTION ALLOWS ONE TO ACCOUNT FOR REALISTIC ALBEDO
C    CONDITIONS OF THE GROUND SURFACE. IT UTILIZES A  THREE LAYER MODEL
C    ATMOSPHERE CHARACTERIZED BY THE STATE OF CLOUDINESS IN EACH LAYER
C
C ----------------------------------------------------------------------
C      THIS CODE IS A COMBINATION OF SEVERAL EARLIER CODES:
C
C      RALPH SHAPIRO: "SOLAR RADIATIVE FLUX CALCULATIONS FROM STANDARD
C      SURFACE  METEOROLOGICAL OBSERVATIONS," AIR FORCE GEOPHYSICS
C      LABORATORY REPORT AFGL-TR-82-0039, MARCH 1, 1982.
C
C      L.D.DUNCAN/D.P.SAUTER "NATURAL ILLUMINATION UNDER REALISTIC
C      WEATHER CONDITIONS", ATMOSPHERIC SCIENCES LABORATORY REPORT
C      ASL-0212, JAN. 1987.
C
C      REPORT PHL 1982-13 (THE NETHERLANDS) BY IR. A.C. VAN BOCHOVE,
C      CONTAINS THE ALGORTIHMS USED FOR FINDING THE POSITIONS OF THE
C      SUN AND MOON, AND THE OVERALL LUNAR/SOLAR ILLUMINATION CONSTANTS.
C
C      THIS VERSION ADAPTED BY A. MILLER (NMSU) FROM L.D.DUNCAN'S (ASL)
C      PROGRAM 'ILLUM.PRO' TO CONFORM (MORE OR LESS) TO D.P.SAUTER'S
C      (ASL) TURBO-PASCAL CODES. (APRIL 1987)  UPDATED BY D. SAUTER
C      IN FEBRUARY, 1990 TO INCORPORATE SEVERAL PROGRAM REVISIONS.
C ----------------------------------------------------------------------
C
C      THIS DRIVER  ACCEPTS INPUTS IN THE EOSAEL CARD-ORDER , ALTHOUGH
C      NOT ALL THE CARDS WHICH ARE NOW ALLOWED ARE ACTUALLY USED.
C
C
C      CONVERSION FROM OLD FORM TO ABOVE WILL BE VIA:
C
C      IH = ILR1 (HIGH CLOUDS, IH = 1,2,3)
C      IM = ILR2 + 3 (MIDDLE CLOUDS, IM= 4,5)
C      IL = ILR3 + 5 (LOW CLOUDS, IL = 6,7,8,9,)
C
C ----------------------------------------------------------------------
C
C      INPUT:
C          CARDS MAY BE INSERTED IN ANY ORDER WITH THE EXCEPTION OF
C      SENTINEL CARDS ('GO' OR 'DONE '- WHICH SIGNIFY THAT EXECUTION IS T
C      BEGIN).  ALL  INPUT DATA ARE ENTERED UNDER FORMAT (A4,6X,7E10.4).
C
C                                  ****
C
C      NOTE THAT ALL DATA MUST BE ENTERED WITH PROPERLY PLACED DECIMAL
C      POINTS EVEN IF THEY SEEM AS THOUGH THEY SHOULD BE INTEGERS.
C               (EVEN THE TIME ON 24-HR TYPE CLOCK)
C
C                                  ****
C
C MNEMONIC             INPUT VARIABLE DESCRIPTION
```

```
C ----------------------------------------------------------------------
C
C   DATE    FMONTH, DAY, YEAR, GTIME
C           FMONTH IS MONTH (1. - 12.)
C           DAY IS DAY OF MONTH (1. - 31.)
C           YEAR IS A.D. YEAR (1977.-1999. FOR MOON CASES)
C           GTIME IS GREENWICH MEAN TIME IN FORM HHMM.  - WHERE THE
C                                          DECIMAL POINTS ARE MANDATORY
C           ***********************************************************
C           ** THERE ARE NO DEFAULTS FOR THESE EXCEPT 1200. FOR TIME **
C           **   PROGRAM WILL ABORT ON ILLEGAL MONTH,DAY OR YEAR     **
C           ***********************************************************
C
C   GEOS    PARAMETERS DESCRIBING THE LOCATION AND TIME OF
C           THE OBSERVATION POINT
C               SLAT - LOCAL LATITUDE
C               SLON - LOCAL LONGITUDE (+EAST, -WEST)
C               (DEFAULT VALUES ARE 0.0, AND 0.0)
C
C   CLDS    STATE OF CLOUDINESS IN EACH OF 3 LAYERS OF THE ATMOSPHERE
C              ILR1=1./2./3.        CLEAR/THIN CI-CS/THICK CI-CS
C              ILR2=1./2.           CLEAR/AS-AC
C              ILR3=1./2./3./4.     CLEAR/FOG-SMOKE/SC-ST/CU-CB
C           ** REMEMBER THAT DECIMAL POINTS ARE NECESSARY **
C           (DEFAULT VALUES FOR THIS CARD ARE: 1., 1., 1.)
C
C   ALBD    RG  - SURFACE ALBEDO
C           (DEFAULT VALUE OF RG IS 0.2)
C
C   CLFR    FR1, FR2, FR2  CLOUD FRACTIONS (0.0 - 1.0) IN HIGH, MIDDLE
C           AND LOW LEVELS RESPECTIVELY.
C           (DEFAULT VALUES ARE 0.0 FOR ALL THREE.)
C
C   WEAX    SIGWX, OBSURF, CEILHT, PRTYP, FRC
C
C           STATE OF WEATHER AND SURFACE CONDITIONS:
C           (USED IF INCOMING DATA IS FOR SURFACE BASED MET.DATA.
C           IF THIS CARD IS PRESENT, DATA ON THE 'CLDS', 'CLFR' AND
C           'ALBD' CARDS WILL BE IGNORED.)
C
C          SIGWX - SIGNIFICANT WEATHER ID, FROM LIST:
C
C          1 - SKY COVER < 50 %                 2 - SKY COVER = 50 %
C          3 - SKY COVER > 50 %                 4 - BLOWING SNOW OR SAN/
C          5 - FOG/HAZE (NON-OBSCURING)         6 - DRIZZLE
C          7 - RAIN                             8 - SNOW/RAIN (NO SHOWER)
C          9 - RAIN/SNOW/HAIL SHOWER           10 - THUNDERSTORM
C
C          OBSURF IS THE OBSERVED STATE OF THE GROUND FROM THE FOLLOWING
C          CHOICES:
C
C           1 - DRY        2 - MOIST        3 - WET        4 - FROZEN
C           5 - ICE        6 - SNOW < 0.5   7 - 0.5 < SNOW < ALL'
C           8 - SNOW (ALL)
C           9 - 0.5 < (LOOSE DRY SNOW/DUST/SAND) < ALL
C          10 - ALL = (LOOSE DRY SNOW/DUST/SAND)
C
C          CEILHT IS THE OBSERVED CEILING HEIGHT IN KM
C
C          PRTYP IS PRECIPITATION TYPE, FROM THE LIST:
C
C          1 - NONE            2 - DRIZZLE            3 - RAIN
C          4 - SNOW            5 - HAIL
C
C          FRC IS THE FRACTION OF SKY COVERED BY CLOUDS
```

```
C
C          (DEFAULTS ARE 1.0, 1.0, 9999.9, 1.0 AND 0.0)
C
C   GO     IS INSTRUCTION TO BEGIN EXECUTION ( WHICH LOOPS BACK FOR
C          ADDITIONAL DATA AND 'GO' CARDS UNTIL THE 'DONE' CARD (SEE
C          BELOW) IS ENCOUNTERED. THE 'GO' CARD SEPARATES DISCRETE SETS
C          OF PARAMETERS - SUCH AS DIFFERENT TIMES OF DAY, ETC.
C
C   DONE   THIS CARD INFORMS THE PROGRAM THAT NO MORE SETS OF DATA ARE
C          TO BE EXPECTED. WHEN THE 'DONE' CARD IS DETECTED, A FLAG IS
C          SET TO BYPASS THE INSTRUCTIONS TO LOOP BACK TO THE BEGINNING
C          FOR ADDITIONAL DATA UPON COMPLETION OF THE COMPUTATIONS WHICH
C          USE THE DATA WHICH WERE IMMEDIATELY AHEAD OF THE 'DONE' CARD.
C
C   ***>  IF ONLY ONE 'PASS' IS TO BE DONE, USE ONLY THE 'DONE' CARD AND
C         DO NOT USE A 'GO' CARD.
C
C   ***>  SAMPLE CARD SETUP FOR TWO SETS OF DATA (OR TWO PASSES) MIGHT
C         CONTAIN THE FOLLOWING CARDS (FROM WHICH NUMERICAL DATA HAVE
C         BEEN OMITTED):
C
C         DATE
C         GEOS
C         ALBD
C         WEAX
C         GO
C         DATE (DIFFERENT FROM THE FIRST ONE) - SEE NEXT NOTE ALSO
C         DONE
C
C  ***>   ANY PARAMETER WHICH IS NOT REDEFINED IN DATA SETS WHICH ARE
C         SUBSEQUENT TO THE FIRST ONE (THE ONE BEFORE THE FIRST 'GO'
C         CARD) NORMALLY RETAIN THEIR MOST RECENT VALUE. THIS MAY LEAD
C         TO INCORRECT BEHAVIOR IF 'SINGLE-LAYER' AND 'THREE-LAYER'
C         FORMS OF INPUT DATA ARE USED WITHIN THE SAME DATA FILE (DECK)
C         SINCE THE USER MAY NOT KNOW WHAT VALUES HAVE BEEN ASSIGNED BY
C         THE SAUTER-DUNCAN ALGORITHM TO SOME PARAMETERS.
C
C  ***>   NOTE ALSO THAT THE SAUTER-DUNCAN PROCEDURES INCLUDE A TERM
C         FOR GALACTIC LIGHT. THE NORMAL 'THREE-LAYER' PROCEDURE
C         (SHAPIRO) DOES NOT INCLUDE THAT TERM, SO OSTENSIBLY
C         IDENTICAL 'SINGLE-LAYER' AND 'THREE-LAYER' DATA SETS
C         MAY NOT IN FACT YIELD THE SAME FINAL RESULTS FOR THE
C         THE ILLUMINANCES.
C
C ----------------------------------------------------------------------
C
C     OUTPUTS:
C
C     ELUMII = SOLAR + LUNAR + GALACTIC ILLUMINATION IN W/M**2 USING 93
C              LUMEN PER WATT CONVERSION FACTOR
C     SUNLIT = SOLAR HORIZONTAL ILLUMINANCE IN LUMERN/SQ-METER
C     MOOLIT = LUNAR HORIZONTAL ILLUMINANCE IN LUMERN/SQ-METER
C     ALTS   = SOLAR ELEVATION IN DEGREES (ABOVE LOCAL HORIZONTAL)
C     AZIS   = SOLAR AZIMUTH IN DEGREES CLOCKWISE FROM NORTH
C     ALTM   = LUNAR ELEVATION ANGLE IN DEGREES
C     AZIM   = LUNAR AZIMUTH ANGLE IN DEGREES
C     DPHASE = PHASE OF MOON (-180. = NEW MOON,+ 180.=  DARK)
C
C  ---------- ADDITIONAL OUTPUTS WHICH ARE NOT PRINTED -------------
C
C     TCLSUN = FRACTIONAL TRANSMITTANCE OF SUNLIGHT FOR CLEAR SKY
C     TCLLUN = FRACTIONAL SKY TRANSMITTANCE OF MOON LIGHT
C
C THE FOLLOWING FOUR QUANTITIES ARE VERY APPROXIMATE AND ARE OBTAINED
C USING A "SEAT OF THE PANTS" ONE LAYER ATMOSPHERE DELTA-EDDINGTON
```

```
C METHOD WITH SAME TRANSMITTANCE AS THE THREE LAYER COMPOSITE DERIVED
C USGIN THE SHAPIRO EQUATIONS TOGETHER WITH:
C             SS ALBEDO (CLEAR) = 0.98, ASSYM G = 0.0
C             SS ALBEDO (CLDY)  = 0.98, ASSYM G = .85
C             (SEE SUBROUTINE DIRDIF)
C
C     RCLSUN = DIRECT/DIFFUSE FLUX RATIO FOR CLEAR SKY (SUN ANGLES)
C     RCDSUN = DIRECT/DIFFUSE FLUX RATIO FOR CLOUDY SKY (SUN)
C     RCLLUN = CLEAR RATIO FOR CASE OF MOON POSITION ANGLES
C     RCDLUN = CLDY RATIO FOR MOON CASE
C***********************************************************************
C     EOSAEL STANDARD COMMON BLOCKS AND DEFINITIONS
C
      COMMON /IOFILE/IOFILE
      COMMON /CONST/ PI, PI2, PIRAD, TWOPI, TORRMB, CDEGK
      COMMON /CLYMAT/ TEMP, PRESS, RH, AH, DP, VIS, CLDAMT, CLDHYT,
     +                FOGPRB, WNDVEL, WNDDIR, IPASCT
C
      CHARACTER FMTS00*234, FMTS01*120, FMTS02*122, FMTS03*73,
     +          FMTS04*122, FMTS05*111, FMTS06*122, FMTS10*230,
     +          FMTS11*15, FMTS12*15, FMTS13*152
C
      COMMON /FMTSBD/ FMTS00, FMTS01, FMTS02, FMTS03, FMTS04, FMTS05,
     +                FMTS06, FMTS10, FMTS11, FMTS12, FMTS13
C
      INTEGER IOIN, IOOUT, IPHFUN, LOUNIT, NDIRTU, NCLIMT, IRELH,
     +        KSTOR, NPLOTU, STDERR
C
      COMMON /IOUNIT/ IOIN, IOOUT, IPHFUN, LOUNIT, NDIRTU, NCLIMT,
     +                IRELH, KSTOR, NPLOTU, STDERR
      COMMON /GEOMET/ PTS(15), IGEOSW
      COMMON /ILUMCM/ ALTS, AZIS, ALTM, AZIM, DPHASE, ELUMI, SUNLIT,
     +                MOOLIT, TCLSUN, TCLLUN, RCLSUN, RCDSUN, RCLLUN,
     +                RCDLUN
C***REV 2/91
      COMMON /ILDATA/ FMONTH, DAY, YEAR, ST, SLAT, SLON, ILR1, ILR2,
     +                ILR3, RG, FR1, FR2, FR3, SIGWX, OBSURF, CEILHT,
     +                PRTYP, FRC, ITARG
C
      INTEGER DATE, TIME, IOFILE
      REAL MOOLIT
C
C
      DIMENSION DAT(7)
      CHARACTER CARD*80, ALPHA1*4, ALPHA2*4, RNAMES(8)*4
      CHARACTER*5 IH1(3), IH2(2), IH3(4)
      CHARACTER REVNO*16, REVDAT*9
      CHARACTER*32 SCCS
      LOGICAL WARNNG
      SAVE WARNNG
      EXTERNAL ILUMBD
C
      DATA WARNNG / .TRUE. /
      DATA RNAMES / 'DATE', 'GEOS', 'CLDS', 'ALBD', 'CLFR', 'WEAX',
     +              'GO  ', 'DONE' /
      DATA IH1 / 'CLEAR', 'CI-CS', 'CI-CS' /
      DATA IH2 / 'CLEAR', 'AS-AC' /
      DATA IH3 / 'CLEAR', 'F-K  ', 'SC-ST', 'CU-CB' /

      DATA RAD / 57.29578 /
      DATA SCCS / '@(#) iluma.f 2.2 02/27/90' /
      DATA REVNO / 'EOSAEL87 REV 2.2' /
      DATA REVDAT / '02/27/90' /
C
   30 FORMAT(1H0,///' *** UNRECOGNIZABLE INPUT DATA CARD DETECTED IN ROU
```

```
     1TINE ILUMA *** '/
     C10X,'FIRST CONTENTS WERE : ',1X,2A4//)
   40 FORMAT(1H1)
   50 FORMAT(5X,25(1H*),' INPUTS  ',25(1H*)/
     2   /5X,'FOR THE DATE OF ',I2,1H/,I2,1H/,I2)
   60 FORMAT (5X,'DAYTIME CONDITIONS'//74(1H')//)
   70 FORMAT (5X,'NIGHTTIME CONDITIONS'//74(1H')//)
   80 FORMAT (5X,'GREENWICH TIME            ',I2,1X,1HH,I4,1X,3HMIN,
     1   /5X,'LOCAL LATITUDE      =  ',F7.2,' DEG ',
     2   /5X,'LOCAL LONGITUDE     =  ',F7.2,' DEG')
   90 FORMAT (5X,'PHASE ANGLE          =  ',F7.2,' DEG',
     1  / 5X,    'MOON''S ZENITH ANGLE =  ',F7.2,'DEG')
  100 FORMAT (5X,'FIRST  LAYER: FRACTIONAL COVER: ',F5.2,', TYPE: ',A5)
  110 FORMAT (57X,'- THIN CLOUD')
  120 FORMAT (57X,'- THICK CLOUD')
  130 FORMAT (5X,'SECOND LAYER: FRACTIONAL COVER: ',F5.2,', TYPE: ',A5)
  140 FORMAT (5X,'THIRD  LAYER: FRACTIONAL COVER: ',F5.2,', TYPE: ',A5)
  150 FORMAT (5X,'SURFACE ALBEDO ',F6.3)
  160 FORMAT (////5X,25(1H*),' OUTPUTS ',25(1H*)//
     C       5X,'SOLAR ELEVATION ANGLE = ',F7.2,' DEGREES.'/
     C       5X,'SOLAR AZIMUTH  ANGLE  = ',F7.2,' DEGREES.'/
     C       5X,'LUNAR ELEVATION ANGLE = ',F7.2,' DEGREES.'/
     C       5X,'LUNAR AZIMUTH  ANGLE  = ',F7.2,' DEGREES.'/
     C       5X,'LUNAR PHASE  ANGLE    = ',F7.2,' DEGREES.'//
     C       5X,'SOLAR ILLUMINANCE = ',F11.2,' LUMENS/SQ-METER.'/
     C       5X,'LUNAR ILLUMINANCE = ',F11.4,' LUMENS/SQ-METER.'/
     C       5X,'NET  ILLUMINANCE  = ',F11.4,' LUMENS/SQ-METER.'//
     C       5X,'INTEGRATED TOTAL FLUX = ',F9.2,' WATTS/SQ-METER.')
C
  170 FORMAT (/' ILUMA: MONTH, MM =',I12,
     1  /' MM SHOULD BE GREATER THAN 0 AND SMALLER THAN 13')
  180 FORMAT (/' ILUMA: DAY, ID =',I12,
     1  /' ID SHOULD BE GREATER THAN 0 AND SMALLER THAN 32')
  190 FORMAT(' THIS IS A SPARE FORMAT FOR FUTURE USE IF NEEDED')
C 200 FORMAT (/' ILUMA: LUNAR ZENITH ANGLE, ZN =',E12.4,
C    1  /' ZN SHOULD BE SMALLER THAN 85 DEG')
  210 FORMAT(/' ILUMA DIAGNOSTIC: FATAL ERROR NO. ',I3,' OCCURED IN SUBR
     1OUTINE ILLUM.'/)
  220 FORMAT(//' ILUMA: PREMATURE END OF INPUT DATA FILE ENCOUNTERED ON
     1LUN ',I3//' PROBABLE CAUSE: MISSING ''DONE'' CARD'//)
C
C
      IF (WARNNG) THEN
C   PRINT MAIN HEADER
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        WRITE(IOOUT,FMTS10) ' I L U M A  '
     1                       ,'                             '
     2                       ,'    ILLUMINATION FROM SURFACE  '
     3                       ,'  METEOROLOGICAL OBSERVATIONS '
     4                       ,REVNO,REVDAT
        WARNNG = .FALSE.
      ENDIF
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU,FMTS10) ' I L U M A  '
     1                       ,'                             '
     2                       ,'    ILLUMINATION FROM SURFACE  '
     3                       ,'  METEOROLOGICAL OBSERVATIONS '
     4                       ,REVNO,REVDAT
        WARNNG = .FALSE.
      ENDIF
      ENDIF
C
C     INITIALIZE OR RESET SOME PARAMETERS
C
      DEFALT = 1.E-30
```

```
      MAXNAM = 8
      IPASS = 0
      IEND = 0
C
  230 CONTINUE
      IPASS = IPASS+1
      IDWX = 0
      ID2 = 0
      IERR = 0
C
C***REV 2/91
      IF (ITARG .EQ. 1 .OR. ITARG .EQ. 2) GOTO 325
C********
  240 CONTINUE
C
C   READ IN THE DATA
C
      READ(IOIN,'(A)',END=440) CARD
      READ(CARD,FMTS11,ERR=242) ALPHA1,ALPHA2,(DAT(L),L = 1,7)
      GOTO 243
C
242   IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      WRITE(IOOUT,'(A)') ' A NON EOSAEL FORMAT INPUT CARD ENCOUNTERED'
      WRITE(IOOUT,'(A)') CARD
      ENDIF
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
      WRITE(NDIRTU,'(A)') ' A NON EOSAEL FORMAT INPUT CARD ENCOUNTERED'
      WRITE(NDIRTU,'(A)') CARD
      ENDIF
      STOP
  243 CONTINUE
C
C
C     MAKE SURE THAT THE IDENTIFIER CHARACTERS ARE ALL UPPER CASE
C
      CALL UCA (ALPHA1)
C
C   CHECK FOR CARD TYPES
C
      DO 250 KK = 1, MAXNAM
       IF (ALPHA1 .NE. RNAMES(KK)) GOTO 250
       GOTO ( 270, 280, 290, 300, 310, 320, 340, 330 ),KK
  250 CONTINUE
C
  260 CONTINUE
C   UNKNOWN CARD TYPE
C
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      WRITE(IOOUT, 30)ALPHA1,ALPHA2
      ENDIF
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
      WRITE(NDIRTU, 30)ALPHA1,ALPHA2
      ENDIF
      IERR = 1
      GOTO 450
C
C     DATE CARD
C
  270 CONTINUE
      FMONTH = DAT(1)
      DAY = DAT(2)
      YEAR = DAT(3)
      MM = NINT(FMONTH)
      ID = NINT(DAY)
      IY = NINT(YEAR-1900.0)
```

```
      DATE = 10000*IY+100*MM+ID
      ST = DAT(4)
C
C     CONVERT TO INTERNAL FORM   =   HH.MM
C
      NHRS = AINT(ST/100.0)
      NMIN = AINT(ST-100*NHRS)
      TIME = NHRS*100+NMIN
      ST = NHRS+FLOAT(NMIN)/100.0
      GOTO 240
C
C.....OBSERVATION POINT PARAMETERS CARD.....
C
  280 SLAT = DAT(1)
      SLON = DAT(2)
      GOTO 240
C
C.....STATE OF CLOUDINESS CARD.....
C
  290 ILR1 = IFIX(DAT(1))
      ILR2 = IFIX(DAT(2))
      ILR3 = IFIX(DAT(3))
      GOTO 240
C
C.....SURFACE ALBEDO CARD.....
C
  300 RG = DAT(1)
      GOTO 240
C
C.....CLOUD FRACTIONS CARD
C
  310 CONTINUE
      FR1 = DAT(1)
      FR2 = DAT(2)
      FR3 = DAT(3)
      GOTO 240
C
C     SURFACE MET DATA CARD
C
  320 CONTINUE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-4-2--------------------------
C REMOVE SIGWX; THIS VARIABLE IS NO LONGER USED.
C      SIGWX = DAT(1)
C-HSTX---SCENE SHADOWS-------------------------------------------
C
      OBSURF = DAT(2)
      CEILHT = DAT(3)
      PRTYP = DAT(4)
      FRC = DAT(5)
      IDWX = 1
C
C     RESET ANY DATA LEFT OVER FROM 3-LAYER INPUT MODE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-4-1--------------------------
C REMOVE INITIALIZATION OF FR1, FR2, AND FR3.
C-HSTX---SCENE SHADOWS-------------------------------------------
C
      GOTO 240
C
C***REV 2/91
  325 MM = NINT(FMONTH)
      ID = NINT(DAY)
      IY = NINT(YEAR-1900.)
      DATE = 10000*IY+100*MM+ID
```

```
      NHRS = AINT(ST/100.0)
      NMIN = AINT(ST-100*NHRS)
      TIME = NHRS*100+NMIN
      ST = NHRS+FLOAT(NMIN)/100.0
      IF (ITARG .EQ. 2) THEN
       IDWX = 1
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-4-1---------------------------
C REMOVE INITIALIZATION OF FR1, FR2, AND FR3.
C-HSTX---SCENE SHADOWS--------------------------------------------
C
      ELSE
       IDWX = 0
      ENDIF
C*****
C
C.....START EXECUTION.....
C
  330 CONTINUE
C
C     DONE CARD COMES HERE
C
      IEND = 1
  340 CONTINUE
C
C   SET DEFAULT VALUES AND CHECK INPUT CONSISTENCY
C
C     SOME OF THESE MAY NEED TO BE CHANGED TO REFLECT USE OF DIFFERENT
C     SUN / MOON LOCATING ROUTINES
C
      IF (MM .LT. 1 .OR. MM .GT. 12) GOTO 390

      IF (ID .LT. 1 .OR. ID .GT. 31) GOTO 400

      IF (SLAT .LT. DEFALT) SLAT = 0.0
      IF (SLON .LT. -180.0 .OR. SLON .GT. 180.0) SLON = 0.0
      IF (ST .LT. 0.0 .OR. ST .GT. 24.0) ST = 12.0
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-4-1---------------------------
C REMOVE CONSISTENCY CHECK OF ILR1, ILR2, AND ILR3.
C-HSTX---SCENE SHADOWS--------------------------------------------
C
      IF (RG .LT. 0.0 .OR. RG .GT. 1.0) RG = 0.0
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-4-1---------------------------
C REMOVE CONSISTENCY CHECK OF FR1, FR2, AND FR3.
C-HSTX---SCENE SHADOWS--------------------------------------------
C
C     IF ANY WEAX DATA ARE OUT OF ALLOWED RANGE:
C
      IF (IDWX .NE. 0) THEN
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-4-2---------------------------------
C SIGWX NO LONGER USED; CLOUD INFORMATION IS INPUT IN SGR.
C      IF (SIGWX .LT. 1.0 .OR. SIGWX .GT. 10.0) SIGWX = 1.0
C-HSTX---SCENE SHADOWS--------------------------------------------
C
       IF (OBSURF .LT. 1.0 .OR. OBSURF .GT. 10.0) OBSURF = 1.0
       IF (CEILHT .LT. 0.0) CEILHT = 9999.9
       IF (PRTYP .LT. 1.0 .OR. PRTYP .GT. 5.0) PRTYP = 1.0
       IF (FRC .LT. 0.0 .OR. FRC .GT. 1.0) FRC = 0.0
      ENDIF
C
C     OTHER INITIALIZATIONS
C     GLOWRA IS USED ONLY FOR SAUTER-DUNCAN NIGHT-SKY ILLUMINATION
```

```
C     ADJUSTMENT
C
C     SKIP THE NEXT STEPS IS 1-LAYER INPUT DATA FLAG IS NOT SET BY CALLE
C
      IF (IDWX .EQ. 0) GOTO 350
C
      GLOWRA  =  1.0
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-4-2---------------------------
C IDWX AND SIGWX NO LONGER USED; ILR3 FOR FOG IS SET IN SGR.
C      IDWX = SIGWX
C-HSTX---SCENE SHADOWS--------------------------------------------
C
      IDSURF = OBSURF
      IDPR = PRTYP
C
C     SET GROUND ALBEDO BASED ON SURFACE CONDITIONS
C
      IF (IDSURF .GE. 1 .AND. IDSURF .LE. 4) RG = 0.25
      IF (IDSURF .EQ. 5) RG = 0.6

      IF (IDSURF .EQ. 6) RG = 0.43

      IF (IDSURF .GE. 7 .AND. IDSURF .LE. 10) RG = 0.6
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-4-1-------------------------------
C REMOVE LOGIC TO DEFINE FR1, FR2, FR3, ILR1, ILR2, AND ILR3.  THEY
C ARE NOW USER INPUTS.  ILR1, ILR2, AND IRL3 ARE ENTERED WITH THE
C CLOUD INDICES USED BY THE THERMAL MODEL; THEY MUST BE CHANGED TO
C MATCH WHAT ILUMA IS ACCUSTOMED TO.  ALSO, CHANGE THE LOGIC TO DEFINE
C ID2 FROM VALUES OF 1 TO 8 TO VALUES OF 1 FOR CLEAR AND 2 FOR CLOUDY.
      ID2 = 1
      IF (FR1.GE.0.1.OR.FR2.GE.0.1.OR.FR3.GE.0.1) ID2 = 2
      IF (IDPR .GT. 1 .AND. IDPR .LT. 6) ID2 = 2
C
      IF (ILR1.EQ.0) THEN
      ILR1 = 1
      ELSEIF (ILR1.EQ.1) THEN
      ILR1 = 2
      ELSEIF (ILR1.EQ.2) THEN
      ILR1 = 3
      ENDIF
C
      IF (ILR2.EQ.0) THEN
      ILR2 = 1
      ELSEIF (ILR2.EQ.3) THEN
      ILR2 = 2
      ENDIF
C
      IF (ILR3.EQ.0) THEN
      ILR3 = 1
      ELSEIF (ILR3.EQ.4) THEN
      ILR3 = 3
      ELSEIF (ILR3.EQ.5) THEN
      ILR3 = 4
      ENDIF
C-HSTX---SCENE SHADOWS--------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-4-2---------------------------
C IDWX NO LONGER USED; ILR3 FOR FOG IS SET IN SGR.
C       IF (FR3 .LE. 0.1 .AND. IDWX .EQ. 5) ILR3 = 2
C-HSTX---SCENE SHADOWS--------------------------------------------
C
  350 CONTINUE
C
```

```
      IF (IDWX .EQ. 0) GLOWRA  =  0.0
C
C     TRANSLATONS
C
      IH = ILR1
      IM = ILR2+3
      IL = ILR3+5
      MM = NINT(FMONTH)
      NHRG = NHRS
C
C     IF NHRG (GMT HOUR) IS NEGATIVE, THEN THE GREENWICH DATE IS REALLY
C     THE PREVIOUS CALENDAR DAY
C
      IF (NHRG .LT. 0) THEN
       NHRG = NHRG+24
       DATE = DATE-1
      ENDIF
C
      IF (NHRG .GT. 24) THEN
       NHRG = NHRG-24
       DATE = DATE+1
      ENDIF
C RSET THE TIME TO GMT CLOCK
      TIME = NHRG*100+NMIN
C
C   PRINT THE INPUT DATA
C
      IF (IPRFLG .NE. 0) THEN
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        IF (IPASS .NE. 1) WRITE(IOOUT, 40)
        WRITE(IOOUT, 50)MM,ID,IY
        WRITE(IOOUT, 80)NHRG,NMIN,SLAT,SLON
        WRITE(IOOUT, 100)FR1,IH1(ILR1)
        IF (ILR1 .EQ. 2) WRITE(IOOUT, 110)
        IF (ILR1 .EQ. 3) WRITE(IOOUT, 120)
        WRITE(IOOUT, 130)FR2,IH2(ILR2)
        WRITE(IOOUT, 140)FR3,IH3(ILR3)
        WRITE(IOOUT, 150)RG
      ENDIF
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        IF (IPASS .NE. 1) WRITE(NDIRTU, 40)
        WRITE(NDIRTU, 50)MM,ID,IY
        WRITE(NDIRTU, 80)NHRG,NMIN,SLAT,SLON
        WRITE(NDIRTU, 100)FR1,IH1(ILR1)
        IF (ILR1 .EQ. 2) WRITE(NDIRTU, 110)
        IF (ILR1 .EQ. 3) WRITE(NDIRTU, 120)
        WRITE(NDIRTU, 130)FR2,IH2(ILR2)
        WRITE(NDIRTU, 140)FR3,IH3(ILR3)
        WRITE(NDIRTU, 150)RG
      ENDIF
      ENDIF
C
C   COMPUTE ILLUMINATION
C
C   CALL ILLUM  ROUTINE TO GET SOLAR/LUNAR POSITIONS AND RAW ILLUMIN.
C
      CALL ILLUM ( DATE, TIME, SLON, SLAT, AZISUN, ALTSUN, AZIMOO,
     +             ALTMOO, SUNLIT, MOOLIT, DPHASE, IERR )
C
C     TEST FOR ERROR IN ILLUM
C
      IF (IERR .NE. 0) GOTO 430
C
C     GET SOLAR EFFECTS
C
```

```
      ANGLE = PI2-ALTSUN
      COZEN = COS(ANGLE)
C
C     DUNCAN - SAUTER ADJUSTMENT SETS ZENITH ANGLE TO 5 DEGREES IF IT
C     IS LESS THAN THAT.
C
      IF (COZEN .LT. 0.09) COZEN  =  0.09
      CALL FRATRN ( IH, IM, IL, FR1, FR2, FR3, RG, COZEN, CLDCLR,
     +              ID2, TCLR )
      TCLSUN = TCLR
C
C     GET CRUDE IDEA OF DIRECT TO DIFFUSE FLUX RATIO
C
      SSALB = 0.98
      HGFAC = 0.0
C
C     RCLSUN IS DIRDIF RATIO FOR SUN ANGLE
C
      IF (SUNLIT .LT. 1.0E-15 .OR. COZEN .LE. 0.0) THEN

       RCLSUN = 0.0
       RCDSUN = 0.0
       GOTO 360
      ENDIF
C
      CALL DIRDIF ( SSALB, HGFAC, COZEN, SUNLIT, TCLR, RG, RCLSUN )
C
C DO IT AGAIN FOR CLOUDY CASE
C
      TCLD = TCLR*CLDCLR
      HGFAC = 0.85
C
C     RCDSUN IS DIRDIF RATIO FOR CLDY SUN POS.
C
      CALL DIRDIF ( SSALB, HGFAC, COZEN, SUNLIT, TCLD, RG, RCDSUN )
C
C     ADJUST SOLAR FLUX TO CLOUDY CONDITIONS
C
  360 CONTINUE
      SUNLIT = SUNLIT*CLDCLR
C
C     AND REPEAT FOR MOON
C
      ANGLE = PI2-ALTMOO
      COZEN = COS(ANGLE)
      IF (COZEN .LT. 0.09) COZEN  =  0.09
      CALL FRATRN ( IH, IM, IL, FR1, FR2, FR3, RG, COZEN, CLDCLR,
     +              ID2, TCLR )
      TCLLUN = TCLR
      HGFAC = 0.0
C
      IF (MOOLIT .LE. 1.0E-5 .OR. COZEN .LT. 0.0) THEN

       RCLLUN = 0.0
       RCDLUN = 0.0
       GOTO 370
      ENDIF
C
      CALL DIRDIF ( SSALB, HGFAC, COZEN, MOOLIT, TCLR, RG, RCLLUN )
      TCLD = TCLR*CLDCLR
      HGFAC = 0.85
      CALL DIRDIF ( SSALB, HGFAC, COZEN, MOOLIT, TCLD, RG, RCDLUN )
C
  370 CONTINUE
      MOOLIT = MOOLIT*CLDCLR
```

```
C
C     WEIRD THINGS SOMETIMES HAPPEN
C
C     IF (SUNLIT .LT. 0.0) SUNLIT = 0.0

C     IF (MOOLIT .LT. 0.0) MOOLIT = 0.0

      BRIGHT = SUNLIT+MOOLIT
C
C     CALL FRATRN TO COMPUTE GALACTIC LIGHT ATTENUATION (ASSUMES
C     ZENITH ANGLE OF 45 DEGREES
C
      CALL FRATRN ( IH, IM, IL, FR1, FR2, FR3, RG, 0.707, CLDCLR,
     +              ID2, TCLR )
      GLOWRA = CLDCLR
C
C     GET FINAL OVERALL ILLUMINANCE ELUMI
C
      ELUMI = BRIGHT+GLOWRA*.0008
C
C     CONVERT FLUX FROM LUX TO W/M*M USING 93 LUMEN/WATT FACTOR FROM
C     F.W. SEARS 'OPTICS'
C
C      SUNGLO = SUNLIT/93.0
C      AMOON = MOOLIT/93.0
      ELUMII = ELUMI/93.0
C
C     CONVERT ANGLES TO DEGREES
C
      AZIS = AZISUN*RAD
      AZIM = AZIMOO*RAD
      ALTS = ALTSUN*RAD
      ALTM = ALTMOO*RAD
C
C     PRINT RESULTS
C
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      IF(IPRFLG.NE.0) THEN
        WRITE(IOOUT,*)'HIT ENTER TO CONTINUE'
        READ(IOOUT,*)
        WRITE(IOOUT, 160)ALTS,AZIS,ALTM,AZIM,DPHASE,
     $                        SUNLIT,MOOLIT,ELUMI,ELUMII
      ENDIF
      ENDIF
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
      IF (IPRFLG.NE.0) WRITE(NDIRTU, 160)ALTS,AZIS,ALTM,AZIM,DPHASE,
     $                      SUNLIT,MOOLIT,ELUMI,ELUMII
      ENDIF
C
  380 CONTINUE
C
C     LOOP TO BEGINNING IF NO DONE CARD HAS BEEN FOUND
C
      IF (IEND.NE.1) GOTO 230
      GOTO 450
C
C.....PRINT ERROR MESSAGES.....
C
390   IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      WRITE(IOOUT, 170)MM
      ENDIF
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
      WRITE(NDIRTU, 170)MM
      ENDIF
      IERR = 2
```

```
      GOTO 450
400   IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      WRITE(IOOUT, 180)ID
      ENDIF
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
      WRITE(NDIRTU, 180)ID
      ENDIF
      IERR = 3
      GOTO 450
C      IERR  =  4 IS NOW A SPARE
  410 CONTINUE
      GOTO 450
C420  IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
C       WRITE(IOOUT, 200)ZN
C     ENDIF
C     IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
C       WRITE(NDIRTU, 200)ZN
C     ENDIF
C     IERR = 5
C     GOTO 450
430   IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      WRITE(IOOUT, 210)IERR
      ENDIF
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
      WRITE(NDIRTU, 210)IERR
      ENDIF
      GOTO 450
440   IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      WRITE(IOOUT, 220)IOIN
      ENDIF
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
      WRITE(NDIRTU, 220)IOIN
      ENDIF
      IERR = 7
  450 CONTINUE
C
      RETURN
      END
```

ECR # HSTX - 5 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: COMBIN   Old Date: New

File Name: COMBIN.FOR   New Date: 8/17/93

Implemented By: Don Hamann

Reason for Revision: Required a routine to combine the cloud properties of two cloud layers into a single "representative" layer. The cloud shadowing algorithm that is employed allows for only two cloud layers, whereas input accepts up to three cloud layers.

Description of Revision: The routine utilizes the logic employed to combine layers in the Air Force EOTDA. The combined cloud fraction is from the perspective of a ground observer. The extinction coefficient and thickness of the combined layer are weighted averages of the individual values. The asymmetry parameter is a straight average. The base height is that of the lower layer.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C-HSTX---SCENE SHADOWS---ECR # HSTX-5-1---------------------------------
C
C  NEW ROUTINE TO COMBINE TWO CLOUD LAYERS.
C
C-HSTX---SCENE SHADOWS--------------------------------------------------
C**************************************************************************
C<BEGIN>
C<IDENTIFICATION>      NAME:     COMBIN
C                 TYPE:     FORTRAN SUBROUTINE
C                FILENAME:  COMBIN.FOR
C
C==========================================================================
C<DESCRIPTION>
C               This routine combines the cloud properties of two cloud
C               layers into a single "representative" layer.  It assumes
C               that all clouds are randomly distributed.  This routine
C               assumes that clouds are actually present in the two cloud
C               layers being combined.
C==========================================================================
C<INPUT>
C     COMMON BLOCK VARIABLES:
C      NONE
C==========================================================================
C<OUTPUT>
C     COMMON BLOCK VARIABLES:
C      NONE
C==========================================================================
C<CALLED ROUTINES>
C      NONE
C==========================================================================
C<PARAMETER>
C    CALLING SEQUENCE:
C        COMBIN (CFL,THL,BAL,CGL,HTL,CFU,THU,BAU,CGU,CFNEW,THNEW,BANEW,
C                CGNEW,HTNEW,NCLD)
C    INPUT:
C       HTL   Lower cloud base height. (km)
C           CFL    Cloud fraction of lower cloud layer. (fraction 0.-1.)
C       CGL   Cloud asymmetry parameter of lower cloud layer.
C       CFU   Cloud fraction of upper cloud layer. (fraction 0.-1.)
C       THL   Cloud thickness of lower layer. (km)
C       THU   Cloud thickness of upper layer. (km)
C       CGU   Cloud asymmetry parameter of upper cloud layer.
C       BAL   Ext. coeff. of lower cloud layer. (km-1)
C       BAU   Ext. coeff. of upper cloud layer. (km-1)
C    OUTPUT:
C       HTNEW      Cloud base of combined layer. (km)
C       CFNEW  Cloud fraction of combined layer. (fraction 0.-1.)
C       THNEW      Cloud thickness of combined layer. (km)
C       BANEW      Extinction coefficient of combined layer. (km-1)
C       CGNEW      Cloud asymmetry parameter of combined layer.
C       NCLD  Number of cloud layers.
C==========================================================================
C<HISTORY>
C  CREATED AUGUST, 1993.  HUGHES STX CORPORATION.
C==========================================================================
C<END>
C
C List of variables:
C      BAL        Extinction coefficient of lower cloud layer. (km-1)
C      BANEW Extinction coefficient of combined layer. (km-1)
C      BAU        Extinction coefficient of upper cloud layer. (km-1)
C      CFL        Cloud fraction of lower cloud layer. (fraction 0.-1.)
C      CFNEW      Cloud fraction of combined layer. (fraction 0.-1.)
C      CFU        Cloud fraction of upper cloud layer. (fraction 0.-1.)
C      CGL        Cloud asymmetry parameter of lower cloud layer.
```

```
C      CGNEW Cloud asymmetry parameter of combined cloud layer.
C      CGU        Cloud asymmetry parameter of upper cloud layer.
C      HTL        Lower cloud base height. (km)
C      HTNEW Cloud base of combined layer. (km)
C      THL        Cloud thickness of lower layer. (km)
C      THNEW Cloud thickness of combined layer. (km)
C      THU        Cloud thickness of upper layer. (km)
C
      SUBROUTINE COMBIN (CFL, THL, BAL, CGL, HTL, CFU, THU, BAU, CGU,
     +             CFNEW, THNEW, BANEW, CGNEW, HTNEW, NCLD)
C
C  THIS ROUTINE ASSUMES THAT CLOUDS ARE ACTUALLY PRESENT IN THE
C  TWO CLOUD LAYERS BEING COMBINED.
C
      IF ( CFL .EQ. 0.0 .OR. CFU .EQ. 0.0 ) THEN
C
C         WRITE(*,*)
C         WRITE(*,*) ' ERROR IN SUBROUTINE COMBIN:  CLOUD FRACTION '
C         WRITE(*,*) ' IS ZERO IN AT LEAST ONE OF THE TWO CLOUD '
C         WRITE(*,*) ' LAYERS BEING PROCESSED BY THIS ROUTINE.  THE'

C         WRITE(*,*) ' OUTPUT PARAMETERS OF COMCLD ARE BEING SET TO'
C         WRITE(*,*) ' -999.'
C         WRITE(*,*)
C
         CFNEW = -999.
      THNEW = -999.
      BANEW = -999.
      CGNEW = -999.
      HTNEW = -999.
C
      ELSE
C
C     COMPUTE THE CLOUD EXTINCTION COEFFICIENT OF COMBINED CLOUD LAYER
C
         BANEW = (CFL*BAL*THL + CFU*BAU*THU)/(CFL*THL + CFU*THU)
C
C        COMPUTE THE CLOUD FRACTION OF THE COMBINED CLOUD LAYER
C
         CFNEW = CFL + CFU * ( 1. - CFL )
C
C     COMPUTE THE CLOUD THICKNESS OF THE COMBINED CLOUD LAYER
C
      THNEW = (CFL*THL + CFU*THU)/CFNEW
C
C     COMPUTE THE ASYMMETRY PARAMETER OF COMBINED CLOU LAYER
C     *** NOTE: THIS VALUE IS THE AVERAGE OF TWO VALUES
C
      CGNEW =  ( CGU + CGL ) * 0.5
C
C        THE CLOUD BASE HEIGHT OF THE COMBINED LAYER IS ASSUMED TO
C        BE THE BASE HEIGHT OF THE LOWER LAYER.
C
      HTNEW = HTL
C
C     SET CLOUD FRACTION OF HIGH CLOUD TO ZERO INDICATING THAT
C     THREE CLOUD LEVELS HAVE BEEN REDUCED INTO TWO CLOUD LEVELS.
C
      CFU = 0.0
C
C     REDUCE NUMBER OF CLOUD LAYERS FROM THREE TO TWO.
C
      NCLD = NCLD - 1
C
      ENDIF
```

```
C
      RETURN
      END
```

ECR # HSTX - 6 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: INITI

Old Date: 3/2/93

File Name: ILMDAT.FOR

New Date: 8/17/93

Implemented By: Don Hamann

Reason for Revision: In order to support partly cloudy radiance computation, the directionally dependent diffuse, directionally independent diffuse and direct radiance variables have to be collected and stored for all possible cloud situations or for bracketing conditions (target scene in and out of cloud shadow).

Description of Revision: Re-dimensioned the following variables in RADIA COMMON block: I0(20), I1(20) => I0(20,4), I1(20,4)
SURF(30),SURF0(30) => SURF(30,4),SURF0(30,2)
F(20), PTHRD(30) => F(20,4), PTHRD(30,2)
ISTAR(20,30) => ISTAR(20,30,2)

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C***********************************************************************
C<BEGIN>
C<IDENTIFICATION>          NAME:  INITI
C                          TYPE:  FORTRAN SUBROUTINE
C                      FILENAME:  SACB.F
C======================================================================
C<DESCRIPTION>
C    INITIALIZES THE RADIOMETRIC DATA
C======================================================================
C<INPUT>
C    COMMON BLOCK VARIABLES:
C        / ATMOS /  NLEV, RHO, Z
C        / CONST /  DGTRD, DIAG, LUOUT, PI
C        / GEOM /   NOBS, PHIO, THETO, UNOT, XLAM, BTA, PHI, PHIOB, THET
C        / RADIA /  ALBEDO, FNOT, TAUSTR, A, ALPHA, AP, BET, BETA,
C                   BETAA, BETAR, G, GP, K, P, TAU, TAUP
C        / TARGS /  AZTARG, NTARG, THTARG
C======================================================================
C<OUTPUT>
C    COMMON BLOCK VARIABLES:
C        / ATMOS /  NLAY
C        / CONST /  DGTRD, DIAG, PI
C        / GAUSS /  AA, BB, X
C        / GEOM /   UNOT, BTA, PHI,
C        / RADIA /  FNOT, TAUSTR, ALPHA, AP, BET, BETA,
C                   BETAR, G, GP, K, P, TAU, TAUP
C        / TARGS /  CTARG
C======================================================================
C<CALLED ROUTINES>
C     SIGRAY          - (SUBR)  CALCULATES THE RALEIGH VOLUME SCATTERING
C                               COEFFICIENT
C======================================================================
C<PARAMETER>
C     NONE
C======================================================================
C<HISTORY>
C  UPDATED FALL 1988.  MODIFIED BY OPTIMETRICS, INC IN JANUARY 1989 TO I
C  PERFORMANCE PREDICTIONS FOR A PARTICULAR WEAPON SYSTEM.
C======================================================================
C<END>
      SUBROUTINE INITI
      COMMON/ATMOS/PRES(21),Z(21),RHO(21),NLEV,NLAY
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-6-1-----------------------------------
C RE-DIMENSIONED THE FOLLOWING VARIABLES TO SUPPORT PARTLY CLOUDY
C COMPUTATION:
C       I0(20), I1(20)       ===> I0(20,4), I1(20,4)
C       SURF(30), SURF0(30) ===> SURF(30,4), SURF0(30,2)
C       F(20), PTHRD(30)     ===> F(20,4), PTHRD(30,2)
C       ISTAR(20,30)           ===> ISTAR(20,30,2)
C
C      COMMON/RADIA/A(20),G(20),GP(20),BETAA(20),BETAR(20),
C     1               BETA(20),K(20),P(20),ALPHA(20),BET(20),
C     2               TAU(0:20),I0(20),I1(20),F(20),TF(20),FNOT,
C     3               NANG,PF(180,20),ANG(180,20),I2(20),TAUP(0:20),
C     4               ISTAR(20,30),PTHRD(30),SING(30),AP(20),PHF(30)
C     5               ,ALBEDO,SURF(30),SURF0(30),TAUSTR,VIS,CAPTP(20),
C     6               B1,B2
      COMMON/RADIA/A(20),G(20),GP(20),BETAA(20),BETAR(20),
     1               BETA(20),K(20),P(20),ALPHA(20),BET(20),
     2               TAU(0:20),I0(20,4),I1(20,4),F(20,4),TF(20),FNOT,
     3               NANG,PF(180,20),ANG(180,20),I2(20),TAUP(0:20),
     4               ISTAR(20,30,2),PTHRD(30,2),SING(30),AP(20),PHF(30)
     5               ,ALBEDO,SURF(30,4),SURF0(30,2),TAUSTR,VIS,CAPTP(20),
     6               B1,B2
```

```
C-HSTX---SCENE SHADOWS-----------------------------------------------------
C
      COMMON/GEOM/THETO,PHIO,UNOT,XLAM,NOBS,PHI(30),BTA(30),NLOS,
     1            XOB(30),YOB(30),ZOB(30),THETOB(30),PHIOB(30)
      COMMON/BCONST/DGTRD,LUOUT,LUIN
      COMMON /IOUNIT/ IOIN, IOOUT, IPHFUN, LOUNIT, NDIRTU, NCLIMT,
     +                IRELH, KSTOR, NPLOTU, STDERR
      COMMON /CONST/PI,PI2,PIRAD,TWOPI,TORRMB,CDEGK
      COMMON/TARGS/NTARG,XTARG(29),YTARG(29),ZTARG(29),THTARG(29)
     1            ,AZTARG(29),RTARG(29),CTARG(29)
      COMMON/GAUSS/ AA(40,40),BB(40),X(40)
      COMMON/IOFILE/IOFILE
CUV      REAL I0,I1,I2,ISTAR,K,ISTR
      REAL I0,I1,I2,ISTAR,K
      INTEGER IOFILE
CP    LOGICAL DIAG
C-----------------------------------------------------------------------
      DATA BIGEXP /88./
C=======================================================================
C
C*********************************************************
C
C   PRES  REAL VECTOR OF ATMOSPHERIC PRESSURES IN MB.
C   Z     REAL VECTOR OF ATMOSPHERIC LEVELS IN KM.
C   A     REAL VECTOR OF SINGLE SCATTERING ALBEDOS
C   RHO   REAL VECTOR OF ATMOSPHERIC DENSITY IN GM**M-3
C   G     REAL VECTOR OF ASYMMETRY PARAMETERS
C   GP    REAL VECTOR OF MODIFIED ASYMMETRY PARAMETERS
C   BETAA REAL VECTOR OF AEROSOL EXTINCTION COEFS IN KM**-1
C   BETAR REAL VECTOR OF RAYLEIGH SCATTERING COEFS IN KM**-1
C   BETA  REAL VECTOR OF TOTAL EXTINCTION COEFS IN KM**-1
C   K     REAL VECTOR OF PARAMETER USED IN DELTAED SOLUTION
C   P     REAL VECTOR OF PARAMETER USED IN DELTAED SOLUTION
C   ALPHA REAL VECTOR OF PARAMETER USED IN DELTAED SOLUTION
C   BET   REAL VECTOR OF PARAMETER USED IN DELTAED SOLUTION
C   TAU   REAL VECTOR OF LAYER OPTICAL THICKNESSES
C   NLEV  INTEGER OF THE NUMBER OF ATMOSPHERIC LAYERS
C   XLAM  REAL OF THE WAVELENGTH USED IN MICRO METERS
C   THETO REAL OF THE SOLAR ZENITH ANGLE IN DEGREES
C   PHIO  REAL OF THE SOLAR AZIMUTH IN DEGREES WEST OF SOUTH
C   UNOT  REAL VALUE OF THE COSINE OF THE SOLAR ZENITH ANGLE
C   PHNOT REAL VALUE OF THE SOLAR AZIMUTH ANGLE IN DEGREES
C   THETOBREAL VALUE OF THE OBSERVATION ZENITH ANGLE IN DEGREES
C   PHIOB REAL VALUE OF THE OBSERVATION AZIMUTH ANGLE IN DEGREES
C   ZOB   REAL VALUE OF THE OBSERVER HEIGHT IN KM.
C   ALBEDO REAL VALUE OF THE SURFACE ALBEDO
C   I0    REAL VECTOR OF EDDINGTON INTENSITY
C   I1    REAL VECTOR OF EDDINGTON INTENSITY
C   I2    REAL VECTOR OF MODIFIED INTENSITY
C   ISTAR REAL ARRAY OF PATH FUNCIOTN
C
C************************************************************
C
C     *** THIS ROUTINE INITIALIZES THE RADIOMETRIC DATA
C
C
C     *** CALCULATE THE RAYLEIGH SCATTERING COEFFICIENT
C
      NANG = 179
      DO 6 N = 1,NLEV - 1
         DO 5 L = 1,NANG
            ANG(L+1,N) = 180.0 / FLOAT(NANG + 1) * FLOAT(L)
            PF(L,N) = -9.99
 5       CONTINUE
         ANG(1,N) = 0.0
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```
            ANG(NANG,N) = 180.0
  6     CONTINUE
 CP     DIAG = .FALSE.
        RHOTOP = RHO(1)
        SIGTOP = SIGRAY(XLAM,RHOTOP)
        DO 10 N = 1,NLEV-1
           BETAR(N) = ( RHO(N) + RHO(N+1))/2.0 / RHOTOP * SIGTOP
 10     CONTINUE
        PI = ASIN(1.0) * 2.0
        DGTRD = PI / 180.
 CUV       POVR2 = PI /2.0
        FNOT  = 1.0
        NLAY = NLEV - 1
 C
 C      *** CALCULATE THE COSINE OF THE SOLAR ZENITH ANGLE
 C
        UNOT = COS(THETO * DGTRD)
        IF(UNOT.LT.0.0)THEN
        IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
          WRITE(IOOUT,*)'  '
          WRITE(IOOUT,*)'  CAUTION, YOUR INPUTS HAVE SPECIFIED A '
          WRITE(IOOUT,*)'  TIME AND LOCATION SUCH THAT THE SUN '
          WRITE(IOOUT,*)'  AND THE MOON ARE BELOW THE HORIZON,'
          WRITE(IOOUT,*)'  SKY TO GROUND RATIO '
          WRITE(IOOUT,*)'  CALCULATIONS MAY BE ERRONEOUS'
          WRITE(IOOUT,*)'  '
        ENDIF
        IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
          WRITE(NDIRTU,*)'  '
          WRITE(NDIRTU,*)'  CAUTION, YOUR INPUTS HAVE SPECIFIED A '
          WRITE(NDIRTU,*)'  TIME AND LOCATION SUCH THAT THE SUN '
          WRITE(NDIRTU,*)'  AND THE MOON ARE BELOW THE HORIZON,'
          WRITE(NDIRTU,*)'  SKY TO GROUND RATIO '
          WRITE(NDIRTU,*)'  CALCULATIONS MAY BE ERRONEOUS'
          WRITE(NDIRTU,*)'  '
        ENDIF
        END IF
 C
 C      *** FIND SCALE HEIGHT (SCHT) AS PROPOSED BY ELTERMAN
 C
        BET55 = 3.912 / VIS
        BET55 = BET55 - BETAR(NLAY)
        SCHT = -5.0/(ALOG(5.0E-3/BET55))
 C
 C      *** CALCULATE THE ORDINARY AND MODIFIED OPTICAL THICKNESS OF EACH
 C
 CUV       SCAPT = 0.0
        SCAPTP = 0.0
        TAUSTR = 0.
        TAUSRP = 0.
        DO 20  N = 1,NLAY
           IF(Z(N+1) .LE. 5.0 .AND. BETAA(N) .EQ. 0.0) THEN
              BETAA(N) = BET55 * EXP(-Z(N+1) / SCHT)
           ENDIF
           BETA(N) =  BETAA(N) + BETAR(N)
 C
 C         *** ADJUST THE HENYEY GREESTEIN ASYMMETRY PARAMETER TO ACCOUNT
 C             FOR RAYLEIGH SCATTERING
 C
           G(N) = G(N) * (BETA(N) - BETAR(N)) / BETA(N)
           TAU(N) = (Z(N) - Z(N+1)) * BETA(N)
           TAUP(N) = (1.0 - A(N) * G(N) * G(N)) * TAU(N)
           TAUSTR = TAUSTR + TAU(N)
           TAUSRP = TAUSRP + TAUP(N)
           TAU(N) = TAUSTR
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```
           TAUP(N) = TAUSRP
CP         IF(DIAG) WRITE(LUOUT,1000)N,BETAR(N),BETAA(N),BETA(N),TAU(N),
CP    1                                  TAUP(N),TAUSTR,TAUSRP
C1000      FORMAT(' DIAGNOSTIC',I3,7E10.3)
 20     CONTINUE
C
C       *** CALCULATE DELTA-EDDINGTON PARAMETERS
C
        DO 30  N = 1, NLAY
C
C       *** THE NEXT THREE STATEMENTS IMPLEMENT THE DELTA EDDINGTON METHOD
C
        FP = G(N) * G(N)
        AP(N) = A(N) * (1.0 - FP) / (1.0 - A(N) * FP)
        GP(N) = (G(N) - FP) / (1.0 - FP)
        CAPTP(N) = (1.0 - GP(N)) * (Z(N) - Z(N+1)) * BETA(N) *
      1            (1.0 - A(N) * G(N) * G(N))
        SCAPTP = SCAPTP + CAPTP(N)
        CAPTP(N) = SCAPTP
        OMINA = (1.0 - AP(N))
        OMINAG = (1.0 - AP(N) * GP(N))
        K(N) = (3.0 * OMINA * OMINAG) ** 0.5
        OMINKU = (1.0 - K(N) * K(N) * UNOT * UNOT)
        P(N) = (3.0 * OMINA / OMINAG) ** 0.5
        ALPHA(N) = 3.0 * AP(N) * FNOT * UNOT * UNOT *
      1            (1.0 + GP(N) * OMINA) / (4.0 * OMINKU)
        BET(N) = 3.0 * AP(N) * FNOT * UNOT *
      1          (1.0 + 3.0 * GP(N) * OMINA * UNOT * UNOT)
      2          / (4.0 * OMINKU)
CP      IF(DIAG) WRITE(LUOUT,1010)N,OMINA,OMINAG,OMINKU,K(N),P(N)
CP    1                             ,ALPHA(N),BET(N)
C1010 FORMAT(' DIAGNOSTIC',I3,7E10.3)
  30    CONTINUE
C
C       *** INITIALIZE COEF MATRIX AND COLUMN VECTORS
C
        DO 40 N = 1, 2 * NLAY
           BB(N) = 0.0
           X(N) = 0.0
           DO 50 M = 1, 2 * NLAY
             AA(N,M) = 0.0
  50       CONTINUE
  40    CONTINUE
C
C       *** LOAD 2N BY 2N MATRIX FOR SOLUTION BY GAUSSIAN ELIMINATION
C
        AA(1,1) = (1.0 + 2.0 * P(1) / 3.0)
        AA(1,2) = (1.0 - 2.0 * P(1) / 3.0)
        BB(1) = ALPHA(1) + 2.0 * BET(1) / 3.0
        DO 65  N = 2, 2 * (NLAY -1), 2
           I = N / 2
           IP1 = I + 1
           NP1 = N + 1
           NP2 = N + 2
           NM1 = N - 1
           EMKT = EXP(-K(I) * TAUP(I))
           EPKT = EXP(K(I) * TAUP(I))
           EMKPT = EXP(-K(IP1) * TAUP(I))
           EPKPT = EXP(K(IP1) * TAUP(I))
           DEXPO = TAUP(I) / UNOT
C-----------------------------------------------------------------------
           IF (ABS(DEXPO) .GT. BIGEXP) THEN
              EMTUO = 0.0
           ELSE
              EMTUO = EXP(-DEXPO)
```

```
         ENDIF
C=======================================================================
         AA(N,NM1) = EMKT
         AA(N,N) = EPKT
         AA(N,NP1) = -EMKPT
         AA(N,NP2) = -EPKPT
         BB(N) = EMTU0 * (ALPHA(I) - ALPHA(IP1))
         AA(NP1,NM1) = AA(N,NM1) * P(I)
         AA(NP1,N) = -AA(N,N) * P(I)
         AA(NP1,NP1) = AA(N,NP1) * P(IP1)
         AA(NP1,NP2) = -AA(N,NP2) * P(IP1)
         BB(NP1) = EMTU0 * (BET(I) - BET(IP1))
 65   CONTINUE
      TAUST = TAUSRP
      B2 = (3.0 * UNOT * FNOT * (1.0 - ALBEDO) * (2.0 + 3.0 * UNOT +
     1     (2.0 - 3.0 * UNOT) * EXP(-TAUST/UNOT))) / (4.0 * (4.0 +
     2      3.0 * (1.0 - ALBEDO) * SCAPTP))
      B1 = (3.0 * UNOT * UNOT / 4.0 + UNOT / 2.0) * FNOT - 2.0 * B2 /3.0
      AA(NP2,NP1) = (1.0 - ALBEDO - 2.0 * (1.0 + ALBEDO)
     1              * P(IP1) / 3.0) * EXP(-K(IP1) * TAUST)
      AA(NP2,NP2) = (1.0 - ALBEDO + 2.0 * (1.0 + ALBEDO)
     1              * P(IP1) / 3.0) * EXP(K(IP1) * TAUST)
      DEXPO = TAUST / UNOT
C-----------------------------------------------------------------------
      IF (ABS(DEXPO) .GT. BIGEXP) THEN
         TEMP = 0.
      ELSE
         TEMP = EXP(-DEXPO)
      ENDIF
      BB(NP2) = ((1.0 - ALBEDO) * ALPHA(IP1) - 2.0 *
     1           (1.0 + ALBEDO) * BET(IP1) / 3.0 +
     2           ALBEDO * UNOT * FNOT) * TEMP
C=======================================================================
CP    IF(DIAG) THEN
CP       DO 70  I = 1, 2 * NLAY
CP          WRITE(LUOUT,1040) I,(AA(I,J),J=1,2*NLAY),BB(I)
C1040       FORMAT(' DIAGNOSTIC',1I3,9E10.3,E12.3)
CP70     CONTINUE
CP    ENDIF
      NLOS = 0
      DO 77 N = 1,NOBS
         DO 75 M = 1,NTARG
            NLOS = NLOS + 1
            DX = (XTARG(M) - XOB(N))
            DY = (YTARG(M) - YOB(N))
            DZ = (ZTARG(M) - ZOB(N))
            R = DX * DX + DY * DY
            R = R**0.5
            THETOB(NLOS) = 90.0 - ATAN2(DZ,R)/DGTRD
            PHIOB(NLOS) = ATAN2(DX,DY)/DGTRD
CP          THETOB(2) = 95.5
            THETOB(2) = 90.00
CP          PHIOB(2) = 180.
CP          PHIOB(2) = TARGAZ
CP          WRITE(*,*)'PHIOB IS ',PHIOB(NLOS)
C           WRITE(*,1200) XOB(N),XTARG(M),YOB(N),YTARG(M),ZOB(N),
C    1                    ZTARG(M),THETOB(NLOS),PHIOB(NLOS)
  75     CONTINUE
  77  CONTINUE
C
C     *** CALCULATE THE RELATIVE AZIMUTH ANGLE AND ANGLE BETWEEN THE
C         LINE TO SIGHT AND THE INCOMING DIRECT BEAM RADIATION
C
      DO 80  N = 1, NLOS
         PHI(N) = (PHIOB(N) - PHI0) * DGTRD
```

```
          U = COS(  THETOB(N) * DGTRD)
          BTA(N) = U * UNOT + (1.0 - U * U)**0.5
     1              * (1.0 - UNOT * UNOT)**0.5 * COS( PHI(N))
 80    CONTINUE
C
C      *** CALCULATE THE COSINE OF THE ANGLE BETWEEN THE NORMAL
C          TO THE TARGET AND THE SOLAR DIRECTION
C
       DO 90  N = 1,NTARG
          U = COS(THTARG(N) * DGTRD)
          PHIHOL = (AZTARG(N) - PHI0) * DGTRD
CP        WRITE(*,*)'U AND UNOT ARE ',U,UNOT
          CTARG(N) = U * UNOT + (1.0 - U * U) **0.5
     1               * (1.0 - UNOT * UNOT)**0.5 * COS(PHIHOL)
CP        WRITE(*,*)'CTARG IS ',CTARG(N)
 90    CONTINUE
C
C      *** IF LAYER PHASE FUNCION IS NOT INPUT THEN USE
C          A HENYEY GREENSTEIN APPROXIMATION FOR THE LAYER
C
       DO 100  N = 1, NLAY
          DO 110  L = 1, NANG
             BTT = COS(ANG(L,N) * DGTRD)
             IF(PF(L,N) .EQ. -9.99) PF(L,N) = (1.0 - G(N) * G(N)) /
     1                              (4.0 * PI * ( 1.0 - 2.0 * G(N) *
     2                              BTT + G(N) * G(N)) ** 1.5)
             PF(L,N) = PF(L,N) * BETAA(N) + 3.0 / 16.0 * PI
     1                 * (1.0 + BTT * BTT) * BETAR(N)
             PF(L,N) = PF(L,N) / (BETAA(N) + BETAR(N))
 110      CONTINUE
 100   CONTINUE
C
C      *** CONVERT THE PHASE FUNCTION ANGLES TO THEIR RESPECTIVE COSINES
C
       DO 120 N = 1,NLAY
          DO 130 L = 1, NANG
             ANG(L,N) = COS(ANG(L,N) * DGTRD)
 130      CONTINUE
 120   CONTINUE
       RETURN
       END
C
C                                 <END OF UNIT: INITI>
```

ECR # HSTX - 7 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: DELTED
Old Date: 8/11/93
File Name: CONTRAST.FOR
New Date: 8/17/93

Implemented By: Don Hamann

Reason for Revision: Enabled FASCAT calculations to be performed on atmospheric layers for all possible cloud situations.

Description of Revision: Added cloud situation iteration number as an argument. Re-dimensioned the variables I0, I1, SURF, SURF0, F, PTHRD, and ISTAR. Perform delta-Eddington calculations using atmospheric parameters for the particular cloud situation.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 7 - 2

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: DELTED　　Old Date: 9/14/93

File Name: CONTRAST.FOR　　New Date: 9/14/93

Implemented By: Dan DeBenedictis

Reason for Revision: ISTAR needs to be saved only for bracketing cloud situations.

Description of Revision: Index ISTAR with II for the first and last cloud situations. Overwrite ISTAR values for other cloud situations. Set II index equal to the cloud situation loop counter, or to 2 if the counter is greater than 2.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C
C<BEGIN>
C<IDENTIFICATION>          NAME:  DELTED
C                          TYPE:  FORTRAN SUBROUTINE
C                      FILENAME:  SACC.F
C=====================================================================
C<DESCRIPTION>
C    DELTA-EDDINGTON ROUTINE CALCULATED RADIATIVE INTENSITIES AND FLUXES
C
C=====================================================================
C<INPUT>
C    COMMON BLOCK VARIABLES:
C        / ATMOS / NLAY, NLEV
C        / CONST / DGTRD, DIAG, LUOUT, PI
C        / GAUSS /  X
C        / GEOM / NOBS, UNOT, BTA, THETOB
C        / RADIA / FNOT, ALPHA, BET, BETA, BETAA, BETAR, F, G, ISTAR,
C                  I0, I1, I2, K, P, PHF, TAU, TAUP, TF
C=====================================================================
C<OUTPUT>
C    COMMON BLOCK VARIABLES:
C        / RADIA / F, G, I0, I1, I2, ISTAR, PHF, TF
C=====================================================================
C<CALLED ROUTINES>
C    ELIMIN      -    (SUBR)    SOLVES SYSTEM OF EQUATIONS
C=====================================================================
C<PARAMETER>
C       I - CLOUD SITUATION NUMBER
C
C    CALLING SEQUENCE:
C      DELTED (I)
C=====================================================================
C<HISTORY>
C  UPDATED FALL 1988.  MODIFIED BY OPTIMETRICS, INC IN JANUARY 1989 TO I
C  PERFORMANCE PREDICTIONS FOR A PARTICULAR WEAPON SYSTEM.
C=====================================================================
C<END>
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-7-1--------------------------------
C ADD CLOUD SITUATION NUMBER AS ARGUMENT
C       SUBROUTINE DELTED
      SUBROUTINE DELTED (I)
C-HSTX---SCENE SHADOWS-------------------------------------------------
C
        COMMON/ATMOS/PRES(21),Z(21),RHO(21),NLEV,NLAY
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-7-1--------------------------------
C RE-DIMENSIONED THE FOLLOWING VARIABLES TO SUPPORT PARTLY CLOUDY
C COMPUTATION:
C      I0(20), I1(20)       ===> I0(20,4), I1(20,4)
C      SURF(30), SURF0(30) ===> SURF(30,4), SURF0(30,2)
C      F(20), PTHRD(30)     ===> F(20,4), PTHRD(30,2)
C      ISTAR(20,30)           ===> ISTAR(20,30,2)
C
C      COMMON/RADIA/A(20),G(20),GP(20),BETAA(20),BETAR(20),
C     1          BETA(20),K(20),P(20),ALPHA(20),BET(20),
C     2          TAU(0:20),I0(20),I1(20),F(20),TF(20),FNOT,
C     3          NANG,PF(180,20),ANG(180,20),I2(20),TAUP(0:20),
C     4          ISTAR(20,30),PTHRD(30),SING(30),AP(20),PHF(30)
C     5          ,ALBEDO,SURF(30),SURF0(30),TAUSTR,VIS,CAPTP(20),
C     6          B1,B2
      COMMON/RADIA/A(20),G(20),GP(20),BETAA(20),BETAR(20),
     1          BETA(20),K(20),P(20),ALPHA(20),BET(20),
     2          TAU(0:20),I0(20,4),I1(20,4),F(20,4),TF(20),FNOT,
     3          NANG,PF(180,20),ANG(180,20),I2(20),TAUP(0:20),
```

```
     4           ISTAR(20,30,2),PTHRD(30,2),SING(30),AP(20),PHF(30)
     5           ,ALBEDO,SURF(30,4),SURF0(30,2),TAUSTR,VIS,CAPTP(20),
     6           B1,B2
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
      COMMON/GEOM/THET0,PHI0,UNOT,XLAM,NOBS,PHI(30),BTA(30),NLOS,
     1            XOB(30),YOB(30),ZOB(30),THETOB(30),PHIOB(30)
      COMMON/TARGS/NTARG,XTARG(29),YTARG(29),ZTARG(29),THTARG(29)
     1            ,AZTARG(29),RTARG(29),CTARG(29)
      COMMON/BCONST/DGTRD,LUOUT,LUIN
      COMMON /CONST/PI,PI2,PIRAD,TWOPI,TORRMB,CDEGK
      COMMON/GAUSS/ AA(40,40),BB(40),X(40)
      COMMON/IOFILE/IOFILE
      COMMON/IOUNIT/IOIN,IOOUT,IPHFUN,LOUNIT,NDIRTU,NCLIMT,IRELH,
     1              KSTOR,NPLOTU,STDERR
      INTEGER IOFILE
      DIMENSION C1(20),C2(20),AN(180),PFN(180)
      REAL I0,I1,I2,ISTAR,K
CP    LOGICAL DIAG
C-----------------------------------------------------------------------
      DATA BIGEXP /88.0/
C=======================================================================
C
C     *** CALL SUBROUTINE TO SOLVE SYSTEM OF EQUATIONS
C
CP    WRITE(*,*)'IN DELTED NLAY AND ERR ARE ',NLAY,ERR
      CALL ELIMIN(2 * NLAY ,ERR)
C
C     *** FORMULATE C1 AND C2 VECTORS
C
      NN = 0
      DO 10 N = 1, NLAY
         NN = NN + 1
         NN = NN + 1
CP       IF(DIAG) WRITE(LUOUT,1020)N,C1(N),C2(N)
C1020    FORMAT(' DIAGNOSTIC',I3,2E10.3)
   10 CONTINUE
C
C     *** CALCULATE INTENSITIES AND FLUXES
C
      DO 20 N = 1, NLEV-1
         ARG = K(N) * TAUP(N)
       IF (ARG .GT. 50. ) THEN
         IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
           WRITE(IOOUT,*) 'ARG IS TOO LARGE'
         ENDIF
         IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
           WRITE(NDIRTU,*) 'ARG IS TOO LARGE'
         ENDIF
         STOP
         ENDIF
         DEXPO = TAUP(N) / UNOT
C-----------------------------------------------------------------------
         IF (ABS(DEXPO) .GT. BIGEXP) THEN
            ETU0 = 0.0
         ELSE
            ETU0 = EXP(-DEXPO)
         ENDIF
C=======================================================================
C
C-HSTX---SCENE SHADOWS----ECR # HSTX-7-1--------------------------------
C RE-DIMENSION ARRAYS I0, I1, AND F TO ACCOUNT FOR CLOUD CONTRIBUTION.
C     I = 1
C         One iteration of the loop for the conditions:
C           both layers clear
```

```
C           one layer overcast, one layer clear
C           both layers overcast
C     I = 2
C         Two iterations of the loop for the conditons:
C           one partly cloudy layer, one clear layer
C           one partly cloudy layer, one overcast layer
C     I = 4
C         Four iterations of the loop for the conditon:
C           two partly cloudy layers
C
       IO(N,I) = B1 - 0.75 * UNOT * UNOT * FNOT * ETUO -B2 *CAPTP(N)
       I1(N,I) = B2 - 0.75 * UNOT * FNOT * ETUO
       F(N,I) = PI * (IO(N,I) + 2.0 / 3.0 * I1(N,I))
       TF(N) = F(N,I) + UNOT * PI * FNOT * ETUO
CP     WRITE(*,*)'IO AND I1 IN TF ARE ',IO(N,I),I1(N,I)
CP       WRITE(*,*)'TF IS ',TF(N)
CP     IF(DIAG) WRITE(LUOUT,1030)N,EMK,EPK,ETUO,IO(N,I),I1(N,I),
CP    +                             F(N,I),TF(N)
C1030    FORMAT(' DIAGNOSTIC',I3,7E10.3)
C-HSTX---SCENE
SHADOWS------------------------------------------------------
C
   20 CONTINUE
C
C     *** CALCULATE THE VALUE OF I2 AND ISTAR
C
      SINOT = (1.0 - UNOT * UNOT) ** 0.5
      DO 30 N = NLAY, 1, -1
         DO 30 L = 1, NLOS
            DO 25 LL = 1,NANG
               AN(LL) = ANG(LL,N)
               PFN(LL) = PF(LL,N)
  25        CONTINUE
            CSTHOB = COS(THETOB(L) * DGTRD)
            TAUX = TAUP(N)
            SINOB = (1.0 - CSTHOB * CSTHOB) ** 0.50
            BT = BTA(L)
            IF (BT .GT. COS(25.0 * DGTRD)) TAUX = TAU(N)
CJ      CHANGE INTERPOLATION FROM BESSEL TO CUBIC SPLINE
CJ      AUGUST 1992  J.FITZGERREL, P.GILLESPIE
          PHF(L) = CUBINT(BT,AN,PFN,NANG)
CJ          PHF(L) = BSL1F(BT,AN,PFN,NANG)
C-----------------------------------------------------------------------
            IF (ABS(TAUX/UNOT) .GT. BIGEXP) THEN
               TERM = 0.0
            ELSE
               TERM = EXP(-TAUX/UNOT)
            ENDIF
            EPS = PI * FNOT * TERM
C=======================================================================
C           PHF(L) = ((1.0 - G(N) * G(N))/(4.0 * PI * ( 1.0 - 2.0 * G(N)
C    1      BT + G(N) * G(N)) ** 1.5) * BETAA(N) + 3.0 / (16.0 * PI) *
C    2      (1.0 + COS(BT) ** 2) * BETAR(N)) / BETA(N)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-7-1-----------------------------------
C RE-DIMENSIONED ARRAYS IO, I1, AND ISTAR TO ACCOUNT FOR CLOUD
CONTRIBUTION.
C         I = 1 - CLEAR SKY.
C         I = 2 - TOP CLOUD OR BOTTOM CLOUD ONLY (ONE CLOUD).
C         I = 4 - TOP AND BOTTOM CLOUD (TWO CLOUDS).
C-HSTX---SCENE SHADOWS---ECR # HSTX-7-2-----------------------------------
C ISTAR NEEDS TO BE CALCULATED FOR ONLY CLEAR OR OVERCAST
C
          I2(N) = 4.0 * PI * IO(N,I) * PHF(L) * EPS * SINOB * SINOT /
    1                 (4.0 * PI * IO(N,I) + PHF(L) * EPS)
```

```
CP          IF(DIAG) WRITE(LUOUT,*) ' TERMS ',TERM1,TERM2,TERM3,TERM4
C
          II = I
          IF (I.GT.2) II = 2
          ISTAR(N,L,II) = BETA(N) * (PHF(L) * EPS + I0(N,I)
     2                    + G(N) * I1(N,I) * CSTHOB
     3                    + G(N) * I2(N) * COS(PHI(L)))
C-HSTX---SCENE SHADOWS-------------------------------------------------
C
   30 CONTINUE
      RETURN
      END
C
C                                 <END OF UNIT: DELTED>
```

ECR # HSTX - 8 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: CONTST
Old Date: 8/17/93

File Name: CONTRAST.FOR
New Date: 8/20/93

Implemented By: Dan DeBenedictis

Reason for Revision: Compute average value of diffuse radiance over four possible cloud situations. Compute bracketing values of path radiance, direct radiance, and total radiance for the target scene in and out of cloud shadow.

Description of Revision: Re-dimension the variables I0, I1, SURF, SURF0, F, PTHRD, and ISTAR. Add cloud situation number (I) and solar zenith angle (SZA) as arguments. Add the COMMON block CLOUD to access cloud information. Call PCDIF to compute the average diffuse radiance and the correction for forward scattering.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 8 - 2

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: CONTST

Old Date: 8/20/93

File Name: CONTRAST.FOR

New Date: 8/27/93

Implemented By: Don Hamann

Reason for Revision: To maintain information on the probability of a cloud-free path through each cloud layer and on the probability of the target scene in direct light.

Description of Revision: Added variable PSCLD and array PCF(2) to CLOUD COMMON block to maintain probability information.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 8 - 3

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: CONTST

Old Date: 8/27/93

File Name: CONTRAST.FOR

New Date: 9/14/93

Implemented By: Dan DeBenedictis

Reason for Revision: Bracketing values of transmittance (TN) must be computed for clear and/or overcast.

Description of Revision: Re-dimension the variable TN and use SAVE to save the values of TN for each call to CONTST.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 8 - 4

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: CONTST

Old Date: 9/14/93

File Name: CONTRAST.FOR

New Date: 9/17/93

Implemented By: Don Hamann

Reason for Revision: Fix an error in the calls to PCDIF. Use temporary variables in the calls. Add a flag to keep track of the cloud situation.

Description of Revision: Added variable ICLDF to CLOUD COMMON block to maintain information on cloud situation. Created local array SURFA(4) to temporarily store direct radiance for call to PCDIF. Store directionally dependent diffuse, directionally independent diffuse, and direct radiance in temporary variables for call to PCDIF. Which values are loaded depends on the cloud situation.

Notes: ICLDF flag = 1 for two clear layers, 2 for one overcast layer, 3 for two overcast layers, 4 for one clear layer and one partly cloudy, 5 for one overcast layer and one partly cloudy, and 6 for two partly cloudy layers.

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 8 - 5

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: CONTST
Old Date: 9/17/93

File Name: CONTRAST.FOR
New Date: 10/20/93

Implemented By: Melanie J. Gouveia

Reason for Revision: Update equations for direct and diffuse radiance to more closely match the literature (Shettle and Weinman, 1970; Joseph, Wiscombe, and Weinman, 1976; Hering and Johnson, 1984). Make the subroutine more modular by moving the setup for and calls to PCDIF to the new DIFUSE routine.

Description of Revision: Use the Delta-Eddington optical depth, rather than regular optical depth, for all direct radiance calculations. Use diffuse = I0 - 2/3 I1 for upward line-of-sight, diffuse = I0 + 2/3 I1 + CORR for downward LOS, and diffuse = I1 + CORR/2 for horizontal LOS.

Notes: The upward and downward LOS equations are found in the literature. The horizontal LOS equation is an average of the upward and downward.

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C<BEGIN>
C<IDENTIFICATION>         NAME:  CONTRAST
C                         TYPE:  FORTRAN SUBROUTINE
C                     FILENAME:  SACC.F
C=======================================================================
C<DESCRIPTION>
C    CALCULATES THE PATH RADIANCES, THE TRANSMITTED BACKGROUND RADIANCES
C    AND THE APPARENT SPECTRAL CONTRASTS ALONG THE VARIOUS LINES OF SIGH
C=======================================================================
C<INPUT>
C    COMMON BLOCK VARIABLES:
C        / ATMOS / NLAY, NLEV, Z
C        / CONST / DGTRD, DIAG, LUOUT
C        / GEOM / NOBS, UNOT, THETOB
C        / RADIA / ALBEDO, FNOT, TAUSTR, BETA, I0, I1, ISTAR
C        / TARGS / NTARG, CTARG, THTARG, ZTARG
C        / CLOUD / NUMCLD, MLOOP, ZC1, ZC2, CF1, CF2
C=======================================================================
C<OUTPUT>
C    COMMON BLOCK VARIABLES:
C        / RADIA / PTHRD, SURF
C=======================================================================
C<CALLED ROUTINES>
CJ   BSL1F       -    (SUBR)    ACCESSES BESSEL INTERPOLATION ROUTINE
CJ   CUBINT      -    (SUBR)    ACCESSES CUBIC SPLINE ROUTINE
C    SIMPNE      -    (SUBR)    PERFORMS SIMPSON RULE INTEGRATION
C=======================================================================
C<PARAMETER>
C       I      - CLOUD SITUATION NUMBER
C         SZA     - SOLAR ZENITH ANGLE
C
C    CALLING SEQUENCE:
C        CONTST (I,SZA)
C=======================================================================
C<HISTORY>
C  UPDATED FALL 1988
C=======================================================================
C<END>
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1------------------------------------
C ADD CLOUD SITUATION NUMBER AND SOLAR ZENITH ANGLE AS ARGUMENTS
C     SUBROUTINE CONTST
      SUBROUTINE CONTST (I,SZA)
C-HSTX---SCENE SHADOWS-----------------------------------------------------
C
CP      PARAMETER(MAXEXP = 30)
      COMMON/ATMOS/PRES(21),Z(21),RHO(21),NLEV,NLAY
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1------------------------------------
C RE-DIMENSIONED THE FOLLOWING VARIABLES TO SUPPORT PARTLY CLOUDY
C COMPUTATION:
C      I0(20), I1(20)      ===> I0(20,4), I1(20,4)
C      SURF(30), SURF0(30) ===> SURF(30,4), SURF0(30,2)
C      F(20), PTHRD(30)    ===> F(20,4), PTHRD(30,2)
C      ISTAR(20,30)          ===> ISTAR(20,30,2)
C
C      COMMON/RADIA/A(20),G(20),GP(20),BETAA(20),BETAR(20),
C     1         BETA(20),K(20),P(20),ALPHA(20),BET(20),
C     2         TAU(0:20),I0(20),I1(20),F(20),TF(20),FNOT,
C     3         NANG,PF(180,20),ANG(180,20),I2(20),TAUP(0:20),
C     4         ISTAR(20,30),PTHRD(30),SING(30),AP(20),PHF(30)
C     5         ,ALBEDO,SURF(30),SURF0(30),TAUSTR,VIS,CAPTP(20),
C     6         B1,B2
      COMMON/RADIA/A(20),G(20),GP(20),BETAA(20),BETAR(20),
     1             BETA(20),K(20),P(20),ALPHA(20),BET(20),
```

```
     2             TAU(0:20),I0(20,4),I1(20,4),F(20,4),TF(20),FNOT,
     3             NANG,PF(180,20),ANG(180,20),I2(20),TAUP(0:20),
     4             ISTAR(20,30,2),PTHRD(30,2),SING(30),AP(20),PHF(30)
     5             ,ALBEDO,SURF(30,4),SURF0(30,2),TAUSTR,VIS,CAPTP(20),
     6             B1,B2
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
      COMMON/GEOM/THETO,PHI0,UNOT,XLAM,NOBS,PHI(30),BTA(30),NLOS,
     1            XOB(30),YOB(30),ZOB(30),THETOB(30),PHIOB(30)
      COMMON/BCONST/DGTRD,LUOUT,LUIN
      COMMON /CONST/PI,PI2,PIRAD,TWOPI,TORRMB,CDEGK
      COMMON/TARGS/NTARG,XTARG(29),YTARG(29),ZTARG(29),THTARG(29)
     1            ,AZTARG(29),RTARG(29),CTARG(29)
      COMMON/IOUNIT/IOIN,IOOUT,IPHFUN,LOUNIT,NDIRTU,NCLIMT,IRELH,
     1              KSTOR,NPLOTU,STDERR
      COMMON/IOFILE/IOFILE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1-----------------------------------
C ADD CLOUD COMMON BLOCK TO ACCESS CLOUD INFORMATION.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-2---------------------------------
C ADDED VARIABLE PSCLD AND ARRAY PCF(2) TO CLOUD COMMON BLOCK TO MAINTAIN
C INFORMATION ON PROBABILITY OF CLOUD-FREE PATH THROUGH EACH CLOUD LAYER
C AND THE PROBABILITY OF THE TARGET IN DIRECT LIGHT.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-4---------------------------------
C ADDED VARIABLE ICLDF TO CLOUD COMMON BLOCK TO MAINTAIN INFORMATION ABOUT
C CLOUD SITUATION.
C     COMMON /CLOUD/NUMCLD, MLOOP, CLDBTA(2),CLDG(2), LYRCLD(2),
C    +                THK1, THK2, THK3, ITY1, ITY2, ITY3,
C    +                ZC1,ZC2,ZC3,CF1,CF2,CF3
      COMMON /CLOUD/ICLDF,NUMCLD, MLOOP, CLDBTA(2),CLDG(2), LYRCLD(2),
     +                THK1, THK2, THK3, ITY1, ITY2, ITY3,
     +                ZC1,ZC2,ZC3,CF1,CF2,CF3,PCF(2),PSCLD
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
      INTEGER IOFILE
      REAL I0,I1,I2,ISTAR,K
CP    LOGICAL DIAG
C
C     *** THIS SUBROUTINE CALCULATES THE PATH RADIANCES,
C         THE TRANSMITTED BACKROUND RADIANCES AND THE APPARENT
C         SPECTRAL CONTRASTS ALONG THE VARIOUS LINES OF SIGHT.
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-3-----------------------------
C RE-DIMENSION AND SAVE THE TRANSMISSION VALUE (TN) TO COMPUTE THE
C TRANSMITTED TARGET RADIANCE AT OBSERVER WITH AND WITHOUT CLOUDS
C     DIMENSION R(20),RAD(21),PD(20),TN(20)
      DIMENSION R(20),RAD(21),PD(20),TN(20,2)
      SAVE TN
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C     *** INITIALIZE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1-----------------------------
C SET IN/OUT OF CLOUD SHADOW FLAG
      II = I
      IF (II.GT.1) II = 2
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
      L = 0
      IER = 0
CP    WRITE(*,*)'NOBS AND NTARG ARE ',NOBS,NTARG
      DO 222  N = 1,NOBS
         DO 333 M = 1,NTARG
            L = L + 1
            DIST = 0.0
```

```
            SUM = 0.0
            ISTOP = 0
            CSTHOB = COS(THETOB(L) * DGTRD)
C
C           *** FOR UPWARD DIRECTED LINES OF SIGHT
C               FIND THE LEVEL IN WHICH THE OBSERVATION IS TAKEN
C               AND THE NUMBER OF LEVELS THRU WHICH THE TRANSMISSION
C               MUST BE CALCULATED
C
            IF(THETOB(L) .GE. 0.0 .AND. THETOB(L) .LT. 85.0) THEN
CP          WRITE(*,*)'UPWARD LINES OF SITE AND THETOB ',THETOB(L)
               DO 999  J = 1, NLEV
                  IF(Z(J) .GE. ZOB(N)) THEN
                     NLOCO = J
                  ENDIF
                  IF(Z(J) .GE. ZTARG(M)) THEN
                     NLOCT = J
                  ENDIF
 999           CONTINUE
               NP = NLOCO - NLOCT
C
               R(1) = 0.0
               DIST = (Z(NLOCO) - ZOB(N))
               R(2) = DIST / CSTHOB
               SUM = SUM + DIST / CSTHOB * BETA(NLOCO)
               SLP = DIST / CSTHOB
               TRV= 1.0 / BETA(NLOCO) * (1.0 - EXP(-R(2) * BETA(NLOCO)))
               TRV = TRV / SLP
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1-------------------------------
C RE-DIMENSIONED ARRAY ISTAR TO ACCOUNT FOR CLOUD CONTRIBUTION.
               RAD(1) = ISTAR(NLOCO,L,II)
               RAD(2) = ISTAR(NLOCO-1,L,II)
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-3-------------------------------
C RE-DIMENSIONED ARRAY TN TO ACCOUNT FOR CLOUD CONTRIBUTION.
             TN(1,II) = TRV
             IF(TN(1,II) .GE. .005) ISTOP = 1
             TN(2,II) = EXP(-SUM)
             IF(TN(2,II) .GE. .005) ISTOP = 2
             PD(1) = TN(1,II) * RAD(1)
             PD(2) = TN(2,II) * RAD(2)
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
               IF (NP .GT. 1) THEN
                  DO 888 J = 1, NP - 1
                     DIST =  Z(NLOCO-J) - Z(NLOCO-J+1)
                     R(J+2) = R(J+1) + DIST / CSTHOB
                     SLP = DIST / CSTHOB
                     TRV= 1.0 / BETA(NLOCO-J) *
     1                    (1.0 - EXP(-DIST * BETA(NLOCO-J) /
     2                     CSTHOB)) / SLP
                     SUM = SUM + DIST / CSTHOB * BETA(NLOCO-J)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1-------------------------------
C RE-DIMENSIONED ARRAY ISTAR TO ACCOUNT FOR CLOUD CONTRIBUTION.
                     RAD(J+2) = ISTAR(NLOCO-J-1,L,II)
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-3-------------------------------
C RE-DIMENSIONED ARRAY TN TO ACCOUNT FOR CLOUD CONTRIBUTION.
C                 TN(J+2,II) = TN(J+1,II) * TRV
                  TN(J+2,II) = EXP(-SUM)
                  PD(J+2) = TN(J+2,II) * RAD(J+2)
```

```
                 IF(TN(J+2,II) .GE. 0.005) ISTOP = J + 2
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
 888              CONTINUE
               ENDIF
               DIST = ZTARG(M) - Z(NLOCT+1)
CP             WRITE(*,*)'ZTARG AND ZNLOCT+1 ',ZTARG(M),Z(NLOCT+1)
               R(NP+2) = R(NP+1) + DIST / CSTHOB +.001
               SUM = SUM + DIST / CSTHOB * BETA(NLOCT)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1------------------------------
C RE-DIMENSIONED ARRAY ISTAR TO ACCOUNT FOR CLOUD CONTRIBUTION.
               RAD(NP+2) = ISTAR(NLOCT,L,II)
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-3------------------------------
C RE-DIMENSIONED ARRAY TN TO ACCOUNT FOR CLOUD CONTRIBUTION.
             TN(NP+2,II) = EXP(-SUM)
             PD(NP+2) = TN(NP+2,II) * RAD(NP+2)
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C              *** CALCULATE THE PATH RADIANCE FROM THE OBSERVER
C                  TO THE TARGETS ABOVE
C
C              *** INTEGRATE THE PATH FUNCTION FROM OBSERVER TO TARGET
C
               IF(ISTOP .LE. 1) STOP 'ISTOP'
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1------------------------------
C RE-DIMENSIONED ARRAY PTHRD TO ACCOUNT FOR CLOUD CONTRIBUTION.
               PTHRD(L,II) = SIMPNE(R,PD,ISTOP,IER)
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C              *** ADD TARGET TRANSMITTED RADIANCES
C
C              *** START WITH THE CONTRIBUTION FROM THE TARGET ILLUMINAT
C                  BY THE DIRECT BEAM USING SCALED OPTICAL DEPTH SO AS T
C                  INCLUDE THE FORWARD SCATTERED CONTRIBUTION HERE
C
               TAUTRG= TAUP(NLOCT) - (ZTARG(M) - Z(NLOCT+1))
     1                    * BETA(NLOCT) * (1.0 - A(NLOCT) *
     2                    G(NLOCT) * G(NLOCT))
CP             WRITE(*,*)'RTARG IS ',RTARG(M)
CP             WRITE(*,*)'CTARG IS ',CTARG(M)
CP             WRITE(*,*)'FNOT IS ',FNOT
CP             WRITE(*,*)'EXP IS ',EXP(-TAUTARG/UNOT)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1------------------------------
C RE-DIMENSIONED ARRAY SURF TO ACCOUNT FOR CLOUD CONTRIBUTION.
               SURF(L,I) = FNOT * CTARG(M) * RTARG(M) *
     1                       EXP (-TAUTRG / UNOT)
CP             WRITE(*,*)'UPWARD LOS SURF DIR IS ',SURF(L,I)
               IF (SURF(L,I) .LT. 0.0) SURF(L,I) = 0.0
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C              *** ADD THE CONTRIBUTION FROM THE TARGET ILLUMINATED BY
C                  THE DIFFUSE FLUX WHICH IS ASSUMED TO BE THE UPWARD FL
C                  UNLESS THE TARGET NORMAL IS HORIZONTAL IN WHICH CASE
C                  THE FLUX IS THE AVERAGE OF THE UPWARD AND DOWNWARD VA
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1------------------------------
C COMPUTE AVERAGE COMPONENTS OF DIFFUSE RADIANCE OVER ALL CLOUD
C SITUATIONS AND TOTAL RADIANCE FOR TARGET IN DIRECT LIGHT AND IN
C CLOUD SHADOW.  RE-DIMENSIONED ARRAYS SURF AND SURFO TO ACCOUNT FOR
C CLOUD CONTRIBUTION.
```

```
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-3-----------------------------
C RE-DIMENSIONED ARRAY TN TO ACCOUNT FOR CLOUD CONTRIBUTION.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-4-----------------------------
C STORE DIRECTIONALLY DEPENDENT DIFFUSE, DIRECTIONALLY INDEPENDENT
C DIFFUSE, AND DIRECT RADIANCE IN TEMPORARY VARIABLES FOR CORRECT
C COMPUTATION OF AVERAGE DIFFUSE RADIANCE FOR PARTICULAR CLOUD
C SITUATION.  USE TEMPORARY VARIABLES IN CALLS TO PCDIF.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-5-----------------------------
C MOVE TEMPORARY VARIABLES AND PCDIF CALLS TO DIFUSE SUBROUTINE.
C ELIMINATE DEPENDENCE ON THTARG.
            IF (I.EQ.MLOOP) THEN
                 CALL DIFUSE (L,NLOCT,SZA,AVEIO,AVEI1,CORR)
C
C                 IF(THTARG(M) .NE. 90.0) THEN
                    SURFO(L,1) = SURF(L,1) + RTARG(M) *
     1                            (AVEIO - 2.0 / 3.0 * AVEI1)
                    SURFO(L,2) = SURF(L,MLOOP) + RTARG(M) *
     1                            (AVEIO - 2.0 / 3.0 * AVEI1)
C                 ELSE
C                    SURFO(L,1) = SURF(L,1) +  AVEIO * RTARG(M)
C                    SURFO(L,2) = SURF(L,MLOOP) +  AVEIO * RTARG(M)
C                 ENDIF
CP               WRITE(*,*)'SURF DIR + DIF IS ',SURFO(L,1),SURFO(L,2)
C
C              *** MULTIPLY THE SURFACE RADIANCE BY THE TRANSMISSION FRO
C                  TARGET TO THE OBSERVER
C
CP               WRITE(*,*)'IO AND I1 IN SURF ARE ',AVEIO,AVEI1
CP               WRITE(*,*)'PTHRD AND SURFO IN CNTRST
',PTHRD(1,1),SURFO(1,1)
             SURF(L,1) = SURFO(L,1) * TN(NP+2,II)
             SURF(L,2) = SURFO(L,2) * TN(NP+2,II)
              ENDIF
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
C              *** ELSE FOR DOWNWARD LINES OF SIGHT
C                  FIND THE LEVEL IN WHICH THE OBSERVATION IS TAKEN
C                  AND THE NUMBER OF LEVELS THRU WHICH THE TRANSMISSION
C                  MUST BE CALCULATED
C
            ELSE IF (THETOB(L) .GT. 95.0) THEN
CP          WRITE(*,*)'DOWNWARD LINES OF SITE'
CP             WRITE(*,*)'PHIOB IS ',PHIOB(L)
CP             WRITE(*,*)'NLOCO AND NLOCT ',NLOCO,NLOCT
               DO 777  J = NLEV, 1, -1
                  IF(Z(J) .LE. ZOB(N)) THEN
                     NLOCO = J - 1
                  ENDIF
                  IF(Z(J) .LE. ZTARG(M)) THEN
                     NLOCT = J - 1
                  ENDIF
 777           CONTINUE
               NP = NLOCT - NLOCO
CP             WRITE(*,*)'NLOCO, NLOCT, AND NP ',NLOCO,NLOCT,NP
C
               R(1) = 0.0
               DIST =  (ZOB(N) - Z(NLOCO+1))
               SUM = SUM + DIST / ABS(CSTHOB) * BETA(NLOCO)
               R(2) = DIST / ABS(CSTHOB)
               SLP = DIST / ABS(CSTHOB)
               TRV= 1.0 / BETA(NLOCO) *
     1              (1.0 - EXP(-R(2) * BETA(NLOCO)))
               TRV = TRV / SLP
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1-----------------------------
```

```
C RE-DIMENSIONED ARRAY ISTAR TO ACCOUNT FOR CLOUD CONTRIBUTION.
               RAD(1) = ISTAR(NLOCO,L,II)
               RAD(2) = ISTAR(NLOCO+1,L,II)
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-3------------------------------
C RE-DIMENSIONED ARRAY TN TO ACCOUNT FOR CLOUD CONTRIBUTION.
             TN(1,II) = TRV
             TN(2,II) = EXP(-SUM)
             IF(TN(2,II) .GE. 0.005) ISTOP = 2
             PD(1) = RAD(1) * TN(1,II)
             PD(2) = RAD(2) * TN(2,II)
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
               IF(NP .GT. 1) THEN
                  DO 555  J = 1, NP - 1
                     DIST = Z(NLOCO+J) - Z(NLOCO+J+1)
                     R(J+2) = R(J + 1) + DIST / ABS(CSTHOB)
                     SLP = DIST / ABS(CSTHOB)
                     TRV= 1.0 / BETA(NLOCO-J) *
     1                    (1.0 - EXP(-DIST * BETA(NLOCO-J)
     2                    / ABS(CSTHOB))) / SLP
                     SUM = SUM + DIST / ABS(CSTHOB) * BETA(NLOCO+J)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1------------------------------
C RE-DIMENSIONED ARRAY ISTAR TO ACCOUNT FOR CLOUD CONTRIBUTION.
                     RAD(J+2) = ISTAR(NLOCO+J-1,L,II)
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-3------------------------------
C RE-DIMENSIONED ARRAY TN TO ACCOUNT FOR CLOUD CONTRIBUTION.
                 TN(J+2,II) = EXP(-SUM)
C                TN(J+2,II) = TN(J+1,II) * TRV
                 PD(J+2) = TN(J+2,II) * RAD(J+2)
                 IF(TN(J+2,II) .GE. 0.005) ISTOP = J + 2
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
 555              CONTINUE
               ENDIF
               DIST = Z(NLOCT) - ZTARG(M)
CP             WRITE(*,*)'R, NP ',R,NP
CP             WRITE(*,*)'R(NP+1) ',R(NP+1)
CP             WRITE(*,*)'ZLOCT, ZTARG ',Z(NLOCT),ZTARG(M)
CP             WRITE(*,*)'DIST, CSTHOB ',DIST,CSTHOB
               R(NP+2) = R(NP+1) + DIST / ABS(CSTHOB) + .001
               SUM = SUM + DIST / ABS(CSTHOB) * BETA(NLOCT)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1------------------------------
C RE-DIMENSIONED ARRAY ISTAR TO ACCOUNT FOR CLOUD CONTRIBUTION.
               RAD(NP+2) = ISTAR(NLOCT,L,II)
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-3------------------------------
C RE-DIMENSIONED ARRAY TN TO ACCOUNT FOR CLOUD CONTRIBUTION.
             TN(NP+2,II) = EXP(-SUM)
             PD(NP+2) = RAD(NP+2) * TN(NP+2,II)
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C              *** CALCULATE THE PATH RADIANCE TO THE TARGETS BELOW
C
C              *** INTEGRATE PATH FUNTION FROM OBSERVER TO TARGET
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1------------------------------
C RE-DIMENSIONED ARRAY PTHRD TO ACCOUNT FOR CLOUD CONTRIBUTION.
               PTHRD(L,II) = SIMPNE(R,PD,ISTOP,IER)
```

```
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C              *** ADD TARGET TRANSMITTED RADIANCES
C                  FIRST CALCULATE THE INHERENT RADIANCES DUE TO THE
C                  DIRECT BEAM AND FORWARD SCATTERED COMPONENT
C
               TAUTGP = TAUP(NLOCT) - (ZTARG(M) - Z(NLOCT+1))
     1                   * BETA(NLOCT) * (1.0 - A(NLOCT) *
     2                    G(NLOCT) * G(NLOCT))
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1--------------------------------
C RE-DIMENSIONED ARRAY SURF TO ACCOUNT FOR CLOUD CONTRIBUTION.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-5--------------------------------
C USE DELTA-EDDINGTON OPTICAL DEPTH, RATHER THAN REGULAR OPTICAL
C OPTICAL DEPTH, IN DIRECT RADIANCE CALCULATION.  ELIMINATE REGULAR
C OPTICAL DEPTH AND ADDIFF VARIABLE FROM CALCULATION.  SCALED OPTICAL
C DEPTH INCLUDES FORWARD SCATTERED COMPONENT.
C               TAUTRG= TAU(NLOCT) - (ZTARG(M) - Z(NLOCT+1))
C     1                   * BETA(NLOCT)
C               ADDIFF = FNOT * UNOT
C     1                  * (EXP(-TAUTGP / UNOT) - EXP(-TAUTRG/ UNOT))
C               SURF(L,I) = FNOT * CTARG(M) * RTARG(M) *
C     1                      EXP (-TAUTRG / UNOT)
               SURF(L,I) = FNOT * CTARG(M) * RTARG(M) *
     1                      EXP (-TAUTGP / UNOT)
CP             WRITE(*,*)'DOWNWARD LOS SURF DIR IS ',SURF(L,I)
CP             WRITE(*,*)'FNOT,UNOT,TAUTGP, ',FNOT,UNOT,TAUTGP
CP             WRITE(*,*)'TAUTRG,CTARG,RTARG ',TAUTRG,CTARG(M),RTARG(M)
               IF (SURF(L,I) .LT. 0.0) SURF(L,I) = 0.0
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C              *** ADD THE INHERENT RADIANCE DUE TO THE AVERAGE OF THE U
C                  DOWNWARD DIFFUSE TERMS UNLESS THE UNIT NORMAL IS VERT
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1------------------------------
C COMPUTE AVERAGE COMPONENTS OF DIFFUSE RADIANCE OVER ALL CLOUD
C SITUATIONS AND TOTAL RADIANCE FOR TARGET IN DIRECT LIGHT AND IN
C CLOUD SHADOW.  RE-DIMENSIONED ARRAYS SURF AND SURFO TO ACCOUNT FOR
C CLOUD CONTRIBUTION.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-3------------------------------
C RE-DIMENSIONED ARRAY TN TO ACCOUNT FOR CLOUD CONTRIBUTION.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-4------------------------------
C STORE DIRECTIONALLY DEPENDENT DIFFUSE, DIRECTIONALLY INDEPENDENT
C DIFFUSE, AND DIRECT RADIANCE IN TEMPORARY VARIABLES FOR CORRECT
C COMPUTATION OF AVERAGE DIFFUSE RADIANCE FOR PARTICULAR CLOUD
C SITUATION.  USE TEMPORARY VARIABLES IN CALLS TO PCDIF.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-5------------------------------
C MOVE TEMPORARY VARIABLES AND PCDIF CALLS TO DIFUSE SUBROUTINE.
C ELIMINATE DEPENDENCE ON THTARG.  MODIFY DOWNWARD DIFFUSE EQUATION
C TO MATCH EOTDA.
            IF (I.EQ.MLOOP) THEN
                 CALL DIFUSE (L,NLOCT,SZA,AVEIO,AVEI1,CORR)
C
C                 IF(THTARG(M) .EQ. 0.0) THEN
C                    SURFO(L,1) = SURF(L,1) + RTARG(M) *
C     1                           (F(NLOCT) / PI + ADDIFF)
C                    SURFO(L,2) = SURF(L,MLOOP) + RTARG(M) *
C     1                           (F(NLOCT) / PI + ADDIFF)
                    SURFO(L,1) = SURF(L,1) + RTARG(M) *
     1                          (AVEIO + 2.0 / 3.0 * AVEI1 + CORR)
                    SURFO(L,2) = SURF(L,MLOOP) + RTARG(M) *
     1                          (AVEIO + 2.0 / 3.0 * AVEI1 + CORR)
C                 ELSE
C                    SURFO(L,1) = SURF(L,1) + RTARG(M) * (AVEIO +
C     1                           ADDIFF / 2.0)
```

```
C                    SURFO(L,2) = SURF(L,MLOOP) + RTARG(M) * (AVEIO +
C     1                           ADDIFF / 2.0)
C                 ENDIF
CP               WRITE(*,*)'SURF DIR + DIF IS ',SURFO(L,1),SURFO(L,2)
CP               WRITE(*,*)'IO AND ADDIFF ARE ',AVEIO,ADDIFF
C
C              *** MULTIPLY BY THE TRANSMITTANCE BETWEEN THE TARGET AND
C                  OBSERVER
C
CP               WRITE(*,*)'PTHRD AND SURFO IN CNTRST ',PTHRD(1),SURFO(1)
             SURF(L,1) = SURFO(L,1) * TN(NP+2,II)
             SURF(L,2) = SURFO(L,2) * TN(NP+2,II)
              ENDIF
C-HSTX---SCENE SHADOWS----------------------------------------------------
C
C              *** ELSE IF THE OBSERVATION ANGLE IS NEARLY HORIZONTAL US
C                  MODIFIED PATH INTEGRATION TO FIND PATH RADIANCE
C
            ELSE IF(THETOB(L) .GE. 85.0 .AND. THETOB(L) .LE. 95.0) THEN
CP          WRITE(*,*)'HORIZONTAL LINE OF SIGHT'
CP             WRITE(*,*)'PHIOB IS ',PHIOB(L)
               DO 444  J = NLEV, 1, -1
                  IF(Z(J) .LE. ZOB(N)) THEN
                     NLOCO = J - 1
                  ENDIF
                  IF(Z(J) .LE. ZTARG(M)) THEN
                     NLOCT = J - 1
                  ENDIF
444            CONTINUE
               NP = NLOCT - NLOCO
C
               DIST =  (ZOB(N) - ZTARG(M))**2 +
     1                 (YOB(N) - YTARG(M))**2 + (XOB(N) - XTARG(M))**2
               DIST = SQRT(DIST)
               DEFAC = (1.0 - A(NLOCO) * G(NLOCO) * G(NLOCO))
               DEFAC = 1.0
               SUM =  DIST * BETA(NLOCO) * DEFAC
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1-------------------------------
C RE-DIMENSIONED ARRAY ISTAR TO ACCOUNT FOR CLOUD CONTRIBUTION.
               RAD(1) = ISTAR(NLOCO,L,II)
C-HSTX---SCENE SHADOWS------------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-3-------------------------------
C RE-DIMENSIONED ARRAY TN TO ACCOUNT FOR CLOUD CONTRIBUTION.
             TN(1,II) = EXP(-SUM)
             PD(1) = RAD(1) * TN(1,II)
C-HSTX---SCENE SHADOWS------------------------------------------------
C
C              *** CALCULATE THE PATH RADIANCE TO THE TARGETS
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1-------------------------------
C RE-DIMENSIONED ARRAY PTHRD TO ACCOUNT FOR CLOUD CONTRIBUTION.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-3-------------------------------
C RE-DIMENSIONED ARRAY TN TO ACCOUNT FOR CLOUD CONTRIBUTION.
             PTHRD(L,II) = RAD(1) * (1.0 - TN(1,II)) / BETA(NLOCO)
C-HSTX---SCENE SHADOWS------------------------------------------------
C
C              *** ADD TARGET TRANSMITTED RADIANCES
C                  FIRST CALCULATE THE INHERENT RADIANCES DUE TO THE
C                  DIRECT BEAM AND FORWARD SCATTERED COMPONENT
C
               TAUTGP = TAUP(NLOCT) - (ZTARG(M) - Z(NLOCT+1))
     1                    * BETA(NLOCT) * (1.0 - A(NLOCT) *
     2                    G(NLOCT) * G(NLOCT))
```

```
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1------------------------------
C RE-DIMENSIONED ARRAY SURF TO ACCOUNT FOR CLOUD CONTRIBUTION.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-5--------------------------------
C USE DELTA-EDDINGTON OPTICAL DEPTH, RATHER THAN REGULAR OPTICAL
C OPTICAL DEPTH, IN DIRECT RADIANCE CALCULATION.  ELIMINATE REGULAR
C OPTICAL DEPTH AND ADDIFF VARIABLE FROM CALCULATION.  SCALED OPTICAL
C DEPTH INCLUDES FORWARD SCATTERING COMPONENT.
C               TAUTRG= TAU(NLOCT) - (ZTARG(M) - Z(NLOCT+1))
C     1                   * BETA(NLOCT)
C               ADDIFF = FNOT * UNOT
C     1                  * (EXP(-TAUTGP / UNOT) - EXP(-TAUTRG/ UNOT))
C               SURF(L,I) = FNOT * CTARG(M) * RTARG(M) *
C     1                      EXP (-TAUTRG / UNOT)
               SURF(L,I) = FNOT * CTARG(M) * RTARG(M) *
     1                      EXP (-TAUTGP / UNOT)
CP             WRITE(*,*)'HORIZONTAL LOS SURF DIR IS ',SURF(L,I)
               IF (SURF(L,I) .LT. 0.0) SURF(L,I) = 0.0
C-HSTX---SCENE SHADOWS-----------------------------------------------
C
C              *** ADD THE INHERENT RADIANCE DUE TO THE AVERAGE OF THE U
C                  DOWNWARD DIFFUSE TERMS UNLESS THE UNIT NORMAL IS VERT
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-1------------------------------
C COMPUTE AVERAGE COMPONENTS OF DIFFUSE RADIANCE OVER ALL CLOUD
C SITUATIONS AND TOTAL RADIANCE FOR TARGET IN DIRECT LIGHT AND IN
C CLOUD SHADOW.  RE-DIMENSIONED ARRAYS SURF AND SURFO TO ACCOUNT FOR
C CLOUD CONTRIBUTION.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-3------------------------------
C RE-DIMENSIONED ARRAY TN TO ACCOUNT FOR CLOUD CONTRIBUTION.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-4------------------------------
C STORE DIRECTIONALLY DEPENDENT DIFFUSE, DIRECTIONALLY INDEPENDENT
C DIFFUSE, AND DIRECT RADIANCE IN TEMPORARY VARIABLES FOR CORRECT
C COMPUTATION OF AVERAGE DIFFUSE RADIANCE FOR PARTICULAR CLOUD
C SITUATION.  USE TEMPORARY VARIABLES IN CALLS TO PCDIF.
C-HSTX---SCENE SHADOWS---ECR # HSTX-8-5------------------------------
C MOVE TEMPORARY VARIABLES AND PCDIF CALLS TO DIFUSE SUBROUTINE.
C ELIMINATE DEPENDENCE ON THTARG.  MODIFY HORIZONTAL DIFFUSE EQUATION
C TO BE AVERAGE OF UPWARD AND DOWNWARD.  CORRECT TRANSMITTANCE TO BE
C TN(1,1) AND TN(1,2) FOR HORIZONTAL LINE-OF-SIGHT, RATHER THAN
C TN(NP+2,1) AND TN(NP+2,2).
            IF (I.EQ.MLOOP) THEN
                 CALL DIFUSE (L,NLOCT,SZA,AVEIO,AVEI1,CORR)
C
C                 IF(THTARG(M) .EQ. 0.0) THEN
C                    SURFO(L,1) = SURF(L,1) + RTARG(M) *
C     1                            (F(NLOCT) / PI + ADDIFF)
C                    SURFO(L,2) = SURF(L,MLOOP) + RTARG(M) *
C     1                            (F(NLOCT) / PI + ADDIFF)
                    SURFO(L,1) = SURF(L,1) + RTARG(M) *
     1                            (AVEIO + CORR / 2.0)
                    SURFO(L,2) = SURF(L,MLOOP) + RTARG(M) *
     1                            (AVEIO + CORR / 2.0)
C                 ELSE
C                    SURFO(L,1) = SURF(L,1) + RTARG(M) * (AVEIO +
C     1                       ADDIFF / 2.0)
C                    SURFO(L,2) = SURF(L,MLOOP) + RTARG(M) * (AVEIO +
C     1                       ADDIFF / 2.0)
C                 ENDIF
CP               WRITE(*,*)'SURF DIR + DIF IS ',SURFO(L,1),SURFO(L,2)
CP               WRITE(*,*)'IO, ADDIFF, AND F ARE ',AVEIO,
CP   &             ADDIFF,F(NLOCT)
C
C              *** MULTIPLY BY THE TRANSMITTANCE BETWEEN THE TARGET AND
C                  OBSERVER
```

```
C
CP              WRITE(*,*)'PTHRD AND SURFO IN CNTRST',PTHRD(1,1),SURFO(1,1)
              SURF(L,1) = SURFO(L,1) * TN(1,1)
              SURF(L,2) = SURFO(L,2) * TN(1,2)
               ENDIF
C-HSTX---SCENE SHADOWS------------------------------------------------------
C
          ELSE
            IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
            WRITE(IOOUT,*) ' OBSERVATION ANGLE OUT OF RANGE '
            ENDIF
            IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
            WRITE(NDIRTU,*) ' OBSERVATION ANGLE OUT OF RANGE '
            ENDIF
            ENDIF
333      CONTINUE
222   CONTINUE
      RETURN
      END
C
C          <END OF UNIT: CONTRAST>
C
```

ECR # HSTX - 9 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: GETCLD Old Date: New

File Name: GETCLD.FOR New Date: 8/17/93

Implemented By: Don Hamann

Reason for Revision: New routine to set the atmospheric data for the cloud layers found.

Description of Revision: If there are three cloud layers, call COMBIN to combine the middle and high layers. Define the cloud base height, fraction, extinction coefficient, and asymmetry parameter for the remaining cloud layers. Find the atmospheric layer containing each cloud. Set the number of cloud situations.

Notes: It is assumed that the sensor is not in a cloud layer. It is also assumed that, for this routine to be called, there is at least one cloud layer.

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 9 - 2

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: GETCLD

Old Date: 8/17/93

File Name: GETCLD.FOR

New Date: 8/27/93

Implemented By: Don Hamann

Reason for Revision: To generate values for the probability of a cloud-free path through the cloud layers and the probability that the target scene is in direct light.

Description of Revision: Added variable PSCLD and array PCF(2) to the CLOUD COMMON block. Added the GEOM COMMON block to access the variable THETO and the BCONST COMMON block to access the variable DGTRD, which are both used to compute the probability. Methodology based on Allen and Malick (1983).

Notes: Assume that the target is below all input cloud layers.

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 9 - 3

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: GETCLD

Old Date: 8/27/93

File Name: GETCLD.FOR

New Date: 9/14/93

Implemented By: Michael Oberlatz

Reason for Revision: The unit conversion for the cloud base heights from feet to kilometers is no longer needed, since the heights are input in kilometers rather than feet.

Description of Revision: The unit conversion is commented out.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 9 - 4

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: GETCLD
Old Date: 9/14/93

File Name: GETCLD.FOR
New Date: 9/15/93

Implemented By: Melanie J. Gouveia

Reason for Revision: Fix the error that, for clear sky cases, gave 100.0 for the probability that the target is in cloud shadow. Also fix the error in the determination of the number of cloud situations.

Description of Revision: Remove the initialization of the probability that the target is in direct light to 100.0; this is now done in STG. Set MLOOP = 1 for 2 clear layers, 1 overcast and 1 clear layer, and 2 overcast layers. Set MLOOP = 2 for 1 partly cloudy layer and 1 clear, and 1 partly cloudy layer and 1 overcast. Set MLOOP = 4 for 2 partly cloudy layers.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 9 - 5

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: GETCLD

Old Date: 9/15/93

File Name: GETCLD.FOR

New Date: 9/17/93

Implemented By: Don Hamann

Reason for Revision: In order to prevent uninitialized data from corrupting the proper execution of the program, all cloud shadow parameters are reset. Added flag to keep track of the cloud situation.

Description of Revision: Added variable ICLDF to CLOUD COMMON block to maintain information on cloud situation. Set ICLDF, depending on number of clouds and cloud fractions. Reset CLDBTA, CLDG, LYRCLD, PCF, cloud fraction, base height, thickness, and type as necessary.

Notes: ICLDF flag = 1 for two clear layers, 2 for one overcast layer, 3 for two overcast layers, 4 for one clear layer and one partly cloudy, 5 for one overcast layer and one partly cloudy, and 6 for two partly cloudy layers.

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 9 - 6

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: GETCLD
Old Date: 9/17/93

File Name: GETCLD.FOR
New Date: 10/20/93

Implemented By: Don Hamann

Reason for Revision: Cloud information is reorganized in GETCLD to facilitate more efficient processing. The cloud thickness and cloud type variables were not properly assigned during the reorganization process in GETCLD.

Description of Revision: Reset the array values for cloud type, ITY, and cloud thickness, THK, according to an array of cloud indices, INXCLD.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C-HSTX---SCENE SHADOWS---ECR # HSTX-9-1-------------------------------------
C NEW ROUTINE TO SET ATMOSPHERIC DATA FOR LAYERS CONTAINING CLOUDS.
C-HSTX---SCENE SHADOWS------------------------------------------------------
C
C***************************************************************************
C<BEGIN>
C<IDENTIFICATION>       NAME: GETCLD
C                       TYPE: FORTRAN SUBROUTINE
C                     FILENAME:     GETCLD.FOR
C
C===========================================================================
=
C<DESCRIPTION>
C           GETCLD defines the number of cloud layers, asymmetry
C           parameters, and the extinction coefficients for the cloud
C           layers found.  GETCLD determines the probability of a cloud
C           free path.  GETCLD also calls COMBIN to combine three
C           cloud layer properites into two cloud layer properties if
C           there are more than two cloud layers.  It is assumed that
C           the sensor is not in a cloud layer.
C===========================================================================
C<INPUT>
C     COMMON BLOCK VARIABLES:
C       / CLOUD / ITY1, ITY2, ITY3 Cloud types for each cloud layer.
C       / CLOUD / CF1,  CF2,  CF3 Cloud cover fractions for each cloud.
C       / CLOUD / ZC1,  ZC2,  ZC3 Cloud base heights for each cloud.
C       / CLOUD / THK1, THK2, THK3 Cloud thickness for each cloud.
C       / GEOM  / THETO            Zenith angle of illumination source
C                                  (deg).
C       / BCONST/ DGTRD            Degrees to radians conversion factor.
C===========================================================================
=
C<OUTPUT>
C     COMMON BLOCK VARIABLES:
C       / CLOUD / ICLDF     Cloud situation index.
C       / CLOUD / NUMCLD    Number of cloud layers.
C       / CLOUD / CLDBTA    Array of cloud extinction coefficients.
C       / CLOUD / CLDG      Array of cloud asymmetry parameters.
C       / CLOUD / LYRCLD    Array of layer position of clouds.
C       / CLOUD / CF1, CF2  High and low cloud fractions.
C       / CLOUD / ZC1, ZC2  High and low cloud base heights.
C       / CLOUD / ITY1,ITY2 High and low cloud types.
C       / CLOUD / PCF(2)    High and low cloud-free path probability.
C       / CLOUD / PSCLD     Probability that target is in direct light.
C===========================================================================
C<CALLED ROUTINES>
C      COMBIN - (SUBROUTINE) COMBINES MIDDLE AND HIGH CLOUDS INTO
C           ONE CLOUD LAYER.
C===========================================================================
C<PARAMETER>
C    CALLING SEQUENCE:
C        GETCLD
C===========================================================================
C<HISTORY>
C  CREATED AUGUST, 1993.  HUGHES STX CORPORATION.
C===========================================================================
C<END>
C
C List of variables:
C      AMT  Cloud fraction for a particular layer. (0.0 - 1.0)
C      CB   Array of cloud extinction coefficients for five cloud types.
C      CF   Array of cloud fractions. (fraction 0-1)
C           I = 1 for upper cloud layer.
C           I = 2 for lower cloud layer.
C      CG   Array of cloud asymmetry parameters for five cloud types.
```

```
C      CLDBTA Array of extinction coefficients.
C           I = 1 for upper cloud layer
C           I = 2 for lower cloud layer.
C      CLDG Array of cloud asymmetry parameters.
C           I = 1 for upper cloud layer.
C           I = 2 for lower cloud layer.
C      CN   Intermediate variable.
C      DGTRD Degrees to radians conversion factor.
C      ICLD Cloud index.
C      ICLDF Cloud situation index.
C           ICLDF = 1 two clear layers
C           ICLDF = 2 one overcast layer
C           ICLDF = 3 two overcast layers
C           ICLDF = 4 one clear layer, one partly cloudy layer
C           ICLDF = 5 one overcast layer, one partly cloudy layer
C           ICLDF = 6 two partly cloudy layers
C      ILR  Array of cloud types. (1-5)
C           I = 1 for upper cloud layer.
C           I = 2 for lower cloud layer.
C           ILR = 1 Thin Ci  (high)
C           ILR = 2 Thick Ci (high)
C           ILR = 3 As/Ac    (middle)
C           ILR = 4 St/Sc    (low)
C           ILR = 5 Cu/Cb    (low)
C      INXCLD Array of cloud indices.
C           I = 1 for upper cloud layer
C           I = 2 for lower cloud layer.
C      LYRCLD Array of layer position of clouds.
C           I = 1 for upper cloud layer.
C           I = 2 for lower cloud layer.
C      N    Cloud layer index.
C      NLEV Number of layers in atmosphere.
C      NUMCLD Number of cloud layers.
C      PN   Intermediate variable.
C      PCF  Array of probability of cloud-free path. (0.0 - 1.0)
C           I = 1 for upper cloud layer.
C           I = 2 for lower cloud layer.
C      PSCLD Probability of target in direct light. (0.0 - 100.0)
C      THETO Solar zenith angle. (degrees)
C      Z    Array of atmospheric layer heights. (1000 ft.)
C      ZC   Array of cloud base heights. (km)
C           I = 1 for upper cloud layer.
C           I = 2 for lower cloud layer.
C      ZCLOUD Cloud base height. (km)
C
      SUBROUTINE GETCLD
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-9-2----------------------------------
C ADDED VARIABLE PSCLD AND ARRAY PCF(2) TO CLOUD COMMON BLOCK TO MAINTAIN
C INFORMATION ON PROBABILITY OF CLOUD-FREE PATH THROUGH EACH CLOUD LAYER
C AND THE PROBABILITY OF THE TARGET IN DIRECT LIGHT.  ADDED GEOM COMMON
C BLOCK TO ACCESS VARIABLE THETO AND BCONST COMMON BLOCK TO ACCESS
C VARIABLE DGTRD.
C-HSTX---SCENE SHADOWS---ECR # HSTX-9-5----------------------------------
C ADDED VARIABLE ICLDF TO CLOUD COMMON BLOCK TO MAINTAIN INFORMATION ABOUT
C CLOUD SITUATION.
C     COMMON /CLOUD/NUMCLD, MLOOP, CLDBTA(2),CLDG(2), LYRCLD(2),
C    +              THK1, THK2, THK3, ITY1, ITY2, ITY3,
C    +              ZC1, ZC2, ZC3, CF1, CF2, CF3
      COMMON /CLOUD/ICLDF,NUMCLD, MLOOP, CLDBTA(2),CLDG(2), LYRCLD(2),
     +              THK1, THK2, THK3, ITY1, ITY2, ITY3,
     +              ZC1, ZC2, ZC3, CF1, CF2, CF3, PCF(2), PSCLD
      COMMON/GEOM/  THETO,PHIO,UNOT,XLAM,NOBS,PHI(30),BTA(30),NLOS,
     +              XOB(30),YOB(30),ZOB(30),THETOB(30),PHIOB(30)
      COMMON/BCONST/DGTRD,LUOUT,LUIN
```

```
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
      COMMON/ATMOS/PRES(21),Z(21),RHO(21),NLEV,NLAY
C
      DIMENSION CG(5),CB(5),INXCLD(2),CF(3),ZC(3),ITY(3),THK(3)
C
      LOGICAL SET(2) /.FALSE., .FALSE./
C
C     SET COMMON VALUES TO ARRAY NOTATION FOR CONVENIENT MANIPULATION
C
      EQUIVALENCE ( ZC1, ZC(1) ),   ( CF1, CF(1) ),
     +              ( ITY1, ITY(1) ), ( THK1, THK(1) )
      EQUIVALENCE ( ZC2, ZC(2) ),   ( CF2, CF(2) ),
     +              ( ITY2, ITY(2) ), ( THK2, THK(2) )
      EQUIVALENCE ( ZC3, ZC(3) ),   ( CF3, CF(3) ),
     +              ( ITY3, ITY(3) ), ( THK3, THK(3) )
C
C     EXTINCTION COEFFICIENTS FOR THE FIVE CLOUD TYPES
C
      DATA CB/1.40, 2.40, 8.80, 2.80, 8.13/
C
C     ASYMMETRY PARAMETERS FOR THE FIVE CLOUD TYPES
C
      DATA CG/0.85, 0.85, 0.85, 0.85, 0.85/
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-9-2----------------------------------
C INITIALIZE PROBABILITY THAT TARGET IS IN DIRECT LIGHT (NO CLOUDS).
C-HSTX---SCENE SHADOWS---ECR # HSTX-9-4----------------------------------
C REMOVE INITIALIZATION FOR PROBABILITY THAT TARGET IS IN DIRECT LIGHT.
C THIS IS NOW DONE IN STG.
C       PSCLD = 100.
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
C     INITIALIZE CLOUD OUTPUTS BASED ON NUMBER OF CLOUDS FOUND.
C
      IF ( NUMCLD .EQ. 3 .OR. NUMCLD .EQ. 2 ) THEN
C
C     IF NUMBER OF CLOUD LAYERS IS THREE COMBINE THREE CLOUD LAYERS
C     INTO TWO CLOUD LAYERS.
C
      IF ( NUMCLD .EQ. 3 ) THEN
C
C       NOTE: SENSOR IS ASSUMED TO BE BELOW MIDDLE CLOUDS
C
C       COMBINE HIGH AND MIDDLE CLOUDS
C
        ILO = 2
        IHI = 1
C
        CFLO = CF(ILO)
        TKLO = THK(ILO)
        BALO = CB(ITY(ILO))
        CGLO = CG(ITY(ILO))
        HTLO = ZC(ILO)
C
        CFHI = CF(IHI)
        TKHI = THK(IHI)
        BAHI = CB(ITY(IHI))
        CGHI = CG(ITY(IHI))
C
        CALL COMBIN(CFLO,  TKLO,  BALO,  CGLO,  HTLO,
     +                  CFHI,  TKHI,  BAHI,  CGHI,
     +                  CFNEW, TKNEW, BANEW, CGNEW, HTNEW, NUMCLD )
C
        CLDBTA(ILO) = BANEW
```

```
          CLDG(ILO)     = CGNEW
          THK(ILO)      = TKNEW
          CF(ILO)       = CFNEW
          CF(IHI)       = CFHI
C
C         INDICATE CLDBTA AND CLDG VALUES HAVE BEEN COMPUTED.
C
          SET(ILO) = .TRUE.
C
        END IF
C
C       SET LAYER INDICES FOR CLOUD PROPERTIES AT THE PROPER CLOUD LAYER
C
        IF (CF3 .GT. 0.0) INXCLD(2) = 3
        IF (CF1 .GT. 0.0) INXCLD(1) = 1
        IF (CF2 .GT. 0.0 .AND. CF3 .GT. 0.0) INXCLD(1) = 2
        IF (CF2 .GT. 0.0 .AND. CF1 .GT. 0.0) INXCLD(2) = 2
C
        ELSE IF ( NUMCLD .EQ. 1 ) THEN
C
C       SET LAYER INDICES FOR CLOUD PROPERTIES AT THE PROPER CLOUD LAYER
C
        DO 10 ICLD = 1,3
          IF ( CF(ICLD) .GT. 0.0 ) INXCLD(1) = ICLD
 10     CONTINUE
C
        ELSE
C
C       ERROR IN NUMBER OF CLOUD LEVELS DETECTED.
C
        RETURN
C
        END IF
C
C       LOOP ON NUMBER OF CLOUD LAYERS
C
        DO 30 ICLD = 1, NUMCLD
C
C       DEFINE CLOUD BOTTOM.
C
        ZC(ICLD) = ZC(INXCLD(ICLD))
C
C       DEFINE THE CLOUD FRACTION.
C
        CF(ICLD) = CF(INXCLD(ICLD))
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-9-6-----------------------------------
C ASSIGN THE THICKNESS AND CLOUD TYPE ACCORDING TO THE CLOUD INDEX
C VARIABLE.
C
C       DEFINE THE CLOUD THICKNESS
C
        THK(ICLD) = THK(INXCLD(ICLD))
C
C       DEFINE THE CLOUD TYPE
C
        ITY(ICLD) = ITY(INXCLD(ICLD))
C-HSTX---SCENE SHADOWS-----------------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-9-2-----------------------------------
C COMPUTE PROBABILITY OF A CLOUD-FREE SOLAR PATH AS EXPRESSED BY ALLEN
C AND MALICK, 1983.  ALSO CALCULATE PROBABILITY OF TARGET IN DIRECT LIGHT.
          AMT = CF(ICLD)
          PN = 1.0 - AMT * (1.0 + 3.0 * AMT) / 4.0
          CN = 0.55 - AMT / 2.0
```

```
          PCF(ICLD) = PN**(1.0 + CN * TAN(THETO * DGTRD))
          PSCLD = PSCLD * PCF(ICLD)
C-HSTX---SCENE SHADOWS--------------------------------------------------
C
C     DEFINE THE CLOUD EXTINCTION COEFFICIENT UNLESS PREVIOUSLY SET.
C
      IF ( .NOT. SET(ICLD) ) CLDBTA(ICLD) = CB(ITY(INXCLD(ICLD)))
C
C     DEFINE THE CLOUD ASYMMETRY PARAMETER UNLESS PREVIOUSLY SET.
C
      IF ( .NOT. SET(ICLD) ) CLDG(ICLD) = CG(ITY(INXCLD(ICLD)))
C
C     DETERMINE THE ATMOSPHERIC LAYER IN WHICH THE CLOUD IS FOUND.
C     NOTE: LOGIC MIRRORS TARGAC CODE PREVIOUSLY CONTAINED IN ROUTINE STG.
C
      IF ( CF(ICLD) .GT. 0.0 ) THEN
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-9-3----------------------------------
C REMOVED THE UNIT CONVERSION SINCE THE VALUE IS ALREADY ENTERED IN KM
C         ZCLOUD = ZC(ICLD) * 0.0003048
        ZCLOUD = ZC(ICLD)
C-HSTX---SCENE SHADOWS-------------------------------------------------
C
      ELSE
        ZCLOUD = 40.0
      END IF
C
      DO 20 N = 1, NLEV
        IF ( ZCLOUD .LT. Z(N) ) LYRCLD(ICLD) = N
 20   CONTINUE
C
 30   CONTINUE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-9-4---------------------------------
C CORRECT DETERMINATION OF THE NUMBER OF CLOUD SITUATIONS.
C     MLOOP = 1
C         One iteration of the loop for the conditions:
C           both layers clear
C           one layer overcast, one layer clear
C           both layers overcast
C     MLOOP = 2
C         Two iterations of the loop for the conditons:
C           one partly cloudy layer, one clear layer
C           one partly cloudy layer, one overcast layer
C
C           First iteration for:
C               two clear layers
C               one overcast layer, one clear layer
C           Second iteration for:
C               one clear layer, one overcast layer
C               two overcast layers
C     MLOOP = 4
C         Four iterations of the loop for the conditon:
C           two partly cloudy layers
C
C           First iteration for:
C               two clear layers
C           Second iteration for:
C               high cloud layer only
C           Third iteration for:
C               low cloud layer only
C           Fourth iteration for:
C               both cloud layers
C-HSTX---SCENE SHADOWS---ECR # HSTX-9-5---------------------------------
C DETERMINE AND SAVE THE CLOUD SITUATION FLAG.
```

```
      IF ( NUMCLD .EQ. 1 ) THEN
         IF ( CF1 .EQ. 1.0 .OR. CF2 .EQ. 1.0 ) THEN
          MLOOP = 1
          ICLDF = 2
         ELSE
          MLOOP = 2
          ICLDF = 4
         END IF
      ELSE IF ( NUMCLD .EQ. 2 ) THEN
         IF ( CF1 .EQ. 1.0 .AND. CF2 .EQ. 1.0 ) THEN
          MLOOP = 1
          ICLDF = 3
        ELSE IF ( CF1 .NE. 1.0 .AND. CF2 .NE. 1.0 ) THEN
          MLOOP = 4
          ICLDF = 6
         ELSE
          MLOOP = 2
          ICLDF = 5
         END IF
      END IF
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-9-5----------------------------------
C ZERO OUT VALUES FOR CLEAR LAYERS.
      DO 40 ICLD = NUMCLD+1, 3
      CF(ICLD)  = 0.0
      ZC(ICLD)  = 0.0
      THK(ICLD) = 0.0
      ITY(ICLD) = 0
      IF ( ICLD .EQ. 2 ) THEN
        CLDBTA(ICLD) = 0.0
        CLDG(ICLD)   = 0.0
        LYRCLD(ICLD) = 0
        PCF(ICLD)    = 1.0
      END IF
40    CONTINUE
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
      RETURN
      END
```

ECR # HSTX - 10 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: PCDIF

Old Date: New

File Name: PCDIF.FOR

New Date: 8/17/93

Implemented By: Dan DeBenedictis

Reason for Revision: New routine to compute average partly cloudy diffuse radiance or correction for forward scattering.

Description of Revision: Computes radiance as a weighted average of up to four possible cloud situations: two clear layers, upper overcast and lower clear, upper clear and lower overcast, and two overcast layers. Methodology based on Hering and Johnson (1984).

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 10 - 2

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: PCDIF

Old Date: 8/17/93

File Name: PCDIF.FOR

New Date: 9/17/93

Implemented By: Don Hamann

Reason for Revision: Array of direct radiance values entering subroutine was changed to a one-dimensional array. This was done to correctly align the stored radiance values for the cloud situation currently being examined.

Description of Revision: Re-dimensioned two-dimensional array, HS, to a one-dimensional array containing four values for possible cloud situations.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C-HSTX---SCENE SHADOWS---ECR # HSTX-10-1--------------------------------
C NEW ROUTINE TO COMPUTE AVERAGE PARTLY CLOUDY DIFFUSE RADIANCE.
C-HSTX---SCENE SHADOWS--------------------------------------------------
C************************************************************************
C<BEGIN>
C<IDENTIFICATION>   NAME:   PCDIF
C                    TYPE:  FORTRAN SUBROUTINE
C                 FILENAME: PCDIF.FOR
C======================================================================
C<DESCRIPTION>
C     Computes partly cloudy radiance according to the sky condition.
C     The algorithms allows for up to 2 cloud layers. This routine
C     was duplicated from Hering's FASCAT 2, CLDFR.  For a description
C     of the equations, see Hering's final report, FASCAT, 1984.
C
C======================================================================
C<INPUT>
C    COMMON BLOCK VARIABLES:
C      NONE
C======================================================================
C<OUTPUT>
C    COMMON BLOCK VARIABLES:
C      NONE
C======================================================================
C<CALLED ROUTINES>
C      NONE
C======================================================================
C<PARAMETER>
C    CALLING SEQUENCE:
C      PCDIF (CLR, A, B, AB, ANS, IOPT, PCF, ZNILL, NUMCLD, CF1, CF2, HS)
C    INPUT:
C     CLR   (REAL)        Radiance, clear sky.
C     A     (REAL)        Radiance, top cloud.
C     B     (REAL)        Radiance, bot cloud.
C     AB    (REAL)        Radiance, two clouds.
C     IOPT  (INTEGER)     Flag indicates above or below cloud.
C     PCF   (REAL)        Probability of cloud free path.
C     ZNILL (REAL)        Zenith angle of illumination source.
C     NUMCLD(INTEGER)     Number of clouds (1 or 2)
C     CF1   (REAL)        Cloud fraction of the top cloud layer.
C     CF2   (REAL)        Cloud fraction of the lower cloud layer.
C     HS(M) (REAL)        Direct radiance for the M-th cloud situation.
C    OUTPUT:
C     ANS   (REAL)        Partly cloudy radiance.
C======================================================================
C<HISTORY>
C  CREATED AUGUST, 1993.  HUGHES STX CORPORATION.
C======================================================================
C<END>
C
C List of variables:
C      A        Radiance, top cloud.
C      AB       Radiance, two clouds.
C      ABLF     Contribution for top and bot cloud. (w/m**2/SR/um)
C      ABLFA    Contribution for top and bot cloud, ref pt below cloud.
C               (w/m**2/SR/um)
C      ALF      Contribution for top cloud. (w/m**2/SR/um)
C      AMT(I)   Cloud amount of the I-th level ( 1 = top).
C      ANS      Partly cloudy radiance.
C      ATRANS   Trannsmittance of the top level.
C      ATRAN1   Trannsmittance of the top level minus 1.
C      B        Radiance, bottom cloud.
C      BLF      Contribution for bot cloud.  (w/m**2/SR/um)
C      BLFA     Contribution for bot cloud ref pt below cloud.
C               (w/m**2/SR/um)
```

```
C      BTRANS   Trannsmittance of the bot level.
C      BTRAN1   Trannsmittance of the bot level minus 1.
C      CF1      Cloud fraction of the top cloud layer.
C      CF2      Cloud fraction of the lower cloud layer.
C      CL       Contribution for clear sky. (w/m**2/SR/um)
C      CLA      Contribution for clear sky, ref pt below cloud.
C               (w/m**2/SR/um)
C      CLR      Radiance, clear sky.
C      CTHES    Cosine of the illumination source.
C      DEGRAD   Degrees to radians conversion factor.
C      HS(M)    Direct radiance for the M-th cloud situation
C      IOPT     Flag indicates above or below cloud.
C      NUMCLD   Number of clouds (1 or 2)
C      PCF      Probability of cloud free path.
C      ZNILL    Zenith angle of illumination source.
C
      SUBROUTINE PCDIF(CLR,A,B,AB,ANS,IOPT,
     +                   PCF,ZNILL,NUMCLD,CF1,CF2,HS)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-10-2--------------------------------
C CORRECT HS ARRAY TO BE JUST ONE-DIMENSIONAL.
      DIMENSION AMT(2), PCF(2), HS(4)
C-HSTX---SCENE SHADOWS--------------------------------------------------
C
      DEGRAD = .01745329
      CTHES = COS(ZNILL * DEGRAD)
      IF (NUMCLD.LE.1) B = 0.0
      AMT(1) = CF1
      AMT(2) = CF2
      ATRANS = 1.43 * AMT(1) - 1.21 * CTHES * AMT(1) - 2.0 * AMT(1)**2
     $         + 1.21 * CTHES * AMT(1)**2 + 1.57 * AMT(1)**3
      BTRANS = 1.43 * AMT(2) - 1.21 * CTHES * AMT(2) - 2.0 * AMT(2)**2
     $         + 1.21 * CTHES * AMT(2)**2 + 1.57 * AMT(2)**3
      ATRAN1 = 1.0 - ATRANS
      BTRAN1 = 1.0 - BTRANS
      IF (IOPT.EQ.1) THEN
         CL = ATRAN1 * BTRAN1 * CLR
         ALF = ATRANS * BTRAN1 * A
         BLF = BTRANS * ATRAN1 * B
         ABLF = ATRANS * BTRANS * AB
         ANS = CL + ALF + BLF + ABLF
      ELSE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-10-2--------------------------------
C CORRECT HS ARRAY TO BE JUST ONE-DIMENSIONAL.
       CLA = ((ATRAN1 * BTRAN1) - PCF(1) * PCF(2))
     $       * HS(1) * CTHES
       ALFA =  ((ATRANS * BTRAN1) - PCF(2) * (1.0-PCF(1)))
     $       * HS(2) * CTHES
       BLFA =  ((BTRANS * ATRAN1) - PCF(1) * (1.0-PCF(2)))
     $       * HS(3) * CTHES
         ABLFA = ((ATRANS * BTRANS) - (1.0 - PCF(1)) * (1.0 - PCF(2)))
     $       * HS(4) * CTHES
         ANS = CLA + ALFA + BLFA + ABLFA
C-HSTX---SCENE SHADOWS--------------------------------------------------
C
      ENDIF
C
      RETURN
      END
```

ECR # HSTX - 11 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: GETDAT

Old Date: 3/19/93

File Name: FINDR.FOR

New Date: 8/17/93

Implemented By: Don Hamann

Reason for Revision: To support partly cloudy radiance computation by creating additional storage locations for possible cloud situations.

Description of Revision: Re-dimensioned the following variables in RADIA COMMON block:

I0(20), I1(20) => I0(20,4), I1(20,4)
SURF(30),SURF0(30) => SURF(30,4),SURF0(30,2)
F(20), PTHRD(30) => F(20,4), PTHRD(30,2)
ISTAR(20,30) => ISTAR(20,30,2)

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C*************************************************************************
      SUBROUTINE GETDAT
C  THIS ROUTINE INITIALIZES DATA
C*************************************************************************
C -STX TCM2 ----ECR ASL-2-1-----------------------------------------------
C   REMOVED THE COMMON BLOCKS:
C      /TARDIM/ /COEFFS/ /CLOUDS/ /DATRAD/
C   REMOVED THE DATA STATEMENTS:
C      XTEMP1, YRAD1, ALFT1-ALFT3, ALFB1-ALFB29, NLYTR1, NLYBK1
C      DELTR1, DEBK1
C   REMOVED THE INITIALIZING OF THE VARIABLES IN THE COMMON BLOCK COEFFS
C
C   THEY ARE NO LONGER NEEDED DUE TO THE INCORPORATION OF TCM2.
C -STX TCM2------------------------------------------------------
C
      COMMON/ATMOS/PRES(21),Z(21),RHO(21),NLEV,NLAY
C
C-HSTX---SCENE SHADOWS----ECR # HSTX-11-1---------------------------------
C RE-DIMENSIONED THE FOLLOWING VARIABLES TO SUPPORT PARTLY CLOUDY
C COMPUTATION:
C           I0(20), I1(20)         ===> I0(20,4), I1(20,4)
C           SURF(30), SURF0(30) ===> SURF(30,4), SURF0(30,2)
C           F(20), PTHRD(30)    ===> F(20,4), PTHRD(30,2)
C           ISTAR(20,30)          ===> ISTAR(20,30,2)
C
C      COMMON/RADIA/A(20),G(20),GP(20),BETAA(20),BETAR(20),
C     1          BETA(20),K(20),P(20),ALPHA(20),BET(20),
C     2          TAU(0:20),I0(20),I1(20),F(20),TF(20),FNOT,
C     3          NANG,PF(180,20),ANG(180,20),I2(20),TAUP(0:20),
C     4          ISTAR(20,30),PTHRD(30),SING(30),AP(20),PHF(30)
C     5          ,ALBEDO,SURF(30),SURF0(30),TAUSTR,VIS,CAPTP(20),
C     6          B1,B2
      COMMON/RADIA/A(20),G(20),GP(20),BETAA(20),BETAR(20),
     1             BETA(20),K(20),P(20),ALPHA(20),BET(20),
     2             TAU(0:20),I0(20,4),I1(20,4),F(20,4),TF(20),FNOT,
     3             NANG,PF(180,20),ANG(180,20),I2(20),TAUP(0:20),
     4             ISTAR(20,30,2),PTHRD(30,2),SING(30),AP(20),PHF(30)
     5             ,ALBEDO,SURF(30,4),SURF0(30,2),TAUSTR,VIS,CAPTP(20),
     6             B1,B2
C-HSTX---SCENE SHADOWS----------------------------------------------------
      DIMENSION PRES1(18),Z1(18),RHO1(18),BETAA1(17)
      REAL K,I0,I1,I2,ISTAR
      DATA PRES1/54.0,118.0,257.0,299.0,347.0,402.0,463.0,531.0,608.0,
     + 694.0,790.0,897.0,1017.0,1017.0,1017.0,1017.0,1017.0,1018.0/
      DATA Z1/20.0,15.0,10.0,9.0,8.0,7.0,6.0,5.0,4.0,3.0,2.0,1.0,
     + 0.50,0.250,0.125,0.050,0.025,0.0/
      DATA RHO1/87.0,190.0,410.0,460.0,520.0,590.0,660.0,740.0,830.0,
     + 920.0,1000.0,1200.0,1300.0,1300.0,1300.0,1300.0,1300.0,1300.0/
      DATA BETAA1/0.0,0.0,0.0,0.0,0.0,0.0001,0.0001,0.0046,0.0113,
     +0.0278,0.0681,0.3271,0.4094,0.4094,0.4094,0.4094,0.4094/
C
C  CONVERT DATA ARRAYS
C
      DO 50 I = 1,17
      PRES(I) = PRES1(I)
      Z(I) = Z1(I)
      RHO(I) = RHO1(I)
      BETAA(I) = BETAA1(I)
   50 CONTINUE
      PRES(18) = PRES1(18)
      Z(18) = Z1(18)
      RHO(18) = RHO1(18)
      NLEV = 18
      RETURN
      END
```

ECR # HSTX - 12 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: FINDR

Old Date: 8/17/93

File Name: FINDR.FOR

New Date: 9/14/93

Implemented By: Don Hamann

Reason for Revision: To compute and output bracketing ranges for sensors for both clear and cloud shadow conditions.

Description of Revision: Change the variable SOG to an array to store bracketing values. Add the CLOUD COMMON block to access cloud information. Output the probability that the target is in cloud shadow and information about the cloud conditions. Loop over up to 2 sky conditions to compute and output bracketing ranges.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 12 - 2

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: FINDR

Old Date: 9/14/93

File Name: FINDR.FOR

New Date: 9/17/93

Implemented By: Melanie J. Gouveia

Reason for Revision: Fix the error that, for thermal imager devices, printed bracketing ranges and cloud information. Also add cloud situation flag, to obtain more information than just the number of cloud situations.

Description of Revision: Run through the "bracketing ranges" loop only once for thermal imager devices. Print cloud information only for visible devices. Add the variable ICLDF to the /CLOUD/ COMMON block; this flag is 1 for 2 clear layers, 2 for 1 overcast layer and 1 clear, 3 for 2 overcast layers, 4 for 1 partly cloudy layer and 1 clear, 5 for 1 partly cloudy layer and 1 overcast, and 6 for 2 partly cloudy layers.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 12 - 3

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: FINDR
Old Date: 9/17/93

File Name: FINDR.FOR
New Date: 10/7/93

Implemented By: Michael Oberlatz

Reason for Revision: Several constant values sent to the XSCALE routine were being changed in XSCALE. This caused a run-time error for the second cycle of a multiple cycle run.

Description of Revision: Variables set to the constant values were substituted for the constant values in the calls to the XSCALE routine.

Notes: Using temporary variables to store the constant values eliminated the run-time error.

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C***********************************************************************
      SUBROUTINE FINDR ( ITYPE, CFLAG )
C***********************************************************************
C
C ***  THIS SUBROUTINE CALCULATES ACQUISITION RANGES FOR
C      IMAGE INTENSIFIERS (NIGHT VISION DEVICES), FOR
C      DIRECT VIEW OPTICS INCLUDING THE HUMAN EYE, BINOCULARS, AND
C      PERISCOPES, FOR SILICON TVS, AND FOR THERMAL IMAGERS
C      FOR THREE FIXED LEVELS OF PROBABILITY.
C
C     A        TV SYSTEMS PERFORMANCE PARAMETERS
C     A1       I**2 SYSTEMS PERFORMANCE PARAMETERS (1ST PARA=SYSTEM,
C               2ND = VARIABLE, 3RD=CONTRAST LEV., 4TH=LIGHT LEVEL)
C     AL       ILLUMINATION (FT-CDLS)
C     ACK      ILLUMINATION LEVEL INDICATOR
C     AMAG     SENSOR MAGNIFICATION ARRAY
C     CD       CLEAR DAY PARAMETERS
C     C        APPARENT CONTRAST
C     CLIM     LOWER USABLE CONTRAST THRESHOLD FOR DEVICE TYPE
C     CNTRST   TARGET/BACKGROUND INHERENT CONTRAST
C     DIM      MINIMUM TARGET DIMENSION (METERS)
C     DEPS     ARRAY OF SENSOR DEPRESSION ANGLES (DEG)
C     HO       HEAVY OVERCAST PARAMETERS
C     ICRSD    CROSS INDEX FOR DEVICE TYPE (INDEXED TO 5)
C     ICTYP    INDEX FOR SPECTRAL REGION IN CALL TO CONTRAST
C     ICYCLE   ACQUISITION LEVEL--RESOLVABLE CYCLES
C     IDEV     INDEX OF DEVICE TYPE: 1 FOR DVO, 2 FOR I**2, 3 FOR TV
C              4 FOR THERMAL IMAGERS, OR 5 FOR USER DEFINED
C     IPF      INDEX FOR FIXED PROBABILITY LEVELS
C     ITYPE    INDEX OF DEVICE TYPE: 1 = I**2, 2 = DVO, 3 = TV
C              4 = TI
C     LSC      INDEX FOR SENSOR NUMBER
C     NSNSR    NUMBER OF SENSORS OF TYPE IDEV
C     OC       OVERCAST DAY PARAMETERS
C     PF       VALUES FOR FIXED LEVELS OF PROB. OF PERFORMANCE
C     PR       ARRAY OF RANGES FOR FIXED PROB. LEVELS
C     PS       ARRAY OF PROBABILITIES
C     PSS      PROBABILITY OF ACQUISITION AT RANGE R
C     R        RANGE (KM)
C     RC       RESOLVABLE CYCLES
C     RNDELT   DELTA-Ts COMPUTED BY TCM2
C     SG,SOG   SKY TO GROUND RATIO
C     SO       SUNSET OVERCAST PARAMETERS
C     TEMPS2   TARGET TEMPERATURES COMPUTED BY TCM2
C     VIS      VISIBILITY (KM)
C     WAVE     WAVELENGTH USED IN SKY TO GROUND CALCULATION
C
      PARAMETER(IDVOP = 1,INTENS = 2,ITELE = 3,ITHER = 4,IUSR = 5)
      REAL INDEX
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-12-1----------------------------------
C CHANGE SKY-TO-GROUND RATIO VARIABLE TO AN ARRAY IN ORDER TO SAVE
C INFORMATION FOR POSSIBLE SKY CONDITIONS.  INCLUDE /CLOUD/ COMMON BLOCK
C TO ACCESS CLOUD INFORMATION.
C-HSTX---SCENE SHADOWS---ECR # HSTX-12-2----------------------------------
C ADDED VARIABLE ICLDF TO CLOUD COMMON BLOCK TO MAINTAIN INFORMATION ABOUT
C CLOUD SITUATION.
C     REAL SOG
      REAL SOG(2)
      COMMON /CLOUD/ICLDF,NUMCLD, MLOOP, CLDBTA(2),CLDG(2), LYRCLD(2),
     +              THK1, THK2, THK3, ITY1, ITY2, ITY3,
     +              ZC1, ZC2, ZC3, CF1, CF2, CF3, PCF(2), PSCLD
C-HSTX---SCENE SHADOWS----------------------------------------------------
C
      COMMON/IOFILE/IOFILE
```

```
      COMMON/INOUT/INTER,IRPT,EFLAG
      COMMON/IOUNIT/IOIN,IOOUT,IPHFUN,LOUNIT,NDIRTU,NCLIMT,IRELH,
     1              KSTOR,NPLOTU,STDERR
      COMMON /IBLOCK/ RECVAL(111,7), RECUSE(21), IPTR(21), IBEGIN(22)
      COMMON /CHBLCK/ RECFLD(21)
      COMMON/RCFUN/A1(4,4,4,3),A(7),AT(5,7),ILOOP,IAL,C,RCC3(2),
     1 RC1(3),RC2(3),RC3(2,3),ICLRC,IFIRST,ALOGC,
     2 AA(7),CC(30),YY(30),AAMAG,NPTS
      COMMON/SCALEX/TTEMPC,RD,AINVHT
CP   THE SCALEX COMMON BLOCK IS USED TO GET INFO FROM SGR TO
CP   FINDR FOR XSCALE CALLS. PSG DEC 92
CRF 17 APR 92 UPGRADE TO XSCALE92  COMMON/SCALEX/TTEMPC,RD,AINVHT
      COMMON/ILLUMI/AL,ILLUM,L22,ACK,IL1,IL2
C       XRANG1 AND XRANG2 HAVE BEEN ADDED TO THE SINANG COMMON BLOCK
C       SEE COMMENTS NEAR THE CALLS TO XSCALE FOR REASONING. RF AUG89.
      COMMON/SINANG/SINANG,R,XSTRN1,XSTRN2,XRANG1,XRANG2
CRF 17 APR 92  COMMON/XSCL/ZZZ(999),BETA(999),RELH(999),NNZPTS,SLNFLG
CRF   REMOVE SLNFLG FROM XSCL COMMON BLOCK IN UPGRADE TO XSCALE92
      COMMON/XSCL/ZZZ(999),BETA(999),RELH(999),NNZPTS
      COMMON/ASCENE/NTARID,NBKID,ITARID,IBKID,RLATT,RLONG,ELEV
      COMMON / GNERIC / GNRICT,GNRICB
C STX TCM2 --ECR ASL-7-1 ----------------------------------------
C ADD COMMON BLOCK TEMPS2
      COMMON/TEMPS2/TEMPB(10),RNDELT(5)
C INCREASE THE DIMENSIONS OF THE TARGET DIMENSION ARRAYS
      COMMON/TARDIM/XSIZE(22),YSIZE(22),ZSIZE(22)
C CHANGE VARIABLE DEP TO ALT
      COMMON/THRM/NRTM,TTARG,TBKG,TEMPC,DEWP,ALT,VIS,IAERO,RNRT,CEIL
     +                ,AINV,WINDS,ELEVA,ASP,ID,IOP
C INCREASE THE DIMENSIONS OF THE TIME ARRAYS
      COMMON/TIMES/NTIM,NRUNTM,TRLTOT(7),IDATE,ITIMOT,TOT,
     + JDATE(11),JTIME(11)
C ADD COMMON BLOCK INTZZ
      COMMON /INTZZ/ IFUN,IDEV,CLIM5,NPROB,PFF(3)
      COMMON/EXTCN/BETA1,BETA2,EXTC1,EXTC2
C ADD DEPS = ARRAY OF SENSOR DEPRESSION ANGLES (DEG)
C FOR WHICHTCM2 COMPUTES TEMPERATURES
      REAL DEPS(5)
C STX TCM2------------------------------------------------------------
      CHARACTER PLACE*3,CDEV*4
      DIMENSION WAVE(5),ALL(3),A6(7),AT1(7),AT2(7),AT3(7)
      DIMENSION SMEX(3)
      DIMENSION ICRST(5),CLIM(5)
      DIMENSION A2(4,4,3),A3(4,4,3),A4(4,4,3),A5(4,4,3)
      DIMENSION PS(20,3),PR(20,3),PF(3),RGNAME(4),NSNSR(5)
      DIMENSION BETA1(999),BETA2(999),EXTC1(999),EXTC2(999)
      DIMENSION EXTC(2)
      INTEGER IOIN,IOOUT,IPHFUN,LOUNIT,NDIRTU,NCLIMT
      INTEGER IRELH,KSTOR,STDERR,NPLOTU,IOFILE
      CHARACTER CHRDEV*20,NMSND*15,AMOK*1,RGNAME*11,RECFLD*4
C     CHARACTER*15 NMSND
      LOGICAL ILOOP,IAL,IFIRST,IMONO,IUP,IDOWN,INTER,CFLAG,EFLAG
      LOGICAL RECUSE,GNRICT,GNRICB
CRF   XSCALE92 DEFAULT VALUES START   17 APR 92
      DIMENSION Q(3,2),QAVE(2),DECPER(3),XMEAN(3),XMODE(3),
     +    WAVRFN(20),RESPFN(20)
      COMPLEX UM
CRF   XSCALE92 DEFAULT VALUES STOP   17 APR 92
      DATA DEPS/70.,30.,10.,5.,0./
      DATA NSNSR/14,4,1,5,1/
      DATA ICRST/1,2,3,4,5/
      DATA WAVE/0.55,0.65,0.70,10.0,0.0/
      DATA CLIM/0.020,0.01,0.010,0.062,0.0/
CUV      DATA ALL/0.01,0.001,0.0001/
      DATA A2/0.017,0.126,0.01384,
```

```
     1 1.84055,0.126,0.9,0.03687,1.02402,0.9,1.0,0.72074,0.07119,
     2 0.,0.,0.,0.,0.043,0.136,0.02418,2.87864,0.136,0.454,
     3 0.05507,1.50680,0.454,0.910,0.113,0.99335,0.91,1.0,0.78141,
     4 0.07255,0.127,0.381,0.07332,2.74653,0.381,0.912,0.15917,1.45473,
     5 0.912,1.0,0.81656,0.09212,0.,0.,0.,0./
      DATA A3/0.02,0.09,0.01374,3.37995,
     1 0.09,0.25,0.031,1.91679,0.25,0.92,0.05267,1.4302,0.92,1.0,
     2 0.69676,0.13897,0.04,0.2,0.02904,3.85956,0.2,0.86,0.06319,
     3 2.30429,0.86,1.0,0.70616,0.17396,0.,0.,0.,0.,
     4 0.116,0.88,0.1004,3.44559,0.88,1.0,0.78033,0.19080,
     5 0.,0.,0.,0.,0.,0.,0.,0./
      DATA A4/0.02,0.066,0.01270,
     1 2.74653,0.066,0.942,0.03878,0.88612,0.942,1.0,0.55019,
     2 0.14938,0.,0.,0.,0.,0.089,0.165,0.04982,
     3 3.4295,0.165,0.871,0.12779,0.73817,0.871,1.0,0.58444,0.15346,
     4 0.,0.,0.,0.,0.288,0.405,0.2048,1.70463,0.405,
     5 0.918,0.30831,0.68193,0.,0.,0.,0.,0.,0.,0./
      DATA A5/0.02,0.054,0.01232,
     1 7.07417,0.054,0.945,0.00946,8.34029,0.945,1.0,0.68714,
     2 0.57725,0.,0.,0.,0.,0.02,0.9,0.02059,9.31636,
     3 0.9,1.0,0.66963,0.72914,0.,0.,0.,0.,0.,0.,0.,0.,
     4 0.1,0.88,0.07068,9.90871,0.88,1.0,
     5 0.74509,0.65388,0.,0.,0.,0.,0.,0.,0.,0./
      DATA A6/38.122,3.455,2.894,3.786,1.223,.211,.012/
      DATA AT1/3.621222,0.859897,-0.075664,0.007368,-0.004656,
     1          0.000614,0.000013/
      DATA AT2/4.797984,0.938367,-0.235704,0.010507,0.012939,
     1          -0.000996,-0.000203/
      DATA AT3/0.248778,0.061437,-0.018147,0.003975,-0.000452,
     1          0.000321,-0.000111/
      DATA PF/0.75,0.50,0.25/
      CONST=0.017453293
CRF   XSCALE92 DEFAULT VALUES START   17 APR 92
      DO 701 IX=1,3
      DECPER(IX) = 0.0
      XMEAN(IX) = 0.0
      XMODE(IX) = 0.0
 701  CONTINUE
      IWATER = 0
      NBR = 0
      DO 702 IX = 1,20
      WAVRFN(IX) = 0.0
      RESPFN(IX) = 0.0
 702  CONTINUE
      ALT = 0.0
CRF   XSCALE92 DEFAULT VALUES STOP   17 APR 92
C
C      RESTRUCTURE DATA ARRAYS
C
      RGNAME(3) = 'RECOGNITION'
      RGNAME(4) = 'RECOGNITION'
      RGNAME(1) = 'DETECTION  '
      DO 800 I =1,4
      DO 800 J = 1,4
        DO 800 K = 1,3
          A1(1,I,J,K) = A2(I,J,K)
          A1(2,I,J,K) = A3(I,J,K)
          A1(3,I,J,K) = A4(I,J,K)
          A1(4,I,J,K) = A5(I,J,K)
  800 CONTINUE
      DO 300 I = 1, 7
      A(I) = A6(I)
      AT(1,I) = AT1(I)
      AT(2,I) = AT1(I)
      AT(3,I) = AT2(I)
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```
      AT(4,I) = AT2(I)
      AT(5,I) = AT3(I)
  300 CONTINUE
C
C  SET DEVICE TYPE
C
45    CONTINUE
CRF   THE FOLLOWING LINE IS COMMENTED OUT TO ALLOW THE USER DEFINED
CRF   MODE TO OPERATE PROPERLY
CRF      IDEV = ICRST(ITYPE)
C--STX TCM2--ECR ASL-7-1 -------------------------------------------------
C FOR THE PC VERSION
C FOR MAINFRAME COMMENT OUT THESE FOUR LINES UP TO NEXT STX LABEL
C IF CFLAG IS TRUE THIS MEANS TCM2 DONE NOW JUMP TO THE OUTPUT
      IF (CFLAG) THEN
      CFLAG = .FALSE.
      GOTO 777
      ENDIF
C--STX TCM2--------------------------------------------------------
CRF  MOVED THE FOLLWOING LINE FROM 10 LINES ABOVE; THIS ALLOWS USER
CRF  DEFINED MODE TO OPERATE.  5 MAR 92
      IDEV = ICRST(ITYPE)
      IF(IDEV .EQ. IUSR) THEN
       IF(INTER) THEN
      WRITE(IOOUT,*)
     +  'YOU HAVE CHOSEN TO RUN THIS PORTION OF THE TARGET '
      WRITE(IOOUT,*)
     +  'ACQUISITION MODEL FOR A USER SPECIFIED DEVICE. IN'
      WRITE(IOOUT,*)
     +  'ORDER TO CALCULATE DETECTION AND RECOGNITION RANGES'
      WRITE(IOOUT,*)
     +  'FOR YOUR DEVICE YOU MUST SPECIFY THE PERFORMANCE'
      WRITE(IOOUT,*)'PARAMETERS FOR THE DEVICE. AS A MINIMUM YOU WILL'
      WRITE(IOOUT,*)'BE ASKED TO SUPPLY INFORMATION ABOUT THE SENSOR'
      WRITE(IOOUT,*)
     +  'PERFORMANCE CURVE; I.E. THE CURVE WHICH SPECIFIES'
      WRITE(IOOUT,*)'SPATIAL FREQUENCY AS A FUNCTION OF CONTRAST.'
      WRITE(IOOUT,*)'PRESS C TO CONTINUE '
      READ(IOIN,*)CKEY
      WRITE(IOOUT,*)'THE SPATIAL FREQUENCY MUST HAVE UNITS OF CYCLES'
      WRITE(IOOUT,*)'PER MILLIRADIAN.  YOU MUST ALSO KNOW THE'
      WRITE(IOOUT,*)
     +  'WAVELENGTH REGION IN WHICH THE SENSOR IS RESPONSIVE'
      WRITE(IOOUT,*)
     +  'IF YOUR SENSOR PERFORMANCE FUNCTION IS OF THE FORM;'
      WRITE(IOOUT,*)'                                              '
      WRITE(IOOUT,*)'   Y = T0 + T1 + T2 + ... + T6,'
      WRITE(IOOUT,*)'                                              '
      WRITE(IOOUT,*)'WHERE Y IS SPATIAL FREQUENCY IN CYCLES PER'
      WRITE(IOOUT,*)'MILLIRADIAN AND EACH TERM T(I) IS OF THE FORM ;'
      WRITE(IOOUT,*)'                                              '
      WRITE(IOOUT,*)'   T(I) = A(I) * LN(C) ** I,                  '
      WRITE(IOOUT,*)'                                              '
      WRITE(IOOUT,*)'WHERE C IS CONTRAST,  THEN YOU NEED ONLY      '
      WRITE(IOOUT,*)'SPECIFY THE CONSTANTS A(I), I = 0,6 WHICH     '
      WRITE(IOOUT,*)'WILL BE REQUESTED LATER.  '
      WRITE(IOOUT,*)'PRESS C TO CONTINUE '
      READ(IOIN,*)CKEY
      WRITE(IOOUT,*)'IF YOU DO NOT KNOW THE COEFFICIENTS'
      WRITE(IOOUT,*)'IN THE ABOVE FORM, BUT KNOW AT LEAST'
      WRITE(IOOUT,*)'FIVE POINTS ON THE CURVE, YOU MAY ENTER '
      WRITE(IOOUT,*)'THE INFORMATION IN A POINT BY POINT FORMAT.'
      WRITE(IOOUT,*)'THE FINAL FORM FOR THE INFORMATION WHICH WILL '
      WRITE(IOOUT,*)'BE ACCEPTED BY THIS MODULE, IS A SEPARATE'
      WRITE(IOOUT,*)'USER SUPPLIED FUNCTION WHICH MUST BE NAMED'
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      WRITE(IOOUT,*)'"USERRC".  THIS FUNCTION MUST BE COMPILED AND'
      WRITE(IOOUT,*)'LINKED PRIOR TO THE CONTINUED EXECUTION OF THIS'
      WRITE(IOOUT,*)'MODULE.'
      WRITE(IOOUT,*)'PRESS C TO CONTINUE '
      READ(IOIN,*)CKEY
      WRITE(IOOUT,*)'IF YOU DO NOT HAVE THE NECESSARY INFORMATION'
      WRITE(IOOUT,*)
     +  'ON SENSOR PERFORMANCE IN ANY OF THE THREE FORMATS'
      WRITE(IOOUT,*)'GIVEN ABOVE, YOU MAY EXIT AT THIS TIME BY SIMPLY'
      WRITE(IOOUT,*)
     +  'ENTERING "0" AND "RETURN". IF YOU WISH TO CONTINUE,'
      WRITE(IOOUT,*)'SPECIFY THE FORM OF THE SENSOR PERFORMANCE CURVE'
      WRITE(IOOUT,*)
     +  'BY ENTERING A NUMBER TO THE LEFT OF THE LIST BELOW'
      WRITE(IOOUT,*)
      WRITE(IOOUT,*)'0.  NO INFORMATION AVAILABLE -- HALT EXECUTION'
      WRITE(IOOUT,*)'1.  COEFFICIENTS -- A(I)'
      WRITE(IOOUT,*)'2.  POINT BY POINT ENTRY'
      WRITE(IOOUT,*)'3.  USER DEFINED ROUTINE'
      READ(IOIN,*)IFUN
      WRITE(IOOUT,*)IFUN
      WRITE(IOOUT,*)
      IF(IFUN .EQ. 0) THEN
        RETURN
      ELSE IF (IFUN .EQ. 1) THEN
        WRITE(IOOUT,*)
     +    'YOU HAVE CHOSEN TO ENTER THE SENSOR PERFORMANCE'
        WRITE(IOOUT,*)'IN THE FORM OF EXPANSION COEFFICIENTS.'
        WRITE(IOOUT,*)
        WRITE(IOOUT,*)
     +    'YOU WILL BE ASKED TO PROVIDE SEVEN COEFFICIENTS'
        WRITE(IOOUT,*)'A(0),A(1),...,A(6)'
        WRITE(IOOUT,*)
        WRITE(IOOUT,*)
        DO 50 I = 1,7
          WRITE(IOOUT,*)'ENTER THE COEFFICIENT FOR SUBSCRIPT ', I-1
          READ(IOIN,*)AA(I)
          WRITE(IOOUT,*)AA(I)
50        CONTINUE
      ELSE IF(IFUN .EQ. 2) THEN
        WRITE(IOOUT,*)
        WRITE(IOOUT,*)
     +    'YOU HAVE CHOSEN TO ENTER THE SENSOR PERFORMANCE'
        WRITE(IOOUT,*)
     +    'IN A POINT BY POINT FORMAT.  YOU MAY ENTER FROM'
        WRITE(IOOUT,*)
     +    'FROM 5 TO 30 POINTS ALONG THE CURVE.  YOUR POINTS'
        WRITE(IOOUT,*)'MUST BE ENTERED IN PAIRS --C(I),Y(I)--, WHERE'
        WRITE(IOOUT,*)'Y(I) IS THE SPATIAL FREQUENCY IN CYCLES PER'
        WRITE(IOOUT,*)'MILLIRADIAN, AND C(I) IS THE CONTRAST AT THE'
        WRITE(IOOUT,*)'ITH POINT.  YOU MUST ENTER THE PAIRS SUCH THAT'
        WRITE(IOOUT,*)'THE VALUES OF C(I) ARE EITHER MONOTONICALLY '
        WRITE(IOOUT,*)'INCREASING OR DECREASING.  THE VALUES OF C(I)'
        WRITE(IOOUT,*)'MUST BE BETWEEN 0 AND 1.  YOU MUST INCLUDE ONE'
        WRITE(IOOUT,*)'PAIR FOR A CONTRAST OF 0.0 AND ONE PAIR FOR A '
        WRITE(IOOUT,*)
     +    'CONTRAST OF 1.0.  BEGIN BY ENTERING THE NUMBER OF'
        WRITE(IOOUT,*)
     +    'POINTS, FROM 5 TO 30, WHICH YOU INTEND TO ENTER.'
        WRITE(IOOUT,*)'YOUR FIRST CONTRAST VALUE MUST BE EITHER'
        WRITE(IOOUT,*)'A 0.0 OR 1.0'
55        CONTINUE
        WRITE(IOOUT,*)
        WRITE(IOOUT,*)'ENTER THE NUMBER OF POINTS ON THE SENSOR'
        WRITE(IOOUT,*)'PERFORMANCE CURVE'
```

```
        WRITE(IOOUT,*)
        READ(IOIN,*)NPTS
        WRITE(IOOUT,*)NPTS
        WRITE(IOOUT,*)
        IF (NPTS .LT. 5 .OR. NPTS .GT. 30) THEN
          WRITE(IOOUT,*)'YOU MAY ONLY ENTER FROM 5 TO 30 POINTS'
          GO TO 55
        ENDIF
        IMONO = .TRUE.
        IUP = .FALSE.
        IDOWN = .FALSE.
        DO 60 I = 1, NPTS
          WRITE(IOOUT,*)'ENTER PAIR C(I), Y(I) FOR POINT ',I
          READ(IOIN,*)CC(I),YY(I)
          WRITE(IOOUT,*)CC(I),YY(I)
          WRITE(IOOUT,*)
          IF(CC(I) .LT. 0. .OR. CC(I) .GT. 1.0) THEN
            WRITE(IOOUT,*)
     +          'YOU HAVE ENTERED A VALUE OF CONTRAST OUTSIDE'
            WRITE(IOOUT,*)'OF THE ALLOWABLE RANGE (FROM 0.0 TO 1.0)'
            WRITE(IOOUT,*)'TRY AGAIN'
            GO TO 55
          ENDIF
          IF(I .GE. 2 ) THEN
            CHOLD = CC(I-1)
            IF(CHOLD .GT. CC(I)) IDOWN = .TRUE.
            IF(CHOLD .LT. CC(I)) IUP = .TRUE.
            IMONO = .NOT. ( IUP .AND. IDOWN)
            IF ( .NOT. IMONO) THEN
            WRITE(IOOUT,*)'THE CONTRAST VALUES MUST BE MONOTONIC'
            WRITE(IOOUT,*)'TRY AGAIN'
            GO TO 55
            ENDIF
            IF(I .EQ. NPTS) THEN
            IF(CC(I) .NE. 1. .AND. CC(I) .NE. 0.0) THEN
              WRITE(IOOUT,*)'IF 0.0 AND 1.0 ARE TO BE INCLUDED'
              WRITE(IOOUT,*)'IN YOUR CONTRAST ARRAY, THEN YOUR'
              WRITE(IOOUT,*)'LAST ENTRY MUST BE EITHER A 0.0 OR'
              WRITE(IOOUT,*)'A 1.0'
              GO TO 55
            ENDIF
            ENDIF
          ELSE
            IF(CC(1) .NE. 0.0 .AND. CC(1) .NE. 1.0) THEN
            WRITE(IOOUT,*)'IF THE CONTRAST ARRAY IS TO BE MONOTONIC'
            WRITE(IOOUT,*)'AND INCLUDE 0 AND 1 THEN YOUR LIST'
            WRITE(IOOUT,*)'MUST START WITH 0 OR 1.  TRY AGAIN'
            GO TO 55
            ENDIF
          ENDIF
60        CONTINUE
CD   REV 8/18/89
61        FORMAT(A4,6X,4E10.4)
CP61        FORMAT(A4,6X,2I10,2E10.4)
62        FORMAT(A4,6X,7E10.4)
63        FORMAT(A4,6X,6E10.4)
64        FORMAT(A4,6X,2E10.4)
CD   REV 8/18/89
      ELSE IF( IFUN .EQ. 3) THEN
        WRITE(IOOUT,*)
        WRITE(IOOUT,*)'YOU HAVE CHOSEN TO ENTER YOUR OWN SENSOR '
        WRITE(IOOUT,*)'PERFORMANCE CURVE VIA A USER DEFINED FUNCTION.'
        WRITE(IOOUT,*)'FOR INFOMATION ON THE NATURE OF THIS CURVE'
        WRITE(IOOUT,*)'PLEASE CONSULT THE USERS MANUAL ON TARGAC.'
        WRITE(IOOUT,*)
```

```
     +    'NOTE THAT AT THIS TIME IN THE EXECUTION YOU MUST'
        WRITE(IOOUT,*)'HAVE PREVIOUSLY COMPILED AND LINKED A FUNCTION'
        WRITE(IOOUT,*)'NAMED "USRFUN" IN ORDER TO CONTINUE EXECUTION'
        WRITE(IOOUT,*)'IF THIS IS NOT THE CASE,  YOU MAY EXIT THE'
        WRITE(IOOUT,*)'PROGRAM BY ENTERING A 0 TO THE PROMPT BELOW.'
        WRITE(IOOUT,*)
        WRITE(IOOUT,*)'IF YOU WISH TO HALT THE PROGRAM HERE ENTER "0"'
        WRITE(IOOUT,*)
     +    'AND "RETURN", TO CONTINUE ENTER "1" AND "RETURN"'
        READ(IOIN,*)IHALT
        WRITE(IOOUT,*)IHALT
        WRITE(IOOUT,*)
        IF(IHALT .EQ. 0) RETURN
      ELSE
        WRITE(IOOUT,*)'YOU MUST ENTER A CHOICE FROM 0 TO 3; TRY AGAIN'
        GO TO 45
      ENDIF
      WRITE(IOOUT,*)
     +  'YOU MAY ALSO WANT TO ENTER A MAGNIFICATION FACTOR'
      WRITE(IOOUT,*)'FOR YOUR DEVICE.  IF YOU DO NOT KNOW THE '
      WRITE(IOOUT,*)'MAGNIFICATION FACTOR ENTER 1.0'
      READ(IOIN,*)AAMAG
      WRITE(IOOUT,*)AAMAG
      WRITE(IOOUT,*)
      WRITE(IOOUT,*)'YOU ARE NOW ASSURED OF HAVING SENSOR PERFORMANCE'
      WRITE(IOOUT,*)'INFORMATION FOR YOUR SENSOR.  YOU MAY FACILITATE'
      WRITE(IOOUT,*)
     +  'THE REMAINDER OF THE EXECUTION OF THIS PROGRAM IF'
      WRITE(IOOUT,*)
     +  'YOU CAN CLASSIFY IT AS ONE OF THE MAIN SENSOR TYPES'
      WRITE(IOOUT,*)'IE A DVO, I**2, TV, OR TI.  CHOOSING ONE OF'
      WRITE(IOOUT,*)
     +  'THE MAIN DEVICE TYPES FOR YOUR SENSOR AT THIS POINT'
      WRITE(IOOUT,*)'WILL ONLY AFFECT THE SPECTRAL INFORMATION PASSED'
      WRITE(IOOUT,*)'TO THE CONTRAST AND/OR THE SKY/GROUND ROUTINES'
      WRITE(IOOUT,*)
65      CONTINUE
      WRITE(IOOUT,*)'CHOOSE AN OPTION'
      WRITE(IOOUT,*)
      WRITE(IOOUT,*)'1. DVO'
      WRITE(IOOUT,*)'2. IMAGE INTENSIFIER'
      WRITE(IOOUT,*)'3. SILICON TV'
      WRITE(IOOUT,*)'4. THERMAL IMAGER'
      READ(IOIN,*)IDEV
      WRITE(IOOUT,*)IDEV
      WRITE(IOOUT,*)
      IF (IDEV .LT. 1 .OR. IDEV .GT. 4) THEN
        WRITE(IOOUT,*)'YOU MUST MAKE A SELECTION FROM THE LIST BELOW'
        GOTO 65
      ENDIF
66      CONTINUE
      WRITE(IOOUT,*)'ENTER THE LOWER LIMIT OF CONTRAST WHICH IS'
      WRITE(IOOUT,*)'CHARACTERISTIC OF YOUR SENSOR.'
      READ(IOIN,*)CLIM(5)
      WRITE(IOOUT,*)CLIM(5)
      WRITE(IOOUT,*)
      IF(CLIM(5) .LT. 0.0) THEN
        WRITE(IOOUT,*)'YOUR CONTRAST LIMIT MUST BE POSITIVE'
        GOTO 66
      ENDIF
CD    REV 8/18/89
      IF (IFUN .EQ. 1) THEN
       WRITE(21,61)'IFUN',FLOAT(IFUN),FLOAT(IDEV),AAMAG,CLIM(5)
       WRITE(21,62)'COEF',AA(1),AA(2),AA(3),AA(4),AA(5),AA(6),AA(7)
      ELSE IF (IFUN .EQ. 2) THEN
```

```
      WRITE(21,61)'IFUN',FLOAT(IFUN),FLOAT(IDEV),AAMAG,CLIM(5)
      WRITE(21,62)'POIN',3.0,CC(1),YY(1),CC(2),YY(2),CC(3),YY(3)
C
      IF (NPTS .LT. 6.0) THEN
        INDEX = 5.0
      ELSE
        INDEX = 6.0
      ENDIF
C
      WRITE(21,62)'POIN',INDEX,CC(4),YY(4),CC(5),YY(5),
     &      CC(6),YY(6)
      IF (CC(7) .GT. 0.0) THEN
       IF (NPTS .LT. 8.0) THEN
         INDEX = INDEX + 1
       ELSE IF (NPTS .GT. 8.0) THEN
         INDEX = INDEX + 3
       ELSE
         INDEX = INDEX + 2
       ENDIF
       WRITE(21,62)'POIN',INDEX,CC(7),YY(7),CC(8),YY(8),
     &     CC(9),YY(9)
      ENDIF
      IF (CC(10) .GT. 0.0) THEN
       IF (NPTS .LT. 11.0) THEN
         INDEX = INDEX + 1
       ELSE IF (NPTS .GT. 11.0) THEN
         INDEX = INDEX + 3
       ELSE
         INDEX = INDEX + 2
       ENDIF
       WRITE(21,62)'POIN',INDEX,CC(10),YY(10),CC(11),YY(11),
     &      CC(12),YY(12)
      ENDIF
      IF (CC(13) .GT. 0.0) THEN
       IF (NPTS .LT. 14.0) THEN
         INDEX = INDEX + 1
       ELSE IF (NPTS .GT. 14.0) THEN
         INDEX = INDEX + 3
       ELSE
         INDEX = INDEX + 2
       ENDIF
       WRITE(21,62)'POIN',INDEX,CC(13),YY(13),CC(14),YY(14),
     &       CC(15),YY(15)
      ENDIF
      IF (CC(16) .GT. 0.0) THEN
       IF (NPTS .LT. 17.0) THEN
         INDEX = INDEX + 1
       ELSE IF (NPTS .GT. 17.0) THEN
         INDEX = INDEX + 3
       ELSE
         INDEX = INDEX + 2
       ENDIF
       WRITE(21,62)'POIN',INDEX,CC(16),YY(16),CC(17),YY(17),
     &       CC(18),YY(18)
      ENDIF
      IF (CC(19) .GT. 0.0) THEN
       IF (NPTS .LT. 20.0) THEN
         INDEX = INDEX + 1
       ELSE IF (NPTS .GT. 20.0) THEN
         INDEX = INDEX + 3
       ELSE
         INDEX = INDEX + 2
       ENDIF
       WRITE(21,62)'POIN',INDEX,CC(19),YY(19),CC(20),YY(20),
     &       CC(21),YY(21)
```

```
       ENDIF
       IF (CC(22) .GT. 0.0) THEN
        IF (NPTS .LT. 23.0) THEN
          INDEX = INDEX + 1
        ELSE IF (NPTS .GT. 23.0) THEN
          INDEX = INDEX + 3
        ELSE
          INDEX = INDEX + 2
        ENDIF
        WRITE(21,62)'POIN',INDEX,CC(22),YY(22),CC(23),YY(23),
     &      CC(24),YY(24)
       ENDIF
       IF (CC(25) .GT. 0.0) THEN
        IF (NPTS .LT. 26.0) THEN
          INDEX = INDEX + 1
        ELSE IF (NPTS .GT. 26.0) THEN
          INDEX = INDEX + 3
        ELSE
          INDEX = INDEX + 2
        ENDIF
        WRITE(21,62)'POIN',INDEX,CC(25),YY(25),CC(26),YY(26),
     &      CC(27),YY(27)
       ENDIF
       IF (CC(28) .GT. 0.0) THEN
        IF (NPTS .LT. 29.0) THEN
          INDEX = INDEX + 1
        ELSE IF (NPTS .GT. 29.0) THEN
          INDEX = INDEX + 3
        ELSE
          INDEX = INDEX + 2
        ENDIF
        WRITE(21,62)'POIN',INDEX,CC(28),YY(28),CC(29),YY(29),
     &     CC(30),YY(30)
       ENDIF
      ELSE IF (IFUN .EQ. 3) THEN
       WRITE(21,61)'IFUN',FLOAT(IFUN),FLOAT(IDEV),AAMAG,CLIM(5)
      ENDIF
CD   REV 8/18/89
       ELSE
      IF (.NOT. RECUSE(6)) THEN
        IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
          WRITE(IOOUT,*)'*****  MISSING IFUN RECORD  *****'
          WRITE(IOOUT,*)
        ENDIF
        IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
          WRITE(NDIRTU,*)'*****  MISSING IFUN RECORD  *****'
          WRITE(NDIRTU,*)
        ENDIF
        EFLAG = .TRUE.
        RETURN
      ENDIF
      IFUN = NINT(RECVAL(6,1))
      IDEV = NINT(RECVAL(6,2))
      AAMAG = RECVAL(6,3)
      CLIM(5) = RECVAL(6,4)
      IF (IDEV .LT. 1 .OR. IDEV .GT. 4) THEN
        IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
          WRITE(IOOUT,*)'**** DEVICE TYPE MISSING OR OUT OF RANGE ****'
          WRITE(IOOUT,*)
        ENDIF
        IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
          WRITE(NDIRTU,*)'**** DEVICE TYPE MISSING OR OUT OF RANGE ****'
          WRITE(NDIRTU,*)
        ENDIF
        EFLAG = .TRUE.
```

```
        RETURN
      ENDIF
      IF(IFUN .EQ. 1) THEN
        IF (.NOT. RECUSE(3)) THEN
          IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
            WRITE(IOOUT,*)'*****  COEFFICIENT RECORD EXPECTED  *****'
            WRITE(IOOUT,*)
          ENDIF
          IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
            WRITE(NDIRTU,*)'*****  COEFFICIENT RECORD EXPECTED  *****'
            WRITE(NDIRTU,*)
          ENDIF
          EFLAG = .TRUE.
          RETURN
        ENDIF
        DO 67 I = 1,7
           AA(I) = RECVAL(3,I)
  67      CONTINUE
      ELSE IF(IFUN .EQ. 2) THEN
        IF (.NOT. RECUSE(21)) THEN
          IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
            WRITE(IOOUT,*)'*****  POINT RECORDS EXPECTED  *****'
            WRITE(IOOUT,*)
          ENDIF
          IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
            WRITE(NDIRTU,*)'*****  POINT RECORDS EXPECTED  *****'
            WRITE(NDIRTU,*)
          ENDIF
          EFLAG = .TRUE.
           RETURN
        ENDIF
        ICTR = 1
        DO 69 J = IBEGIN(21),IPTR(21)
           IEOREC = NINT(RECVAL(J,1))
           IF (IEOREC .GT. ICTR + 3) IEOREC = ICTR + 3
           DO 68 K = ICTR,IEOREC
            IVAL = 2*(MOD(K+2,3)+1)
            CC(K) = RECVAL(J,IVAL)
            YY(K) = RECVAL(J,IVAL+1)
  68         CONTINUE
           ICTR = K
  69      CONTINUE
        NPTS = ICTR - 1
        IDOWN = .FALSE.
        IUP = .FALSE.
        IMONO = .TRUE.
        DO 70 I = 2,NPTS
           CHOLD = CC(I-1)
           IF (CHOLD .GT. CC(I)) IDOWN = .TRUE.
           IF (CHOLD .LT. CC(I)) IUP = .TRUE.
           IMONO = .NOT. (IUP .AND. IDOWN)
           IF (.NOT. IMONO) THEN
            WRITE(IOOUT,*)
     +          '***THE CONTRAST VALUES ARE NOT MONOTONIC.'
            WRITE(IOOUT,*)'CHANGE THE POINT RECORDS AND TRY AGAIN.'
            WRITE(IOOUT,*)
            EFLAG = .TRUE.
            RETURN
           ENDIF
  70      CONTINUE
      ENDIF
       ENDIF
CRF REV 1/27/92
CRF ADDED THE FOLLOWING LINE, CLIM(IDEV) IS USED BELOW FOR THE CONTRAST
CRF LIMIT, THE USERS LIMIT HAS BEEN ENTERED INTO CLIM(5).  SO CLIM(5)
```

```
CRF MUST BE ASSIGNED TO CLIM(IDEV)
      CLIM(IDEV) = CLIM(5)
CRF REV 1/27/92
      ENDIF
CD   REV 8/18/89
  72  FORMAT(A4,6X,5E10.4)
CP72   FORMAT(A4,6X,1I10,4E10.4)
CD   REV 8/18/89
      IF(INTER) THEN
  75    CONTINUE
      WRITE(IOOUT,*)'YOU MAY ENTER FROM 1 TO 3 LEVELS OF PROBABILITY'
      WRITE(IOOUT,*)'FOR WHICH THE DETECTION AND RECOGNITION'
      WRITE(IOOUT,*)'RANGES WILL BE CALCULATED.'
      WRITE(IOOUT,*)'ENTER THE NUMBER OF PROBABILITY LEVELS DESIRED'
      READ(IOIN,*)NPROB
      WRITE(IOOUT,*)NPROB
      WRITE(IOOUT,*)
      IF (NPROB .LT. 1 .OR. NPROB .GT. 3) THEN
        WRITE(IOOUT,*)'THE NUMBER OF LEVELS MUST BE 1, 2, OR 3'
        GO TO 75
      ENDIF
   76   CONTINUE
      WRITE(IOOUT,*)'YOU MAY NOW ENTER',NPROB,' PROBABILITY LEVELS'
      WRITE(IOOUT,*)'BETWEEN 0.1 AND 0.9 IN ASCENDING ORDER AT'
      WRITE(IOOUT,*)'WHICH RANGES ARE TO BE COMPUTED.'
      READ(IOIN,*)(PF(I) , I = 1, NPROB)
      WRITE(IOOUT,*)(PF(I), I = 1, NPROB)
      WRITE(IOOUT,*)
      DO 77 I = 1, NPROB
        IF (PF(I) .LT. 0.1 .OR. PF(I) .GT. 0.9) THEN
          WRITE(IOOUT,*)'THE PROBABILITY LEVELS MUST BE BETWEEN'
          WRITE(IOOUT,*)'0.1 AND 0.9'
          GO TO 76
        ENDIF
   77   CONTINUE
CD   REV 8/18/89
       IF (IDEV .EQ. ITHER) THEN
       WRITE(21,72)'AQUI',FLOAT(NPROB),PF(1),PF(2),PF(3),DIM
       ENDIF
CD   REV 8/18/89
      ELSE
      NPROB = NINT(RECVAL(1,1))
      CALL INTCHK(3,1,NPROB,'AQUI','1ST',3)
      DO 78 I = 1, NPROB
        PF(I) = RECVAL(1,I+1)
        PROBY = .25*I
        IF (I .EQ. 1) THEN
          PLACE = '2ND'
        ELSE IF (I.EQ. 2) THEN
          PLACE = '3RD'
        ELSE
          PLACE = '4TH'
        ENDIF
        CALL REALCK(0.9,0.1,PF(I),'AQUI',PLACE,PROBY)
   78   CONTINUE
      ENDIF
C--STX TCM2   ECR ASL-7-1 ---------------------------------------
C CALL CNTRAS FOR ALL SENSORS EXCEPT THERMALS
      IF(IDEV .NE. ITHER) THEN
      CALL CNTRAS(IDEV,CNTRST,BKGREF)
      CNTRST = ABS(CNTRST)
      CNTRST = AMIN1(CNTRST,1.0)
      ENDIF
C CALL THERML FOR INPUTS
      IF (IDEV.EQ.ITHER) THEN
```

```
      CALL THERML
C******************************************************************
C FOR THE PC VERSION
C FOR MAINFRAME COMMENT OUT THE FOLLOWING LINES UP TO THE NEXT STX LABEL
C SAVE INPUTS FOR TCM2 AND FOR SECOND PASS OF TARGAC
      WRITE(41,*)ITYPE,IDEV,NPROB,PF(1),PF(2),PF(3)
      WRITE(41,*)RECVAL
      WRITE(41,*)RECUSE
      WRITE(41,*)IPTR
      WRITE(41,*)IBEGIN
      WRITE(41,28)RECFLD(11)
 28     FORMAT(A4)
C IF USER DEFINED AND THERMAL SAVE INPUTS
      IF (ITYPE.EQ.5) THEN
          WRITE(41,*)IFUN,AAMAG,CLIM(5),NPTS
          WRITE(41,*)AA
          WRITE(41,*)CC
          WRITE(41,*)YY
      ENDIF
C STX
C FOR THE PC VERSION
C FOR MAINFRAME COMMENT OUT THE FOLLOWING LINE
      RETURN
C FOR THE PC VERSION COMMENT OUT THE FOLLOWING LINE
C FOR MAINFRAME ACTIVATE THE FOLLOWING LINE
C       CALL TCM2
      ENDIF

C AFTER TCM2 IS DONE JUMP TO HERE AND CALL THERMB TO DISPLAY INPUTS AND
C TEMPERATURES FROM TCM2
 777  IF (IDEV.EQ.ITHER) THEN
      CLIM(5)=CLIM5
      DO 2 I=1,3
       PF(I)=PFF(I)
2       CONTINUE
      CALL THERMB
C STX TCM2 ASL-7-1 ********************
C  CNTRST DEFINED AS THE VALUE FOR DEP=0
      CNTRST = RNDELT(5)
C
      IF (GNRICT) THEN
        WRITE(*,*)' ENTER THE TARGET EFFECTIVE WIDTH (M) '
        READ(*,*)YEFF
        WRITE(*,*)
        WRITE(*,*)' ENTER THE TARGET EFFECTIVE HEIGHT (M) '
        READ(*,*)XEFF
      ENDIF
      ENDIF
C
C STX TCM2 ----------------------------------------------

      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
      WRITE(NDIRTU,105)CNTRST
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      WRITE(IOOUT,105)CNTRST
      ENDIF
105   FORMAT(' CONTRAST = ',F6.2)
      CONLIM = CLIM(IDEV)
      IF(ABS(CNTRST) .LT. CONLIM) THEN
       CFLAG = .TRUE.
       RETURN
      ENDIF
      IF(IDEV .NE. ITHER) THEN
      IF(INTER) THEN
```

```
106       CONTINUE
        WRITE(IOOUT,*)'INPUT TARGET MINIMUM DIMENSION IN METERS'
        WRITE(IOOUT,*)' (FOR EXAMPLE 2.4 FOR HEIGHT OF TANK OR)'
        WRITE(IOOUT,*)'  0.5 FOR WIDTH OF MAN)'
        READ(IOIN,*)DIM
        WRITE(IOOUT,*) DIM
        WRITE(IOOUT,*)
        IF(DIM .LT. 0.0) THEN
          WRITE(IOOUT,*)'THE TARGET DIMENSION MUST BE POSITIVE'
          GOTO 106
        ENDIF
CD   REV 8/18/89
        WRITE(21,72)'AQUI',FLOAT(NPROB),PF(1),PF(2),PF(3),DIM
CD   REV 8/18/89
107       CONTINUE
      ELSE
        DIM = RECVAL(1,5)
        CALL REALCK(50.,0.2,DIM,'AQUI','5TH',2.4)
      ENDIF
      ENDIF
C
C  CALL SKY TO GROUND  ROUTINE TO CALCULATE THE SKY TO
C  GROUND RATIO FOR VISIBLE OR NEAR VISIBLE DEVICES
C
      WVLNG = WAVE(IDEV)
      IF (IDEV .NE. ITHER) THEN
C***REV 1/91
      CALL SGR ( BKGREF, WVLNG, VIS, SOG, TTEMPC, DDEWP, ICLIM,
     +             IDEV )
      IF (EFLAG) RETURN
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-12-1----------------------------------
C THE FOLLOWING LINE WAS MOVED TO WITHIN SKY CONDITION LOOP.
C        SG=SOG
C-HSTX---SCENE SHADOWS----------------------------------------------------
C
      TEMPC = TTEMPC
      DEWP = DDEWP
      ENDIF
      ATTN=3.912/VIS
      TEMPA = TEMPC + 273.16
C
C     CALL SUBROUTINE SMINFO TO QUERY THE USER ABOUT THE INCLUSION
C     OF SMOKE SCREEN EFFECTS. *** J. N. CRAIN, 8/12/86 ***
C
      SMEL = 0.
      SMANGE = 0.
CP    CALL SMINFO(TEMPA,DEWP,SMEL,SMEX,SMANGE,ISMYPE,AMOK)
      CALL SMINFO(TEMPA,DEWP,RH,SMEL,SMEX,SMANGE,ISMYPE,AMOK)
C
C     SCHEMATIC IMAGER/SCREEN DIAGRAM, IF SMOKE SCREEN PRESENT.
C
      IF (ISMYPE.GT.1 .AND. AMOK .NE. 'N') THEN
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU,*)' '
        WRITE(NDIRTU,*)'** IMAGER/SCREEN SCHEMATIC (NOT TO SCALE) **'
        WRITE(NDIRTU,*)' '
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        WRITE(IOOUT,*)' '
        WRITE(IOOUT,*)'** IMAGER/SCREEN SCHEMATIC (NOT TO SCALE) **'
        WRITE(IOOUT,*)' '
      ENDIF
      IF (SMANGE.EQ.0.) THEN
        IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
```

```
          WRITE(NDIRTU,*)'[IMAGER]((((SCREEN))))-------------*TARGET*'
          WRITE(NDIRTU,912) SMEL*1000.
        ENDIF
        IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
          WRITE(IOOUT,*)'[IMAGER]((((SCREEN))))-------------*TARGET*'
          WRITE(IOOUT,912) SMEL*1000.
        ENDIF
 912      FORMAT(10X,'<-',F7.2,' M ->')
      ELSE
        IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
          WRITE(NDIRTU,*)' [IMAGER]-----------------((((SCREEN))))',
     &                  '-------------*TARGET*'
          WRITE(NDIRTU,915) SMANGE*1000,SMEL*1000
        ENDIF
        IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
          WRITE(IOOUT,*)' [IMAGER]-----------------((((SCREEN))))',
     &                  '-------------*TARGET*'
          WRITE(IOOUT,915) SMANGE*1000,SMEL*1000
        ENDIF
 915      FORMAT(10X,'<- ',F7.2,' M  ->','<-',F7.2,' M ->')
      ENDIF
      ENDIF
C
C  OBTAIN ILLUMINATION DATA
C
C     CALL ILMDAT(IDEV)
C
C  CHECK FOR SLANT PATH CONDITIONS
C
CRF  NO DEPRESSION ANGLE FOR NON_THERMAL DEVICES 27 FEB 92
      DEP = 0.0
C STX TCM2 ECR ASL-7-1 ----------------------------------------------
C CALCULATE DEPRESSION ANGLE AT 30000 FT
CSTX FIX 1 10-31-91 DEPRESSION ANGLE ONLY FOR THERMAL AS YET C. BACA
      IF(IDEV .EQ. ITHER) THEN
CRF CHANGE AL TO AL1 IN FOLLOWING TWO LINES, AL IS ILLUMINATION
      AL1 = ALT/3280.8
      DEP = ASIN(AL1/9.144111192)
      DEP = 180.0 * DEP/3.14159
C BECAUSE OF ERROR IN COMPUTING TRANSMISSION ALONG A SLANT PATH
C THE FOLLOWING LINE PREVENTS TRANSMISSION CALCULATIONS ALONG A SLANT PATH
C WHEN FIXED DELETE FOLLOWING LINE
      DEP = 0.0
      END IF
C STX TCM2 --------------------------------------------------------
C
      IF(ABS(DEP) .LE. 2.0) THEN
      ISLT = 0
      ANGLE = 0.0
      ELSE
      ISLT = 1
      ANGLE = DEP
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU,*)'CAUTION - SMOKE EFFECTS MAY NOT BE'
        WRITE(NDIRTU,*)'FOR SLANT PATHS'
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        WRITE(IOOUT,*)'CAUTION - SMOKE EFFECTS MAY NOT BE'
        WRITE(IOOUT,*)'FOR SLANT PATHS'
      ENDIF
      ENDIF
      ANGLE = ABS(ANGLE)
      SINANG = SIN(ANGLE * 3.14159 / 180.0)
C
C  CALCULATE HUMIDITIES
```

```
C
      AH = 1322.8314 * EXP(25.22 * (1.0 - 273.16 / (DEWP + 273.16))
     +     + 5.31 * ALOG(273.16 / (DEWP + 273.16))) / TEMPA
      RH = 100.0 * EXP(6885.06 * (1.0 / TEMPA -1.0 / (DEWP + 273.16))
     +     + 5.31 * ALOG(TEMPA /(DEWP + 273.16)))
C
C  CONVERT RAINRATE
C
      RNRT = RNRT * 25.4
C
C  FOR SNOW SET PARTICLE SIZE
C
CRF  17 APR 92   IF(IAERO .EQ. 9) THEN
CRF   CHANGE THE PREVIOUS LINE FOR XSCALE92 AEROSOLS  17 APR 92
      IF (IAERO .EQ. 10) THEN
CUV        RD = 0.002
      ENDIF
C
C  SET CLOUD THICKNESS FOR THERMAL DEVICES
C
      IF(IDEV .EQ. ITHER .AND. CEIL .NE. -1.) THEN
      IF(INTER) THEN
118        CONTINUE
         WRITE(IOOUT,*)'ENTER THE CLOUD THICKNESS (IF KNOWN)'
         WRITE(IOOUT,*)'LESS THAN 10.0 KM, OTHERWISE ENTER 0.0'
         READ(IOIN,*)THICK
         WRITE(IOOUT,*)THICK
         WRITE(IOOUT,*)
         IF(THICK .LT. 0.0 .OR. THICK .GT. 10.) THEN
           WRITE(IOOUT,*)'YOU HAVE ENTERED AN ILLEGAL VALUE'
           WRITE(IOOUT,*)'FOR CLOUD THICKNESS'
           GOTO 118
         ENDIF
      ELSE
         THICK = RECVAL(8,4)
         CALL REALCK(10.0,0.0,THICK,'METD','4TH',0.0)
      ENDIF
      ENDIF
      CEILHT = CEIL
CUV      AINVHT = AINV
CUV      WIND = WINDS * 0.5144
C
C  OBTAIN SOUNDING INFORMATION
C
      IF(IDEV .EQ. ITHER .AND. ISLT .EQ. 1)  THEN
      IF(INTER) THEN
        WRITE(IOOUT,*)'IN ORDER TO CALCULATE GASEOUS ABSORPTION'
        WRITE(IOOUT,*)'FOR SLANT PATH CASES, A VERTICAL SOUNDING'
        WRITE(IOOUT,*)'IS NEEDED.  YOU MAY USE YOUR OWN SOUNDING'
        WRITE(IOOUT,*)'FILE (SEE DOCUMENTATION FOR FILE REQUIRE-'
        WRITE(IOOUT,*)'MENTS) BY ENTERING THE NAME OF THE FILE'
        WRITE(IOOUT,*)'ENCLOSED IN QUOTATION MARKS AT THIS TIME.'
        WRITE(IOOUT,*)'OTHERWISE ENTER NONE IN SINGLE QUOTES'
        WRITE(IOOUT,*)'AND A SOUNDING WILL BE SELECTED FROM THE'
        WRITE(IOOUT,*)'STANDARD ATMOSPHERES.'
        READ(IOIN,*)NMSND
        WRITE(IOOUT,*)
      ELSE
        NMSND = RECFLD(11)
      ENDIF
C
C  CALL FOR SOUNDING FILE
C
      CALL GETSND(RLATT,IDATE,NMSND)
      ENDIF
```

```
C
C
C
      IF(IDEV .EQ. ITHER) THEN
      IF(INTER) THEN
121         CONTINUE
        WRITE(IOOUT,*)'ENTER THE SURFACE PRESSURE IN MILLIBARS'
        READ(IOIN,*)PRES
        WRITE(IOOUT,*)PRES
        WRITE(IOOUT,*)
        IF(PRES .LT. 0.0 .OR. PRES .GT. 1030.) THEN
          WRITE(IOOUT,*)'YOU HAVE ENTERED AN INCORRECT VALUE'
          WRITE(IOOUT,*)'FOR SURFACE PRESSURE'
          GOTO 121
        ENDIF
CD   REV 8/18/89
        WRITE(21,122)'SONDNONE',PRES
 122      FORMAT(A8,2X,E10.4)

C STX TCM2 ECR ASL-7-1 ------------------------------------
C
        WRITE(21,7)'DONE'
        WRITE(21,7)'STOP'
 7        FORMAT(A4)
C STX TCM2-----------------------------------------

CD   REV 8/18/89
      ELSE
        PRES = RECVAL(11,1)
        CALL REALCK(1030.0,500.0,PRES,'SOND','1ST',1030.0)
      ENDIF
      IF(WVLNG .GT. 3.0 .AND. WVLNG .LT. 5.0) THEN
C         IOTEMP = IOIN
C         IOIN = IPHFUN
        CALL IOOPEN(KSTOR,'SCTH.UNT','SCRATCH',0,'FORMATTED',
     +    'TARGAC','FINDR',LUNERR,*130)
        XRANG2 = 20.0
C       HERE AND THE IN THE FOLLOWING XSCALE CALL FOR THE 8-11 BAND,
C       THE PATH LENGTH (IN XRANG_) IS REDUCED UNTIL THE TRANSMITTANCE
C       (IN XSTRN_) IS MEANINGFULLY GREATER THAN ZERO.
C       THE SUBROUTINE EXTIC TAKES THE LOG OF XSTRN_ DIVIDED BY XRANG_
C       TO DETERMINE THE AVERAGE EXTINCTION.  SINCE LOG(0) IS UNDEFINED,
C       THIS IS A BAD THING TO ALLOW.  THIS TEST AVOIDS THE PROBLEM.
C       RF AUG89
CRF233      CALL XSCAIL(3.0,5.0,-20.,ATTN,XSTRN2,IERR,ISLT,IAERO,
CRF  +              XRANG2,ANGLE,CEILHT,ICLIM,RNRT,THICK,RH,WINDS)
CRF  REMOVE THE PREVIOUS TWO LINES, REPLACE WITH THE FOLLOWING 6 LINES
CRF  FOR XSCALE92.   17 APR 92
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-12-3----------------------------
C CHANGED THE CONSTANTS SENT TO XSCALE TO VARIABLES. THESE VALUES
C MAY BE CHANGED IN XSCALE.  THIS CAUSED PROBLEMS WHEN XSCALE ENDED,
C SINCE THE CONSTANTS WERE NO LONGER THE VALUES THAT THEY WERE
C SUPPOSED TO BE.
C 233     CALL XSCALE(3.0,5.0,VIS,IAERO,2,ISLT,NBR,
C     1             RD,DECPER,XMEAN,XMODE,IWATER,
C     2             WAVRFN,RESPFN,
C     3             XRANG2,ANGLE,ALT,CEILHT,THICK,AINVHT,
C     4             RNRT,TEMP,WINDS,RH,XSTRN2,IERR,
C     5             Q,UM,EXT55I,QAVE)
         DUM3 = 3.0
         DUM5 = 5.0
         IDUM2 = 2
 233     CALL XSCALE(DUM3,DUM5,VIS,IAERO,IDUM2,ISLT,NBR,
     1             RD,DECPER,XMEAN,XMODE,IWATER,
```

```
     2               WAVRFN,RESPFN,
     3               XRANG2,ANGLE,ALT,CEILHT,THICK,AINVHT,
     4               RNRT,TEMP,WINDS,RH,XSTRN2,IERR,
     5               Q,UM,EXT55I,QAVE)
C-HSTX---SCENE SHADOWS---------------------------------------------
C
        IF( XSTRN2 .LT. 1.0E-15 ) THEN
          XRANG2 = XRANG2 / 2.0
          IF( XRANG2 .GT. 0.05 ) GOTO 233
          XRANG2 = XRANG2 * 2.0
        ENDIF
C         REWIND IPHFUN
C         IOIN = IOTEMP
        GOTO 135
 130      IERR = 1
 135      CLOSE(KSTOR)
        IF(IERR .EQ. 1) THEN
           EFLAG = .TRUE.
           RETURN
        ENDIF
        JWAVE = 2
        IF (ISLT .EQ. 1) THEN
          BETA2(1) = 0.0
          DO 150 J = 1, NNZPTS
            BETA2(J+1) = BETA(J)
150         CONTINUE
          CALL SLNCOF(EXTC1,EXTC2,SINANG,ELEVA)
CP            ALT = 1.0 * SINANG
CP   CHANGED THE ABOVE LINE TO THE ONE BELOW 16-06-92 TO
CP   ADHERE TO ANSI STANDARDS
          ALT = SINANG
          R = 1.0
        ELSE
          ALT = 1.0
        ENDIF
          CALL EXTIC(JWAVE,ALT,ISLT,EXTC,AH,PRES,VIS,TEMPA,RH,IAERO)
      ELSE IF(WVLNG .GT. 8.0 .AND. WVLNG .LT. 11.0) THEN
C         IOTEMP = IOIN
C         IOIN = IPHFUN
        CALL IOOPEN(KSTOR,'SCTH.UNT','SCRATCH',0,'FORMATTED',
     +    'TARGAC','FINDR',LUNERR,*155)
        XRANG1 = 20.0
CRF 235      CALL XSCAIL(8.0,11.0,-20.,ATTN,XSTRN1,IERR,ISLT,IAERO,
CRF +                XRANG1,ANGLE,CEILHT,ICLIM,RNRT,THICK,RH,WINDS)
CRF    REMOVE THE PREVIOUS 2 LINES, REPLACE WITH FOLLOWING 6 LINES
CRF    FOR XSCALE92.   17 APR 92.
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-12-3---------------------------
C CHANGED THE CONSTANTS SENT TO XSCALE TO VARIABLES. THESE VALUES
C MAY BE CHANGED IN XSCALE.  THIS CAUSED PROBLEMS WHEN XSCALE ENDED,
C SINCE THE CONSTANTS WERE NO LONGER THE VALUES THAT THEY WERE
C SUPPOSED TO BE.
C 235       CALL XSCALE(8.0,11.0,VIS,IAERO,2,ISLT,NBR,
C     1                RD,DECPER,XMEAN,XMODE,IWATER,
C     2                WAVRFN,RESPFN,
C     3                XRANG1,ANGLE,ALT,CEILHT,THICK,AINVHT,
C     4                RNRT,TEMP,WINDS,RH,XSTRN1,IERR,
C     5                Q,UM,EXT55I,QAVE)
           DUM8 = 8.0
           DUM11 = 11.0
           IDUM2 = 2
 235       CALL XSCALE(DUM8,DUM11,VIS,IAERO,IDUM2,ISLT,NBR,
     1                RD,DECPER,XMEAN,XMODE,IWATER,
     2                WAVRFN,RESPFN,
     3                XRANG1,ANGLE,ALT,CEILHT,THICK,AINVHT,
```

```
     4                 RNRT,TEMP,WINDS,RH,XSTRN1,IERR,
     5                 Q,UM,EXT55I,QAVE)
C-HSTX---SCENE SHADOWS---------------------------------------------
C
        IF( XSTRN1 .LT. 1.0E-15 ) THEN
          XRANG1 = XRANG1 / 2.0
          IF( XRANG1 .GT. 0.05 ) GOTO 235
          XRANG1 = XRANG1 * 2.0
        ENDIF
C         REWIND IPHFUN
C         IOIN = IOTEMP
        GOTO 157
 155      IERR = 1
 157      CLOSE(KSTOR)
        IF(IERR .EQ. 1) THEN
           EFLAG = .TRUE.
           RETURN
        ENDIF
        JWAVE = 1
        IF(ISLT .EQ. 1) THEN
          BETA1(1) = 0.0
          DO 160 J = 1,NNZPTS
            BETA1(J+1) = BETA(J)
160         CONTINUE
          CALL SLNCOF(EXTC1,EXTC2,SINANG,ELEVA)
CP            ALT = 1.0  * SINANG
CP    CHANGED THE ABOVE LINE TO THE ONE BELOW 16-06-92 TO
CP    ADHERE TO ANSI STANDARDS
          ALT = SINANG
          R = 1.0
        ELSE
          ALT = 1.0
        ENDIF
          CALL EXTIC(JWAVE,ALT,ISLT,EXTC,AH,PRES,VIS,TEMPA,RH,IAERO)
      ELSE
        IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
         WRITE(IOOUT,*)'PROGRAM HALTED BECAUSE WAVELENGTH OUT OF RANGE'
        ENDIF
        IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
         WRITE(NDIRTU,*)'PROGRAM HALTED BECAUSE WAVELENGTH OUT OF RANGE'
        ENDIF
        STOP
      ENDIF
      ENDIF
C
C ***  DO LOOP FOR 2 ACQUISITION LEVELS--DETECTION AND RECOGNITION
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-12-1-------------------------------
C CHANGE SKY-TO-GROUND RATIO VARIABLE TO AN ARRAY AND ADD DO LOOP IN ORDER
C TO COMPUTE ACQUISITION LEVELS FOR UP TO TWO POSSIBLE SKY CONDITIONS.
C WRITE PROBABILITY THAT TARGET SCENE IS IN CLOUD SHADOW.  WRITE SKY
C CONDITION.
C-HSTX---SCENE SHADOWS---ECR # HSTX-12-2-------------------------------
C REMOVE EXTRA ITERATION FOR THERMAL IMAGER DEVICES.
      IF (IDEV .EQ. ITHER) THEN
         JSTOP = 1
      ELSE
         IF ( MLOOP .EQ. 1 ) THEN
            JSTOP = 1
         ELSE
            JSTOP = 2
         END IF
C
         IF(IOFILE.EQ.1.OR.IOFILE.EQ.2)
     1      WRITE(NDIRTU,*) 'PROBABILITY OF TARGET IN CLOUD SHADOW:',
```

```
     2        100.0 - PSCLD
          IF(IOFILE.EQ.0.OR.IOFILE.EQ.2)
     1       WRITE(IOOUT,*) 'PROBABILITY OF TARGET IN CLOUD SHADOW:',
     2          100.0 - PSCLD
C
          IF ( NUMCLD .EQ. 2 ) THEN
             IF ( CF1 .NE. 1.0 .AND. CF2 .NE. 1.0 ) THEN
                IF(IOFILE.EQ.1.OR.IOFILE.EQ.2)
     1             WRITE(NDIRTU,*) 'TWO PARTLY CLOUDY LAYERS.'
               IF(IOFILE.EQ.0.OR.IOFILE.EQ.2)
     1             WRITE(IOOUT,*) 'TWO PARTLY CLOUDY LAYERS.'
             ELSE IF ( CF1 .NE. 1.0 .OR. CF2 .NE. 1.0 ) THEN
                IF(IOFILE.EQ.1.OR.IOFILE.EQ.2)
     1             WRITE(NDIRTU,*) '1 PTLY CLDY LYR, 1 OVRCST LYR.'
                IF(IOFILE.EQ.0.OR.IOFILE.EQ.2)
     1             WRITE(IOOUT,*) '1 PTLY CLDY LYR, 1 OVRCST LYR.'
             ELSE
                IF(IOFILE.EQ.1.OR.IOFILE.EQ.2)
     1             WRITE(NDIRTU,*) 'TWO OVERCAST LAYERS.'
                IF(IOFILE.EQ.0.OR.IOFILE.EQ.2)
     1             WRITE(IOOUT,*) 'TWO OVERCAST LAYERS.'
             END IF
          ELSE IF ( NUMCLD .EQ. 1 ) THEN
             IF ( CF1 .NE. 1.0 ) THEN
               IF(IOFILE.EQ.1.OR.IOFILE.EQ.2)
     1             WRITE(NDIRTU,*) 'ONE PARTLY CLOUDY LAYER.'
               IF(IOFILE.EQ.0.OR.IOFILE.EQ.2)
     1             WRITE(IOOUT,*) 'ONE PARTLY CLOUDY LAYER.'
             ELSE
                IF(IOFILE.EQ.1.OR.IOFILE.EQ.2)
     1             WRITE(NDIRTU,*) 'ONE OVERCAST LAYER.'
                IF(IOFILE.EQ.0.OR.IOFILE.EQ.2)
     1             WRITE(IOOUT,*) 'ONE OVERCAST LAYER.'
             END IF
          ELSE
             IF(IOFILE.EQ.1.OR.IOFILE.EQ.2)
     1          WRITE(NDIRTU,*) 'BOTH LAYERS CLEAR.'
             IF(IOFILE.EQ.0.OR.IOFILE.EQ.2)
     1          WRITE(IOOUT,*) 'BOTH LAYERS CLEAR.'
          END IF
      ENDIF
C
      DO 500 JCLOUD=1,JSTOP
C-HSTX---SCENE SHADOWS-----------------------------------------------------
C
      DO 500 JCYCLE=1,2
C
C *** INCREMENT RANGE
C
      R=0.0
      RO = 0.50
CRF REV 1/27/92
CRF REMOVED FOLLOWING LINE, THIS WRITES OVER IDEV WHICH IS STILL
CRF NEEDED
CRF     IDEV = ICRST(ITYPE)
CRF REV 1/27/92
      NSN = NSNSR(ITYPE)
      DO 6 IPF=1,3
        DO 5 LSC = 1,NSN
          PR(LSC,IPF)=0.0
          PS(LSC,IPF)=99.
5         CONTINUE
6       CONTINUE
      IF(IDEV .EQ. ITHER) THEN
        DUM1 = 0.5
```

```
        CALL EXTIC(JWAVE,DUM1,ISLT,EXTC,AH,PRES,VIS,TEMPA,RH,IAERO)
        ICYCLE = 3 * JCYCLE - 2
C STX TCM2 ECR ASL-7-1 *****************************************
C  FOR THERMAL IMAGER, START RANGE MARCHING DIRECTLY OVER TARGET.
CRF   DISAGREE NOW< THIS IS NOT THE AIR FORCE 5 MAR 92
CRF          R=ALT
      ELSE
        ICYCLE = 2 * JCYCLE - 1
      ENDIF
      CFLAG = .FALSE.
1       R=R+0.1
      SMATH = 0.
      IF (R.GT.SMANGE) SMATH = AMIN1(R-SMANGE,SMEL)
      KEY = 0
C
C STX TCM2 ECR ASL-7-1 ****************************************
C  FOLLOWING CALCULATIONS WERE RELOCATED FROM UPSTREAM IN FINDR AND
C  COMMENTS ADDED.
C
C  CALCULATE EFFECTIVE TARGET SIZE FOR MENU TARGETS
C
C  COMPUTE YEFF
C
CRF  AS SUGGESTED BY C. BACA ON HP VERSION, CHANGE IF BELOW TO
CRF  LINE BELOW IT, THAT IS, IF NOT GENERIC AND  YES THERMAL
CRF      IF (.NOT. GNRICT) THEN
      IF (.NOT. GNRICT .AND. IDEV .EQ. ITHER) THEN
CRF        DEP=ASIN(ALT/R)
CRF   REPLACE THE LINE COMMENTED OUT ABOVE WITH THE IF BLOCK
CRF   DIRECTLY BELOW
      IF (ALT .GT. R) THEN
        DEP = ASIN(1.0)
      ELSE
        DEP = ASIN(ALT/R)
      END IF
       PHI=DEP
       PSI=ASP*CONST
       XDIM=XSIZE(ID)
       YDIM=YSIZE(ID)
       ZDIM=ZSIZE(ID)
       PART1=ABS(XDIM*SIN(PSI))
       PART2=ABS(YDIM*COS(PSI))
       YEFF=PART1+PART2
C  COMPUTE AELM AND XEFF
       PART1=ZDIM*COS(PHI)*YEFF
       PART2=XDIM*YDIM*SIN(PHI)
       AELM=PART1+PART2
       XEFF=AELM/YEFF
      ENDIF
C
C  COMPUTE CRITICAL TARGET DIMENSION
C
CCB        DIM=AMIN1(XEFF,YEFF)
CCB  CHANGED THE ABOVE COMMENTED LINE TO THE FOLLOWING
      IF (IDEV .EQ. ITHER) DIM=AMIN1(XEFF,YEFF)
C
C *** CALCULATE APPARENT CONTRAST
C
C *** MODIFIED TO INCLUDE SMOKE EFFECTS, 7/21/86 *** J.N.CRAIN ***
C
      IF(IDEV .NE. ITHER) THEN
        SMOKE = EXP(SMEX(3)*SMATH)
          SG = SOG(JCLOUD)
        C=ABS(CNTRST/(1.0+SG*(SMOKE*EXP(ATTN*R)-1.0)))
        C = AMIN1(C,1.0)
```

```
        ALOGC = ALOG(C)
        IF (C .LT. CONLIM .AND. R .LT. .11) THEN
           CFLAG = .TRUE.
           RETURN
        ENDIF
      ELSE
        IF( (R-R0) .GE. 0.25) THEN
          R0 = R0 + 0.50
          CALL EXTIC(JWAVE,R0,ISLT,EXTC,AH,PRES,VIS,TEMPA,RH,IAERO)
        ENDIF
        ATTN = EXTC(JWAVE)
C STX TCM2 ECR ASL-7-1 +++++++++++++++++++++++++++++++++++++
C  EVALUATE INHERENT CONTRAST BY INTERPOLATING ON TCM2 ARRAY.
        CNTRST=UNILIN(DEPS,RNDELT,5,DEP,IEX)
CPUBS  IEX ABOVE APPEARS TO BE USED BEFORE SET, BUT IT IS RETURNED
CPUBS  BY FUNCTION UNILIN 18 NOV 92 PSG
C STX TCM2 --------------------------------------------------
        C = ABS(CNTRST*EXP(-ATTN*R)*EXP(-SMEX(JWAVE)*SMATH))
        ALOGC = ALOG(C)
        IF (C .LT. CONLIM .AND. R .LT. .21) THEN
           CFLAG = .TRUE.
           RETURN
        ENDIF
      ENDIF
      IFIRST = .TRUE.
      DO 220 LSC=1,NSN
         ILOOP = .FALSE.
C
C *** COMPUTE CYCLES ACROSS TARGET, PROBABILITY TO ACQUIRE
C
C
         RC = RCF(ITYPE,LSC,IFUN,CFLAG)
           IF(CFLAG) THEN
             IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
               WRITE(NDIRTU,*)'*** CONTRAST WAS TOO LOW FOR DEVICE',LSC
               WRITE(NDIRTU,*)'    RETRY WITH DIFFERENT COMBINATION OF'
               WRITE(NDIRTU,*)'    TARGET AND BACKGROUND OR DIFFERENT '
               WRITE(NDIRTU,*)'    USER DEFINED INHERENT CONTRAST     '
             ENDIF
             IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
                WRITE(IOOUT,*)'*** CONTRAST WAS TOO LOW FOR DEVICE',LSC
                WRITE(IOOUT,*)'    RETRY WITH DIFFERENT COMBINATION OF'
                WRITE(IOOUT,*)'    TARGET AND BACKGROUND OR DIFFERENT '
                WRITE(IOOUT,*)'    USER DEFINED INHERENT CONTRAST     '
              ENDIF
              ILOOP = .TRUE.
           ENDIF
         IF( .NOT. ILOOP) THEN
            CALL ACQUIR(PSS,R,RC,ICYCLE,DIM)
C
C ***  CHECK FOR PROBABILITIES AT SET LEVELS
C
310          DO 330 IPF=1,NPROB
            IF(ABS(PS(LSC,IPF)-PF(IPF))
     +             .GE. ABS(PSS - PF(IPF))) THEN
             PS(LSC,IPF)=PSS
             PR(LSC,IPF)=R
             IF(PSS.GT. .00000001) KEY=1
           ENDIF
330          CONTINUE
        ENDIF
220     CONTINUE
      IF(KEY.EQ.1) GO TO 1
      DO 225 IPF = 1,NPROB
        DO 225 LSC = 1,NSN
```

```
          IF(PR(LSC,IPF) .EQ. 0.) PR(LSC,IPF) = 9999999.
225     CONTINUE
      IF(ICYCLE.EQ.1) THEN
        IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
          WRITE(IOOUT,*)'HIT ENTER TO CONTINUE'
          READ(IOOUT,*)
        ENDIF
      ENDIF
      IF(ICYCLE.EQ.3.OR.ICYCLE.EQ.4) THEN
        IF(ICRST(ITYPE).EQ.1) THEN
          IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
            WRITE(IOOUT,*)'HIT ENTER TO CONTINUE'
            READ(IOOUT,*)
          ENDIF
        ENDIF
      ENDIF
C
C ***  OUTPUT RANGES FOR SET LEVELS OF PROBABILITY
C
CRF REV 1/27/92
CRF REPLACED IDEV WITH ICRST(ITYPE) IN NEXT 5 STATEMENTS
      IF(ICRST(ITYPE).EQ.1)CDEV(1:4) = 'DVO '
      IF(ICRST(ITYPE).EQ.2)CDEV(1:4) = 'I I '
      IF(ICRST(ITYPE).EQ.3)CDEV(1:4) = 'SITV'
      IF(ICRST(ITYPE).EQ.4)CDEV(1:4) = 'T I '
      IF(ICRST(ITYPE).EQ.5)CDEV(1:4) = 'USR '
CRF REV 1/27/92
      CHRDEV(1:16) = ' DEVICE TYPE IS '
      CHRDEV(17:20) = CDEV
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        WRITE(IOOUT,100)'                   '
        WRITE(IOOUT,100)CHRDEV
      ENDIF
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU,100)'                   '
        WRITE(NDIRTU,100)CHRDEV
      ENDIF
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-12-1-----------------------------------
C ADDITIONAL OUTPUT INFORMATION PROVIDED TO INDICATE CLEAR SKY OR CLOUD
C SHADOW AQUISITION RANGES.
        IF (IDEV .NE. ITHER) THEN
         IF ((JCLOUD.EQ.2).OR.((MLOOP.EQ.1).AND.(NUMCLD.GT.0))) THEN
        IF(IOFILE.EQ.1.OR.IOFILE.EQ.2)
     1       WRITE(NDIRTU,*) 'CLOUD SHADOW CASE:'
        IF(IOFILE.EQ.0.OR.IOFILE.EQ.2)
     1       WRITE(IOOUT,*) 'CLOUD SHADOW CASE:'
         ELSE
        IF(IOFILE.EQ.1.OR.IOFILE.EQ.2)
     1       WRITE(NDIRTU,*) 'CLEAR SKY CASE:'
        IF(IOFILE.EQ.0.OR.IOFILE.EQ.2)
     1       WRITE(IOOUT,*) 'CLEAR SKY CASE:'
         END IF
      END IF
C-HSTX---SCENE SHADOWS-----------------------------------------------------
C
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2)
     1     WRITE(NDIRTU,90) (RGNAME(ICYCLE)),(PF(J),J=1,NPROB)
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2)
     1     WRITE(IOOUT,90) (RGNAME(ICYCLE)),(PF(J),J=1,NPROB)
90      FORMAT(' ',/' ',A11,1X,'RANGE (KM)'/' PROBABILITY LEVEL = ',
     +            3(F3.2,14X))
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU,92) ' SENSOR ID'
      ENDIF
```

```
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        WRITE(IOOUT,92) ' SENSOR ID'
      ENDIF
92      FORMAT(A10)
      DO 420 LSC=1,NSN
        IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
          WRITE(NDIRTU,91)LSC,(PR(LSC,IPF),IPF=1,NPROB)
        ENDIF
        IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
          WRITE(IOOUT,91)LSC,(PR(LSC,IPF),IPF=1,NPROB)
        ENDIF
91        FORMAT(6X,I2,6(12X,F5.1))
420     CONTINUE
500   CONTINUE
      RETURN
100   FORMAT(A20)
1000  FORMAT(10I5)
1100  FORMAT(8F10.7)
1200  FORMAT(A15)
      END
```

ECR # HSTX - 13 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: THERML

Old Date: 3/23/93

File Name: THERML.FOR

New Date: 9/14/93

Implemented By: Michael Oberlatz

Reason for Revision: The cloud base height limits were changed to match the base height limits in the visible section.

Description of Revision: The high cloud base height limits were changed from 9.0 - 20.0 km to 6.1 - 13.7 km. The middle cloud base height limits were changed from 4.0 - 8.0 km to 2.0 - 6.1 km. The low cloud base height limits were changed from 1.0 - 4.0 km to 0.1 - 2.0 km.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C
C***********************************************************************
      SUBROUTINE THERML
C***********************************************************************
C STX TCM2   ECR ASL-8-1 ++++++++++++++++++++++++++++++++++++++++++++++
C THE SUBROUTINE THERML HAS BEEN SPLIT INTO TWO ROUTINES: THERML & THERMB.
C THERML CONTAINS ONLY BLOCK ONE FROM THE ORIGINAL MODEL WITHOUT ANY
C WRITING OF INPUTS TO OUTPUT FILES.
C THERML NOW HAS THE TARGETS AND BACKGROUNDS OF TCM2
C THE ARRAYS FOR TARGETS AND BACKGROUND HAVE BEEN REDIMENSIONED FROM 8 TO
C 23 AND FROM 30 TO 39
C WEATHER & TIME ARRAYS THAT WERE DIMENSIONED BY 17 ARE NOW DIMENSIONED BY
C 11
C
C COMMON BLOCKS AND DIMENSION STATEMENTS NO LONGER NEEDED HAVE BEEN DELETED

      COMMON/WEATHR/WX(11,19),IWX(11,8),ALB,TCORE,TBAR
      COMMON/TIMES/NTIM,NRUNTM,TRLTOT(7),IDATE,ITIMOT,TOT,
     + JDATE(11),JTIME(11)
      COMMON/ASCENE/NTARID,NBKID,ITARID,IBKID,RLATT,RLONG,ELEV,VSPEED,
     + THEAD
      COMMON/OFILE/TITLE
      COMMON/THRM/NRTM,TTRG,TBKG,TMPC,DEWP,ALT,VS,IAERO,RNRT,CEIL
     +           ,AINV,WINDS,ELEVA,ASP,IDTG,IOP
      COMMON/INOUT/INTER,IRPT,EFLAG
      COMMON/IOUNIT/IOIN,IOOUT,IPHFUN,LOUNIT,NDIRTU,NCLIMT,IRELH,
     1              KSTOR,NPLOTU,STDERR
      COMMON /IBLOCK/ RECVAL(111,7), RECUSE(21), IPTR(21), IBEGIN(22)

C STX TCM2   ECR ASL-8-1 ++++++++++++++++++++++++++++++++++++++++++++++
C GNRICB ADDED TO COMMON BLOCK
      COMMON / GNERIC / GNRICT,GNRICB
C STX TCM2 -------------------------------------------------------------
C***REV 1/91
      COMMON /ILDATA/ FMONTH, DAY, YEAR, GTIME, SLAT, SLON, ILR1, ILR2,
     +                ILR3, RG , FR1, FR2, FR3, SIGWX, OBSURF, CEILHT,
     +                PRTYP, FRC, ITARG
      COMMON /ILUMCM/ ALTS, AZIS, ALTMN, AZIM, DPHASE, ELUMI, SUNLIT,
     +                MOOLIT, TCLSUN, TCLLUN, RCLSUN, RCDSUN, RCLLUN,
     +                RCDLUN
C
      INTEGER IOIN,IOOUT,IPHFUN,LOUNIT,NDIRTU,NCLIMT
      INTEGER IRELH,KSTOR,NPLOTU,STDERR
      REAL IH,MOOLIT
      CHARACTER*15 TITLE
      CHARACTER*1 ICDLAY(3)
      DIMENSION IBKDSC(39),ITGDSC(23)
      LOGICAL INTER,RECUSE,GNRICT,GNRICB,EFLAG
      CHARACTER * 36 IBKDSC,ITGDSC
      DATA ICDLAY/'H','M','L'/
CP      DATA CONST/.017453293/
CP   CONST IS COMMENTED OUT BECAUSE IT IS NOT
CP   USED. CONST IS CONVERSION FROM DEGREES TO RADIANS.
CP   ICDLAY APPEARS TO BE FOR USE WITH THE LOW_MEDIUM_HIGH
CP   CLUTTER MODEL. FUTURE USE. PSG NOV 92
C
C
C**************************************************
C                                                *
C       BEGIN BLOCK 1                            *
C                                                *
C  READ INPUT PARAMETERS FROM UNIT 5 AND ENSURE  *
C  THEY ARE REALISTIC AND CONSISTENT.  SUB-      *
C  ROUTINES REALCK AND INTCHK ARE USED TO FLAG   *
C  QUESTIONABLE DATA.                            *
```

```
C                                                 *
C**************************************************
C  SET INPUT RECORD COUNTER INDEX
C
C  INITIALIZE BACKGROUND AND TARGET DESCRIPTORS
C++++++ STX ECR ASL-9-1 ++++++++++++++++++++++++++++++++
C***** TCM2 BACKGROUNDS ********
      IBKDSC(1) = ' TALL GRASS       GROWING  '
      IBKDSC(2) = ' TALL GRASS       DORMANT  '
      IBKDSC(3) = ' MOWED GRASS      GROWING  '
      IBKDSC(4) = ' MOWED GRASS      DORMANT  '
      IBKDSC(5) = ' DECIDUOUS TREES  GROWING  '
      IBKDSC(6) = ' DECIDUOUS TREES  DORMANT  '
      IBKDSC(7) = ' CONIFEROUS TREES GROWING  '
      IBKDSC(8) = ' CONIFEROUS TREES DORMANT  '
      IBKDSC(9) = ' DIRT ROAD        DRY '
      IBKDSC(10) = ' ROCK '
      IBKDSC(11) = ' PLOWED FIELD     WET '
      IBKDSC(12) = ' SNOW ON ROAD         '
      IBKDSC(13) = ' SALT             DRY '
      IBKDSC(14) = ' SALT             DAMP '
      IBKDSC(15) = ' ROAD                  '
      IBKDSC(16) = ' CONCRETE SLAB         '
      IBKDSC(17) = ' GRASS FIELD  '
      IBKDSC(18) = ' TREES        '
      IBKDSC(19) = ' DIRT ROAD        WET '
      IBKDSC(20) = ' PLOWED FIELD     DRY '
      IBKDSC(21) = ' CLAY ROAD '
      IBKDSC(22) = ' UNDISTURBED SNOW     '
      IBKDSC(23) = ' ASPHALT '
      IBKDSC(24) = ' THIN CONCRETE SLAB '
      IBKDSC(25) = ' THICK CONCRETE '
      IBKDSC(26) = ' THICK ASPHALT '
      IBKDSC(27) = ' SOIL     MOIST '
      IBKDSC(28) = ' STANDARD SAND '
      IBKDSC(29) = ' STANDARD WATER  '
      IBKDSC(30) = ' FOLIAGE  DORMANT AND SPARSE '
      IBKDSC(31) = ' FOLIAGE  DORMANT AND MEDIUM '
      IBKDSC(32) = ' FOLIAGE  DORMANT AND DENSE '
      IBKDSC(33) = ' FOLIAGE  GROWING AND SPARSE '
      IBKDSC(34) = ' FOLIAGE  GROWING AND MEDIUM '
      IBKDSC(35) = ' FOLIAGE  GROWING AND DENSE '
      IBKDSC(36) = ' FOLIAGE  VIGOROUS AND SPARSE '
      IBKDSC(37) = ' FOLIAGE  VIGOROUS AND MEDIUM '
      IBKDSC(38) = ' FOLIAGE  VIGOROUS AND DENSE '
      IBKDSC(39) = ' GENERIC BACKGROUND '
C***** TCM2 TARGETS ***********
       ITGDSC(1) = ' T62 - OFF '
       ITGDSC(2) = ' T62 - IDLE '
       ITGDSC(3) = ' T62 - EXERCISED '
       ITGDSC(4) = ' ZIL - OFF '
       ITGDSC(5) = ' ZIL - IDLE '
       ITGDSC(6) = ' ZIL - EXERCISED '
       ITGDSC(7) = ' GENERATOR - OFF '
       ITGDSC(8) = ' GENERATOR - IDLE '
       ITGDSC(9) = ' BUNKER '
       ITGDSC(10) = ' DAM '
       ITGDSC(11) = ' POL '
       ITGDSC(12) = ' BRIDGE '
       ITGDSC(13) = ' HYDROELECTRIC POWER PLANT '
       ITGDSC(14) = ' FT72 - OFF '
       ITGDSC(15) = ' FT72 - IDLE '
       ITGDSC(16) = ' FT72 - EXERCISED '
       ITGDSC(17) = ' FCHOP(APACHE) - OFF '
       ITGDSC(18) = ' FCHOP(APACHE) - HOVER '
```

```
       ITGDSC(19) = ' ANTI-TANK VEHICLE BRDM-2 OFF '
       ITGDSC(20) = ' ANTI-TANK VEHICLE BRDM-2 IDLE '
       ITGDSC(21) = ' ANTI-TANK VEHICLE BRDM-2 EXERCISED '
       ITGDSC(22) = ' POINT SUR SHIP '
       ITGDSC(23) = ' GENERIC TARGET '
C--STX-TCM2-----------------------------------------------
C
CD    SET GENERIC FLAGS
      GNRICT = .FALSE.
      GNRICB = .FALSE.
CD
C***REV 1/91
      ITARG = 1
C
C  INPUT TARGET TYPE
C
      IF(INTER) THEN
   20   CONTINUE
C STX TCM2 -- DISPLAY 23 TARGETS NOW (TCM1 HAD 8)
      WRITE(IOOUT,*) 'ENTER THE TARGET ID NUMBER FROM 0 TO 23'
      WRITE(IOOUT,*) 'BY SELECTING THE NUMBER FROM THE LIST BELOW'
      DO 25 N = 1,11
        WRITE(IOOUT,1000) N,ITGDSC(N),N+12,ITGDSC(N+12)
   25   CONTINUE
      WRITE(IOOUT,1000) 12,ITGDSC(12)
      READ(IOIN,*) NTARID
      WRITE(IOOUT,*) NTARID
      WRITE(IOOUT,*)
C**********************************************************************
CD    SET GENERIC FLAG IS GENERIC TARGET IS CHOSEN
C STX TCM2 ECR ASL-8-1 ++++++++++++++++++++++++++++++++++++++++++++++
C--GENERIC TARGET IS NOW 23 (TCM1 GENERIC TARGET = 8)
      IF (NTARID .EQ. 23) THEN
        GNRICT = .TRUE.
      ELSE
        GNRICT = .FALSE.
      ENDIF
CD
      IF (NTARID .LT. 1 .OR. NTARID .GT. 23) THEN
        WRITE(IOOUT,*) 'THE TARGET ID NUMBER MUST BE BETWEEN 1 AND 23'
        GOTO 20
      ENDIF
C************************************************************************
      ELSE
      NTARID = NINT(RECVAL(12,1))
C STX TCM2 ECR ASL-8-1
C RESET THE UPPER BOUND
      CALL INTCHK(23,1,NTARID,'TARG','1ST',3)
      ENDIF
CD    IF GENERIC TARGET IS CHOSEN, THEN ASK THE USER THE TEMPERATURE
CD    OF THE TARGET, EFFECTIVE TEMPERATURE
      IF (GNRICT) THEN
      WRITE(IOOUT,*)' INPUT THE EFFECTIVE TARGET TEMPERATURE'
      READ(IOIN,*)TTRG
      WRITE(IOOUT,*)TTRG
      WRITE(IOOUT,*)
      ENDIF
C
C STX--TCM2 ASL ECR-8-1 +++++++++++++++++++++++++++++++++++++++
C TCM2 REQUIRES TARGET SPEED OF ONLY EXERCISED VEHICLES  (NEW INPUT)
      IF (INTER) THEN
      IF (NTARID.EQ.3.OR.NTARID.EQ.6.OR.NTARID.EQ.17.OR.NTARID.EQ.21)
     1   THEN
 17         WRITE(IOOUT,*)'ENTER THE VEHICLE SPEED IN METERS PER SECONDS'
        READ(IOIN,*)VSPEED
```

```
          IF (VSPEED.LT.0.OR.VSPEED.GT.25) THEN
            WRITE(IOOUT,*) 'THE RANGE FOR VEHICAL SPEED IS 0 TO 25 M/S'
            GOTO 17
          ENDIF
         ENDIF
        ELSE
        VSPEED = NINT(RECVAL(12,3))
        CALL REALCK(25.,1.,VSPEED,'TARG','3RD',5.0)
        ENDIF
C--STX-TCM2-----------------------------------------------------
C
C  READ NUMBER OF BACKGROUNDS
C
      IF(INTER) THEN
   30   CONTINUE
C STX TCM2 ECR ASL-8-1 +++++++++++++++++
C-- DISPLAY 39 BACKGROUNS NOW (TCM1 HAD 30)
      WRITE(IOOUT,*) 'ENTER THE BACKGROUND ID NUMBER FROM 1 TO 39'
      WRITE(IOOUT,*) 'BY SELECTING THE NUMBER FROM THE LIST BELOW'
      DO 33 N = 1,19
        WRITE(IOOUT,1000) N,IBKDSC(N),N+20,IBKDSC(N+20)
   33   CONTINUE
        WRITE(IOOUT,1000) 20,IBKDSC(20)
      READ(IOIN,*) NBKID
      WRITE(IOOUT,*) NBKID
      WRITE(IOOUT,*)
C***************************************************************
CD    IF THE GENERIC BACKGROUND IS CHOSEN, THE FLAG MUST BE SET '
C  STX TCM2 ASL-8-1 ++++++++++++++++++++
C--GENERIC BACKGROUND IS NOW 39 (TCM1 IT WAS 30)
      IF (NBKID.EQ.39) THEN
        GNRICB = .TRUE.
      ELSE
        GNRICB = .FALSE.
      ENDIF
      IF (NBKID .LT. 1 .OR. NBKID .GT. 39) THEN
        WRITE(IOOUT,*) 'THE BACKGROUND ID NUMBER  MUST BE '
        WRITE(IOOUT,*) ' BETWEEN 1 AND 39'
        GOTO 30
      ENDIF
C**************************************************************
      ELSE
      NBKID = NINT(RECVAL(12,2))
C STX TCM2 ECR ASL-8-1   RESET THE UPPER BOUND
      CALL INTCHK(39,1,NBKID,'TARG','2ND',3)
      ENDIF
C
CD    IF THE GENERIC BACKGROUND IS CHOSEN ASK THE USER THE
CD    EFFECTIVE TEMPERATURE OF THE BACKGROUND
      IF (GNRICB) THEN
      WRITE(IOOUT,*)' INPUT THE EFFECTIVE BACKGROUND TEMPERATURE'
      READ(IOIN,*)TBKG
      WRITE(IOOUT,*)TBKG
      ENDIF
      IDTG = NTARID
C STX TCM2 ECR ASL-8-1 ++++++++++++++++++
C REMOVED PROMPT FOR OPERATING CONDITION AND CALL TO DCODET
C
C  READ IN LATITUDE,LONGITUDE,DAY-OF-THE-YEAR,
C  TIME-OVER-TARGET,AND TARGET AREA ELEVATION.
C
      IF(INTER) THEN
   40   CONTINUE
      WRITE(IOOUT,*) 'ENTER THE LATITUDE IN DEG; POS. FOR N'
      READ(IOIN,*) RLATT
```

```
      WRITE(IOOUT,*) RLATT
      WRITE(IOOUT,*)
      IF(RLATT .GT. 90. .OR. RLATT .LT. -90.) THEN
        WRITE(IOOUT,*) 'THE LATITUDE MUST BE BETWEEN +/- 90 DEG'
        GOTO 40
      ENDIF
   50   CONTINUE
      WRITE(IOOUT,*) 'ENTER THE LONGITUDE IN DEG; POS FOR W'
      READ(IOIN,*) RLONG
      WRITE(IOOUT,*) RLONG
      WRITE(IOOUT,*)
      IF(RLONG .GT. 180. .OR. RLONG .LT. -180.) THEN
        WRITE(IOOUT,*) 'THE LONGITUDE MUST BE BETWEEN +/- 180 DEG'
        GOTO 50
      ENDIF
   60   CONTINUE
      WRITE(IOOUT,*) 'ENTER THE JULIAN DATE BETWEEN 1 AND 366'
      WRITE(IOOUT,*) 'COUNTING FROM JANUARY 1987'
      READ(IOIN,*) IDATE
      WRITE(IOOUT,*) IDATE
      WRITE(IOOUT,*)
      IF(IDATE .LT. 1 .OR. IDATE .GT. 366) THEN
        WRITE(IOOUT,*) 'THE DAY NUMBER MUST BE BETWEEN 1 AND 366'
        GOTO 60
      ENDIF
C***REV 1/91   NEW INTERACTIVE INPUT--REQUESTING YEAR OF INTEREST
C              AS REQUIRED BY ILUMA MODULE
   65   CONTINUE
      WRITE(IOOUT,*) 'ENTER THE YEAR BETWEEN 1977 AND 1999'
      READ(IOIN,*) YEAR
      WRITE(IOOUT,*) YEAR
      WRITE(IOOUT,*)
      IF (YEAR .LT. 1977 .OR. YEAR .GT. 1999) THEN
         WRITE(IOOUT,*) 'THE YEAR MUST BE BETWEEN 1977 AND 1999'
         GOTO 65
      ENDIF
C
   70   CONTINUE
      WRITE(IOOUT,*) 'ENTER THE TIME OF INTEREST IN HHMM Z'
      READ(IOIN,*) ITIMOT
      WRITE(IOOUT,*) ITIMOT
      WRITE(IOOUT,*)
      IF(ITIMOT .LT. 0 .OR. ITIMOT .GT. 2359) THEN
        WRITE(IOOUT,*) 'THE TIME OF INTEREST MUST BE BETWEEN'
        WRITE(IOOUT,*) '0 AND 2359 HOURS ZULU.'
        GOTO 70
      ENDIF
   80   CONTINUE
      WRITE(IOOUT,*) 'ENTER THE TARGET ELEVATION IN FT'
      READ(IOIN,*) ELEV
      WRITE(IOOUT,*) ELEV
      WRITE(IOOUT,*)
      IF(ELEV .LT. 0. .OR. ELEV .GT. 20000.) THEN
        WRITE(IOOUT,*) 'THE ELEV MUST BE BETWEEN 0 AN 20000 FT'
        GOTO 80
      ENDIF
      ELSE
      RLATT = RECVAL(9,1)
      RLONG = RECVAL(9,2)
      IDATE = NINT(RECVAL(9,3))
      ITIMOT = NINT(RECVAL(9,4))
      ELEV = RECVAL(9,5)
C***REV 1/91   NEW BATCH INPUT--YEAR OF INTEREST REQUIRED BY ILUMA MODULE
      YEAR = RECVAL(12,6)
C
```

```
      CALL REALCK(90.0,-90.0,RLATT,'SITE','1ST',55.0)
      CALL REALCK(180.0,-180.0,RLONG,'SITE','2ND',-9.0)
      CALL INTCHK(366,1,IDATE,'SITE','3RD',188)
      CALL INTCHK(2359,0,ITIMOT,'SITE','4TH',1200)
      CALL REALCK(20000.0,0.0,ELEV,'SITE','5TH',1000.0)
C***REV 1/91
      CALL REALCK(1999.0,1977.0,YEAR,'TARG','6TH',1991.0)
C
      ENDIF
C
C***REV 1/91   STORES LATITUDE AND LONGITUDE AS NEEDED BY ILUMA MODULE
      SLAT = RLATT
      SLON = -RLONG
C
C  CONVERT ITIMOT TO TIME IN HOURS (TOT)
      ITOT=ITIMOT/100
      IMIN=ITIMOT-(ITOT*100)
      XMIN=REAL(IMIN)/60.
      TOT=REAL(ITOT)+XMIN
      IF(INTER) THEN
      IF (.NOT. GNRICT) THEN
   86    CONTINUE
C STX TCM2 ECR ASL-8-1 ++++++++++++++++++++++++++++++++++++++++++++++
C TCM2 REQUIRES TARGET HEADING (NEW INPUT)
       WRITE(IOOUT,*) 'INPUT THE TARGET HEADING, 0 - 360 DEG'
       READ(IOIN,*) THEAD
       WRITE(IOOUT,*) THEAD
       WRITE(IOOUT,*)
       IF(THEAD .LT. 0.0 .OR. THEAD .GT. 360.) THEN
        WRITE(IOOUT,*)'THE TARGET HEADING MUST BE BETWEEN 0 AND 360 DEG'
        GOTO 86
       ENDIF
C STX TCM2------------------------------------------------------------
   85    CONTINUE
       WRITE(IOOUT,*) 'INPUT THE TARGET ASPECT ANGLE, 0 - 360 DEG'
       READ(IOIN,*) ASP
       WRITE(IOOUT,*) ASP
       WRITE(IOOUT,*)
       IF(ASP .LT. 0.0 .OR. ASP .GT. 360.) THEN
        WRITE(IOOUT,*)'THE ASPECT ANGLE MUST BE BETWEEN 0 AND 360 DEG'
        GOTO 85
       ENDIF
      ENDIF
      ELSE
C
C STX TCM2-ECR ASL-8-1****************************
C- READ IN TARGET ASPECT ANGLE AND TARGET HEADING.
C
      ASP = RECVAL(12,4)
      CALL REALCK(360.,1.,ASP,'TARG','4TH',360.0)
      THEAD = RECVAL(12,7)
      CALL REALCK(360.,1.,THEAD,'TARG','7TH',90.0)
      ENDIF
C
C  STX TCM2 ECR ASL-8-1***********************************
C  INPUT SENSOR ALTITUDE INSTEAD OF SENSOR DEPRESSION ANGLE
C
      IF(INTER) THEN
   90   CONTINUE
      WRITE(IOOUT,*) 'INPUT THE ALTITUDE OF THE SENSOR IN FT'
      WRITE(IOOUT,*)
      READ(IOIN,*) ALT
      WRITE(IOOUT,*) ALT
      WRITE(IOOUT,*)
      IF(ALT .LT. 0. .OR. ALT .GT. 30000.) THEN
```

```
          WRITE(IOOUT,*) 'THE SENSORS ALTITUDE MUST BE BETWEEN'
          WRITE(IOOUT,*) '0 AND 30000 FT'
          GOTO 90
        ENDIF
        ELSE
C
C  READ SENSOR ALTITUDE STX
C
        ALT = RECVAL(12,5)
        CALL REALCK(30000.0,0.0,ALT,'TARG','5TH',100.0)
        ENDIF
C
STX-TCM2-----------------------------------------------------------------
        IF(INTER) THEN
  100     CONTINUE
        WRITE(IOOUT,*) 'INPUT THE SURFACE ALBEDO FROM 0.0 TO 1.0'
        READ(IOIN,*) ALB
        WRITE(IOOUT,*) ALB
        WRITE(IOOUT,*)
C STX CHANGED IF STATEMENT SO ALBEDO CANNOT BE 0 OR 1 (REAL WORLD)
        IF(ALB .LE. 0.0 .OR. ALB .GE. 1.0) THEN
          WRITE(IOOUT,*) 'THE SURFACE ALBEDO MUST BE '
          WRITE(IOOUT,*) ' BETWEEN 0.0 AND 1.0'
          GOTO 100
        ENDIF
  110     CONTINUE
        WRITE(IOOUT,*) 'INPUT THE AVERAGE AIR TEMPERATURE IN DEG C FOR'
        WRITE(IOOUT,*) 'THE 24 H PERIOD PRIOR TO THE TIME OF INTEREST'
        READ(IOIN,*) TBAR
        WRITE(IOOUT,*) TBAR
        WRITE(IOOUT,*)
        IF (TBAR .LT. -60.0 .OR. TBAR .GT. 60.0) THEN
          WRITE(IOOUT,*) 'YOU HAVE ENTERED AN EXTREME TEMPERATURE'
          WRITE(IOOUT,*) 'THIS PROGRAM ACCEPTS TEMPERATURES BETWEEN'
          WRITE(IOOUT,*) '-60.0 AND +60.0 DEGREES C'
          GOTO 110
        ENDIF
  150     CONTINUE
CD  REV 8/18/89 STX
C STX TCM2 ECR ASL-8-1+++++++++++++++++++++++++++++++++++++++++++++++
C CHANGE 'TARG' RECORD: CHANGE ITARID TO VSPEED, CHANGE DEP TO ALT,
C                        ADD THEAD
      WRITE(21,116)'TARG',FLOAT(NTARID),FLOAT(NBKID),VSPEED,
     &  ASP,ALT,YEAR,THEAD
      WRITE(21,117)'SITE',RLATT,RLONG,FLOAT(IDATE),FLOAT(ITIMOT),
     &  ELEV,TBAR,ALB
  116   FORMAT(A4,6X,7E10.4)
  117   FORMAT(A4,6X,7E10.4)
C STX-TCM2--------------------------------------------
CD  REV 8/18/89
        WRITE(IOOUT,*)' SELECT AEROSOL TYPE'
        WRITE(IOOUT,*)' 1-MARITIME AIR MASS'
        WRITE(IOOUT,*)' 2-URBAN'
        WRITE(IOOUT,*)' 3-RURAL (CONTINENTAL POLAR)'
        WRITE(IOOUT,*)' 4-FOG (HEAVY ADVECTION)'
        WRITE(IOOUT,*)' 5-FOG (MODERATE RADIATION)'
        WRITE(IOOUT,*)' 6-RAIN (DRIZZLE)'
        WRITE(IOOUT,*)' 7-RAIN (WIDESPREAD)'
        WRITE(IOOUT,*)' 8-RAIN (THUNDERSTORM)'
C STX TCM2 CHANGED IAEROL TO IAERO THE VARIBLE IN THE COMMON BLOCK THRM
        READ(IOIN,*) IAERO
        WRITE(IOOUT,*) IAERO
        WRITE(IOOUT,*)
        IF(IAERO .LT. 1 .OR. IAERO .GT. 8) THEN
          WRITE(IOOUT,*) 'THE AEROSOL MODEL MUST BE BETWEEN 1 AND 8'
```

```
          GOTO 150
        ENDIF
      ELSE
C
C  READ IN GROUND ALBEDO AND AVERAGE AIR TEMPERATURE
C  FOR THE 24 HOUR PERIOD PRIOR TO TOT.
C
      ALB = RECVAL(9,7)
      TBAR = RECVAL(9,6)
      IAERO = NINT(RECVAL(14,1))
C STX RESET LIMITS OF ALBEDO
      CALL REALCK(0.99999,0.00001,ALB,'SITE','7TH',0.15)
      CALL REALCK(60.0,-60.0,TBAR,'SITE','6TH',10.0)
C STX CHANGE IAEROL TO IAERO
      CALL INTCHK(8,1,IAERO,'XSCL','1ST',3)
      ENDIF
C
C***REV 1/91   STORES SURFACE ALBEDO FOR USE BY ILUMA MODULE
      RG = ALB
C
      IF(INTER) THEN
  120   CONTINUE
C STX TCM2 ECR ASL-8-1 ************************************
C           TCM2 CAN ONLY HANDLE 30 HOURS OF MET DATA,
C           SO RANGE IS 6 TO 30 FORMERLY 6 TO 48
C           AND MAXIMUM OF 11 NOT 17 MET INPUT TIMES

      WRITE(IOOUT,*) 'INPUT THE NUMBER OF TIMES AT WHICH'
      WRITE(IOOUT,*) 'METEOROLOGICAL DATA IS AVAILABLE.'
      WRITE(IOOUT,*) 'MET DATA IS REQUIRED FOR FROM 6 TO'
      WRITE(IOOUT,*) '30 HRS PRIOR TO THE TIME OF INTEREST'
      WRITE(IOOUT,*) 'REPORTED IN 3 HR INTERVALS AND IS ALSO'
      WRITE(IOOUT,*) 'REQUIRED AT THE TIME OF INTEREST.  THUS,'
      WRITE(IOOUT,*) 'THE NUMBER OF TIMES AT WHICH MET DATA IS'
      WRITE(IOOUT,*) 'AVAILABLE MUST BE AT LEAST 3 AND AT MOST 11'
      READ(IOIN,*) NTIM
      WRITE(IOOUT,*) NTIM
      WRITE(IOOUT,*)
      IF(NTIM .LT. 3 .OR. NTIM .GT. 11) THEN
        WRITE(IOOUT,*) 'YOU HAVE ENTERED AN IMPROPER VALUE'
        WRITE(IOOUT,*) 'FOR THE NUMBER OF TIMES AT WHICH MET'
        WRITE(IOOUT,*) 'DATA IS AVAILABLE'
        GOTO 120
      ENDIF
      ELSE
C
C  READ IN THE NUMBER OF TIMES FOR WHICH METEOROLOGICAL
C  DATA WILL BE INPUT.  AT LEAST SIX HOURS OF ANTICEDENT
C  METEOROLOGICAL DATA ARE REQUIRED TO COMPUTE TARGET/
C  BACKGROUND TEMPERATURES AT A GIVEN TIME.
C
      NTIM = NINT(RECVAL(13,1))
      CALL INTCHK(11,3,NTIM,'TIME','1ST',3)
      ENDIF
C STX TCM2--------------------------------------------------
      IF(INTER) THEN
      WRITE(IOOUT,*) 'YOU WILL NOW BE ASKED TO INPUT THE'
      WRITE(IOOUT,*) 'METEOROLOGICAL DATA VALID FOR TIMES'
      WRITE(IOOUT,*) 'IN THREE HOUR INCREMENTS STARTING'
      WRITE(IOOUT,*) 'AT THE EARLIEST TIME AND PROCEEDING TO THE '
      WRITE(IOOUT,*) 'TIME OF INTEREST.  AT EACH PROMPT THE RANGE '
      WRITE(IOOUT,*) 'OF PERMISSIBLE VALUES WILL BE DISPLAYED.'
CD    REV 9/22/89
       DO 450 I=1,NTIM
       WX(I,14) = -1.0
```

```
  450  CONTINUE
CD    REV 9/22/89
      DO 400 I = 1,NTIM
        WX(I,1)=-3.*(NTIM-I)
        WTME = ABS(WX(I,1))
        WRITE(IOOUT,*) 'YOU WILL NOW BEGIN ENTERING GROUP',I,'DATA'
        WRITE(IOOUT,*) 'MEASURED AT OR FORECAST FOR', WTME, ' HOURS'
        WRITE(IOOUT,*) 'BEFORE THE TIME OF INTEREST'
  130     CONTINUE
        WRITE(IOOUT,*) 'ENTER THE WEATHER INDEX AS FOLLOWS:'
        WRITE(IOOUT,*) '1 - FOR NO PRECIPITATION'
        WRITE(IOOUT,*) '2 - FOR RAIN'
        WRITE(IOOUT,*) '3 - FOR SNOW'
        READ(IOIN,*) IWX(I,1)
        WRITE(IOOUT,*) IWX(I,1)
        IF(IWX(I,1) .LT. 1 .OR. IWX(I,1) .GT. 3) THEN
           WRITE(IOOUT,*) 'THE WEATHER INDEX MUST BE BETWEEN 1 AND 3'
           GOTO 130
        ENDIF
        IF(IWX(I,1) .EQ. 2) THEN
  140       CONTINUE
          WRITE(IOOUT,*) 'ENTER THE PRECIPITATION RATE '
          WRITE(IOOUT,*) 'FROM 0.0 TO 5.0 INCHES/HOUR'
          READ(IOIN,*) WX(I,2)
          WRITE(IOOUT,*) WX(I,2)
          WRITE(IOOUT,*) WX(I,2)
          WRITE(IOOUT,*)
          IF(WX(I,2) .LT. 0.0 .OR. WX(I,2) .GT. 5.0) THEN
            WRITE(IOOUT,*)'YOU HAVE ENTERED AN EXTREME VALUE FOR'
            WRITE(IOOUT,*)'PRECIPITATTION RATE. PLEASE ENTER A NUMBER'
            WRITE(IOOUT,*)'BETWEEN 0.0 AND 5.0'
            GOTO 140
          ENDIF
        ELSE
          WX(I,2) = 0.0
        ENDIF
  160     CONTINUE
        WRITE(IOOUT,*) 'ENTER THE SURFACE AIR TEMPERATURE'
        WRITE(IOOUT,*) 'FROM -60.0 TO 60.0 DEG C'
        READ(IOIN,*) WX(I,3)
        WRITE(IOOUT,*) WX(I,3)
        WRITE(IOOUT,*)
        IF(WX(I,3) .LT. -60.0 .OR. WX(I,3) .GT. 60.0) THEN
          WRITE(IOOUT,*) 'YOU HAVE ENTERED AN EXTREME VALUE FOR'
          WRITE(IOOUT,*) 'THE SURFACE AIR TEMPERATURE. PLEASE '
          WRITE(IOOUT,*) 'ENTER A NUMBER BETWEEN -60 AND 60 DEG C'
          GOTO 160
        ENDIF
  170     CONTINUE
        WRITE(IOOUT,*) 'ENTER A VALUE OF THE DEWPOINT TEMPERATURE'
        WRITE(IOOUT,*) 'IN DEG C.'
        READ(IOIN,*) WX(I,4)
        WRITE(IOOUT,*) WX(I,4)
        WRITE(IOOUT,*)
        IF(WX(I,4) .GT. WX(I,3)) THEN
          WRITE(IOOUT,*) 'YOU HAVE ENTERED A DEWPOINT TEMPERATURE'
          WRITE(IOOUT,*) 'WHICH RESULTS IN A RELATIVE HUMIDITY OF'
          WRITE(IOOUT,*) 'OVER 100 PERCENT. PLEASE CHECK AND REENTER'
          GOTO 170
        ENDIF
        TMPVP1 = VAPOR(WX(I,4))
        IF(TMPVP1 .LT. 0.0) THEN
          WRITE(IOOUT,*) 'YOU HAVE ENTERED AN UNREALISTICALLY LOW'
          WRITE(IOOUT,*) 'VALUE FOR THE DEWPOINT TEMPERATURE. '
          WRITE(IOOUT,*) 'PLEASE CHECK AND REENTER'
```

```
          GOTO 170
        ENDIF
  180     CONTINUE
        WRITE(IOOUT,*) 'ENTER THE SURFACE WIND SPEED IN KNOTS'
        WRITE(IOOUT,*) 'FROM 0.0 TO 70.0'
        READ(IOIN,*) WX(I,5)
        WRITE(IOOUT,*) WX(I,5)
        WRITE(IOOUT,*)
        IF(WX(I,5) .LT. 0.0 .OR. WX(I,5) .GT. 70.) THEN
          WRITE(IOOUT,*) 'YOU HAVE ENTERED AN UNREALISTIC VALUE'
          WRITE(IOOUT,*) 'FOR THE SURFACE WIND SPEED. PLEASE CHECK'
          WRITE(IOOUT,*) 'AND REENTER'
          GOTO 180
        ENDIF
C******************STX ADDITION***************************************
C STX TCM2 ECR ASL-8-1
C TCM2 REQUIRES WIND DIRECTION (NEW INPUT)
        IF (WX(I,5).GT.0.0) THEN
  185       CONTINUE
          WRITE(IOOUT,*) 'ENTER THE SURFACE WIND DIRECTION'
          WRITE(IOOUT,*) 'FROM 1 TO 360'
          READ(IOIN,*) WX(I,18)
          WRITE(IOOUT,*) INT(WX(I,18))
          WRITE(IOOUT,*)
          IF(WX(I,18) .LE. 0.0 .OR. WX(I,18) .GT. 360.0) THEN
            WRITE(IOOUT,*) 'YOU HAVE ENTERED AN UNREALISTIC VALUE'
            WRITE(IOOUT,*) 'FOR THE SURFACE WIND DIRECTION. PLEASE'
            WRITE(IOOUT,*) 'CHECK AND REENTER'
            GOTO 185
          ENDIF
        ENDIF
C******************STX ADDITION***************************************
  190     CONTINUE
        WRITE(IOOUT,*) 'ENTER THE SURFACE VISIBILITY '
        WRITE(IOOUT,*) 'FROM 0.0 TO 100.0 KM'
        READ(IOIN,*)  WX(I,6)
        WRITE(IOOUT,*) WX(I,6)
        WRITE(IOOUT,*)
        IF(WX(I,6) .LT. 0.0 .OR. WX(I,6) .GT. 100.0) THEN
          WRITE(IOOUT,*) 'YOU HAVE ENTERED AN UNREALISTIC VALUE'
          WRITE(IOOUT,*) 'FOR THE SURFACE VISIBILITY. PLEASE CHECK'
          WRITE(IOOUT,*) 'AND REENTER'
          GOTO 190
        ENDIF
C STX TCM2 ECR ASL-8-1 ++++++++++++++++++++++++++++++++++++++++++++++++
C TCM2 CALCULATES SOLAR IRRADIANCE AND SKY IRRADIANCE EVERY 15 MINUTES
C FOR CONSISTENCY THE USER NO LONGER ENTERS THEIR OWN VALUES.
        WX(I,7) = -1.0
        WX(I,8) = -1.0
C STX ------------------------------------------------------------
 260      CONTINUE
        WRITE(IOOUT,*) 'ENTER THE TYPE OF HIGH CLOUD ACCORDING'
        WRITE(IOOUT,*) 'TO THE CODE BELOW'
        WRITE(IOOUT,*) '0 - NONE'
        WRITE(IOOUT,*) '1 - THIN'
        WRITE(IOOUT,*) '2 - THICK'
        READ(IOIN,*) IWX(I,4)
        WRITE(IOOUT,*) IWX(I,4)
        WRITE(IOOUT,*)
        IF(IWX(I,4) .LT. 0 .OR. IWX(I,4) .GT. 2) THEN
          WRITE(IOOUT,*) 'YOU HAVE ENTERED AN ILLEGAL VALUE'
          WRITE(IOOUT,*) 'FOR THE HIGH CLOUD TYPE'
          GOTO 260
        ENDIF
  270     CONTINUE
```

```
      WRITE(IOOUT,*) 'ENTER THE TYPE OF MIDDLE CLOUD ACCORDING'
      WRITE(IOOUT,*) 'TO THE CODE BELOW'
      WRITE(IOOUT,*) '0 - NONE'
      WRITE(IOOUT,*) '3 - ANY MIDDLE CLOUD'
      READ(IOIN,*) IWX(I,5)
      WRITE(IOOUT,*) IWX(I,5)
      WRITE(IOOUT,*)
      IF(IWX(I,5) .NE. 0 .AND. IWX(I,5) .NE. 3) THEN
        WRITE(IOOUT,*) 'YOU HAVE ENTERED AN ILLEGAL VALUE'
        WRITE(IOOUT,*) 'FOR THE MIDDLE CLOUD TYPE'
        GOTO 270
      ENDIF
 280    CONTINUE
      WRITE(IOOUT,*) 'ENTER THE TYPE OF LOW CLOUD ACCORDING'
      WRITE(IOOUT,*) 'TO THE CODE BELOW'
      WRITE(IOOUT,*) '0 - NONE'
      WRITE(IOOUT,*) '4 - LOW STRATIFORM'
      WRITE(IOOUT,*) '5 - LOW CONVECTIVE'
      READ(IOIN,*) IWX(I,6)
      WRITE(IOOUT,*) IWX(I,6)
      WRITE(IOOUT,*)
      IF(IWX(I,6) .NE. 0 .AND. IWX(I,6) .NE. 4
     +                    .AND. IWX(I,6) .NE. 5) THEN
        WRITE(IOOUT,*) 'YOU HAVE ENTERED AN ILLEGAL VALUE'
        WRITE(IOOUT,*) 'FOR THE LOW CLOUD TYPE'
        GOTO 280
      ENDIF
      IF(IWX(I,4) .GT. 0) THEN
 290      CONTINUE
        WRITE(IOOUT,*) 'ENTER THE FRACTIONAL SKY COVERAGE FROM'
        WRITE(IOOUT,*) '0.0 TO 1.0 FOR HIGH CLOUDS'
        READ(IOIN,*) WX(I,9)
        WRITE(IOOUT,*) WX(I,9)
        WRITE(IOOUT,*)
        IF(WX(I,9) .LT. 0.0 .OR. WX(I,9) .GT. 1.0) THEN
          WRITE(IOOUT,*) 'YOU HAVE ENTERED AN ILLEGAL VALUE FOR'
          WRITE(IOOUT,*) 'THE FRACTIONAL COVERAGE OF HIGH CLOUDS'
          GOTO 290
        ENDIF
      ELSE
        WX(I,9) = 0.0
      ENDIF
      IF(IWX(I,5) .GT. 0) THEN
 300      CONTINUE
        WRITE(IOOUT,*) 'ENTER THE FRACTIONAL SKY COVERAGE FROM'
        WRITE(IOOUT,*) '0.0 TO 1.0 FOR MIDDLE CLOUDS'
        READ(IOIN,*) WX(I,10)
        WRITE(IOOUT,*) WX(I,10)
        WRITE(IOOUT,*)
        IF(WX(I,10) .LT. 0.0 .OR. WX(I,10) .GT. 1.0) THEN
          WRITE(IOOUT,*) 'YOU HAVE ENTERED AN ILLEGAL VALUE FOR'
          WRITE(IOOUT,*) 'THE FRACTIONAL COVERAGE OF MIDDLE CLOUDS'
          GOTO 300
        ENDIF
      ELSE
        WX(I,10) = 0.0
      ENDIF
      IF(IWX(I,6) .GT. 0) THEN
 310      CONTINUE
        WRITE(IOOUT,*) 'ENTER THE FRACTIONAL SKY COVERAGE FROM'
        WRITE(IOOUT,*) '0.0 TO 1.0 FOR LOW CLOUDS'
        READ(IOIN,*) WX(I,11)
        WRITE(IOOUT,*) WX(I,11)
        WRITE(IOOUT,*)
        IF(WX(I,11) .LT. 0.0 .OR. WX(I,11) .GT. 1.0) THEN
```

```
            WRITE(IOOUT,*) 'YOU HAVE ENTERED AN ILLEGAL VALUE FOR'
            WRITE(IOOUT,*) 'THE FRACTIONAL COVERAGE OF LOW CLOUDS'
            GOTO 310
          ENDIF
        ELSE
          WX(I,11) = 0.0
        ENDIF
        IF(IWX(I,4) .GT. 0) THEN
  320       CONTINUE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-13-1----------------------------------
C CHANGED THE HIGH CLOUD BASE HEIGHT LIMITS FROM 9.0 - 20.0 TO 6.1 - 13.7
C KM TO MATCH THE VISIBLE INPUT LIMITS
          WRITE(IOOUT,*) 'ENTER THE BASE HEIGHT OF HIGH CLOUDS'
          WRITE(IOOUT,*) 'FROM 6.1 TO 13.7 KM.  IF -1.0 IS ENTERED'
          WRITE(IOOUT,*) 'A DEFAULT VALUE OF 9.0 KM WILL BE USED.'
          READ(IOIN,*) WX(I,12)
          WRITE(IOOUT,*) WX(I,12)
          WRITE(IOOUT,*)
          IF(WX(I,12) .LT. 6.1 .OR. WX(I,12) .GT. 13.7) THEN
            IF(WX(I,12) .NE. -1.0) THEN
            WRITE(IOOUT,*) 'BASE HEIGHT OF HIGH CLOUDS OUT OF RANGE'
            GOTO 320
            ELSE
             WX(I,12) = 9.0
            ENDIF
          ENDIF
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
        ENDIF
        IF(IWX(I,5) .GT. 0) THEN
  330       CONTINUE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-13-1----------------------------------
C CHANGED THE MIDDLE CLOUD BASE HEIGHT LIMITS FROM 4.0 - 8.0 TO 2.0 - 6.1
C KM TO MATCH THE VISIBLE INPUT LIMITS
          WRITE(IOOUT,*) 'ENTER THE BASE HEIGHT OF MIDDLE CLOUDS'
          WRITE(IOOUT,*) 'FROM 2.0 TO 6.1 KM.  IF -1.0 IS ENTERED'
          WRITE(IOOUT,*) 'A DEFAULT VALUE OF 4.0 KM WILL BE USED.'
          READ(IOIN,*) WX(I,13)
          WRITE(IOOUT,*) WX(I,13)
          WRITE(IOOUT,*)
          IF(WX(I,13) .LT. 2.0 .OR. WX(I,13) .GT. 6.1) THEN
            IF(WX(I,13) .NE. -1.0) THEN
            WRITE(IOOUT,*) 'BASE HEIGHT OF MIDDLE CLOUDS'
            WRITE(IOOUT,*) 'OUT OF RANGE'
            GOTO 330
            ELSE
            WX(I,13) = 4.0
            ENDIF
          ENDIF
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
        ENDIF
        IF(IWX(I,6) .GT. 0) THEN
  340       CONTINUE
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-13-1----------------------------------
C CHANGED THE LOW CLOUD BASE HEIGHT LIMITS FROM 1.0 - 4.0 TO 0.1 - 2.0
C KM TO MATCH THE VISIBLE INPUT LIMITS
          WRITE(IOOUT,*) 'ENTER THE BASE HEIGHT OF LOW CLOUDS'
          WRITE(IOOUT,*) 'FROM 0.1 TO 2.0 KM.  IF -1.0 IS ENTERED'
          WRITE(IOOUT,*) 'A DEFAULT VALUE OF 1.0 KM WILL BE USED.'
          READ(IOIN,*) WX(I,14)
          WRITE(IOOUT,*) WX(I,14)
```

```
          WRITE(IOOUT,*)
          IF(WX(I,14) .LT. 0.1 .OR. WX(I,14) .GT. 2.0) THEN
            IF(WX(I,14) .NE. -1.0) THEN
            WRITE(IOOUT,*) 'BASE HEIGHT OF LOW CLOUDS'
            WRITE(IOOUT,*) 'OUT OF RANGE'
            GOTO 340
            ELSE
            WX(I,14) = 1.0
            ENDIF
          ENDIF
C-HSTX---SCENE SHADOWS--------------------------------------------------
C
        ENDIF
  350     CONTINUE
         WRITE(IOOUT,*) 'ENTER THE INVERSION HEIGHT FROM'
         WRITE(IOOUT,*) ' 0.0 TO 3.0 KM'
         READ(IOIN,*) WX(I,15)
         WRITE(IOOUT,*) WX(I,15)
         WRITE(IOOUT,*)
         IF(WX(I,15) .GT. 3.0 .OR. WX(I,15) .LT. 0.) THEN
           WRITE(IOOUT,*) 'YOU HAVE ENTERED AN INVERSION HEIGHT'
           WRITE(IOOUT,*) 'WHICH IS OUT OF RANGE, PLEASE CHECK'
           GOTO 350
         ENDIF
  220    CONTINUE
       WRITE(IOOUT,*) 'ENTER THE CLUTTER INDEX AS FOLLOWS:'
       WRITE(IOOUT,*) '1 - LOW'
       WRITE(IOOUT,*) '2 - MODERATE'
       WRITE(IOOUT,*) '3 - HIGH'
       READ(IOIN,*) IWX(I,8)
       WRITE(IOOUT,*) IWX(I,8)
       WRITE(IOOUT,*)
       IF(IWX(I,8) .LT. 1 .OR. IWX(I,8) .GT. 3) THEN
         WRITE(IOOUT,*) 'YOU HAVE ENTERED AN ILLEGAL VALUE'
         WRITE(IOOUT,*) 'FOR THE CLUTTER INDEX'
         GOTO 220
       ENDIF
CD  REV 8/18/89
C STX TCM2 ECR ASL-8-1 ************************
C ADDED WX(I,18) WIND DIRECTION TO RECORD META
      WRITE(21,398)'META',WTME,FLOAT(IWX(I,1)),WX(I,7),WX(I,8),WX(I,15),
     &  WX(I,18)
      WRITE(21,397)'METB',WTME,WX(I,3),WX(I,4),WX(I,5),WX(I,6),
     &  FLOAT(IWX(I,8))
      WRITE(21,399)'HCLD',WTME,FLOAT(IWX(I,4)),WX(I,9),WX(I,12)
      WRITE(21,399)'MCLD',WTME,FLOAT(IWX(I,5)),WX(I,10),WX(I,13)
      WRITE(21,399)'LCLD',WTME,FLOAT(IWX(I,6)),WX(I,11),WX(I,14)
  397 FORMAT(A4,6X,6E10.4)
  398 FORMAT(A4,6X,6E10.4)
  399 FORMAT(A4,6X,4E10.4)
CD  REV 8/18/89
  400 CONTINUE
CD  REV 8/18/89
       IF (WX(1,15) .LT. 0.01) THEN
       IH = -1.
       ELSE
       IH = WX(1,15)
       ENDIF
       WRITE(21,401)'XSCL',FLOAT(IAERO),IH,WX(1,2)
  401  FORMAT(A4,6X,3E10.4)
CD   REV 8/18/89
      ELSE
C
C  READ THE METEOROLOGICAL DATA FOR TIMES
C  EVERY THREE HOURS BEGINNING (NTIM-1)*3 HOURS PRIOR
```

```
C  TO ITIMOT AND ENDING AT ITIMOT.
C
       DO 500 I=1,NTIM
C
C  COMPUTE THE TIME, RELATIVE TO TOT, OF THE I'TH
C  OBSERVATION.
C
         WX(I,1)=-3.*(NTIM-I)
         K = I -1
         IWX(I,1) = NINT(RECVAL(IBEGIN(18)+K,2))
         CALL INTCHK(3,1,IWX(I,1),'META','2ND',1)
         IF (IWX(I,1) .EQ. 2) THEN
            WX(I,2) = RECVAL(14,3)
            CALL REALCK(100.0,0.0,WX(I,2),'XSCL','3RD',0.0)
            WX(I,2) = WX(I,2)/25.4
         ELSE
            WX(I,2) = 0.0
         ENDIF
         IWX(I,4) = NINT(RECVAL(IBEGIN(15)+K,2))
         IWX(I,5) = NINT(RECVAL(IBEGIN(17)+K,2))
         IWX(I,6) = NINT(RECVAL(IBEGIN(16)+K,2))
         IWX(I,8) = NINT(RECVAL(IBEGIN(19)+K,6))
         DO 505 N = 3,6
            WX(I,N) = RECVAL(IBEGIN(19)+K,N-1)
 505        CONTINUE
C STX TCM2 ECR ASL-8-1 ***********************
C SKY AND SOLAR IRRADIANCE ALWAYS -1 IN RECORD
         WX(I,7) = -1.
         WX(I,8) = -1.
         WX(I,9) = RECVAL(IBEGIN(15)+K,3)
         WX(I,10) = RECVAL(IBEGIN(17)+K,3)
         WX(I,11) = RECVAL(IBEGIN(16)+K,3)
         WX(I,12) = RECVAL(IBEGIN(15)+K,4)
         WX(I,13) = RECVAL(IBEGIN(17)+K,4)
         WX(I,14) = RECVAL(IBEGIN(16)+K,4)
         WX(I,15) = RECVAL(IBEGIN(18)+K,5)
C STX TCM2 ECR ASL-8-1***********************
C ASSIGN WIND DIRECTION FROM RECORD
         WX(I,18) = RECVAL(IBEGIN(18)+K,6)
         CALL INTCHK(2,0,IWX(I,4),'HCLD','2ND',0)
         CALL INTCHK(3,3,IWX(I,5),'MCLD','2ND',0)
         CALL INTCHK(5,4,IWX(I,6),'LCLD','2ND',0)
         CALL INTCHK(3,1,IWX(I,8),'METB','6TH',1)
         CALL REALCK(60.0,-60.0,WX(I,3),'METB','2ND',10.0)
         CALL REALCK(WX(I,3),-60.0,WX(I,4),'METB','3RD',8.0)
         CALL REALCK(70.0,0.0,WX(I,5),'METB','4TH',8.0)
         CALL REALCK(200.0,0.1,WX(I,6),'METB','5TH',10.0)
         CALL REALCK(1368.0,-1.0,WX(I,7),'META','3RD',-1.0)
         CALL REALCK(600.0,-1.0,WX(I,8),'META','4TH',-1.0)
         CALL REALCK(1.0,0.0,WX(I,9),'HCLD','3RD',0.0)
         CALL REALCK(1.0,0.0,WX(I,10),'MCLD','3RD',0.0)
         CALL REALCK(1.0,0.0,WX(I,11),'LCLD','3RD',0.0)
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-13-1-------------------------------
C CHANGED THE CLOUD BASE HEIGHT LIMITS TO MATCH THE VISIBLE INPUT LIMITS
C           CALL REALCK(20.0,9.0,WX(I,12),'HCLD','4TH',9.0)
C           CALL REALCK(8.0,4.0,WX(I,13),'MCLD','4TH',4.0)
C           CALL REALCK(4.0,1.0,WX(I,14),'LCLD','4TH',1.0)
         CALL REALCK(13.7,6.1,WX(I,12),'HCLD','4TH',9.0)
         CALL REALCK(6.1,2.0,WX(I,13),'MCLD','4TH',4.0)
         CALL REALCK(2.0,0.1,WX(I,14),'LCLD','4TH',1.0)
C-HSTX---SCENE SHADOWS-------------------------------------------------
C
         CALL REALCK(3.0,0.0,WX(I,15),'META','5TH',3.0)
C STX TCM2 ECR ASL-8-1******************************
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```
C RECORD CHECK OF WIND DIRECTION
         IF (WX(I,5).GT.0.0)
     &       CALL REALCK(360.,1.,WX(I,18),'META','6TH',270.0)
  500    CONTINUE
      ENDIF
      TRLMAX = WX(1,1) + 6.0
      IF (INTER) THEN
  525   CONTINUE
      WRITE(IOOUT,*) 'ENTER THE NUMBER OF TIMES DURING THE FORECAST'
      WRITE(IOOUT,*) 'PERIOD THAT TARGET/BACKGROUND TEMPERATURES'
      WRITE(IOOUT,*) 'AND/OR SENSOR PERFORMANCE OUTPUT ARE TO BE'
      WRITE(IOOUT,*) 'CALCULATED.  ENTER A NUMBER FROM 1 TO 10'
        WRITE(*,*)'THE NUMBER OF TIMES DURING THE FORECAST PERIOD'
        WRITE(*,*)'THAT THE BACKGROUND/TARGET TEMPERATURES CAN BE'
        WRITE(*,*)'COMPUTED DEPENDS ON THE NUMBER OF MET DATA'
        WRITE(*,*)'SETS INPUT.  FOR EXAMPLE, IF THREE SETS OF MET'
        WRITE(*,*)'DATA ARE INPUT ONLY ONE TEMPERATURE PREDICTION'
        WRITE(*,*)'MAY BE MADE AT TIME 0.0.'
      READ(IOIN,*) NRUNTM
      WRITE(IOOUT,*) NRUNTM
      WRITE(IOOUT,*)
      IF(NRUNTM .LT. 1 .OR. NRUNTM .GT. 10) THEN
        WRITE(IOOUT,*) 'THE NUMBER OF RUN TIMES MUST BE'
        WRITE(IOOUT,*) 'BETWEEN 1 AND 10'
        GOTO 525
      ENDIF
CD  REV 8/18/89
      WRITE(21,526)'TIME',FLOAT(NTIM),FLOAT(NRUNTM)
  526   FORMAT(A4,6X,2E10.4)
CD  REV 8/18/89
      DO 530 I = 1,NRUNTM
  527     CONTINUE
        WRITE(IOOUT,*) 'ENTER THE TIME RELATIVE TO THE TIME'
        WRITE(IOOUT,*) 'OF INTEREST FOR RUN NUMBER',I,'.'
        WRITE(IOOUT,*) 'THE TIME MUST BE LESS THAN OR EQUAL TO 0'
        WRITE(IOOUT,*) 'AND MUST BE IN HH.HH FORMAT'
        READ(IOIN,*) TRLTOT(I)
        WRITE(IOOUT,*) TRLTOT(I)
        WRITE(IOOUT,*)
        IF(TRLTOT(I).LT.TRLMAX-0.0001.OR.TRLTOT(I).GT.0.0 ) THEN
          WRITE(IOOUT,*) 'YOU HAVE ENTERED A RELATIVE TIME WHICH'
          WRITE(IOOUT,*) 'IS OUT OF RANGE. PLEASE ENTER A NUMBER'
          WRITE(IOOUT,*) 'BETWEEN',TRLMAX,'AND 0.0'
          GOTO  527
        ENDIF
CD   REV 8/18/89
      IF (I .EQ. NRUNTM) THEN
        WRITE(21,528)'NRUN',TRLTOT(1),TRLTOT(2),TRLTOT(3),TRLTOT(4),
     +      TRLTOT(5)
      ENDIF
  528   FORMAT(A4,6X,5E10.4)
CD   REV 8/18/89

  530   CONTINUE
C
C  PUT TRLTOT(N) IN CHRONOLOGICAL ORDER
C
      DO 533 J = 2,NRUNTM
        M = J
  532     IF (M .GE. 2) THEN
          IF (TRLTOT(M) .GT. TRLTOT(M-1)) THEN
            TEMP = TRLTOT(M)
            TRLTOT(M) = TRLTOT(M-1)
            TRLTOT(M-1) = TEMP
          ENDIF
```

```
            M = M - 1
            GOTO 532
          ENDIF
  533     CONTINUE
        ELSE
C  READ IN THE NUMBER OF TIMES FOR WHICH TARGET/BACKGROUND
C  TEMPERATURES ARE TO BE COMPUTED.
C
        NRUNTM = NINT(RECVAL(13,2))
        CALL INTCHK(10,1,NRUNTM,'TIME','2ND',1)
C
C  READ IN THE TIMES, RELATIVE TO TOT, FOR WHICH TARGET/
C  BACKGROUND TEMPERATURES ARE TO BE COMPUTED.
C
        ICOUNT = 1
        NPNT = IBEGIN(20)
        DO 535 J = 1,NRUNTM
          IF (ICOUNT .EQ. 8) THEN
            ICOUNT = ICOUNT - 7
            NPNT = IPTR(20)
          ENDIF
          TRLTOT(J) = RECVAL(NPNT,ICOUNT)
          ICOUNT = ICOUNT + 1
 535      CONTINUE
        ENDIF
C
C  CONVERT WX(I,1) TO GMT IN HOURS AND HUNDRED HOURS AND FIND
C  APPROPRIATE GMT DAY.
C
        DO 560 I=1,NTIM
        CALL TCONVR(TOT,WX(I,1),IDATE,JD,GMT,ITIME)
        JDATE(I)=JD
        JTIME(I)=ITIME
  560 CONTINUE
C
C STX TCM2 ECR ASL-8-1+++++++++++++++++++++++++++++++++++++++++++++
C  WRITE INPUT DATA TO FILE FOR TCM2 TO READ AND FOR TARGAC TO READ
C  WHEN TCM2 IS DONE. (PC VERSION ONLY)
C  FOR MAINFRAME COMMENT OUT THE FOLLOWING LINES TO THE STX LABEL
      OPEN(UNIT=41,FILE='COMMON.DAT',STATUS='UNKNOWN')
      WRITE(41,*)RLATT,RLONG,ELEV,THEAD,SLAT,SLON
      WRITE(41,*)NTARID,VSPEED,ASP,ALT,IDTG,ITARG
      WRITE(41,*)NBKID,GNRICB,TBKG,INTER,GNRICT,TTRG
      WRITE(41,*)IDATE,ITIMOT,YEAR
      WRITE(41,*)NTIM,NRUNTM,WTME,TRLTOT,TOT
      WRITE(41,*)ALB,TBAR,IAERO,RG,IH
      WRITE(41,*) JDATE
      WRITE(41,*) JTIME
      WRITE(41,*) WX
      WRITE(41,*) IWX
C*STX*************************************************************
    6 FORMAT(A4)
 1000 FORMAT(1X,I2,A35,I2,A35)
      END
```

ECR # HSTX - 14 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: THERMB

Old Date: 3/19/93

File Name: THERMB.FOR

New Date: 9/14/93

Implemented By: Michael Oberlatz

Reason for Revision: The ceiling height assignment was changed to match the assignment in the visible section.

Description of Revision: The ceiling height is now assigned to the lowest cloud layer with a cloud fraction of greater than 0.7, rather than the lowest layer with a cloud fraction greater than 0.0.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

ECR # HSTX - 14 - 2

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: THERMB

Old Date: 9/14/93

File Name: THERMB.FOR

New Date: 10/20/93

Implemented By: Melanie J. Gouveia

Reason for Revision: The ceiling height assignment was changed to match the Air Force definition, and the assignment in the visible section.

Description of Revision: The ceiling height is now assigned to that height at which clouds at and below the height cover more than 4/8 of the sky. Since the Air Force defines cloud coverage in eighths, this means that the coverage must be at least 5/8, or approximately 0.6.

Notes: This definition of ceiling height was taken from AWSR 105-24, Vol. 1, 1 March 1983.

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C
C***********************************************************************
      SUBROUTINE THERMB
C***********************************************************************
C THIS SUBROUTINE WAS BLOCKS 2 & 3 OF THE ORIGINAL THERML SUBROUTINE.
C THE SPLIT WAS TO ACCOMMODATE THE PC VERSION TO ALLOW TCM2 TO RUN THEN
C RETURN TO THIS ROUTINE, THE SECOND HALF OF THERML TO WRITE THE INPUT OF
C TARGAC AND THE OUTPUT OF TCM2.

C+STX TCM2 ECR ASL-9-1 +++++++++++++++++++++++++++++++++++++++++++
C  RE-DIMENSIONED:
C                WX(17,19) TO WX(11,19),IWX(17,8) TO IWX(11,8)
C                JDATE(17) TO JDATE(11), JTIME(17) TO JTIME(11)
C  TCM2 CAN ONLY HANDLE 30 HOURS OF WEATHER DATA VERSUS 48 FOR TCM1
C -STX TCM2-----------------------------------------------------

      COMMON/IOFILE/IOFILE
      COMMON/WPARM1/ATEMP(2),ADPT(2),ANGLE,RANGE1,HTINV,HTSEN,IHAZE,
     + VIS,IWXX,RR,KFLAG
      COMMON/WEATHR/WX(11,19),IWX(11,8),ALB,TCORE,TBAR
      COMMON/TIMES/NTIM,NRUNTM,TRLTOT(7),IDATE,ITIMOT,TOT,
     + JDATE(11),JTIME(11)
      COMMON/ASCENE/NTARID,NBKID,ITARID,IBKID,RLATT,RLONG,ELEV,VSPEED,
     + THEAD
      COMMON/OFILE/TITLE
      COMMON/THRM/NRTM,TTRG,TBKG,TMPC,DEWP,ALT,VS,IAERO,RNRT,CEIL
     +          ,AINV,WINDS,ELEVA,ASP,IDTG,IOP
      COMMON/TEMPS/TEMPSF(10)
C+STX TCM2 ECR ASL-9-1 +++++++++++++++++++++++++++++++++++++++++++
C NEW COMMON BLOCK
      COMMON/TEMPS2/TEMPB(10),RNDELT(5)
C-STX TCM2------------------------------------------------
      COMMON/RADANC/ZEN(11),SOLRAD(11),SKYRAD(11)
      COMMON/INOUT/INTER,IRPT,EFLAG
      COMMON/IOUNIT/IOIN,IOOUT,IPHFUN,LOUNIT,NDIRTU,NCLIMT,IRELH,
     1            KSTOR,NPLOTU,STDERR
      COMMON /IBLOCK/ RECVAL(111,7), RECUSE(21), IPTR(21), IBEGIN(22)
CD    GENERIC TARGET AND BACKGROUND REV
C+STX TCM2 ECR ASL-9-1 +++++++++++++++++++++++++++++++++++++++++++
C GNRICB ADDED TO COMMON BLOCK
      COMMON / GNERIC / GNRICT,GNRICB
C-STX TCM2------------------------------------------------
CD
C
C***REV 1/91
      COMMON /ILDATA/ FMONTH, DAY, YEAR, GTIME, SLAT, SLON, ILR1, ILR2,
     +                ILR3, RG, FR1, FR2, FR3, SIGWX, OBSURF, CEILHT,
     +                PRTYP, FRC, ITARG
      COMMON /ILUMCM/ ALTS, AZIS, ALTMN, AZIM, DPHASE, ELUMI, SUNLIT,
     +                MOOLIT, TCLSUN, TCLLUN, RCLSUN, RCDSUN, RCLLUN,
     +                RCDLUN
C
      INTEGER IOIN,IOOUT,IPHFUN,LOUNIT,NDIRTU,NCLIMT
      INTEGER IRELH,KSTOR,NPLOTU,STDERR, IOFILE
CD  REV 8/18/89
      REAL IH,MOOLIT
CP IH LOOKS LIKE IT IS UNUSED TO CODE CHECKERS. IT IS USED
CP IN OTHER ROUTINES. LEAVE IT IN FOR NOW. NOV 92 PSG
CD  REV 8/18/89
      DIMENSION ZDFALT(3)
      CHARACTER*15 TITLE
      CHARACTER*1 ICDLAY(3),CLCHAR(3)
CP        CHARACTER*1 STAR(10),DUM1,DUM2,ICDLAY(3),CLCHAR(3)  NOV 92 PSG
      LOGICAL INTER,EFLAG,RECUSE,GNRICT,GNRICB
CP        CHARACTER *3 MRTIT(2)   UNUSED NOV 92 PSG
```

```
CP      CHARACTER *4 FOVTIT(2)  UNUSED NOV 92 PSG
      DATA ICDLAY/'H','M','L'/
      DATA ZDFALT/9.,4.,1./
C
C
C*************************************************
C
C  WRITE INPUT DATA
C
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
      WRITE(NDIRTU,2000)
      WRITE(NDIRTU,2001)TITLE
C STX TCM2 ECR ASL-9-1++++++++++++++++++++++++++++++++++++++
C ADDED TARGET HEADING, TARGET ID, BACKGROUND ID, AND YEAR TO
C            THE OUTPUT FILE TAC.OUT
C STX TCM2--------------------------------------------------
      WRITE(NDIRTU,2002)RLATT,RLONG,ELEV,THEAD
      WRITE(NDIRTU,2046)NTARID
      WRITE(NDIRTU,2052)NBKID
      WRITE(NDIRTU,2003)IDATE,ITIMOT,INT(YEAR)
      WRITE(NDIRTU,2004)ASP
      WRITE(NDIRTU,2006) (TRLTOT(N),N=1,NRUNTM)
      WRITE(NDIRTU,2007)ALB,TBAR
      WRITE(NDIRTU,2008)
      WRITE(NDIRTU,2009) (JDATE(N),N=1,NTIM)
      WRITE(NDIRTU,2010) (JTIME(N),N=1,NTIM)
      WRITE(NDIRTU,2011) (WX(N,1),N=1,NTIM)
      WRITE(NDIRTU,2012) (IWX(N,1),N=1,NTIM)
      WRITE(NDIRTU,2013) (WX(N,2),N=1,NTIM)
      WRITE(NDIRTU,2015) (WX(N,3),N=1,NTIM)
      WRITE(NDIRTU,2016) (WX(N,4),N=1,NTIM)
      WRITE(NDIRTU,2017) (WX(N,5),N=1,NTIM)
C STX TCM2 ECR ASL-9-1 ++++++++++++++++++++
C ADDED WIND DIRECTION TO TAC.OUT
      WRITE(NDIRTU,2117) (WX(N,18),N=1,NTIM)
C STX TCM2----------------------------------
      WRITE(NDIRTU,2018) (WX(N,6),N=1,NTIM)
      WRITE(NDIRTU,2019) (WX(N,7),N=1,NTIM)
      WRITE(NDIRTU,2020) (WX(N,8),N=1,NTIM)
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      WRITE(IOOUT,2000)
C STX TCM2 ECR ASL-9-1 +++++++++++++++++++++++++++++++++
C ADDED TARGET HEADING, TARGET ID, BACKGROUND ID, AND YEAR TO
C            THE OUTPUT DISPLAY (SCREEN)
C STX TCM2 ----------------------------------------------
      WRITE(IOOUT,2001)TITLE
      WRITE(IOOUT,2002)RLATT,RLONG,ELEV,THEAD
      WRITE(IOOUT,2046)NTARID
      WRITE(IOOUT,2052)NBKID
      WRITE(IOOUT,2003)IDATE,ITIMOT,INT(YEAR)
      WRITE(IOOUT,2004)ASP
      WRITE(IOOUT,2006) (TRLTOT(N),N=1,NRUNTM)
      WRITE(IOOUT,2007)ALB,TBAR
      WRITE(IOOUT,2008)
C
      WRITE(IOOUT,*)'HIT ENTER TO CONTINUE'
      READ(IOOUT,*)
C
      WRITE(IOOUT,2009) (JDATE(N),N=1,NTIM)
      WRITE(IOOUT,2010) (JTIME(N),N=1,NTIM)
      WRITE(IOOUT,2011) (WX(N,1),N=1,NTIM)
      WRITE(IOOUT,2012) (IWX(N,1),N=1,NTIM)
      WRITE(IOOUT,2013) (WX(N,2),N=1,NTIM)
      WRITE(IOOUT,2015) (WX(N,3),N=1,NTIM)
```

```
      WRITE(IOOUT,2016) (WX(N,4),N=1,NTIM)
      WRITE(IOOUT,2017) (WX(N,5),N=1,NTIM)
C STX TCM2  ECR ASL-9-1 ++++++++++++++++++++
C ADDED WIND DIRECTION TO SCREEN
      WRITE(IOOUT,2117) (WX(N,18),N=1,NTIM)
C STX TCM2--------------------------------
      WRITE(IOOUT,2018) (WX(N,6),N=1,NTIM)
      WRITE(IOOUT,2019) (WX(N,7),N=1,NTIM)
      WRITE(IOOUT,2020) (WX(N,8),N=1,NTIM)
      ENDIF
      DO 570 I=1,3
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU, 2022)ICDLAY(I),(IWX(N,3+I),N=1,NTIM)
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        WRITE(IOOUT, 2022)ICDLAY(I),(IWX(N,3+I),N=1,NTIM)
      ENDIF
 570  CONTINUE
      DO 580 I=1,3
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU, 2023)ICDLAY(I),(WX(N,8+I),N=1,NTIM)
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        WRITE(IOOUT, 2023)ICDLAY(I),(WX(N,8+I),N=1,NTIM)
      ENDIF
 580  CONTINUE
      DO 590 I=1,3
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU, 2024)ICDLAY(I),(WX(N,11+I),N=1,NTIM)
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
         WRITE(IOOUT, 2024)ICDLAY(I),(WX(N,11+I),N=1,NTIM)
      ENDIF
 590  CONTINUE
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
      WRITE(NDIRTU,2025) (WX(N,15),N=1,NTIM)
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      WRITE(IOOUT,2025) (WX(N,15),N=1,NTIM)
      ENDIF
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
      WRITE(NDIRTU,2069) (IWX(N,8),N=1,NTIM)
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      WRITE(IOOUT,2069) (IWX(N,8),N=1,NTIM)
      WRITE(IOOUT,*)'HIT ENTER TO CONTINUE'
      READ(IOOUT,*)
      ENDIF

C***************************************************
C                                                  *
C        END BLOCK 1                               *
C                                                  *
C***************************************************
C                                                  *
C        BEGIN BLOCK 2                             *
C                                                  *
C        SET DEFAULTS, CALCULATE AND WRITE         *
C        SOLAR AND SKY IRRADIANCE.                 *
C                                                  *
C***************************************************
C
C  PARAMETERS DEFINED BY DEFAULT.
C
C
```

```
      DO 651 I=1,NTIM
C
C  DEFINE RESTRICTION TO VISIBILITY INDEX FOR INSOLATION MODEL
      IWX(I,3)=0
      IF(WX(I,6).LE.11.)IWX(I,3)=1
C
C  COMPUTE PRECIPITATION INDEX FOR INSOLATION MODEL FOR WEATHER
C  PREDICTION TIMES.
      IWX(I,7)=0
      IF(IWX(I,1).GT.1)IWX(I,7)=1

C  CONVERT RAINFALL RATE FROM INCHES/HR TO MM/HR
      WX(I,2)=WX(I,2)*25.4

C  CONVERT WIND SPEED FROM KNOTS TO METERS/HOUR
      WINDS = WX(I,5)
      WX(I,5)=WX(I,5)*1851.984
651   CONTINUE

C  CONVERT STATION ELEVATION FROM FEET TO METERS
      ELEV=ELEV*3.2808
C
C STX TCM2 ECR ASL-9-1 ++++++++++++++++++++++++++++++++++++++++
C REMOVED CODE THAT DEFINED OR REDINED:
C                                      SENSOR ALTITUDE
C                                      BACKGROUND ALBEDO
C                                      AVERAGE AIR TEMPERATURE
C                                      CORE TEMPERATURE
C STX-TCM2------------------------------------------------------
C  LOOP THROUGH CLOUD HEIGHT DATA, IF ANY DEFAULT VALUES
C  ARE REQUIRED, FILL IN WITH THE FOLLOWING DEFAULT CLOUD
C  BASE HEIGHTS.  HIGH CLOUDS=9KM, MIDDLE CLOUDS=4KM,
C  LOW CLOUDS=1KM.
      IPRF=0
      DO 680 N=1,NTIM
      DO 680 I=1,3
        IF(WX(N,I+11).LT.0..AND.WX(N,I+8).GT.0.)THEN
          WX(N,I+11)=ZDFALT(I)
          IPRF=1
        END IF
680   CONTINUE
C
C  WRITE OUT CLOUD HEIGHT DEFAULTS FOR USER.
C
      IF(IPRF.EQ.1)THEN
      WRITE(IOOUT,2033)
      END IF
       VS = WX(NTIM,6)
       TMPC = WX(NTIM,3)
       DEWP = WX(NTIM,4)
       RNRT = WX(NTIM,2)
       CEIL = -1
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-14-1---------------------------------
C THE CEILING HEIGHT CHECK WAS CHANGED TO BE THE LOWEST CLOUD LAYER WITH A
C FRACTION GREATER THAN 0.7, RATHER THAN THE LOWEST EXISTING CLOUD LAYER
C-HSTX---SCENE SHADOWS---ECR # HSTX-14-2----------------------------
C CHANGE THE CEILING HEIGHT TO MATCH THE AIR FORCE DEFINITION: THE
C HEIGHT AT WHICH CLOUDS AT AND BELOW THAT HEIGHT COVER MORE THAN 4/8
C OF THE SKY (FROM AWSR 105-24).  5/8 (0.625) IS THE NEXT INCREMENT.
       FRAC = WX(NTIM,11)
       IF (FRAC.GT.0.6) THEN
          CEIL = WX(NTIM,14)
       ELSE
          FRAC = FRAC + WX(NTIM,10)
```

```
          IF (FRAC.GT.0.6) THEN
             CEIL = WX(NTIM,13)
          ELSE
             FRAC = FRAC + WX(NTIM,9)
             IF (FRAC.GT.0.6) CEIL = WX(NTIM,12)
          ENDIF
       ENDIF
C-HSTX---SCENE SHADOWS---------------------------------------------------
C
       AINV = WX(NTIM,15)

C STX TCM2 -ECR ASL-9-1+++++++++++++++++++++++++++++++++++++
C REMOVED CALL TO RADCOM. TCM2 WILL COMPUTE SOLAR AND/OR SKY IRRADIANCE
C STX-TCM2----------------------------------------------------
C
C  WRITE OUT A SOLAR AND/OR SKY IRRADIANCE VALUES AS COMPUTED
C  BY SUBROUTINES SKYRAD AND INSOL AT THE METEOROLOGICAL
C  INPUT TIMES.
C
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
      WRITE(NDIRTU,2034)
      WRITE(NDIRTU,2009)(JDATE(N),N=1,NTIM)
      WRITE(NDIRTU,2010)(JTIME(N),N=1,NTIM)
      WRITE(NDIRTU,2011)(WX(N,1),N=1,NTIM)
      WRITE(NDIRTU,2035)(ZEN(N),N=1,NTIM)
      WRITE(NDIRTU,2019)(SOLRAD(N),N=1,NTIM)
      WRITE(NDIRTU,2020)(SKYRAD(N),N=1,NTIM)
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      WRITE(IOOUT,2034)
      WRITE(IOOUT,2009)(JDATE(N),N=1,NTIM)
      WRITE(IOOUT,2010)(JTIME(N),N=1,NTIM)
      WRITE(IOOUT,2011)(WX(N,1),N=1,NTIM)
      WRITE(IOOUT,2035)(ZEN(N),N=1,NTIM)
      WRITE(IOOUT,2019)(SOLRAD(N),N=1,NTIM)
      WRITE(IOOUT,2020)(SKYRAD(N),N=1,NTIM)
      ENDIF

C STX TCM2 ECR ASL-9-1 ++++++++++++++++++++++
C SENSOR DEPRESSION ANGLE IS COMPUTED IN FINDR
C STX TCM2-----------------------------------
C
C************************************************
C                                               *
C        END BLOCK 2                            *
C                                               *
C************************************************
C                                               *
C        BEGIN BLOCK 3                          *
C                                               *
C        TCM2 COMPUTES TARGET AND BKGND         *
C        TEMPS, INCLUDING EFFECT OF RAIN.       *
C                                               *
C************************************************
C STX TCM2 ECR ASL-9-1++++++++++++++++++++++++++++
C REMOVED CALLS TO TARG, ALPHA1, ENVMOD
C STX TCM2--------------------------------
C * * * OUTPUT DATA FOR TCM * * *
C
C  WRITE TARGET TEMPERATURES
C
C
C STX TCM2 ECR ASL-9-1 ++++++++++++++++++++++++++++++++++++++++
C REMOVED LOGIC TO DETERMINE STAR
C  STX --THE ASTERISK IS NO LONGER NEEDED BECAUSE TCM2
```

```
C  TAKES ACCOUNT OF RAIN EFFECT ON TARGET/BACKGROUND TEMPERATURES.
C STX TCM2----------------------------------------
C
C  DETERMINE GMT DATE AND TIME FROM OUTPUT TIMES WHICH ARE RELATIVE
C  TO TOT
C  LOOP ON OUTPUT TIMES
      DO 739 N=1,NRUNTM
      CALL TCONVR(TOT,TRLTOT(N),IDATE,JD,GMT,ITIME)
      JDATE(N)=JD
 739  JTIME(N)=ITIME
C
C  WRITE HEADER FOR TARGET TEMPERATURE DATA
      IF(NTARID.NE.0)THEN
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU,2036)
C STX TCM2 ECR ASL-9-1 +++++++++++++++++++++++
C ALTITUDE IS NOW ENTERED IN FEET CONVERT TO KM
        WRITE(NDIRTU,2053)ASP,(ALT/3280.8)
C STX TCM2 --------------------------------
        WRITE(NDIRTU,2037)(JDATE(N),N=1,NRUNTM)
        WRITE(NDIRTU,2038)(JTIME(N),N=1,NRUNTM)
        WRITE(NDIRTU,2039)(TRLTOT(N),N=1,NRUNTM)
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        WRITE(IOOUT,2036)
C STX TCM2 ECR ASL-9-1 ++++++++++++++++++++++++
C ALTITUDE IS NOW ENTERED IN FEET CONVERT TO KM
        WRITE(IOOUT,2053)ASP,(ALT/3281.)
C STX TCM2------------------------------------
        WRITE(IOOUT,2037)(JDATE(N),N=1,NRUNTM)
        WRITE(IOOUT,2038)(JTIME(N),N=1,NRUNTM)
        WRITE(IOOUT,2039)(TRLTOT(N),N=1,NRUNTM)
      ENDIF
C*************************************************
C                                                *
C        BLOCK 3A                                *
C                                                *
C  THE PURPOSE OF THIS SUB-BLOCK IS TO OUTPUT    *
C  TARGET TEMPERATURES.  ALL OF ITS OTHER        *
C  FUNCTIONS HAVE BEEN TAKEN OVER BY TCM2.       *
C                                                *
C*************************************************
C STX TCM2 ECR ASL-9-1 ++++++++++++++++++++++++=
C REMOVED CALL TO OPER
C STX TCM2------------------------------------
CD  IF GENERIC SCENARIO IS CHOSEN, THEN OUTPUT IS DIFFERENT
      IF (.NOT. GNRICT) THEN
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU,2040)IDTG,(TEMPSF(N),N=1,NRUNTM)
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        WRITE(IOOUT,2040)IDTG,(TEMPSF(N),N=1,NRUNTM)
      ENDIF
      ELSE
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU,2040)IDTG,(TTRG,N=1,NRUNTM)
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        WRITE(IOOUT,2040)IDTG,(TTRG,N=1,NRUNTM)
      ENDIF
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
      WRITE(IOOUT,*)'HIT ENTER TO CONTINUE'
      READ(IOOUT,*)
      ENDIF
```

```
C
C*************************************************
C                                                *
C        END BLOCK 3A                            *
C                                                *
C*************************************************
C
      IF(NBKID.NE.0)THEN
C       PRINT OUT BACKGROUND TEMPERATURES
      IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU,2041)
        WRITE(NDIRTU,2037)(JDATE(N),N=1,NRUNTM)
        WRITE(NDIRTU,2038)(JTIME(N),N=1,NRUNTM)
        WRITE(NDIRTU,2039)(TRLTOT(N),N=1,NRUNTM)
      ENDIF
      IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        WRITE(IOOUT,2041)
        WRITE(IOOUT,2037)(JDATE(N),N=1,NRUNTM)
        WRITE(IOOUT,2038)(JTIME(N),N=1,NRUNTM)
        WRITE(IOOUT,2039)(TRLTOT(N),N=1,NRUNTM)
      ENDIF
      ID=NBKID
        IF (.NOT. GNRICB) THEN
          IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
            WRITE(NDIRTU,2042)ID,(TEMPB(N),N=1,NRUNTM)
          ENDIF
          IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
            WRITE(IOOUT,2042)ID,(TEMPB(N),N=1,NRUNTM)
          ENDIF
        ELSE
          IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
            WRITE(NDIRTU,2042)ID,(TBKG,N=1,NRUNTM)
          ENDIF
          IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
            WRITE(IOOUT,2042)ID,(TBKG,N=1,NRUNTM)
          ENDIF
        ENDIF
      ENDIF
      ENDIF
C
C  DO NOT PROCEED TO NEXT SECTION UNDER ANY OF THE FOLLOWING CONDITIONS
      IF(NTARID.EQ.0.OR.NBKID.EQ.0) STOP '97'
C*************************************************
C  FORMAT STATEMENTS
 4    FORMAT(1X,'INSUFFICIENT DATA TO COMPUTE AVERAGE AIR TEMPERATURE')
 2000 FORMAT('1',1X,'INPUT DATA'/)
 2001 FORMAT(1X,'RUN TITLE = ',A10)
 2002 FORMAT(1X,'TARGET LOCATION- LATITUDE =',F6.1,' DEGREES(NORTH',
     + '  POSITIVE)',/18X,'LONGITUDE =',F7.1,' DEGREES(WEST POSITIVE)',/
     + 18X,'ELEVATION =',F8.1,' FEET',/18X,'TARGET HEADING =',F5.1,
     + ' DEGREES')
 2003 FORMAT(1X,'TIME-OVER-TARGET-   GMT DAY-OF-THE',
     + '-YEAR =',I4,/21X,'GMT TIME =',I5,' HUNDRED HOURS',
     + /21X,'YEAR     =',I5)
 2004 FORMAT(1X,'ASPECT ANGLE=',F5.1,' DEGREES  ')
 2006 FORMAT(1X,'OUTPUT TIMES(HOURS RELATIVE TO TOT)=',10F6.1)
 2007 FORMAT(1X,'ALBEDO= ',F5.2,/1X,'AVERAGE AIR ',
     + 'TEMPERATURE(24 HRS)=',F6.1,' DEGREES CENTIGRADE')
 2008 FORMAT(//13X,'TIME DEPENDENT INPUT DATA'/)
 2009 FORMAT(1X,'GMT DATE',4X,17I7)
 2010 FORMAT(1X,'GMT TIME',4X,17I7)
 2011 FORMAT(1X,'REL.TIME',4X,17F7.1)
 2012 FORMAT(1X,'PRECIP.',5X,17I7)
 2013 FORMAT(1X,'PRECIP. RATE',17F7.2)
 2014 FORMAT(1X,'AEROSOL',5X,17I7)
```

```
2015 FORMAT(1X,'TEMPERATURE ',17F7.1)
2016 FORMAT(1X,'DEW POINT',3X,17F7.1)
2017 FORMAT(1X,'WIND SPEED  ',17F7.1)
2117 FORMAT(1X,'WIND DIRECT.',17F7.1)
2018 FORMAT(1X,'VISIBILITY  ',17F7.1)
2019 FORMAT(1X,'SOLAR IRR.  ',17F7.1)
2020 FORMAT(1X,'SKY IRR.    ',17F7.1)
2022 FORMAT(1X,'CLD. TYPE',A2,1X,17I7)
2023 FORMAT(1X,'CLD. FRAC.',A2,17F7.3)
2024 FORMAT(1X,'CLD. HT.',A3,1X,17F7.1)
2025 FORMAT(1X,'INVERSION HT',17F7.1)
2033 FORMAT(2X,'THE FOLLOWING DEFAULT CLOUD BASE HEIGHTS ARE',/
    +' USED WHERE THE USER DOES DEFINE THEM-- HIGH CLOUDS=9KM,',/
    +' MIDDLE CLOUDS=4KM, LOW CLOUDS=1KM.')
2034 FORMAT(///2X,'SOLAR AND SKY IRRADIANCE AT METEOROLOGICAL INPUT',/
    + ' TIMES, COMPUTED BY TCM2.')
2035 FORMAT(1X,'ZENITH ANGLE',17F7.1)
2036 FORMAT(//1X,'EQUIVALENT BLACKBODY TEMPERATURES OF TARGETS')
2037 FORMAT(1X,'GMT DATE',20X,10I7)
2038 FORMAT(1X,'GMT TIME',20X,10I7)
2039 FORMAT(1X,'REL. TIME',20X,10F7.1)
2040 FORMAT(1X,'TARGET',I2,20X,10(2X,F5.1))
2041 FORMAT(///1X,'EQUIVALENT BLACKBODY TEMPERATURES OF BACKGROUNDS')
2042 FORMAT(1X,'BACKGROUND',I3,16X,10(2X,F5.1))
2043 FORMAT(///1X,A31,3X,A3,3X,A4,'   TARGET ID=',I3,2X,A10/)
2046 FORMAT(1X,'TARGET ID=',4I4)
2052 FORMAT(1X,'BACKGROUND ID=',6I4)
2053 FORMAT(1X,'ASPECT ANGLE=',F5.1,' DEGREES   ALTITUDE=',F7.2,
    + ' KM')
2069 FORMAT(1X,'CLUTTER      ',17I7)
     END
```

ECR # HSTX - 15 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: LAYERS
Old Date: New

File Name: LAYERS.FOR
New Date: 10/20/93

Implemented By: Dan DeBenedictis

Reason for Revision: To find a weighted average of the extinction coefficient (BETAA) and the asymmetry parameter (G) for all atmospheric layers that contain some or all of a cloud layer.

Description of Revision: Using the cloud base heights and thickness values, each atmospheric layer is checked for the presence of clouds. When a layer is found to contain a cloud, a weighted average of the extinction coefficient and asymmetry parameter is computed using the percent of cloud in the layer and percentage of the layer that is clear.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C-HSTX---SCENE SHADOWS---ECR # HSTX-15-1---------------------------------
C
C  NEW ROUTINE TO COMPUTE THE EXTINCTION COEFFICIENT AND ASYMMETRY
C  PARAMETERS FOR THE ATMOSPHERIC LAYERS THAT CONTAIN CLOUDS.
C
C-HSTX---SCENE SHADOWS---------------------------------------------------
C************************************************************************
C<BEGIN>
C<IDENTIFICATION>   NAME:   LAYERS
C                    TYPE:   FORTRAN SUBROUTINE
C                 FILENAME: LAYERS.FOR
C=======================================================================
C<DESCRIPTION>
C  Using the cloud base heights and thickness values, each atmospheric
C  layer is checked for the presence of clouds.  When a layer is found
C  to have a cloud, a percentage of how much of the layer contains the
C  cloud is computed.  Then a weigthed average of the extinction
C  coefficient and asymmentry parameters is computed with percentage of
C  cloud and the percentage of clear in the layer.
C=======================================================================
C<INPUT>
C    COMMON BLOCK VARIABLES:
C      /ATMOS/     Z         Array of base heights of the atmos layers.(km)
C      /RADIA/     G(20)     Array of layer asymmetry parameters.
C      /RADIA/     BETAA(20) Array of layer extinction coefficients.
C=======================================================================
C<OUTPUT>
C    COMMON BLOCK VARIABLES:
C      /RADIA/     G(20)      Array of layer asymmetry parameters.
C      /RADIA/     BETAA(20)  Array of layer extinction coefficients.
C=======================================================================
C<CALLED ROUTINES>
C      NONE
C=======================================================================
C<PARAMETER>
C    CALLING SEQUENCE:
C        LAYERS (ZC1,THK1,ZC2,THK2,CLDBTA,CLDG)
C    INPUT:
C      ZC1  Cloud base height for top cloud. (km)
C      ZC2  Cloud base height for lower cloud. (km)
C      THK1 Cloud thickness for top cloud. (km)
C      THK2 Cloud thickness for lower cloud. (km)
C      CLDBTA Array of cloud extinction coefficients.
C           I = 1 for lower cloud layer
C           I = 2 for upper cloud layer.
C      CLDG Array of cloud asymmetry parameters.
C           I = 1 for lower cloud layer.
C           I = 2 for upper cloud layer.
C    OUTPUT:
C      NONE
C=======================================================================
C<HISTORY>
C  CREATED OCTOBER, 1993.  HUGHES STX CORPORATION.
C=======================================================================
C<END>
C
C List of variables:
C      AMOUNT     Amount of the atmospheric layer that contains a cloud.
C      BASE1      Cloud base of the top cloud. (km)
C      BASE2      Cloud base of the lower cloud. (km)
C      PCLD1      Percentage of the layer that is the top cloud.
C      PCLD2 Percentage of the layer that is the lower cloud.
C      PCLR Percentage of the layer that is clear.
C      TOP1 Top of the top cloud. (km)
C      TOP2 Top of the lower cloud. (km)
```

```
C
      SUBROUTINE LAYERS (ZC1,THK1,ZC2,THK2,CLDBTA,CLDG)
C
      DIMENSION CLDBTA(2), CLDG(2)
      COMMON/ATMOS/PRES(21),Z(21),RHO(21),NLEV,NLAY
      COMMON/RADIA/A(20),G(20),GP(20),BETAA(20),BETAR(20),
     1               BETA(20),K(20),P(20),ALPHA(20),BET(20),
     2               TAU(0:20),I0(20,4),I1(20,4),F(20,4),TF(20),FNOT,
     3               NANG,PF(180,20),ANG(180,20),I2(20),TAUP(0:20),
     4               ISTAR(20,30,2),PTHRD(30,2),SING(30),AP(20),PHF(30),
     5               ALBEDO,SURF(30,4),SURF0(30,2),TAUSTR,VIS,CAPTP(20),
     6               B1,B2
C
      BASE1 = ZC1
      TOP1 = ZC1 + THK1
      BASE2 = ZC2
      TOP2 = ZC2 + THK2
      IF (TOP2.GT.ZC1.AND.ZC1.NE.0.0) TOP2 = ZC1
C
      DO I = 18,2,-1
         AMOUNT = 0.0
         PCLR = 0.0
         PCLD1 = 0.0
         PCLD2 = 0.0
C
         IF (BASE1.GE.Z(I).AND.BASE1.LT.Z(I-1).AND.BASE1.NE.0) THEN
            IF (TOP1.LE.Z(I-1)) THEN
             AMOUNT = TOP1 - BASE1
            ELSEIF (TOP1.GT.Z(I-1)) THEN
             AMOUNT = Z(I-1) - BASE1
             BASE1 = Z(I-1)
            ENDIF
            PCLD1 = AMOUNT / (Z(I-1) - Z(I))
         ENDIF
C
         IF (BASE2.GE.Z(I).AND.BASE2.LT.Z(I-1).AND.BASE2.NE.0) THEN
            IF (TOP2.LE.Z(I-1)) THEN
             AMOUNT = TOP2 - BASE2
            ELSEIF (TOP2.GT.Z(I-1)) THEN
             AMOUNT = Z(I-1) - BASE2
             BASE2 = Z(I-1)
            ENDIF
            PCLD2 = AMOUNT / (Z(I-1) - Z(I))
         ENDIF
C
         IF ((PCLD1 + PCLD2).GT.0.0) THEN
            PCLR = 1 - (PCLD1 + PCLD2)
            G(I) = PCLR*G(I) + PCLD1*CLDG(1) + PCLD2*CLDG(2)
            BETAA(I) = PCLR*BETAA(I)+PCLD1*CLDBTA(1)+PCLD2*CLDBTA(2)
         ENDIF
       ENDDO
C
       RETURN
       END
```

ECR # HSTX - 16 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: CNTRAS
Old Date: 5/18/93

File Name: TARGAC.FOR
New Date: 10/8/93

Implemented By: Dan DeBenedictis

Reason for Revision: The background reflectance (BKREF) was not being saved to TAC.SAV when climate data was being used. BKREF is now being saved and accessed with record CONTEXTL.

Description of Revision: Added RECVAL(4,2) to the WRITE statement for writing the record CONTEXTL to TAC.SAV. Update the call to REALCK to reference the CONTEXTL record instead of the METD record for BKREF. Change the lower limit of BKREF from 0.0 to 0.01, as specified in the User's Guide to prevent a divide by zero error.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C***********************************************************************
      SUBROUTINE CNTRAS(KTYPE,CNTRST,BKREF)
C***********************************************************************
C
C    THIS SUBROUTINE CALCULATES THE TARGET/BACKGROUND CONTRAST
C       FOR DIRECT VIEW OPTICS (KTYPE=1), IMAGE INTENSIFIERS
C       (KTYPE=2),  TV'S (KTYPE=3), OR TEMPERATURE CONTRAST
C      (KTYPE=4)
C
C***********************************************************************
C STX TCM2 --ECR ASL-6-1 ------------------------------------------------
C       REMOVED COMMON BLOCK THRM
C       REMOVED CALL TO THERML.  THERML IS CALLED BY FINDR.
C STX TCM2 ------------------------------------------------------------
      COMMON/IOFILE/IOFILE
      COMMON/INOUT/INTER,IRPT,EFLAG
      COMMON/IOUNIT/IOIN,IOOUT,IPHFUN,LOUNIT,NDIRTU,NCLIMT,IRELH,
     1               KSTOR,NPLOTU,STDERR
      COMMON /IBLOCK/ RECVAL(111,7), RECUSE(21), IPTR(21), IBEGIN(22)
      COMMON /CHBLCK/ RECFLD(21)
      INTEGER IOIN,IOOUT,IPHFUN,LOUNIT,NDIRTU,NCLIMT
      INTEGER IRELH,KSTOR,NPLOTU,STDERR,IOFILE
      LOGICAL INTER,EFLAG,RECUSE
      CHARACTER*4 RECFLD
      DIMENSION TGTREF(3,14),BKGREF(3,41)
      DATA TGTREF/.081,.121,.229,.114,.228,.458,.146,.273,.561,.105,
     1 .216,.444,.184,.291,.457,.097,.139,.224,.145,.146,.139,.136,
     2 .252,.498,.267,.238,.198,.375,.394,.428,.449,.422,.370,.323,
     3 .328,.336,.497,.594,.730,.230,.287,.373/
      DATA BKGREF/.329,.393,.494,.172,.211,.273,.175,.243,.322,
     1 .322,.393,.486,.171,.223,.295,.103,.136,.183,.174,.215,.275,
     2 .080,.102,.141,.271,.332,.439,.119,.161,.232,.182,.249,.332,
     3 .093,.143,.195,.165,.228,.320,.087,.114,.158,.471,.487,.517,
     4 .491,.523,.589,.302,.307,.315,.228,.226,.250,.328,.356,.413,
     5 .247,.267,.301,.319,.385,.487,.174,.233,.328,.090,.127,.178,
     6 .736,.702,.609,.137,.152,.168,.380,.399,.440,.219,.237,.272,
     7 .165,.229,.324,.102,.200,.437,.176,.224,.309,.041,.139,.348,
     8 .097,.230,.455,.122,.254,.512,.214,.328,.514,.136,.228,.445,
     9 .172,.231,.355,.151,.282,.559,.185,.316,.562,.946,.924,.876,
     1 .913,.869,.791,.908,.853,.748/
C
C CHOOSE BASIC FUNCTION -- VISIBLE INHERENT CONTRAST
      IF(INTER) THEN
11       CONTINUE
       WRITE(IOOUT,*) 'YOU MAY ENTER YOUR OWN VALUE OF CONTRAST,'
       WRITE(IOOUT,*) 'WHICH YOU MAY PRE-COMPUTE USING THE CODE'
       WRITE(IOOUT,*) 'FASCAT FOR EXAMPLE, OR YOU MAY SELECT FROM'
       WRITE(IOOUT,*) 'A MENU OF TARGET AND BACKGROUND REFLECTANCES'
       WRITE(IOOUT,*) 'AND ALLOW THE MODEL TO CALCULATE THE INHERENT'
       WRITE(IOOUT,*) 'CONTRAST.  IF YOU WISH TO ENTER YOUR OWN VALUE'
       WRITE(IOOUT,*) 'ENTER A 1 TO THE PROMPT BELOW, IF YOU WISH TO'
       WRITE(IOOUT,*) 'SEE THE MENU ENTER A 0'
       READ(IOIN,*)  ICON
       WRITE(IOOUT,*) ICON
       WRITE(IOOUT,*)
       IF (ICON .GT. 1 .OR. ICON .LT. 0) THEN
          WRITE(IOOUT,*) 'YOU MUST ENTER A 0 OR 1.'
          GOTO 11
       ENDIF
       IF(ICON .EQ. 0) THEN
        WRITE(IOOUT,100)
100       FORMAT('ENTER THE NUMBER FOR THE TARGET TYPE OR MATERIAL'/
     1   ' 1 - MAN IN FATIGUES      8 - SUMMER CAMOUFLAGE PAINT'/
     2   ' 2 - OLIVE DRAB PAINT     9 - NAVAL GRAY PAINT'/
     3   ' 3 - LIGHT GREEN PAINT   10 - WEATHERED AIRCRAFT SKIN'/
```

```
     4  ' 4 - FOREST GREEN PAINT  11 - GALVANIZED IRON'/
     5  ' 5 - FOREIGN PAINT 1     12 - CORROSION RESISTANT STEEL'/
     6  ' 6 - FOREIGN PAINT 2     13 - SANDED PLYWOOD'/
     7  ' 7 - FOREIGN PAINT 3     14 - WEATHERED PLYWOOD')
1         READ(IOIN,*)ITARGT
        WRITE(IOOUT,*) ITARGT
        WRITE(IOOUT,*)
        IF (ITARGT.LT.1.OR.ITARGT.GT.14) THEN
          WRITE(IOOUT,*)' ILLEGAL TARGET TYPE CHOSEN-- TRY AGAIN'
          GO TO 1
        ENDIF
        WRITE(IOOUT,101)
101       FORMAT('ENTER THE NUMBER FOR THE TYPE OF BACKGROUND '/
     1   ' 1 - BARE SOIL           3 - VEGETATION'/
     2   ' 2 - ROAD                4 - SNOW')
2         READ(IOIN,*) IBKTYP
        WRITE(IOOUT,*) IBKTYP
        WRITE(IOOUT,*)
        IF(IBKTYP.EQ.1) THEN
          WRITE(IOOUT,102)
102         FORMAT('ENTER THE NUMBER FOR THE SPECIFIC BACKGROUND'/
     1     '  1 - DRY SAND           11 - DRY SANDY LOAM'/
     2     '  2 - WET SAND           12 - WET SANDY LOAM'/
     3     '  3 - DRY CLAY           13 - DRY PLOWED FIELD'/
     4     '  4 - WET CLAY           14 - WET PLOWED FIELD'/
     5     '  5 - DRY LOAM           15 - SALT'/
     6     '  6 - WET LOAM           16 - CORAL'/
     7     '  7 - DRY LOAM CLAY      17 - GRANITE'/
     8     '  8 - WET LOAM CLAY      18 - SANDSTONE'/
     9     '  9 - DRY LOAM SILT      19 - LIMESTONE'/
     1     ' 10 - WET LOAM SILT      20 - MIXED ROCKS')
          READ(IOIN,*)IBACKG
          WRITE(IOOUT,*)IBACKG
          WRITE(IOOUT,*)
        ELSE IF (IBKTYP.EQ.2) THEN
          WRITE(IOOUT,103)
103         FORMAT('ENTER THE NUMBER FOR THE SPECIFIC BACKGROUND'/
     1     ' 1 - CLAY ROAD           5 - ASPHALT'/
     2     ' 2 - DRY DIRT ROAD       6 - CONCRETE'/
     3     ' 3 - WET DIRT ROAD       7 - AIRPORT APRON'/
     4     ' 4 - SNOW COVERED ROAD   8 - TANK TRAIL')
          READ(IOIN,*)IBACKG
          WRITE(IOOUT,*) IBACKG
          WRITE(IOOUT,*)
          IBACKG=IBACKG+20
        ELSE IF (IBKTYP.EQ.3) THEN
          WRITE(IOOUT,104)
104         FORMAT('ENTER THE NUMBER FOR THE SPECIFIC BACKGROUND'/
     1     ' 1 - LIVE GRASS              6 - DORMANT BROADLEAF TREES'/
     2     ' 2 - DEAD GRASS              7 - ACTIVE SHRUBS'/
     3     ' 3 - ACTIVE CONIFERS         8 - DORMANT SHRUBS'/
     4     ' 4 - DORMANT CONIFERS        9 - LIVE CROP FOLIAGE'/
     5     ' 5 - ACTIVE BROADLEAF TREES 10 - DEAD CROP FOLIAGE')
          READ(IOIN,*)IBACKG
          WRITE(IOOUT,*) IBACKG
          WRITE(IOOUT,*)
          IBACKG=IBACKG+28
        ELSE IF (IBKTYP.EQ.4) THEN
          WRITE(IOOUT,105)
105         FORMAT('ENTER THE NUMBER FOR THE SPECIFIC BACKGROUND'/
     1     ' 1 - FRESH DRY SNOW      3 - METAMORPHOSED SNOW'/
     2     ' 2 - WET SNOW')
          READ(IOIN,*)IBACKG
          WRITE(IOOUT,*)IBACKG
          WRITE(IOOUT,*)
```

```
          IBACKG=IBACKG+38
        ELSE
          WRITE(IOOUT,*)' ILLEGAL BACKGROUND TYPE CHOSEN-- TRY AGAIN'
          GO TO 2
        ENDIF
        IF(IBACKG.LT.0.OR.IBACKG.GT.41) THEN
          WRITE(IOOUT,*)' ILLEGAL BACKGROUND TYPE CHOSEN-- TRY AGAIN'
          GO TO 2
        ENDIF
CD  REV 8/18/89
        WRITE(21,201)'CONTINTL',FLOAT(ITARGT),FLOAT(IBACKG)
CD  REV 8/18/89
       ELSE
  12      CONTINUE
        WRITE(IOOUT,*) 'YOU HAVE CHOSEN TO ENTER YOUR OWN VALUE OF'
        WRITE(IOOUT,*) 'INHERENT CONTRAST.  YOU MUST ENTER A NUMBER'
        WRITE(IOOUT,*) 'WHOSE ABSOLUTE VALUE IS LESS THAN 1.0 '
        WRITE(IOOUT,*) 'ENTER THE VALUE BELOW.'
        READ(IOIN,*) CNTRST
        WRITE(IOOUT,*) CNTRST
        WRITE(IOOUT,*)
        CNTRST = ABS(CNTRST)
        IF(CNTRST .GT. 1.0) THEN
          WRITE(IOOUT,*) 'THE ABSOLUTE VALUE OF CONTRAST MUST BE'
          WRITE(IOOUT,*) 'LESS THAN OR EQUAL TO 1.0'
           WRITE(IOOUT,*)
          GO TO 12
        ENDIF
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-16-1--------------------------------
C MOVE THIS WRITE STATEMENT TO AFTER THE BACKGROUND REFLECTANCE IS KNOWN.
CD  REV 8/18/89
C       WRITE(21,202)'CONTEXTL',CNTRST
CD  REV 8/18/89
C-HSTX---SCENE SHADOWS--------------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-16-1--------------------------------
C MINIMUM VALUE OF BKREF HAS BEEN CHANGED FROM 0.0 TO 0.01, AS SPECIFIED
C IN USER'S GUIDE, TO PREVENT DIVIDE BY ZERO ERROR.
         WRITE(IOOUT,*)'YOU MUST ALSO ENTER A VALUE FOR THE BACKGROUND'
         WRITE(IOOUT,*)'REFLECTANCE. ENTER A VALUE BETWEEN 0.01 AND 1.0'
  13     READ(IOIN,*) BKREF
         WRITE(IOOUT,*) BKREF
         WRITE(IOOUT,*)
         IF(BKREF .LT. 0.01 .OR. BKREF .GT. 1.0) THEN
          WRITE(IOOUT,*)'YOUR INPUT IS OUT OF RANGE.  PLEASE ENTER A'
          WRITE(IOOUT,*)'NUMBER BETWEEN 0.01 AND 1.0'
          GOTO 13
         ENDIF
C-HSTX---SCENE SHADOWS--------------------------------------------------
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-16-1--------------------------------
C ADD BACKGROUND REFLECTANCE TO THE CONTEXTL RECORD.  IT HAS BEEN REMOVED
C FROM THE METD RECORD.
CD  REV 8/18/89
C       RECVAL(8,7) = BKREF
        WRITE(21,201)'CONTEXTL',CNTRST,BKREF
CD  REV 8/18/89
C-HSTX---SCENE SHADOWS--------------------------------------------------
C
        RETURN
       ENDIF
       ELSE
       IF (RECFLD(4) .EQ. 'EXTL') THEN
C
```

```
C-HSTX---SCENE SHADOWS---ECR # HSTX-16-1------------------------------
C BACKGROUND REFLECTANCE IS NO LONGER IN THE METD RECORD.  IT HAS BEEN
C MOVED TO THE CONTEXTL RECORD.  MINIMUM VALUE HAS BEEN CHANGED FROM
C 0.0 TO 0.01, AS SPECIFIED IN USER'S GUIDE, TO PREVENT DIVIDE BY ZERO
C ERROR.
          CNTRST = RECVAL(4,1)
C            BKREF = RECVAL(8,7)
          BKREF = RECVAL(4,2)
          CALL REALCK(1.0,0.0,CNTRST,'CONT','1ST',1.0)
          CALL REALCK(1.0,0.01,BKREF,'CONT','2ND',.5)
C-HSTX---SCENE SHADOWS------------------------------------------------
C
          RETURN
        ELSE
          ITARGT = NINT(RECVAL(4,1))
          IBACKG = NINT(RECVAL(4,2))
          CALL INTCHK(14,1,ITARGT,'CONT','1ST',3)
          CALL INTCHK(41,1,IBACKG,'CONT','2ND',1)
        ENDIF
        ENDIF
  200   FORMAT(10I5)
CD  REV 8/18/89
  201   FORMAT(A8,2X,2E10.4)
  202   FORMAT(A8,2X,E10.4)
CD  REV 8/18/89
        BKREF=BKGREF(KTYPE,IBACKG)
        IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
        WRITE(IOOUT,*)'BACKGROUND REFLECTANCE =',BKREF
        ENDIF
        IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
        WRITE(NDIRTU,*)'BACKGROUND REFLECTANCE =',BKREF
        ENDIF
        CNTRST=(TGTREF(KTYPE,ITARGT)-BKREF)/BKREF
        RETURN
        END
C
```

ECR # HSTX - 17 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: DIFUSE Old Date: New

File Name: DIFUSE.FOR New Date: 10/20/93

Implemented By: Melanie J. Gouveia

Reason for Revision: New routine to compute the components of diffuse radiance. Removing this code from the CONTST routine makes CONTST more modular.

Description of Revision: Set the values of directionally independent and dependent diffuse radiance and direct radiance (forward scattering around cloud edges) to be used for weighted averages. Call PCDIF to compute the averages.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C-HSTX---SCENE SHADOWS---ECR # HSTX-17-1----------------------------------
C
C  NEW ROUTINE TO COMPUTE COMPONENTS OF DIFFUSE RADIANCE.
C
C-HSTX---SCENE SHADOWS---------------------------------------------------
C************************************************************************
C<BEGIN>
C<IDENTIFICATION>       NAME:   DIFUSE
C                       TYPE:   FORTRAN SUBROUTINE
C                     FILENAME: DIFUSE.FOR
C
C==========================================================================
C<DESCRIPTION>
C               This routine computes the components of diffuse radiance.
C==========================================================================
C<INPUT>
C     COMMON BLOCK VARIABLES:
C        / CLOUD / ICLDF, NUMCLD, MLOOP
C        / RADIA / I0(20,4),I1(20,4),SURF(30,4)
C==========================================================================
C<OUTPUT>
C     COMMON BLOCK VARIABLES:
C      NONE
C==========================================================================
C<CALLED ROUTINES>
C      NONE
C==========================================================================
C<PARAMETER>
C    CALLING SEQUENCE:
C        DIFUSE (L,NLOCT,SZA, AVEI0,AVEI1,CORR)
C    INPUT:
C               L        Target-sensor viewing number.
C               NLOCT    Atmospheric layer containing the target.
C               SZA      Solar zenith angle.
C    OUTPUT:
C               AVEI0    Weighted average directionally independent diffuse
C                        radiance term.
C               AVEI1    Weighted average directionally dependent diffuse
C                        radiance term.
C               CORR     Weighted average forward scattering correction
C                        term.
C==========================================================================
C<HISTORY>
C  CREATED OCTOBER, 1993.  HUGHES STX CORPORATION.
C==========================================================================
C<END>
C
C List of variables:
C      AVEI0    Weighted average directionally independent diffuse
C               radiance term.
C      AVEI1    Weighted average directionally dependent diffuse
C               radiance term.
C      CORR     Weighted average forward scattering correction term.
C      I0       Directionally independent diffuse radiance term.
C      I1       Directionally dependent diffuse radiance term.
C      L        Target-sensor viewing number.
C      NLOCT    Atmospheric layer containing the target.
C      SURF     Direct radiance.
C      SURFA    Temporary variable to store directionally dependent
C               diffuse, directionally independent diffuse, and direct
C               radiance.
C      SZA      Solar zenith angle.
C
      SUBROUTINE DIFUSE (L,NLOCT,SZA,AVEI0,AVEI1,CORR)
C
```

```
       COMMON /CLOUD/ICLDF,NUMCLD, MLOOP, CLDBTA(2),CLDG(2), LYRCLD(2),
      1              THK1, THK2, THK3, ITY1, ITY2, ITY3,
      2              ZC1,ZC2,ZC3,CF1,CF2,CF3,PCF(2),PSCLD
       COMMON/RADIA/A(20),G(20),GP(20),BETAA(20),BETAR(20),
      1             BETA(20),K(20),P(20),ALPHA(20),BET(20),
      2             TAU(0:20),I0(20,4),I1(20,4),F(20,4),TF(20),FNOT,
      3             NANG,PF(180,20),ANG(180,20),I2(20),TAUP(0:20),
      4             ISTAR(20,30,2),PTHRD(30,2),SING(30),AP(20),PHF(30)
      5             ,ALBEDO,SURF(30,4),SURF0(30,2),TAUSTR,VIS,CAPTP(20),
      6             B1,B2
C
       REAL I0,I1,I2,ISTAR,K
       REAL SURFA(4)
C
C LOAD TEMPORARY VARIABLES WITH DIRECT AND DIFFUSE RADIANCE TERMS FOR
C VARIOUS CLOUD SITUATIONS.
C
       IF ( ICLDF .EQ. 2 ) THEN
          SURFA(1) = 0
          SURFA(2) = SURF(L,1)
          SURFA(3) = 0
          SURFA(4) = 0
          CLR0 = 0
          A0 = I0(NLOCT,1)
          B0 = 0
          AB0 = 0
          CLR1 = 0
          A1 = I1(NLOCT,1)
          B1 = 0
          AB1 = 0
       ELSEIF ( ICLDF .EQ. 3 ) THEN
          SURFA(1) = 0
          SURFA(2) = 0
          SURFA(3) = 0
          SURFA(4) = SURF(L,1)
          CLR0 = 0
          A0 = 0
          B0 = 0
          AB0 = I0(NLOCT,1)
          CLR1 = 0
          A1 = 0
          B1 = 0
          AB1 = I1(NLOCT,1)
       ELSEIF ( ICLDF .EQ. 5 ) THEN
          SURFA(1) = 0
          SURFA(2) = SURF(L,1)
          SURFA(3) = 0
          SURFA(4) = SURF(L,2)
          CLR0 = 0
          A0 = I0(NLOCT,1)
          B0 = 0
          AB0 = I0(NLOCT,2)
          CLR1 = 0
          A1 = I1(NLOCT,1)
          B1 = 0
          AB1 = I1(NLOCT,2)
       ELSE
          SURFA(1) = SURF(L,1)
          SURFA(2) = SURF(L,2)
          SURFA(3) = SURF(L,3)
          SURFA(4) = SURF(L,4)
          CLR0 = I0(NLOCT,1)
          A0 = I0(NLOCT,2)
          B0 = I0(NLOCT,3)
          AB0 = I0(NLOCT,4)
```

```
            CLR1 = I1(NLOCT,1)
            A1 = I1(NLOCT,2)
            B1 = I1(NLOCT,3)
            AB1 =I1(NLOCT,4)
         END IF
C
C COMPUTE THE WEIGHTED AVERAGE (OVER POSSIBLE CLOUD SITUATIONS) OF
C DIRECTIONALLY INDEPENDENT DIFFUSE RADIANCE.
C
      CALL PCDIF (CLR0,A0,B0,AB0,
     +                AVEI0,1,PCF,SZA,NUMCLD,CF1,CF2,SURFA)
C
C COMPUTE THE WEIGHTED AVERAGE (OVER POSSIBLE CLOUD SITUATIONS) OF
C DIRECTIONALLY DEPENDENT DIFFUSE RADIANCE.
C
      CALL PCDIF (CLR1,A1,B1,AB1,
     +                AVEI1,1,PCF,SZA,NUMCLD,CF1,CF2,SURFA)
C
C COMPUTE THE CORRECTION DUE TO FORWARD SCATTER OF DIRECT RADIANCE
C THROUGH CLOUD EDGES
C
      CALL PCDIF (DUM,DUM,DUM,DUM,
     +            CORR,2,PCF,SZA,NUMCLD,CF1,CF2,SURFA)
C
      RETURN
      END
```

ECR # HSTX - 18 - 1

ENGINEERING CHANGE RECORD FOR TARGAC-3

Routine Name: ILMDAT

Old Date: 8/17/93

File Name: ILMDAT.FOR

New Date: 10/20/93

Implemented By: Melanie J. Gouveia

Reason for Revision: All of the conditions included in the significant weather input are now included as part of other inputs.

Description of Revision: Omitted SIGWX from the WRITE statements for writing the record ILUM to TAC.SAV. A dummy value of 0.0 is written instead.

Notes:

As appropriate, attach the following:

1. Code listing with changes highlighted
2. Test records

```
C***********************************************************************
      SUBROUTINE ILMDAT ( IDEV )
C***********************************************************************
C
      PARAMETER (IDVOP = 1, INTENS = 2, ITELE = 3, ITHER = 4, IUSR = 5)
C
      COMMON /INOUT/ INTER, IRPT, EFLAG
      COMMON /IOFILE/ IOFILE
      COMMON /IOUNIT/ IOIN, IOOUT, IPHFUN, LOUNIT, NDIRTU, NCLIMT,
     +                IRELH, KSTOR, NPLOTU, STDERR
      COMMON /IBLOCK/ RECVAL(111,7), RECUSE(21), IPTR(21), IBEGIN(22)
C***REV 1/91
      COMMON /CHBLCK/ RECFLD(21)
      COMMON /ILLUMI/ AL, ILLUM, L22, ACK, IL1, IL2
      COMMON /ILDATA/ FMONTH, DAY, YEAR, GTIME, SLAT, SLON, ILR1, ILR2,
     +                ILR3, RG, FR1, FR2, FR3, SIGWX, OBSURF, CEILHT,
     +                PRTYP, FRC, ITARG
      COMMON /ILUMCM/ ALTS, AZIS, ALTMN, AZIM, DPHASE, ELUMI, SUNLIT,
     +                MOOLIT, TCLSUN, TCLLUN, RCLSUN, RCDSUN, RCLLUN,
     +                RCDLUN
C
      DIMENSION ALL(3)
      REAL MOOLIT
      INTEGER IOIN, IOOUT, IPHFUN, LOUNIT, NDIRTU, NCLIMT, IRELH
      INTEGER KSTOR, NPLOTU, STDERR, IOFILE
      LOGICAL INTER, EFLAG, RECUSE
C***REV 1/91
      CHARACTER*4 RECFLD
C
      DATA ALL / 0.01, 0.001, 0.0001 /
C
      IF (IDEV .EQ. INTENS) THEN
C***REV 1/91
         ITARG = 2
C******
         IF (INTER) THEN
  100       CONTINUE
C***REV 1/91   ILUMA OPTION ADDED TO INTERACTIVE MENU
            WRITE(IOOUT,*)' THE I**2 DEVICE MODULE REQUIRES THE AMBIENT'
            WRITE(IOOUT,*)' ILLUMINATION AS INPUT.  YOU MAY ENTER THIS'
            WRITE(IOOUT,*)' INFORMATION BY '
            WRITE(IOOUT,*)'    0 - SELECT THE PHASE OF THE MOON FROM ',
     +                    'A MENU'
            WRITE(IOOUT,*)'    1 - TO INPUT A VALUE FOR ILLUMINATION'
            WRITE(IOOUT,*)'    2 - EOSAEL ILUMA MODULE TO COMPUTE ',
     +                    'THE ILLUMINATION'
          WRITE(IOOUT,*)'CAUTION SHOULD BE USED IN INTERPRETING'
          WRITE(IOOUT,*)'RESULTS UNDER LOW LIGHT CONDITIONS. '
          WRITE(IOOUT,*)'RESEARCH SHOWS THAT CUTURAL LIGHTING CAN '
          WRITE(IOOUT,*)'SIGNIFICANTLY CONTRIBUTE TO LIGHT LEVELS '
          WRITE(IOOUT,*)'UNDER LOW LIGHT CONDITIONS. '
            READ(IOIN,*) ICHILL
            WRITE(IOOUT,*)ICHILL
            WRITE(IOOUT,*)
            IF (ICHILL .LT. 0 .OR. ICHILL .GT. 2) THEN
               WRITE(IOOUT,*)' YOU HAVE MADE AN ILLEGAL ENTRY'
               WRITE(IOOUT,*)' TRY AGAIN'
               GOTO 100
            ENDIF
            IF (ICHILL .EQ. 0) THEN
  110          CONTINUE
               WRITE(IOOUT,*)' SELECT THE PHASE OF THE MOON'
               WRITE(IOOUT,*)'      1  --   FULL MOON'
               WRITE(IOOUT,*)'      2  --   QUARTER MOON'
               WRITE(IOOUT,*)'      3  --   NO MOON'
```

```
               READ(IOIN,*) IMOON
               WRITE(IOOUT,*)IMOON
               WRITE(IOOUT,*)
               IF (IMOON .LT. 1 .OR. IMOON .GT. 3) THEN
                 WRITE(IOOUT,*)'YOU HAVE MADE AN ILLEGAL ENTRY'
                  WRITE(IOOUT,*)'FOR THE PHASE OF THE MOON -- TRY AGAIN'
                  GOTO 110
               ELSE
                  AL = ALL(IMOON)
              ENDIF
            ELSE IF (ICHILL .EQ. 1) THEN
  120          CONTINUE
               WRITE(IOOUT,*)' ENTER THE ILLUMINATION IN FOOT CANDLES:'
              WRITE(IOOUT,*)'   **NOTE** THE ILLUMINATION MUST BE ',
     +               'STRICTLY LESS THAN 1'
               READ(IOIN,*) AL
               WRITE(IOOUT,*)AL
               WRITE(IOOUT,*)
               IF (AL .GT. 1.0) GOTO 120
            ENDIF
C***REV 1/91   CALLS ILUMA MODULE TO CALCULATE ILLUMINATION, IF THE
C              "INTL" FLAG IS SET, AND SOLAR AND LUNAR POSITIONS
            CALL ILUMA ( 1, IERR )
C
C***REV 1/91   ILLUMINATION INTERNALLY CALCULATED BY ILUMA
C              CONVERTED FROM LUMENS/SQ METER TO FOOT CANDLES
            IF (ICHILL .EQ. 2) THEN
               AL = ELUMI / 10.76
             IF (AL .LT. 0.0001 .OR. AL .GT. 0.01) THEN
             IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
               WRITE(IOOUT,*)
               WRITE(IOOUT,*)'*** ILLUMINATION VALUE OUT OF RANGE'
               WRITE(IOOUT,*)'    DEFAULT VALUE WILL BE USED'
               WRITE(IOOUT,*)
             ENDIF
             IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
               WRITE(NDIRTU,*)
               WRITE(NDIRTU,*)'*** ILLUMINATION VALUE OUT OF RANGE'
               WRITE(NDIRTU,*)'    DEFAULT VALUE WILL BE USED'
               WRITE(NDIRTU,*)
             ENDIF
                  AL = ALL(1)
               ENDIF
            ENDIF
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-18-1-------------------------
C ELIMINATE SAVE OF SIGWX; THIS VARIABLE IS NO LONGER USED.
C***REV 1/91
            DUM = 0.0
            IF (ICHILL .EQ. 0) THEN
             WRITE(21,1200)'ILUMEXTL',-FLOAT(IMOON),DUM,OBSURF,PRTYP
            ELSE IF (ICHILL .EQ. 1) THEN
               WRITE(21,1200)'ILUMEXTL',AL,DUM,OBSURF,PRTYP
            ELSE
               WRITE(21,1200)'ILUMINTL',AL,DUM,OBSURF,PRTYP
            ENDIF
C-HSTX---SCENE SHADOWS-------------------------------------------
C
         ELSE
C           IF (.NOT. RECUSE(7))) THEN
C              CHILL = -1.0
C           ELSE
C              CHILL = RECVAL (7,1)
C           ENDIF
C***REV 1/91   CALLS ILUMA MODULE TO CALCULATE ILLUMINATION, IF THE
```

```
C              "INTL" FLAG IS SET, AND SOLAR AND LUNAR POSITIONS
            CALL ILUMA ( 1, IERR )
C
C***REV 1/91   BATCH OPTION TO CALCULATE ILLUMINATION INTERNALLY BY ILUMA
C              OR EXTERNALLY SUPPLIED BY THE USER
            IF (RECFLD(7) .EQ. 'EXTL') THEN
               CHILL = RECVAL(7,1)
            ELSE
               CHILL = ELUMI / 10.76
            ENDIF
C
            IF (CHILL .LT. 0.0) THEN
               ICHILL = NINT(ABS(CHILL))
               CALL INTCHK(3,1,ICHILL,'ILUM','1ST',1)
               AL = ALL(ICHILL)
            ELSE
               AL = CHILL
             IF (RECFLD(7) .EQ. 'EXTL') THEN
                  CALL REALCK(0.01,0.0001,AL,'ILUM','1ST',99999.0)
                  IF (AL .EQ. 99999.0) AL = ALL(1)
               ELSE
              IF (AL .LT. 0.0001 .OR. AL .GT. 0.01) THEN
                IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
                  WRITE(IOOUT,*)
                  WRITE(IOOUT,*)'*** ILLUMINATION VALUE OUT OF RANGE'
                  WRITE(IOOUT,*)'    DEFAULT VALUE WILL BE USED'
                  WRITE(IOOUT,*)
                ENDIF
                IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
                  WRITE(NDIRTU,*)
                  WRITE(NDIRTU,*)'*** ILLUMINATION VALUE OUT OF RANGE'
                  WRITE(NDIRTU,*)'    DEFAULT VALUE WILL BE USED'
                  WRITE(NDIRTU,*)
                ENDIF
                     AL = ALL(1)
                  ENDIF
               ENDIF
            ENDIF
         ENDIF
         ILLUM = -INT(ALOG10(AL) + 1.0)
CUV      IL22 = -INT(ALOG10(AL))
         ACK = 10.00 ** (- (1 + ILLUM))
C
      ELSE IF (IDEV .EQ. IDVOP .OR. IDEV .EQ. ITELE) THEN
C***REV 1/91
         ITARG = 2
         IF (INTER) THEN
  130       CONTINUE
C***REV 1/91   ILUMA OPTION ADDED TO INTERACTIVE MENU
            WRITE(IOOUT,*)' THIS DEVICE MODULE REQUIRES THE AMBIENT'
            WRITE(IOOUT,*)' ILLUMINATION AS INPUT.  YOU MAY ENTER THIS'
            WRITE(IOOUT,*)' INFORMATION BY '
            WRITE(IOOUT,*)'    0 - TO INPUT A VALUE FOR ILLUMINATION'
            WRITE(IOOUT,*)'    1 - EOSAEL ILUMA MODULE TO COMPUTE ',
     +                     'THE ILLUMINATION'
            READ(IOIN,*) ICHILL
            WRITE(IOOUT,*)ICHILL
            WRITE(IOOUT,*)
            IF (ICHILL .NE. 0 .AND. ICHILL .NE. 1) THEN
               WRITE(IOOUT,*)' YOU HAVE MADE AN ILLEGAL ENTRY'
               WRITE(IOOUT,*)' TRY AGAIN'
               GOTO 130
            ENDIF
            IF (ICHILL .EQ. 0) THEN
  140          CONTINUE
```

```
               WRITE(IOOUT,*)' ENTER THE ILLUMINATION IN FOOT CANDLES:'
               WRITE(IOOUT,*)'   **NOTE** THE ILLUMINATION MUST BE ',
     +                       'GREATER THAN 1'
               READ(IOIN,*) AL
               WRITE(IOOUT,*)AL
               WRITE(IOOUT,*)
               IF (AL .LT. 1.0) GOTO 140
            ENDIF
C***REV 1/91   CALLS ILUMA MODULE TO CALCULATE ILLUMINATION, IF THE
C              "INTL" FLAG IS SET, AND SOLAR AND LUNAR POSITIONS
            CALL ILUMA ( 1, IERR )
C***REV 1/91   ILLUMINATION INTERNALLY CALCULATED BY ILUMA
C              CONVERTED FROM LUMENS/SQ METER TO FOOT CANDLES
            IF (ICHILL .EQ. 1) THEN
               AL = ELUMI / 10.76
             IF (AL .LT. 1.0 .OR. AL .GT. 10000.0) THEN
             IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
               WRITE(IOOUT,*)
               WRITE(IOOUT,*)'*** ILLUMINATION VALUE OUT OF RANGE'
               WRITE(IOOUT,*)'    DEFAULT VALUE WILL BE USED'
               WRITE(IOOUT,*)
             ENDIF
             IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
               WRITE(NDIRTU,*)
               WRITE(NDIRTU,*)'*** ILLUMINATION VALUE OUT OF RANGE'
               WRITE(NDIRTU,*)'    DEFAULT VALUE WILL BE USED'
               WRITE(NDIRTU,*)
             ENDIF
                  AL = 1000.0
               ENDIF
            ENDIF
C
C-HSTX---SCENE SHADOWS---ECR # HSTX-18-1-------------------------
C ELIMINATE SAVE OF SIGWX; THIS VARIABLE IS NO LONGER USED.
C***REV 1/91
            DUM = 0.0
            IF (ICHILL .EQ. 0) THEN
               WRITE(21,1200)'ILUMEXTL',AL,DUM,OBSURF,PRTYP
            ELSE
               WRITE(21,1200)'ILUMINTL',AL,DUM,OBSURF,PRTYP
            ENDIF
C-HSTX---SCENE SHADOWS-------------------------------------------
C
         ELSE
C***REV 1/91   BATCH OPTION TO CALCULATE ILLUMINATION INTERNALLY BY ILUMA
C              OR EXTERNALLY SUPPLIED BY THE USER
C              CALLS ILUMA MODULE TO CALCULATE ILLUMINATION, IF THE
C              "INTL" FLAG IS SET, AND SOLAR AND LUNAR POSITIONS
            CALL ILUMA ( 1, IERR )
            IF (RECFLD(7) .EQ. 'EXTL') THEN
               AL = RECVAL(7,1)
               CALL REALCK(10000.0,1.0,AL,'ILUM','1ST',1000.0)
            ELSE
               AL = ELUMI / 10.76
             IF (AL .LT. 1.0 .OR. AL .GT. 10000.0) THEN
             IF(IOFILE.EQ.0.OR.IOFILE.EQ.2) THEN
               WRITE(IOOUT,*)
               WRITE(IOOUT,*)'*** ILLUMINATION VALUE OUT OF RANGE'
               WRITE(IOOUT,*)'    DEFAULT VALUE WILL BE USED'
               WRITE(IOOUT,*)
             ENDIF
             IF(IOFILE.EQ.1.OR.IOFILE.EQ.2) THEN
               WRITE(NDIRTU,*)
               WRITE(NDIRTU,*)'*** ILLUMINATION VALUE OUT OF RANGE'
               WRITE(NDIRTU,*)'    DEFAULT VALUE WILL BE USED'
```

```
               WRITE(NDIRTU,*)
             ENDIF
                  AL = 1000.0
               ENDIF
            ENDIF
         ENDIF
         IL1 = 4 - INT(ALOG10(AL))
         ACK = 1000.0 * 10.0 ** (1 - IL1)
         IL2 = IL1 +1
         IF (ALOG10(AL) - FLOAT(INT(ALOG10(AL))) .EQ. 0.0) THEN
            IL2 = IL1
            ACK = ACK * 10.0
         ENDIF
      ELSE
         RETURN
      ENDIF
 1000 FORMAT(10I5)
 1100 FORMAT(8F10.7)
C***REV 1/91
 1200 FORMAT(A8,2X,4E10.4)
C
      RETURN
      END
C
```

APPENDIX D: TARGAC Small-Scale Feature Shadows Design Document

The report presents an overview of the problem, reviews the scope of this effort, details assumptions, references relevant documents, and provides a design overview. This appendix focuses on the *design specifics* of the TARGAC-2 code modifications to support small-scale feature shadow-cued detection and shadow-induced clutter. The areas treated include (1) modifications to existing code and (2) the addition of new modules and supporting data structures.

The modifications to TARGAC-2 (the existing TARGAC code) are discussed first with the aid of high-level flowcharts of the TARGAC-2 code, and some high-level dataflow diagrams. The new modules are discussed with the aid of detailed data flow diagrams. The dataflow diagrams specify the information flow and transformations that must be performed to achieve the new functionality. These dataflow representations are further factored into modules as represented in the software hierarchy diagram presented at the end of the appendix.

During the course of this research, it was noted that the PC and UNIX versions of the TARGAC-2 code are different in some ways. First, it seems that the routines are partitioned up among files different between the PC and UNIX versions. Second, both versions seem to have several routines that compute approximately the same functions -- probably due to work by mulitiple programmers. All of the modifications in this design were applied to the UNIX version.

1. Code Modifications

The modifications to TARGAC-2 include minor changes in the CNTRAS module, modifications to the input codes to support the collection of required scene statistics, and an additional loop inserted into the main routine to support multiple calls for different viewer angles relative to the sun/moon and to display the detection and recognition probabilities.

Figure 1 shows the current overall control flow for the interactive visible and near-IR codes. Data on background scene, atmospherics, etc. are input and various initializing computations are performed. The control then enters the TARGAC routine FINDR where the detection and output are performed.

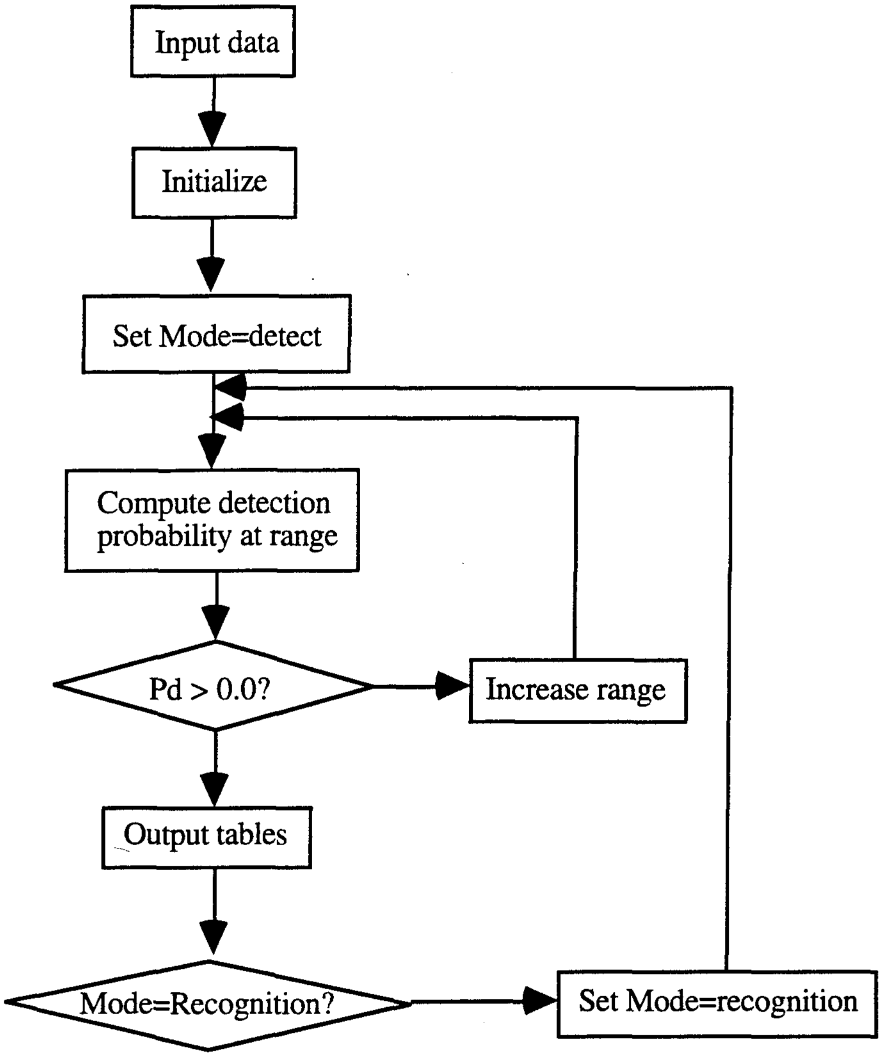

Figure 1. Control Flow Overview.

In FINDR, more initializations are performed and the system enters an outer loop to compute detection probabilities in the first transit and recognition probabilities in the second transit. Inside the detect loop, a smaller convergence loop finds the maximum ranges for detection at various levels of probability. The results are accumulated in a table as the loop is traversed at increasing ranges. As long as the detection probability remains non-zero, the range is increased and the computation is repeated. When the target can no longer be detected, the loop fails and the accumulated tables of ranges are output.

The main control modification (as shown in figure 2) will be to add another loop to compute detection and recognition probabilities for various viewing angles relative to the source of illumination. An additional check can be made to test if the level of direct to diffuse light is high enough to cause shadow effects. If no shadows exist in the scene, the probabilities of detection and recognition will not vary with view angle. Additional minor modifications will be made in the input and output routines to support the additional scene information required and to support table outputs for multiple viewing angles.

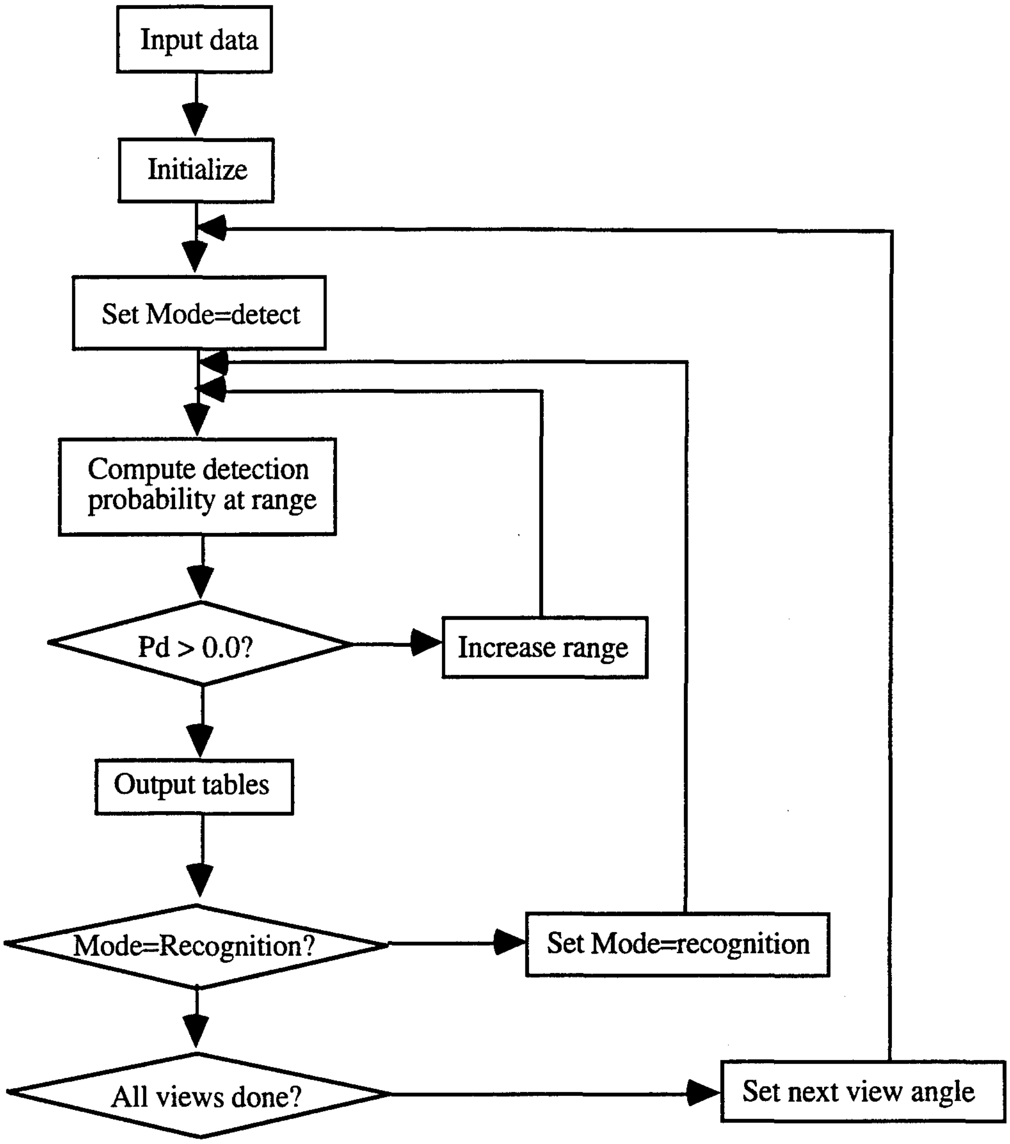

Figure 2. Modified Control Flow.

2. New and Modified Modules

The new modules include routines to support the use of shadow information in computing clutter and shadow-cued probabilities of detection and recognition. They are called SCR, ACQUIR, and SHADOWS. The SCR module computes the shadow-enhanced signal-to-clutter ratios which are passed to the ACQUIR module. ACQUIR computes probabilities of detection and recognition based on Schmeider's clutter experiments. Although the current TARGAC code includes an ACQUIR module, it will undergo a major rewrite and hence is here considered a new module. The SHADOWS module provides data to support the shadow-cued detection algorithms introduced in the new ACQUIR module.

To better understand the new modules in context, consider the excerpt of TARGAC-2 shown in figure 3. Data on the background, atmospherics, and target are combined in the computation labelled CONTRAST to yield the apparent contrast at the target. (The CONTRAST computation in figure 3 includes the TARGAC-2 CNTRAS subroutines and other calls.) The apparent contrast is passed to the RCF module which uses the sensor characteristics and the sky-to-ground ratio (SGR) to compute the resolvable cycles per milliradian of angle subtended by the target given the contrast. The resolved cycles are then used with target range and size to compute the probability of detection.

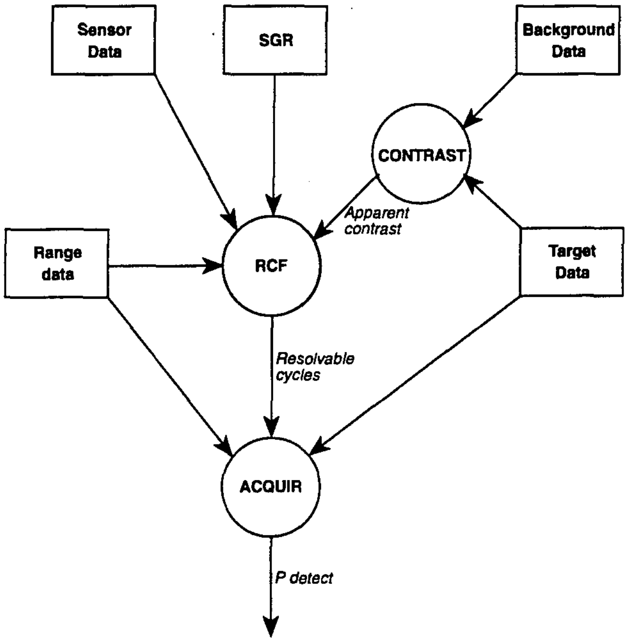

Figure 3. Existing TARGAC Code (Excerpt).

Figure 4 shows most of the new code (less some routines for additional data input). There are two major changes: (1) the path through CNTRAS, RCF, and ACQUIR has been augmented by a second parallel path, and (2) two new modules have been added to support shadow-based clutter and detection algorithms. New data areas have also been added to support the new algorithms. In figure 4, the modified modules and data areas are shaded, and the new modules and data areas are shown with heavy outlines.

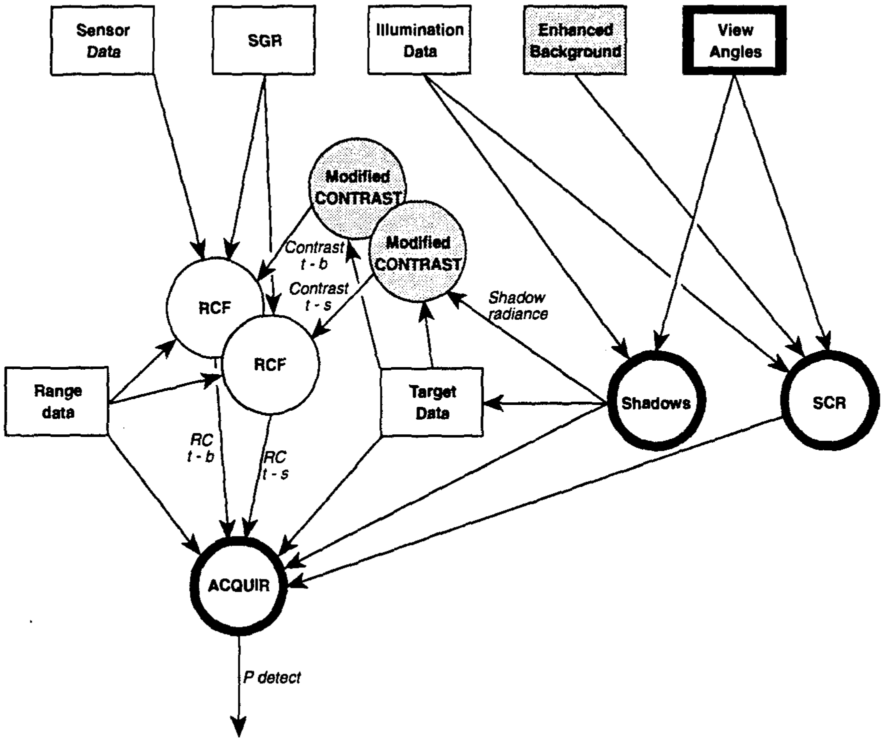

Figure 4. Modified TARGAC Code (Excerpt).

The two parallel paths are used to compute independent resolvable cycles for target-on-shadow and target-on-background. In actuality, the present TARGAC code computes resolvable cycles for target-on-background. This computation was modified slightly, and a second path will be added to compute resolvable cycles for target-on-shadow. The CNTRAS module was modified to use the appropriate weighting factors that result from splitting the target into separate portions adjacent to shadow and background. Note that for certain view angles, the target completely obscures the shadow so this component would be zero.

The two new modules work together with the rewritten ACQUIR module to combine the target-on-shadow and target-on-background detection probabilities. The SCR module computes the signal-to-clutter ratio (SCR) based on statistical scene data and shadow effects that arise from viewing angle. The SHADOWS module computes the expected radiance within shadow areas for use in computing target-to-shadow contrast. It also computes a weighting factor that is used to eventually combine the shadow and background detection probabilities within ACQUIR.

We now present these three new modules in detail. Each module description includes a processing narrative and annotated data flow diagram.

2.1 SCR Module

The SCR module computes the signal-to-clutter ratio (SCR) for an expected scene. The SCR is used with empirically derived data (see Schmeider) to alter the maximum ranges for detection and recognition based on expected clutter in the target area. Generally, the detection and recognition ranges decrease with increasing clutter.

The SCR computation presented here addresses two issues related to clutter not previously treated in Tactical Decision Aid codes. First, SCR computes a clutter index for the scene that is based on statistical information about the scene. Second, it includes clutter effects that are due to shadows. The adjustments for shadow effects are fairly sophisticated. The viewed shadow geometries depend both on the sun angle relative to the target and the viewing angle relative to the sun.

The clutter computation requires statistical information about clutter objects in the scene. These include 3-dimensional clutter objects such as trees, bushes, rock outcroppings, etc., and flat clutter objects such as soil types and ground cover. Once obtained, the system computes the expected clutter index.

In the modified TARGAC code, the statistical information may be obtained by one of two methods. The simplest allows the user to choose from a variety of sample scenes similar to those in Chapter 15 of the *Electro-Optical Tactical Decison Aid User's Manual* [Freni, et al. 1993]. Several menu sessions can be performed to obtain detailed statistical information in many "layers," including large scale ground covers, small scale ground covers, and various types of 3-dimensional clutter objects. The system would then compute the required statistical information keyed to the selected scenes. A second method will allow the more sophisticated user to input statistics derived from imagery. In this case, precise information could be obtained from several suspected target locations and fused into an accurate model of scene clutter. These approaches contrast with the more traditional approach of selecting low, medium, and high clutter indicators from a set of three sample images.

2.1.1 Overview of the Computation

In this section we present an overview of the SCR computation. Figure 5 shows the basic order of processing. Figure 6 is a data flow diagram with explicit computations called out by index numbers appearing on specific functions in the diagram.

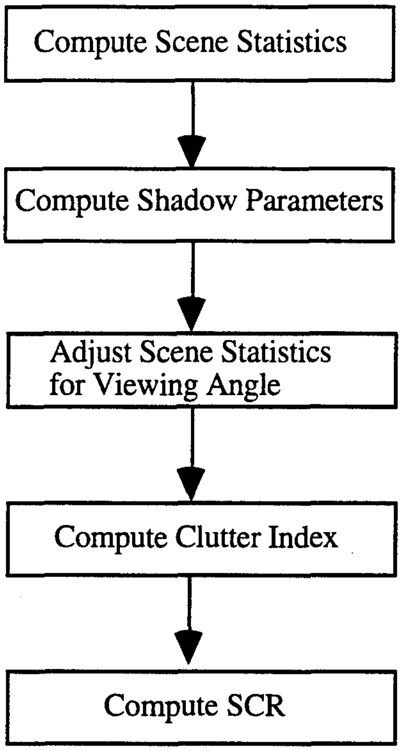

Figure 5. Overview of the Computation.

The computation begins with statistical scene parameters elicited in functions 1 and 2 by one of the methods described above. Scene parameters consist of expected object densities in the x-axis and y-axis, mean and variance for size (assuming a gaussian distribution), mean and variance for reflectance, and various aspect and inclination parameters. The scene parameters are referred to as *flat parameters* and *3-d parameters* for 2-dimensional and 3-dimensional clutter respectively. The 3-d parameters are then used to compute shadow geometries in function 4, assuming spherical clutter objects. These comprise a third set of parameters referred to as *shadow parameters.*

The flat, shadow, and 3-d parameters are then passed through several transformations (described in the main report) to account for viewing angle as determined by the height of the observer above the target and the viewing angle relative to the sun or moon (function 3). All three parameters are compressed in the y-axis (relative to the viewer's frame of reference) to account for scene compression due to low depression angles (function 5). This transformation is required because experiments have shown that detection range decreases with depression angle (see Schmeider et al. 1982).

The shadow and flat parameters are then further transformed to account for compressed aspect ratio (function 7) and angle of inclination for shadows induced by the viewing angle relative to the illumination source (function 6). Note that the 3-d parameters retain the same aspect ratios because they are assumed to be spherical and have the same aspect from all viewing angles.

Once the parameters have been adjusted for viewing angle, they are combined into a single clutter index *CI* as follows. Conceptually, a sample region is broken into cells roughly the size of the target, and the background radiance is computed for each cell. The clutter index is the root-mean-square of variations in radiance between adjacent cells as depicted in the equation below.

$$CI = \sqrt{\frac{\sum_i \sigma_i^2}{N}}$$

Here the summation of variance is taken over *adjacent* cells and divided by the total number of adjacent components in the sum.

The CI computation can be performed in one of two ways. The first is to use the statistical information on scene objects and perform a closed form solution assuming independence between the various components. The second is to perform a fast Monte-Carlo computation on a small synthetically generated scene. This second approach was adopted for the research effort because of its simplicity and flexibility.

In the Monte-Carlo approach, the flat, shadow, and 3-d parameters are used to fill a small 2-dimensional matrix with radiance values. The fill is performed in several passes. First, the flat parameters are filled in function 9 starting with the coarsest information and finishing with the finest grain information. The shadow parameters are then used to attenuate the flat radiances in function 10. Finally, the 3-d parameters are used to overlay the 3-dimensional clutter objects on the background (function 11). It should be noted that the clutter objects are overlaid independent of the shadow information. It was believed that this simplifying assumption would still result in a good approximation of the clutter index for synthetic scenes.

Once the matrix has been filled in, it is used to compute the average background radiance in function 12, and to compute the clutter index in fuction 13. The final SCR computation is is performed in function 14.

2.1.2 Supporting Data Structures

We now describe two language independent data structures required to support the SCR module. The first is a record type holding statistical scene information and the second is a matrix for the Monte-Carlo computation of the clutter index.

The clutter objects are not stored individually; rather, a statistical summary is stored for clutter that is stratified into several layers. There are a total of six layers. The first three layers give statistical parameters for small, medium, and large scale ground coverings. The next two layers consist of small and large scale 3-d clutter objects. Each layer is described by a single "record" or collection of related variables.

All clutter objects are assumed to be circular. Flat objects are described by ellipses, and 3-d objects are described by spheres. The record summarizes the average densities of objects in the x and y planes, parameters for a gaussian distribution (i.e., mean and variance) on reflectance (for trees and ground coverings), and inclination. The size of objects in the layer as measured by the major axis is assumed to follow a gaussian distribution, and the relation between major-axis and minor-axis is summarized by the aspect field.

A language-independent representation of the data stored for each layer is shown below in record format.

LAYER_REC
X_DENSITY - density of object spacing in x-axis
Y_DENSITY - density of object spacing in y-axis
MEAN_SIZE - assume gaussian distribution on object sizes in layer
VAR_SIZE - variance of the object sizes in layer
ASPECT - but all objects have the same aspect imposed by view angles
MEAN_REF - assume gaussian distribution on object reflectances in layer
VAR_REF - variance of the object reflectances in layer
INCLINATION - all objects have the same inclination (used for shadows)
END_REC

The computation of the clutter index uses a small (50 by 50) table of cells. Each cell covers an area of the scene from the viewer's frame of reference that is roughly the same area as the expected target.

2.1.3 Data flow Representation

The computation appears in data flow representation in figure 6. The diagram consists of three types of object. The *data areas* hold information for repeated use, and are depicted as boxes. *Data transformations* are depicted as circles, and accept *data tokens* on their inputs and produce transformed tokens on the outputs. Descriptions are provided for all data areas, tokens and transformations appearing in the diagram.

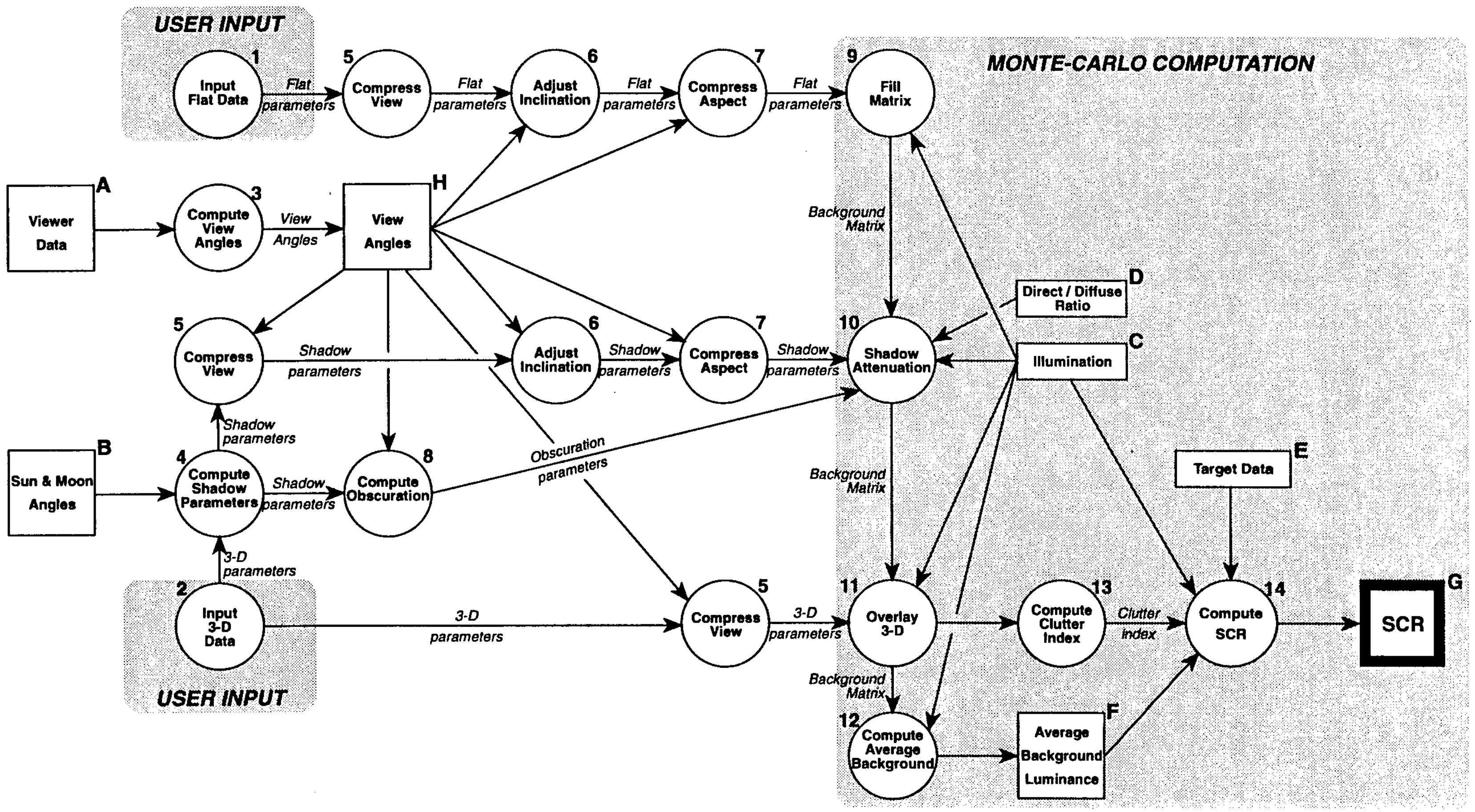

Figure 6. Data Flow Representation.

2.1.3.1 Data Areas

A) *Viewer data* - Viewer height and viewing angle relative to a ray from target to sun.

B) *Sun/moon angles* - Azimuth and elevation of the source of direct illumination relative to the target. These values are stored in the variables AZISUN, ALTSUN, AZIMOO, ALTMOO once they are calculated in the subroutine ILLUM located in the file AUXLRY/rtdlib.f.

C) *Illumination* - Illumination intensity at ground level. Sum of direct and diffuse components, which are calculated in subroutine DIRDIF from the file AUXLRY/rtdlib.f and stored separately in the variables FDIR and FDIF. Solar and lunar illumination are available in the variables SUNLIT and MOOLIT from the routine ILLUM in AUXLRY/rtdlib.f.

D) *Dirdif ratio* - The ratio of direct to diffuse illumination intensities at ground level. The direct and diffuse components are calculated in subroutine DIRDIF from the file AUXLRY/rtdlib.f and stored separately in the variables FDIR and FDIF. Solar and lunar illumination are available in the variables SUNLIT and MOOLIT from the routine ILLUM in AUXLRY/rtdlib.f.

E) *Target data* - Target location in desired coordinate system, target reflectance, type and size. The target location is stored in the variables RLATT and RLONG inside the subroutine FINDR which is in TARGAC/targac.f. Reflectance for different targets is either read from a table or received from the operator inside the subroutine CNTRAS which is in the file TARGAC/targac.f. Type is held in the variable ITARGT inside CNTRAS, and the size is stored in different locations, one of which is DIM in the subroutine FINDR inside targac.f.

F) *Average background radiance* - Intensity of background radiance averaged over a large background. Computed from the 2-d, 3-d, and shadow information in scene.

G) *SCR* - Signal-to-clutter ratio used to compute probability of detection and probability of recognition.

H) *View angles* - The elevation and azimuth of the observer relative to the target.

2.1.3.2 Data Tokens

Flat parms - Parameters for two categories of ground cover: large scale cover encompassing moderately large land areas and small scale covering areas roughly the size of targets. Parameters include means and variances for reflectance, diameter, and densities in the x and y coordinates.

3d parms - Parameters for two categories of 3-dimensional clutter objects: trees and objects roughly the size of targets (i.e., shrubs, etc). Parameters include means and variances for reflectance, diameter, and densities in the x and y coordinates.

Shadow parms - Parameters describing shadow *geometries* (i.e., no luminance data) for the two types of 3-d clutter objects provided. These include major axis, minor axis, inclination from the y-axis, and densities in the x- and y-axes.

View angles - The elevation and azimuth of the observer relative to the target.

Obscuration parms - The fraction of shadows obscured by the objects that cast them. Computed from sun and view angles.

Background matrix - A small (roughly 50 by 50) matrix of cells used for a Monte-Carlo computation of the clutter index. Cells are roughly the size of a target, and filled with radiance values derived from the flat, 3-d, and shadow parms above.

Clutter index - The rms clutter index presented in Schmeider, computed from the filled background matrix.

2.1.3.3 Data Transformations

1) *Input flat data* - The information to compute the *flat parms* are provided by an outside source. This could range from a simple user interface asking the user to choose from a menu of sample pictures, to a sophisticated automatic analysis of imagery. Currently, most of this data is gathered through the subroutine CNTRAS which is located in the file TARGAC/targac.f. The data is either read in from data files or through use of a text menu interface to the operator. Depending upon the source of the data, different approaches are required to extract the appropriate statistical parameters used to compute the SCR.

2) *Input 3-d data* - Same as above but for 3-d clutter objects in the scene.

3) *Compute view angles* - Accepts the viewer height and view angle relative to the sun, and computes the elevation and azimuth of the viewer relative to the target.

4) *Compute shadow parms* - Computes the appropriate shadow parameters assuming spherical clutter objects. Parameters include major and minor axes, inclination, and x and y densities.

5) *Compress view* - Accepts view angles and modifies the densities in the y-axis. The compression represents how objects separated in the y-dimension (relative to viewer's frame of reference) appear closer together when viewed at low depression angles.

6) *Adjust inclination* - Accepts view angles and adjusts the inclination of ellipses in the viewer's frame of reference.

7) *Compress aspect* - Accepts view angles and modifies the y-dimensions (aspect) relative to the viewer frame of reference. The compression represents how flat objects appear compressed in the y-dimension (viewer's frame of reference) when viewed at low depression angles.

8) *Compute obscuration* - Accepts sun and viewer angles and computes the fraction of an object's shadow that would be obscured by the object when viewed from the viewer's position.

9) *Fill matrix* - Fills the matrix with radiance values for flat clutter. Reflectances are first inserted based on the flat parms corrected for the viewer's frame of reference. Large scale clutter is inserted first, and then small scale clutter is overlaid. A second pass then uses the radiance at ground to replace reflectance values with irradiance values.

10) *Shadow attenuation* - The background matrix containing irradiance values is now adjusted to account for shadows. Cells to update are chosen according to the shadow parms and the dirdif ratio is used to attenuate the cell's irradiance by the appropriate factor.

11) *Overlay 3-d* - The background matrix is overlaid with irradiance values for 3-d clutter objects according to the 3-d parms. Spherical Lambertian reflectors are assumed.

12) *Compute average background* - A pass is made over the background matrix to compute the average irradiance of the background. This value is used in later calculations to compute contrast at the target.

13) *Compute clutter index* - A pass is made over the matrix to compute the rms clutter index presented in Schmeider.

14) *Compute SCR* - The clutter index is combined with the average background irradiance and target irradiance to obtain the SCR presented in Schmeider.

2.2 SHADOWS Module

The SHADOWS module computes target shadow information to support the use of shadow information for target cueing. The first output is the target shadow radiance based on the reflectance of the synthetic background computed in the SCR module. The second output is a weighting parameter that expresses how much of the target is adjacent to its shadow, and how much of the target is adjacent to the background. The weighting factor is used by the ACQUIR Module to properly combine the separately computed resolvable contrasts against shadow and background into a single probability of detection.

2.2.1 Overview of the Computation

The computation is fairly straightforward as shown in figure 7. In what follows we also reference the data flow diagram (figure 8) at the end of this section. Each data flow function is referred to by index number.

The target shadow length is computed in function 1. The geometry is adjusted for viewer angle relative to the sun in function 2 and passed to two independent computations. The first of these computes the fraction of target area adjacent to shadow versus the area adjacent to background, or *Pd ratio.* This ratio is computed in functions 4 and 5.

The second independent computation calculates the expected radiance within the target shadow. It uses the ratio of direct to diffuse light computed in function 6 to compute the actual shadow radiance in function 3.

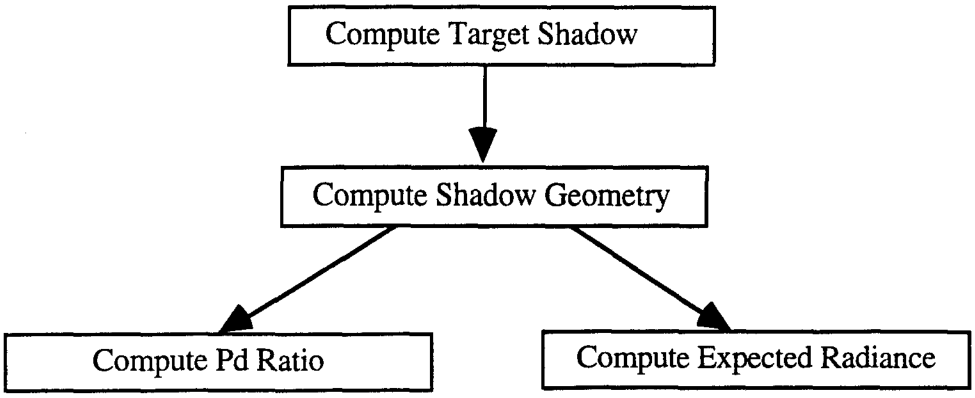

Figure 7. Overview of Shadow Module Computation.

2.2.2 Supporting Data Structures

No significant new data structures are required to support the SHADOWS module.

2.2.3 Data Flow Diagram

The major functional components of the shadow computation are broken out by the data flow diagram shown in figure 8. In this diagram persistent data objects are depicted as boxes, data transformations are shown as circles, and data passing between transformations are represented as arcs.

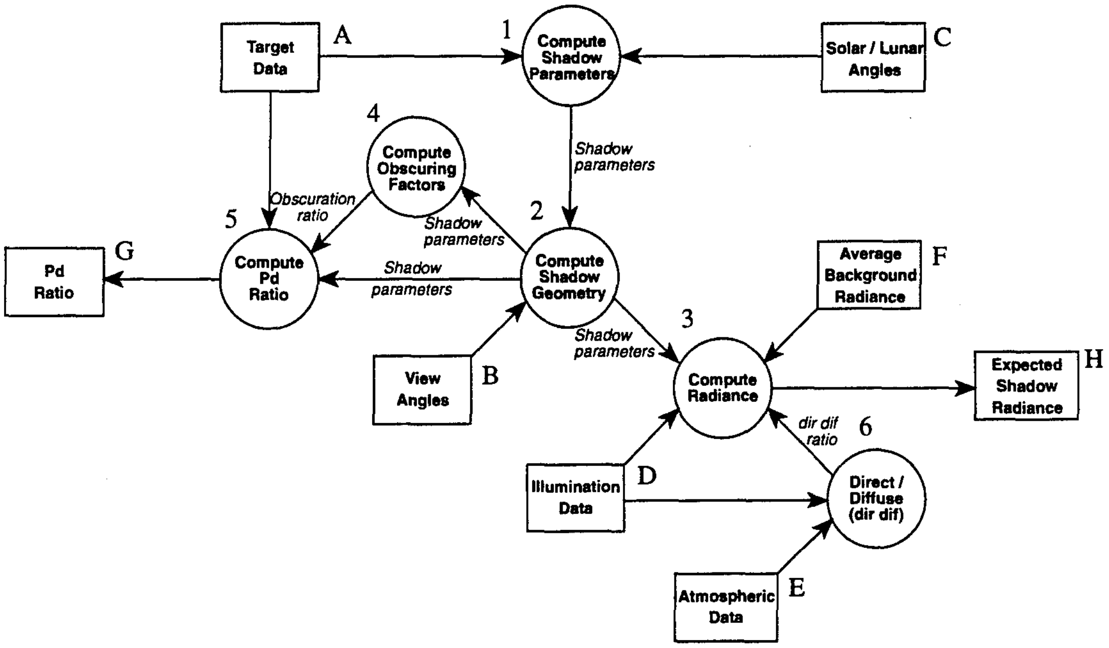

Figure 8. Data Flow Diagram for Shadow Module Computation.

2.2.3.1 Data Areas

A) *Target data* - Target location in desired coordinate system, target reflectance, type and size. The target location is stored in the variables RLATT and RLONG inside the subroutine FINDR which is in TARGAC/targac.f. Reflectance for different targets is either read from a table or received from the operator inside the subroutine CNTRAS which is in the file TARGAC/targac.f. Type is held in the variable ITARGT inside CNTRAS, and the size is stored in different locations, one of which is DIM in the subroutine FINDR inside targac.f.

B) *View angles* - The elevation and azimuth of the observer relative to the target.

C) *Solar/lunar angles* - Azimuth and elevation of the source of direct illumination relative to the target. These values are stored in the variables AZISUN, ALTSUN, AZIMOO, ALTMOO once they are calculated in the subroutine ILLUM located in the file AUXLRY/rtlib.f.

D) *Illumination data* - Illumination intensity at ground level. Sum of direct and diffuse components, which are calculated in subroutine DIRDIF from the file AUXLRY/rtdlib.f and stored separately in the variables FDIR and FDIF. Solar and lunar illumination are available in the variables SUNLIT and MOOLIT from the routine ILLUM in AUXLRY/rtdlib.f.

E) *Atmospheric data* - Atmospheric transmittance factors. These are stored in variables named XSTRN_ in the file TARGAC/targac.f.

F) *Average background irradiance* - Intensity of background irradiance averaged over a large background. Computed in *Compute SCR* from the 2-d, 3-d, and shadow information in scene.

G) *Pd ratio* - The weighting factor used to combine the probability of detection or recognition from target-to-shadow contrast and target-to-background contrast.

H) *Shadow radiance* - The expected radiance within shadow areas based on the average background reflectances and the direct and diffuse light at ground level.

2.2.3.2 Data Tokens

Shadow parms - Parameters describing target shadow *geometry* (i.e., no luminance data). This includes major axis, minor axis, and inclination from the y-axis.

Obscure ratio - The fraction of the target shadow that is obscured by the target from the viewer's frame of reference.

Dirdif ratio - The ratio of direct to diffuse illumination intensities at ground level. It is calculated in the subroutine DIRDIF in AUXLRY/rtdlib.f and named RATIO.

2.2.3.3 Data Functions

1) *Compute shadow parms* - Computes the appropriate shadow parameters assuming spherical clutter objects. Parameters include major and minor axes, inclination, and x and y densities.

2) *Compute shadow geometry* - Computes the appropriate shadow parameters assuming spherical clutter objects. Parameters include major and minor axes, inclination, and x and y densities.

3) *Compute radiance* - Computes the expected radiance within shadow areas based on the average background reflectances and the direct and diffuse light at ground level.

4) *Compute obscuration* - Accepts sun and viewer angles and computes the fraction of an object's shadow that would be obscured by the object when viewed from the viewer's position.

5) *Compute Pd ratio* - Computes the fraction of the target adjacent to shadow and the fraction adjacent to background. The ratio is used to weight the shadow and background detection probabilities within ACQUIR.

6) *Dir/dif* - Computes the ratio of diffuse to direct light at ground level. Subroutine DIRDIF is located in AUXLRY/rtdlib.f.

2.3 ACQUIR Module

ACQUIR computes the probability of detection and recognition given the resolvable cycles of the sensor and transmitted contrast, the object range and size, and the clutter index. The module is a direct replacement for the current module, and implements two improvements. First, the detection and recognition probabilities are computed using a novel technique which combines probabilities for target-on-background and target-on-shadow. Second, the actual detection probabilities are computed by fast data look-up and interpolation routines.

The probability of detection and recognition is computed using dual detection algorithms for target-on-background and target-on-shadow. Target area is split between the portion adjacent to shadow and the portion adjacent to background; the two components are then used in separate detection computations. These independent probabilities of detection (or recognition) are then combined to provide a composite probability of detection (or recognition).

The probability computation is performed by fast table look-up and interpolation routines. This approach has the advantage that the mapping between cycles on target and detection probability can be modified on the fly by swapping in new look-up tables. Furthermore, mappings that are hard to fit by closed-form functions are easily accommodated by the table look-up approach.

2.3.1 Overview of the Computation

The Pd ratio (computed in the SHADOWS Module) is first used to compute the relative target area in function 1 that will be used by the target-on-shadow and target-on-background detection calculations. Both computations then proceed in parallel. Function 2 accepts the range and resolvable cycles and computes the cycles on target for the shadows case and the background case.

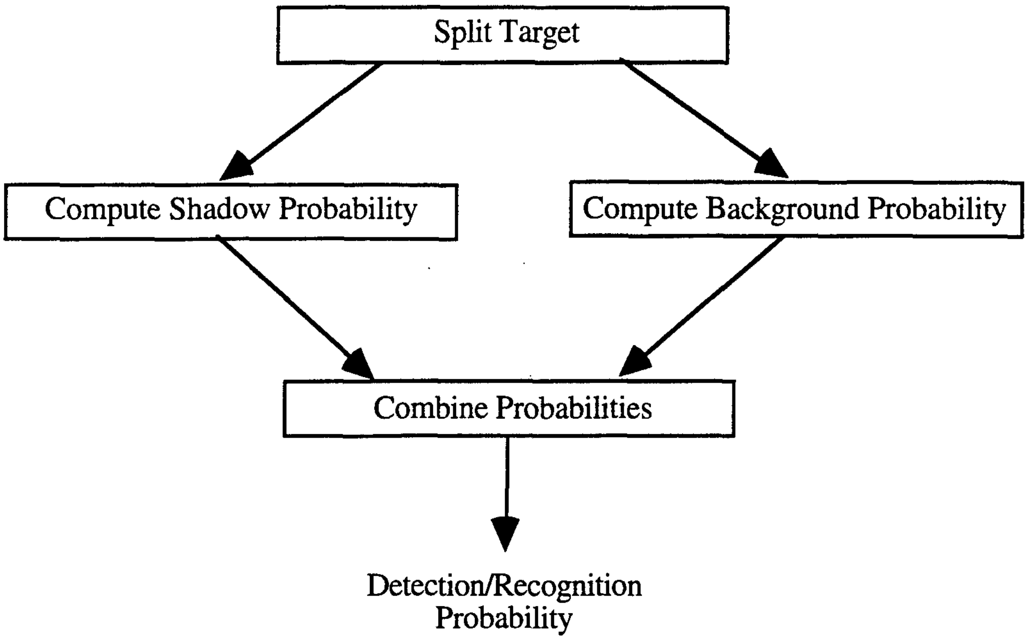

Figure 9. Overview of ACQUIR Module Computation.

The signal-to-clutter ratio is binned into coarser categories (if necessary) in function 3 and used to index the proper interpolation vectors from the Cycles Table. The proper interpolation vector is passed to both detection computations and used to interpolate the detection probability as follows. First, a binary search is used to find the proper position of the *cycles-on-target* in the sorted cycles list. Typically, it will fall between two adjacent components in the list. The position of *cycles on target* between the two bounding elements in the list is then approximated linearly and this same linear factor is used to approximate the value of the cycles-to-probability mapping in the Pd/Pf table.

These two independently computed probabilities are then passed down to function 5 where they are combined (weighted by the Pd ratio) to produce a composite probability of detection.

2.3.2 Supporting Data Structures

The ACQUIR module replacement uses new data structures to compute the probabilities of detection and recognition by interpolation. This requires two arrays. The first array is 1-dimensional and consists of an ordered list of probability thresholds. The second array is two dimensional. Each row of array 2 corresponds to a particular range of

SCR values and consists of a list of the minimum number of cycles-on-target required for that level of detection/recognition probability given the level of clutter indicated by SCR.

2.3.3 Data flow Diagram

The major functional components of the ACQUIR computation are broken out by the data flow diagram shown in figure 10. In this diagram, persistent data objects are depicted as boxes, data transformations are shown as circles, and data passing between transformations are represented as arcs.

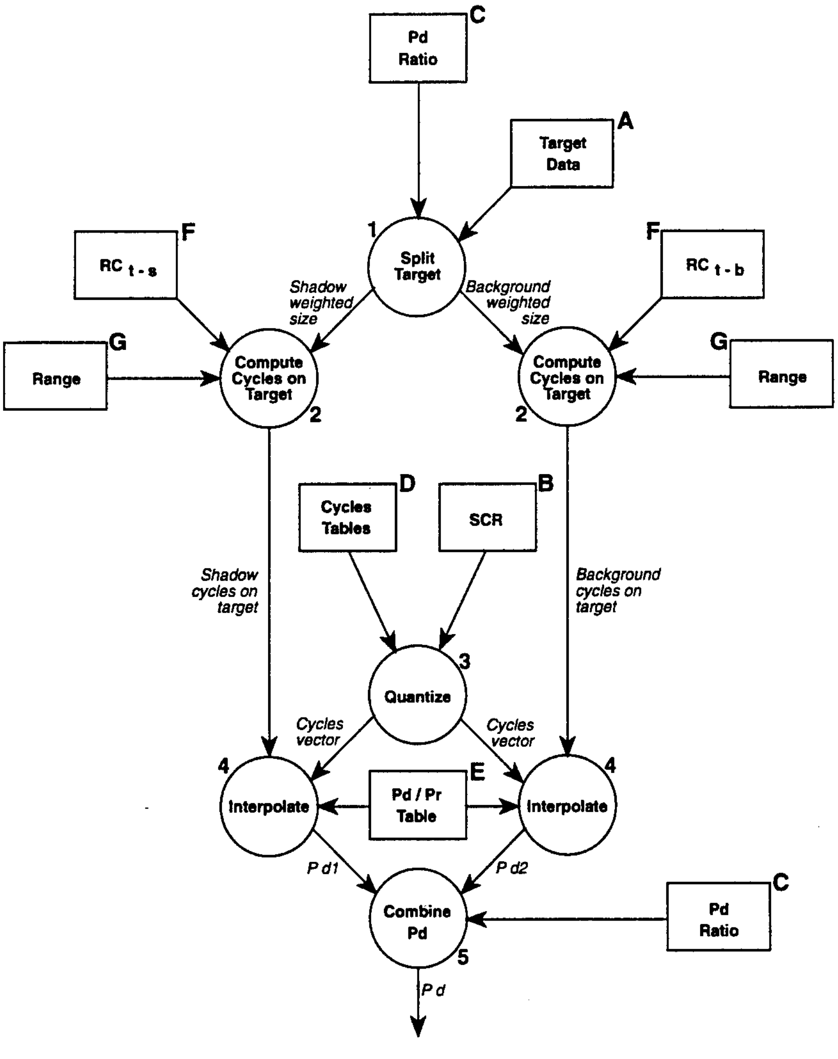

Figure 10. Data flow Diagram for ACQUIR Module.

2.3.3.1 Data Areas

A) *Target data* - Target location in desired coordinate system, target reflectance, type and size. The target location is stored in the variables RLATT and RLONG inside the subroutine FINDR which is in TARGAC/targac.f. Reflectance for different targets is either read from a table or received from the operator inside the subroutine CNTRAS which is in the file TARGAC/targac.f. Type is held in the variable ITARGT inside CNTRAS, and the size is stored in different locations, one of which is DIM in the subroutine FINDR inside targac.f.

B) *SCR* - Signal-to-clutter ratio used to compute probability of detection and probability of recognition.

C) *Pd ratio* - The weighting factor used to combine the probability of detection or recognition from target-to-shadow contrast and target-to-background contrast.

D) *Cycles table* - Tables of minimum cycles required on target parameterized by detection and recognition probabilities. (Drawn from Schmeider). TARGAC-2 presently appears to contain the proper arrays in DCYC, located in file targac.f.

E) *Pd/Pr Table* - Tables of probability values parameterizing the *Cycles table.* TARGAC-2 presently appears to contain the proper arrays near DCYC, located in file targac.f.

F) *RC values* - Resolvable cycles given contrast and imaging equipment parameters. Two values are used: one for contrast between target and background and one for contrast between target and its shadow.

2.3.3.2 Data Tokens

Shadow weighted size - Size of target weighted by fraction of target against shadow.

Background weighted size - Size of target weighted by fraction of target against background.

Shadow cycles-on-target - Resolvable cycles on portion of target against shadow.

Background cycles on target - Resolvable cycles on portion of target against background.

Cycles vector - Vector of minimum number of cycles required on target given clutter parameters. Vector is parameterized by probability entries in *Pd/Pr Table.*

Pd - Probability of detection.

2.3.3.3 Data Functions

1) *Split target* - Splits the target size based on fraction of target against background.

2) *Compute cycles-on-target* - Computes the number of cycles on the target given the range, the maximum target dimension, and the sensor characteristics.

3) *Quantize* - Buckets the SCR into coarser grained measurements and extracts proper row from the *Cycles table.*

4) *Interp* - Accepts two input arrays and a search index. The first array is the "parameter" array, and the second is the "function" array. It locates the position within the parameter array, and interpolates between two adjacent cells if necessary. The interpolation "distance" is then used to interpolate the appropriate value from the same two adjacent cells in the function array.

5) *Combine Pd* - Combines the detection probabilities from shadow and background contrast according to the *Pd ratio.*

2.4 Software Structure

We now present the structure of the proposed software modifications to TARGAC. Figure 11 shows the first level of TARGAC. (Note that figure 11 only shows the first level of software decomposition under the FINDR routine.) Figure 12 shows a detailed view of the software structure for the proposed new codes. In both figures, major routines are represented by boxes, and downward arcs in the diagram indicate subroutine and function calls. Hatched boxes are routines devoted exclusively to IR and are not treated.

Heavily outlined boxes indicate TARGAC-2 modules that will be modified or replaced, and shaded boxes represent new modules. The module descriptions for figure 12 are outlined in the following section. The suggested FORTRAN module names are included in parentheses.

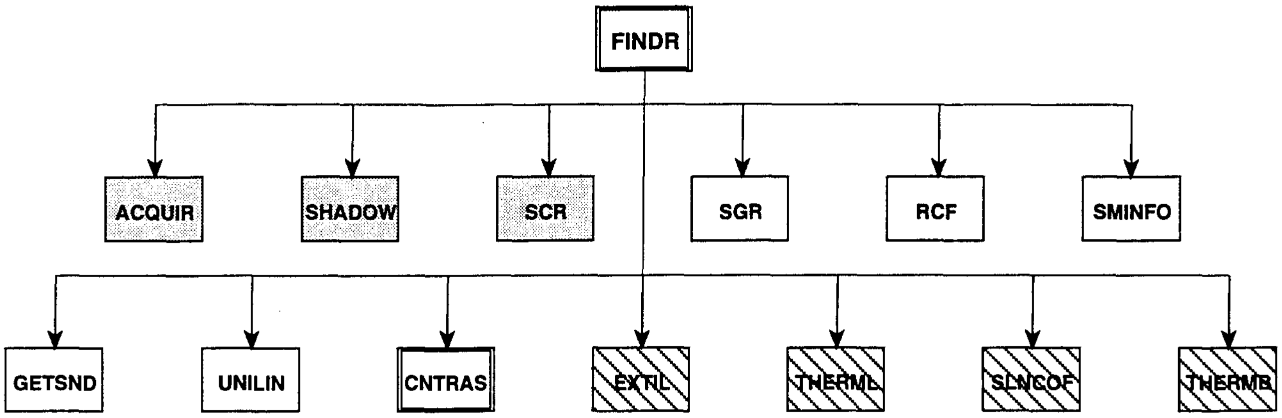

Figure 11. Decomposition of the FINDR routine.

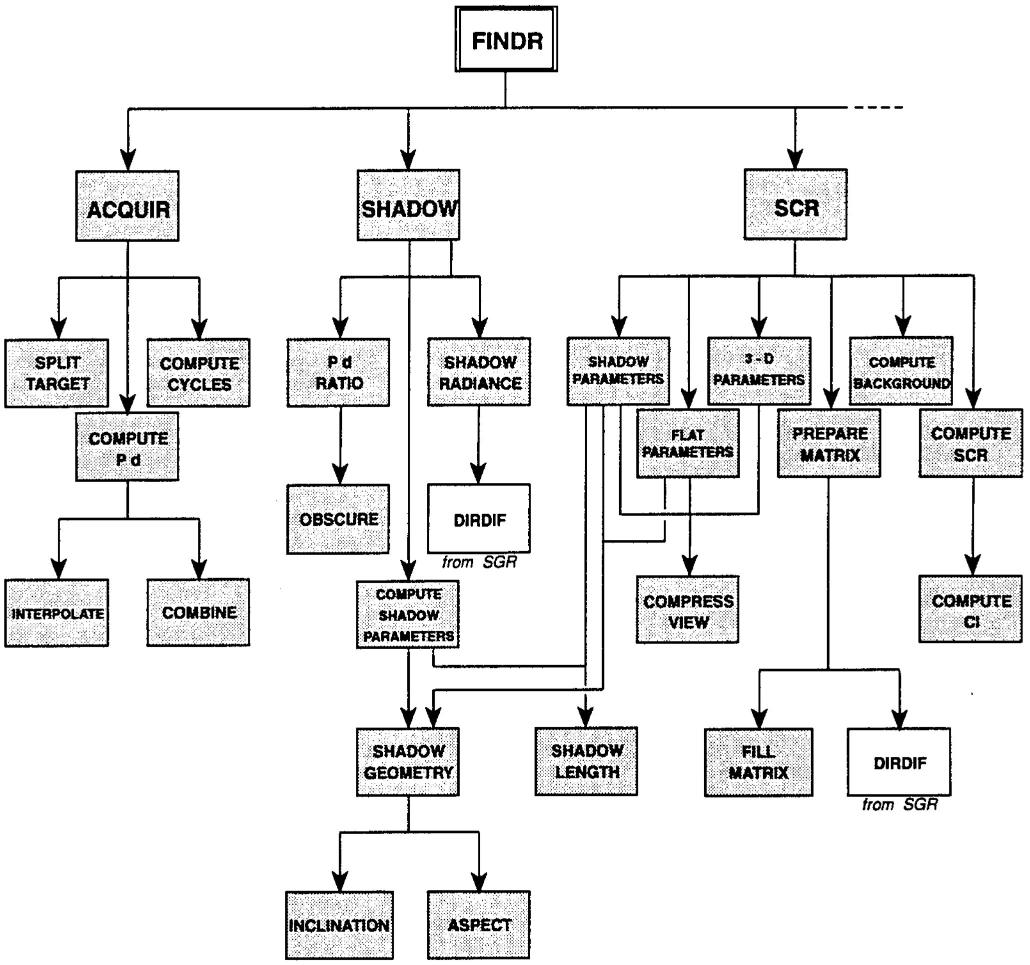

Figure 12. Detailed Software Structure.

2.4.1 New Module Descriptions

ACQUIR (ACQUIR) - Accepts the resolvable cycles across target for target-on-shadow and target-on-background, the shadow detection weighting factors, and Signal-to-Clutter Ratio to determine the probabilities of detection and recognition for the given viewer to target range.

SPLIT TARGET (SPLTGT) - Called by ACQUIR to compute the relative portions of the target against background and against shadow, and returns the two target sizes to be used in the dual detection algorithms.

COMPUTE CYCLES (GETCYC) - Accepts the size of the target and range, and computes the cycles across the target.

COMPUTE Pd (GETPD) - Accepts the number of cycles on target, weighting factors, and SCR to compute the probabilities of detection and recognition using calls to INTERPOLATE and COMBINE.

INTERPOLATE (INTER) - Accepts an argument list, a function list, and an input argument. The argument list is ordered, and the function list contains values of a function evaluated at the discrete points defined in the argument list (i.e., it is a discrete mapping from arguments to some other space). The routine interpolates the value of the function on the input argument in two steps. First, it calculates the relative position of the input argument between two adjacent cells in the argument list. It then uses this information to linearly interpolate within the function list.

COMBINE (CMBINE) - Accepts the Pd ratio and recombines the two detection/recognition probabilities into a single detection/recognition probability using the Pd ratio as a weighting factor. Empirically-derived rules for combining may apply.

SHADOW (SHADW) - Accepts target sizing data and solar/lunar angles (computed in the subroutine ILLUM from AUXLRY/rtdlib.f) to compute the Pd ratio and the expected shadow radiance. The Pd ratio designates the relative portion of the target-on-shadow to target-on-background to use in the separate detection algorithms, and the final combining. The expected shadow radiance is used to compute the target-on-shadow contrast.

TARGET SHADOW PARMS (GETTSP) - Computes the size of the target shadow (assuming direct illumination) given the solar/lunar angles (from subroutine ILLUM), target characteristics, and the viewing angles. It calls SHADOW SIZE to compute basic shadow geometry from the target size and solar/lunar angles, and then calls SHADOW GEOMETRY to adjust for viewer angle.

SHADOW SIZE (SHSIZE) - Computes the shadow size parameters given an object size and the solar/lunar angles, which are calculated by the subroutine ILLUM and held in the variables AZISUN, ALTSUN, AZIMOO and ALTMOO.

SHADOW GEOMETRY (SHGEOM) - Adjusts the shadow size parameters for viewer angle relative to the sun and the observed object.

ASPECT (APSECT) - Adjusts the x-axis and y-axis measurements in the viewer's frame of reference for an object based on view angle.

INCLINATION (INCLIN) - Adjusts the inclination in the viewer's frame of reference for an object based on view angle.

Pd RATIO (PRATIO) - Computes the fraction of the target that is adjacent to its shadow and adjacent to its background. The ratio is used to compute cycles on target for the detection algorithms, and for combining the target-on-shadow and target-on-background detection/recognition probabilities into a single probability.

OBSCURE (OBSCUR) - Computes the portion of the shadow that is obscured by the target in the viewer's frame of reference.

SHADOW RADIANCE (SHRAD) - Computes the expected radiance from shadowed areas using the expected background reflectance, which comes from the subroutine CNTRAS, and the ratio of direct to diffuse light at ground level which is computed in the subroutine DIRDIF from AUXLRY/rtdlib.f.

SCR (SCR) - Oversees the conversion of input data to statistical background parameters, and uses them to compute a clutter index, signal-to-clutter ratio, and average background radiance.

FLAT PARMS (FLTPRM) - Accepts statistical information on expected cluttering ground cover in the target area and computes the statistics for the flat clutter component. Currently, background information is read in via the subroutine CNTRAS.

3D PARMS (D3PRM) - Accepts statistical information on expected 3-d clutter objects in the target area and computes the statistics for the 3-d clutter component. Currently, most target information is read in by the subroutine CNTRAS.

SHADOW PARMS (SHPRM) - Computes the statistics for the flat clutter component due to shadows from the statistical parameters for 3-d clutter objects.

COMPRESS VIEW (COMPRS) - Adjusts the y-density of objects in a scene (viewer's frame of reference) to account for viewer angle.

PREPARE MATRIX (PREPMTX) - Places radiance values into the 50 by 50 scene matrix for the Monte-Carlo computation of Clutter Index using a three phase algorithm. In the first phase, flat parameters are used to fill in reflectances cell by cell, in several passes. The first pass uses the largest scale covering data and the last pass uses the lowest scale (smallest) covering data. A third pass then uses the average reflectance per cell to fill in average radiances for each cell. In the second phase, the radiances are attenuated by shadow information, and in the third phase, radiances from 3-d clutter objects are overlaid on the matrix.

FILL MATRIX (FILMTX) - Fills a matrix with values based on passed size and density parameters. All objects are assumed to be elliptical. A flag indicates if the values should replace old matrix values, or be averaged with old values.

COMPUTE BACKGROUND (GETBGD) - Accepts a matrix of radiances and computes the average.

COMPUTE SCR (GETSCR) - Computes the signal-to-clutter ratio from the target radiance, average background radiance, and clutter index.

COMPUTE CI (GETCI) - computes the clutter index from a matrix of scene radiances.

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