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The United States Navy is developing a computer workstation capable of ingesting real time satellite data, called the Tactical Environmental Support System, third generation, or TESS(3). This computer is expected to reside at both ashore and afloat sites. One of the main functions of TESS(3) is to process digital satellite data from the NOAA and DMSP satellites. The baseline processing include the automated scheduling, ingest, navigation and display of the imagery. The Naval Oceanographic and Atmospheric Laboratory (NOARL) is augmenting the capability with cloud analysis software that is capable of detailed cloud analysis and classification.

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TACTICAL ENVIRONMENTAL SUPPORT SYSTEM [TESS(3)] SATELLITE CLOUD ANALYSES

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ABSTRACT

The United States Navy is developing a computer workstation, capable of ingesting real time satellite data, called the Tactical Environmental Support System, third generation, or TESS(3). This computer is expected to reside at both ashore and afloat sites. One of the main functions of TESS(3) is to process digital satellite data from the NOAA and DMSP satellites. The baseline processing include the automated scheduling, ingest, navigation and display of the imagery. The Naval Oceanographic and Atmospheric Laboratory (NOARL) is augmenting the capability with cloud analysis software that is capable of detailed cloud analysis and classification.

INTRODUCTION

The Tactical Environmental Support System (TESS(3)) is the third generation TESS to be deployed with the operational Navy to aid in the tactical decision making process at sea. The TESS(3) is far advanced from its predecessors in both hardware and software. TESS(3) hardware is one of the most advanced and powerful processing systems in the fleet (see Fig. 1 for a carrier configuration), which consists of

CONCURRENT MASSCOMP 6605 (3 68030 CPUs)

1.2 Gigabytes of on line storage
16 Megabytes of RAM
Two graphic workstations

The TESS(3) software was developed under the DoD 2167 software documentation standard and is made up of six Computer Software Configuration Items (CSCIs) for the administration and application processing of data products. TESS(3) has the ability to acquire real time National Oceanographic and Atmospheric Administration (NOAA) and Defense Meteorological Satellite Program (DMSP) series satellite data for use in producing data products. The AN/SMQ-11 Meteorological Data Receiver - Recorder Antenna system was Navy designed as a stand alone processing system. With the arrival of TESS(3) the AN/SMQ-11 has the capability to pass acquired satellite data to the TESS(3) satellite data processing software. All data coming into TESS(3) are put into a commercial relational database management system for use by all application subsystems. The database schema for TESS(3) is a subset of the Naval Environmental Operational Nowcasting System (Jurkevics et al., 1990).[2]

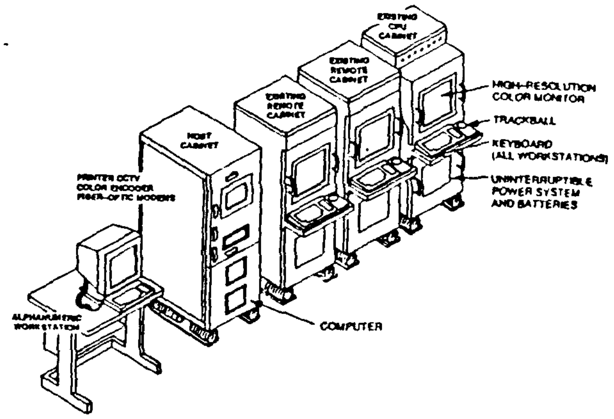

Fig. 1. TESS(3) carrier configuration.

SATELLITE DATA PROCESSING

The satellite data processing subsystem within TESS(3) (see Fig. 2) acquires real time NOAA series Advanced Very High Resolution Radiometer (AVHRR), TIROS Operational Vertical Sounder (TOVS), High Infrared Resolution Sounder (HIRS), and Microwave Sounding Unit (MSU), and DMSP Operational Line Scanner (OLS), and Special Sensor Microwave Imager data sets. The AN/SMQ-11 tracks and receives 14 minutes of data for each of these sensors. The satellite data are earth located and calibrated and stored on disk. Upon completion of the pass the data are immediately assessable.

Cloud Analysis Executive

The functional description for the Cloud Analysis Executive is to allow the forecaster to identify cloud free areas and to extract cloud top temperatures. The Cloud Analysis Executive (CAE) as designed in Fig. 3, allows the forecaster to: 1) identify cloud and cloud free

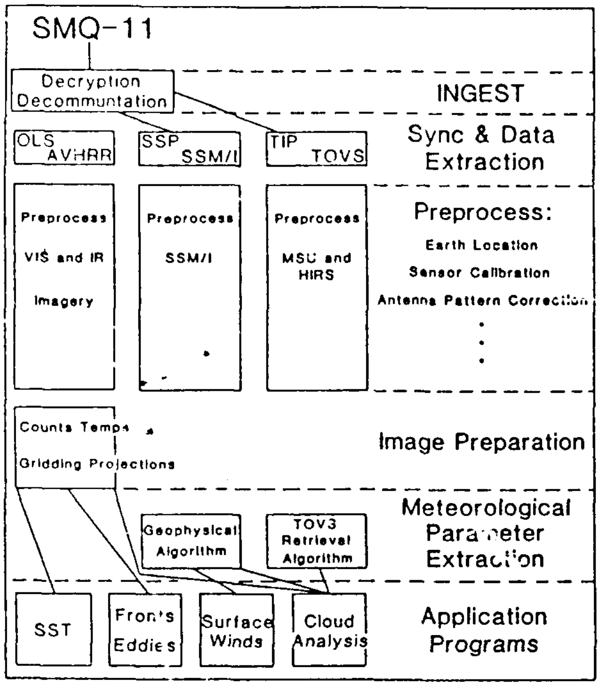

Fig. 2. Satellite data processing subsystem.

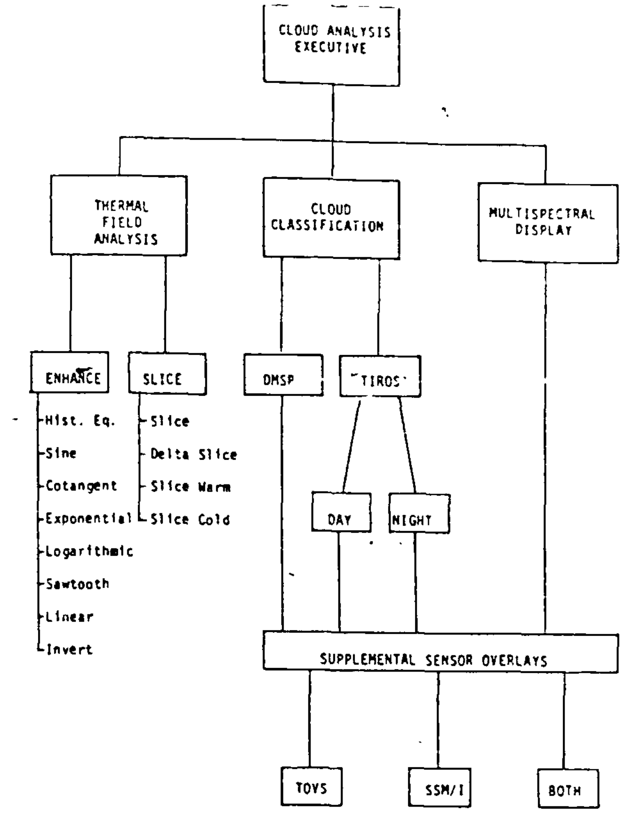

Fig. 3. Cloud analysis executive.

areas through the use of enhancement curves and multispectral imaging, 2) blend cloud data with radiosonde or satellite derived vertical sounding data for computation of cloud top temperature and heights, 3) display selected cloud top temperatures through the use of color slicing, 4) classify clouds and identify the cloud types, and 5) enhance classification of temperature images with the water vapor and liquid water supplemental sensors.

The CAE is a forecaster interactive program that depends upon the knowledge and skill of an operational forecaster. The design of the CAE is to minimize the knowledge the forecaster must have with satellite remote sensing, image processing, and computer interaction. The forecaster interacts through a window environment which leads the forecaster through the interactive steps necessary to perform the cloud analysis function.

Processing Selection

The cloud analysis software requires the forecaster to select a DMSP or NOAA satellite pass from those available on disk. Once a pass is selected, a subsample image is displayed on the display system. The forecaster then uses the trackball to select the center point of the area of interest. That area of interest is redisplayed at full resolution in a 1024 x 1024 pixel screen. Once the full resolution image is displayed, the operator has the option to further analyze the cloud analysis function.

CLOUD ANALYSIS

The TESS(3) cloud analysis will be a composite product making use of information from several sensors. The cloud analysis allows a forecaster to gain knowledge of the mesoscale region through multispectral imaging, thermal field analysis, and cloud classification.

Multispectral Imaging

The CAE provides multispectral imaging capability from the AVHRR data sets. This subprocess displays low, middle, and high cloud types through the use of color composite imaging. AVHRR channel three is represented by red, channel four by green, and channel five by blue. The technique used by d'Entremont and Thomason (1987)[1] show cloud free areas as black over water and brown hues over land. The TESS(3) forecaster needs to apply photo interpretation techniques to identify the individual and multilayered cloud types within the processing field of view. Each of the cloud levels have distinctive color composite signatures, high clouds such as cirrus appear cyan in color (contributions from channels 4 and 5), medium level clouds have more green to yellow hues, and lower, warmer clouds appear magenta in color (contributions from channels 3 and 5). These colors may be used to infer cloud optical properties and cloud emissivities.

The TESS(3) image display system has eight bit planes (256 colors) with which to represent raster imagery, so many of the cloud types appear white due to display saturation and not because of the data values. The AVHPR ten bit data are mapped to eight bits for display. The eight bit temperature counts are used by the multispectral imaging to calculate a frequency distribution function. This frequency distribution is used to build a density slice color table and an eight bit composited pixel for display.

For the experienced TESS(3) forecaster this eight bit composite image provides an area for creativity in the operators forecast.

Thermal Field Analysis

The CAE allows the TESS(3) forecaster to perform a thermal field analysis using channel four of the AVHRR. The forecaster is offered a series of processing steps to perform on the thermal imagery. A selection of enhancement functions (see Fig. 4) are available to the TESS(3) forecaster: 1) histogram equalization, 2) sawtooth, 3) exponential, 4) logarithmic, 5) sine, 6) arctangent, 7) linear, and 8) invert. The functions are applied to the color lookup table only, the imagery data are unchanged.

The thermal field analysis functions also provide the forecaster with the ability to threshold temperatures interactively on the display screen. Any temperature may be selected to color slice in the overlay plane. Ranges of this threshold temperature may be selected for display in the second overlay plane.

Supplemental sensor data for the TOVS or SSM/I can be displayed on the overlay plane of the display. This augments the forecasters ability to determine the synoptic weather patterns in their area of operation.

Enhancements. The use of the enhancement functions is as follows: 1) Histogram - this brings out all gray scale radiances in equal proportion, 2) Sawtooth - groups gray scale values into bins of sixteen gray scale values each, 3) Exponential - when there are small clusters of gray scale radiances and the gray scale distribution is unequal within the image, the exponential function enhances the

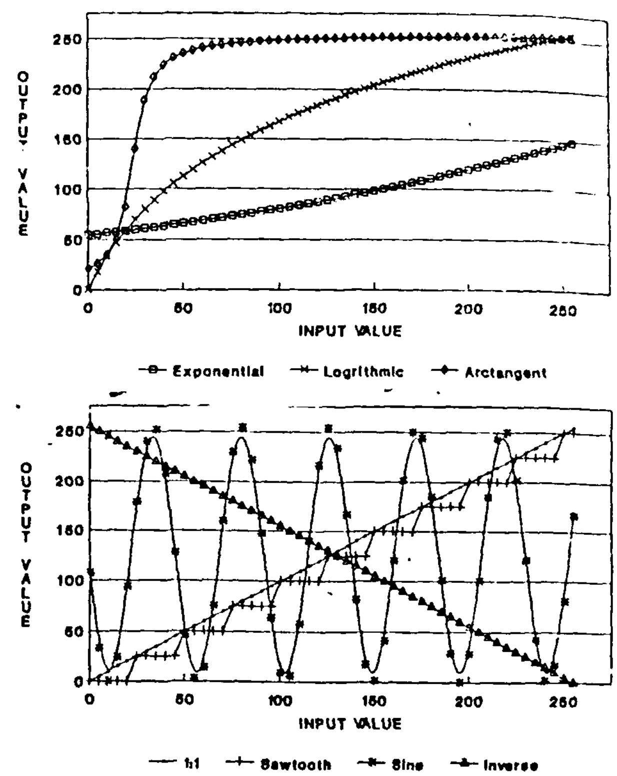

Fig. 4. Enhancement curves.

overall appearance, 4) Logarithmic - provides enhancement of high and low clouds within the image, 5) Sine - produces edge detection for multilayered clouds, 6) Arctangent - enhances the cloud no-cloud boundaries, 7) Linear - straight gray scale remapping, 8) Invert - inverts the gray scale i.e., light is dark and vice versa.

Thresholds. Temperature threshold color slicing is an option that allows the TESS(3) forecaster to select a temperature to highlight in the image. The thermal image data are read from the displayed image, and where the pixel matches the threshold slice temperature an overlay pixel is lit and displayed. This process is interactive and may be repeated as many times as the forecaster requires, but only one selection is displayed in the overlay plane at one time.

Threshold Range. Upon completion of the temperature threshold overlay process, the forecaster may chose to look at ranges around the selected threshold temperature. The second overlay plane is used for the threshold criteria. The thermal image, the first and second overlays are displayed on the screen which reflect the image and the threshold range requested. Options such as every pixel colder than the threshold temperature, every pixel warmer than the threshold temperature, or a plus and minus range about the threshold temperature are possible selections. This process is interactive and the forecaster can complete any number of these operations to strengthen their forecasting capability.

Supplemental Sensors. The thermal field analysis functionality provides the TESS(3) forecaster the use of supplemental sensor data from the NOAA Tiros Operational Vertical Sounder (TOVS), and the Special Sensor Microwave/Imager (SSM/I) to overlay the thermal imagery on the display screen. The use of the TOVS data are to provide the forecaster with the ability to determine cloud top temperatures and height information. The temperature data are taken directly from the thermal imagery on the display screen. For cloud top height the TOVS retrievals are used. The TOVS sounding most representative of the air mass is selected by the forecaster. A temperature, height lookup is performed from the AVHRR and TOVS retrieval data. The values of the temperature and height are displayed in the overlay plane over the thermal image.

The DMSP SSM/I environmental data records allow the TESS(3) forecaster to have an overlay displayed with water vapor, liquid cloud water, and liquid water values displayed in the overlay plane over the thermal image. The SSM/I data are time coincident with the OLS thermal field data sets, but may be up to three hours different from the AVHRR thermal field data sets. This not withstanding, the use of SSM/I data with the thermal field data is additional information to the tactical decision maker at sea.

Cloud Classification

The CAE provides a cloud classification procedure using a model developed at the Naval Postgraduate School (Wash et al. 1985).[4] Cloud classification is performed on both the AVHRR and OLS data. The AVHRR cloud classification makes use of the multispectral component of albedos and temperatures to classify clouds. The program is a box classifier (see Fig. 5) employing the use of predetermined class thresholds for albedo, temperature, and a texture component to define the cloud type. Liljas (1986)[3] use of AVHRR channel three to discriminate low, warm clouds at night has been incorporated into the cloud classification algorithm. The model separates ten cloud classes for daytime AVHRR passes, and seven distinct classes at nighttime. The emphasis for TESS(3) is to provide the tactical decision maker a product that provides timely and accurate cloud information.

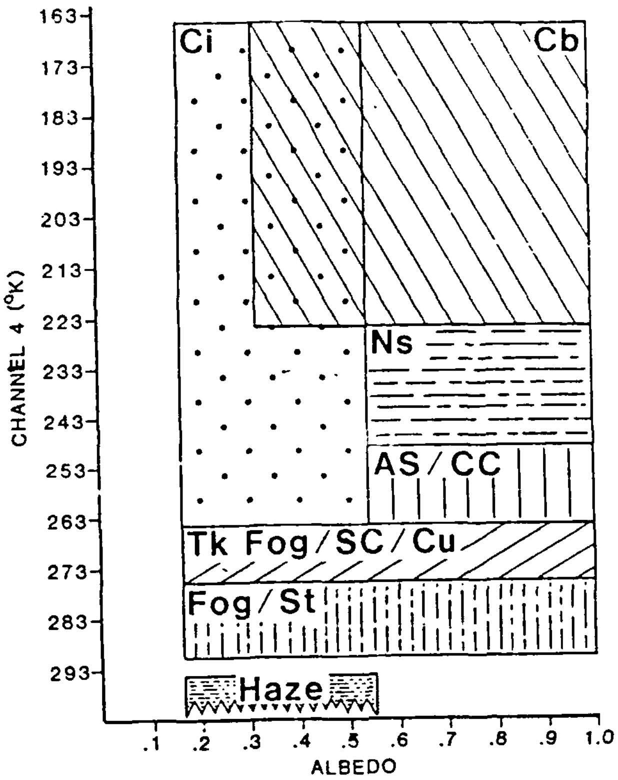

Fig. 5. Box classifier.

Due to spectral limitations and spatial resolution differences, the OLS classifier makes use of only the thermal channel. This allows classification of low, middle, and high clouds.

Supplemental Sensors. Supplemental sensor data from the TOVS and/or the SSM/I may be overlaid by the TESS(3) forecaster. The forecaster can make use of these supplemental sensor overlays to better interpret the environmental conditions and prepare weather briefings. Cloud top temperature, and height, are displayed on the overlay plane over the

cloud type, through forecaster interaction with the trackball. SSM/I derived water vapor, cloud liquid water, and liquid water can be built on the overlay plane over the cloud classification image.

DISCUSSION

The TESS(3) CAE is operationally ready in the first quarter of 1991. Forecasters may choose the CAE menu option to use and interactively work with the real time satellite data to produce a cloud analysis. Availability to timely synoptic cloud information such as cloud types and the auxiliary cloud analysis information is important to the TESS(3) forecaster to identify, track, and diagnose mesoscale weather within the ship's operational area. TESS(3) is capable of providing the Navy oceanographer/meteorologist environmental support at sea in a nowcasting arena. TESS(3) cloud analysis contains dramatic improvements to the tools of the forecasters and extends the Navy's effectiveness at sea.

REFERENCES

1. d'Entremont, R.P., Thomason L.W., 1987: "Interpreting Meteorological Satellite Images Using a Color-Composite Technique", Bulletin of the American Meteorological Society, Vol. 68, No. 7.

2. Jurkevics, A., Titus, R., Clark, J., 1990: "Environmental Data-base for the Naval Environmental Operational Nowcasting System", Proceedings, Sixth International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology, Feb. 5-9, Anaheim, CA, pp80-83.

3. Liljas, E., 1986: "Use of the AVHRR 3.7 Micrometer Channel in Multispectral Cloud Classification", SMHI Promis-Rapporter.

Wash, C.H., Spray, L.A., Chou, L.C., 1985: "Satellite Cloud and Precipitation Analysis Using a Minicomputer", NPS-63-85-003, Technical Report.

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