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AFGWC TECHNICAL MEMORANDUM 78-003

AFGWC-TM-78-003

POINT ANALYSIS USER'S GUIDE

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and

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Approved For Public Release;
Distribution Unlimited

HQ Air Force Global Weather Central
Offutt AFB, Nebraska 68113

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This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

THOMAS D. MADIGAN, Colonel, USAF
Chief, Technical Services Division

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The new Point Analysis (PA) process was developed to correct specific deficiencies in the previous process (AFGWC Point Analysis Documentation,1 Aug 1974. These deficiencies, identified by the 3rd Weather Wing Point Analysis Conference in March of 1976, fall into three general categories. First, the moisture modeling technique had a deficiency of moisture through the tropopause. Second, there was a lack of observed density data for the 80km to 250km region. Finally, the production process required an excessive number of manual tasks. The new PA process employs a new tropopause moisture modeling technique; includes, when—

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PREFACE

The new Point Analysis (PA) process was developed to correct specific deficiencies in the previous process (AFGWC Point Analysis Documentation, 1 Aug 1974).

These deficiencies, identified by the 3rd Weather Wing Point Analysis Conference in March of 1976, fall into three general categories. First, the moisture modeling technique had a deficiency of moisture through the tropopause. Second, there was a lack of observed density data for the 80 km to 250 km region. Finally, the production process equired an excessive number of manual tasks.

The new PA process employs a new tropopause moisture modeling technique; includes, when available, rocket sonde (ROCOB) observations; and reduces the manual tasks to directing and quality controlling the automated process.

The work described here is primarily the result of the efforts of Capt Paul T. Nipko, Special Projects Branch of the Production Division, AFGWC. It is based on the work of his predecessor, Capt Robert D. Abbey; and includes the tropopause moisture modeling technique developed by Capt Lawrence D. Mendenhall, USAFETAC.

TABLE OF CONTENTS

1. INTRODUCTION

The Air Force Global Weather Central (AFGWC) Point Analysis (PA) is a process which produces a description of the atmospheric conditions above and around a given point on the earth. The final product includes a vertical profile, a gridded cloud depiction, and a site weather pseudo surface observation.

The point analyses are produced by both AFGWC and USAF Environmental Technical Applications Center (USAFETAC). The algorithms used by both centralized production systems are identical, however the completeness of their respective data bases can differ significantly. In each case the final product represents a blend of computer-processed information and the judgement of an experienced weather analyst.

The PA process is triggered by a user request specifying a time and location. Normally, USAFETAC will process requests received later than 18 hours after the event time. AFGWC is charged with responding immediately to the more timely requests. This limitation is driven by the lifetime of the data base at AFGWC. Only those data which are available in the data base at the time of request are included in the AFGWC analysis.

AFGWC response time for a PA request within an 18-hour window is rarely more than four hours and is usually much less.

2. INPUT

The user specifies the location (latitude and longitude) and the time for which a point analysis is required.

The PA process uses observed data, analyzed data, and climatological data. Observed data include RAOB, PIBAL and ROCOB observations; surface observations; and certain parameters which define solar flux and geomagnetic field intensity. Analyzed data include the upper air analysis fields and the three dimensional nephanalysis (3DNeph). Climatological data from the U.S. Standard Atmospheric Supplements, 1966, are used to extend the vertical profile above the level of observed data.

3. CONSTRUCTION OF VERTICAL PROFILE

The construction of the vertical profile is an eleven step process. These steps are:

(1) identify a suitable raob to use as a skeletal structure for the profile,

(2) obtain values from the analysis fields for data missing at mandatory levels of the profile,

(3) complete the basic profile through various analysis techniques (interpolation, extrapolation, regression),

(4) add PIBAL and ROCOB data to the basic profile,

(5) add climatological data for the 5 millibar (mb) level to the top of the profile (if necessary to extend it to 100K feet),

(6) interpolate meteorological values to levels at 500 foot intervals,

(7) compute density for each 500 foot level,

(8) compute absolute humidity for each 500 foot layer,

(9) compute moisture scale height for each 500 foot layer below 50K feet,

(10) compute precipitable water content for each 500 foot layer below 100K feet, and

(11) extend the profile above 100K feet.

3.1 Establishment of Skeletal Structure - RAOB Data

The first step in constructing a vertical profile is to search the data base for a suitable sounding. A suitable sounding is defined as one that is: (1) within 15 hours of the requested time, (2) within twice a specified radius (usually 150nm), (3) characterized by at least four values of dewpoint depression, (4) at least as high as a specified pressure level (usually 400mb), and (5) validated by data base management procedures. An example of the data available in a suitable RAOB is shown in Figure 1. The decision logic used to select the best sounding among those which are suitable is shown in Figure 2.

If no suitable sounding is identified, the data in the upper air analysis fields are used for the skeletal structure, unless the user has specified that analysis fields should not be used.

3.2 Addition of Analysis Fields - Basic Profile

Analysis fields are used to fill missing data at the mandatory levels of the skeletal profile (unless othersise specified). Analysis data are available at grid points in the AFGWC Northern Hemispheric, Southern Hemispheric and Tropical grids. Figures 3, 4 and 5 show the areas of the world which are included by each of the above grids. Figure 6 depicts the pressure levels and data which are normally available in the analysis fields. Note that the 70, 50, 30, 20 and 10 millibar (mb) levels are only available for the Northern Hemispheric and Tropical grids, and only for twelve-hourly data times (00Z and 12Z). If data available in the analysis fields are missing in the skeletal profile, the values are obtained through bilinear interpolation of the analysis fields. The combination of analysis fields with the skeletal profile is henceforth referred to as the "basic profile".

3.3 Completion of the Basic Profile

This section describes the mathematical techniques and meteorological methods used to obtain values for missing data. The basic profile may have missing data at significant RAOB levels. If analysis fields are not used, data may also be missing at mandatory RAOB levels.

The surface elevation is a critical value to the interpolation/extrapolation schemes used to obtain values for these missing data. If, for any reason, the surface elevation is missing, and the value can not be interpolated from the AFGWC Fixed Terrain Fields; then this RAOB is reclassified as unsuitable and another search is conducted for a suitable RAOB.

Completion of the basic profile is a five step process:

(1) Determine the surface pressure if missing.

(2) Determine missing temperature values throughout.

(3) Determine missing moisture values throughout.

(4) Determine missing height values throughout.

(5) Obtain horizontal wind components.

3.3.1 Surface Pressure

The upper air levels of the basic profile are quality controlled to insure that pressure is filled. If the surface pressure is missing and an analysis fields level exists below the surface, the pressure is interpolated from the subterranean level to the surface. Otherwise, the pressure is extrapolated from the lowest upper air level of the RAOB. The extrapolation formula is essentially the same equation as that used to obtain height values for the U.S. Standard Atmospheric Supplements, 1966, (appendix A.2).

3.3.2 Temperature Throughout

There are two methods to obtain a value for a missing surface temperature. If a subterranean analysis level exists, the surface temperature is interpolated between the subterranean level and the lowest upper level with temperature data. The interpolation scheme assumes that temperature varies directly with the natural log of pressure. This is analagous to drawing a straight line between the temperature values at two pressure levels on a thermodynamic diagram. If a subterranean analysis level is not available; then the product is assumed to be constant from the surface to the lowest upper level is solved for SRM, then the equation of state for the surface is solved for temperature.

If temperature data do not extend to the top of the basic profile, the highest temperature data are extrapolated to the top. The extrapolation scheme uses a lapse rate based on the highest temperature data and the climatological temperature value for the 120,000 foot level (appendix A.3).

Once the temperature values for the surface and the profile top are known, all missing temperatures are interpolated.

3.3.3 Moisture and Height Throughout

There are seven steps required to complete the moisture profile:

(1) Calculate mixing ratio from pressure, temperature and dewpoint.

(2) Complete mixing ratio to highest moisture data.

(3) Calculate missing heights throughout.

(4) Determine the tropopause moisture.

(5) Set a constant mixing ratio at and above the hygropause.

(6) Interpolate missing mixing ratios.

(7) Compute dewpoints throughout.

3.3.3.1 Calculate mixing ratio from P, T, T_d

Moisture data in a RAOB and in the analysis fields are given as dewpoint depression. Dewpoint is calculated from temperature and dewpoint depression. Vapor pressure is calculated for these levels from pressure, temperature and dewpoint (appendix A.4.2). Finally, mixing ratios for these levels can be calculated from pressure and vapor pressure (appendix A.4.3). Moisture data for levels with a temperature less than -40^{o}c are discarded as unreliable.

3.3.3.2 Mixing Ratio to Highest Mixing Ratio Data

If the surface mixing ratio is missing, an attempt is made to interpolate a value using the lowest upper level with moisture data and a subterranean analysis level. If no subterranean analysis level exists, the mixing ratio is assumed to be constant from the surface to the lowest upper level with moisture data. Other missing mixing ratios (below the highest level with moisture data) are obtained by interpolation between the closest levels with moisture data. The interpolation formula is derived from the assumption that the change in the natural log of mixing ratio is inversely proportional to the change in height (appendix A.4).

3.3.3.3 Height Throughout

Missing height values are extrapolated from the nearest level with pressure, height and moisture data. The extrapolation formula is the same as that used to compute heights for the U.S. Standard Atmospheric Supplement, 1966 (appendix A.2).

3.3.3.4 Tropopause Moisture

The tropopause of the basic profile is determined in accordance with AWSM 105-124. If the tropopause is undefined the new moisture modeling technique cannot be used. The RAOB must be reclassified as unsuitable and another search is conducted for a suitable RAOB. If the tropopause is defined, the next step is to interpolate pressures and temperatures for the three levels: (1) 1KM above the tropopause, (2) 1 KM below the tropopause , and (3) 3KM below the tropopause. Then, calculate the lapse rates between the tropopause and each of these three levels. These lapse rates, the tropopause temperature and the natural log of the tropopause pressure are the predictors used by a regression equation to determine the tropopause dewpoint (appendix A.4.1). The tropopause mixing ratio is calculated from pressure, temperature and dewpoint.

3.3.3.5 Mixing Ratio Above Tropopause

The hygropause is defined to be the level above which mixing ratio remains constant. The dependent data used to derive the regression equation of 4.3.4.3 indicate that the hygropause is consistently located 1KM above the tropopause (USAFETAC Report 7584). A constant mixing ratio of 3 parts per million (ppm) is set for levels at or above the hygropause.

3.3.3.6 Mixing ratio, highest data to tropopause

The mixing ratios are interpolated for levels between the highest moisture data and the tropopause (appendix A.4).

3.3.3.7 Dewpoint Throughout

All missing dewpoints are calculated from pressure, temperature and mixing ratio (appendix A.5).

3.4 Addition of PIBAL/ROCOB Data

PIBAL and/or ROCOB data associated with the RAOB are added to the basic profile. Figure 7 is an example of PIBAL data typically associated with a RAOB. Figure 8 is an example of ROCOB data. The addition of PIBAL/ROCOB data is accomplished in 6 steps:

(1) Merge the PIBAL/ROCOB levels into the basic profile.

(2) Combine duplicated levels.

(3) Interpolate pressure for levels added below the basic profile top.

(4) Interpolate temperature for added PIBAL levels.

(5) Determine moisture values at added levels.

(6) Calculate pressure for ROCOB levels added above the basic profile top. The profile resulting from these six steps will be referred to as the "merged profile".

3.4.1 Merge the PIBAL/ROCOB Levels Into the Basic Profile

PIBAL/ROCOB levels are fitted into the basic profile by height. Any pressure data which are included in the PIBAL or ROCOB are discarded. This is necessary to assure that merging the different data types does not result in a pressure inversion.

3.4.2 Combine Duplicated Levels

The following hierarchy determines which values are used if two or more different observation types report the same physical properties at the same level:

(1) PIBAL winds are used over both RAOB and ROCOB winds, (2) RAOB winds are used over ROCOB winds, and (3) RAOB temperature is used over ROCOB temperature.

3.4.3 Determine Pressure for Levels Added Below the Basic profile top

Pressure is extrapolated from the nearest basic profile level to the added level (appendix A.2)

3.4.4 Interpolated Temperatures for Added PIBAL Levels

Missing temperatures are interpolated as in section 3.3.2

3.4.5 Determine Moisture Values at Added Levels

For levels added below the basic profile top missing mixing ratios are interpolated (appendix A.4). ROCOB levels added above the top of the basic profile are, by definition, above the hygropause. Therefore, a constant mixing ratio of 3ppm is used. Missing dewpoints below 100,000 feet are calculated from pressure, temperature and mixing ratio (appendix A.5). No attempt is made to extend the dewpoint profile above 100,000 feet.

3.4.6 Calculate Pressure for ROCOB Levels Added Above the Basic profile top

The gas constant for moist air is a function of mixing ratio alone. Therefore, pressures for ROCOB levels (added above the basic profile top) can be calculated using the equation of state. A check is required to determine if the pressure at the top of the basic profile is less than the first ROCOB level pressure calculated from the equation of state. If a physical inconsistency exists a new pressure value is extrapolated for the top of the basic profile.

3.4.7 Wind Components

For each level with wind data, the wind direction and speed are resolved into horizontal components. Values for each wind component are interpolated to those levels missing wind data. A linear interpolation in height is used. Wind components are extrapolated to only two levels above the highest data. A linear extrapolation is made for each component, using the average vertical rate of change for the u and v components over the highest three levels.

3.5 Extension to 100K Feet

The merged profile must extend to a height of at least 100,000 feet above ground level (AGL). If it does not already do so, the 5mb level (always above 100,000 feet AGL) is added to the top of the merged profile. Height and temperature values are extrapolated to this level (appendices A.6 and A.3). The mixing ratio is set at 3ppm.

3.6 Transformation to 500 Foot Levels

The merged profile is transformed from non-linear pressure levels to linear height levels. Values of pressure, horizontal wind components, temperature and mixing ratio are interpolated to 500 foot levels. A dewpoint value is calculated for each 500 foot level from pressure, temperature and mixing ratio (appendix A.5).

3.7 Computation of Density for Each 500 Foot Level

Two methods are used to calculate missing density values. Below the lowest ROCOB data, density values are calculated from the equation of state. Above the lowest ROCOB data, missing density values are linearly interpolated in height from ROCOB data.

3.8 Computation of Absolute Humidity for Each 500 Foot Layer.

The absolute humidity (water vapor density) is calculated from mixing ratio and density (appendix A.7). The values of mixing ratio and density at each 500 foot level are assumed to be constant for the layer above.

3.9 Moisture Scale Height

The moisture scale height, msh, is defined:

$$msh = m_v \frac{1.}{(1.1 - rh)}$$

where m_v = the mass of mater vapor and rh = relative humidity (decimal value). The expression $\left(\frac{1}{1.1 - rh}\right)$ weights the amount of moisture in the layer such that the value for moisture scale height increases the closer the moisture is to saturation. 1.1 is used in the denominator instead of 1. so that moisture scale height will not be undefined for the saturated case. The five steps necessary to calculate moisture scale height are: (1) calculate the mass of vapor in a column of air having a horizontal cross section of one square meter ($m_v = p_v$ (thickness) , (2) calculate the saturation vapor pressure, e_s from the temperature (goff-gratch equation - appendix A.4.2), (3) calculate the saturating ratio, w_s, from pressure and saturation vapor pressure (appendix A.4.3), (4) calculate the relative humidity from mixing ratio and saturation mixing ratio ($rh = w/w_s$), and (5) calculate the moisture scale height for the layer.

3.10 Computation of Precipitable Water Content, (PWC), for Each 500 Foot Level

There are three steps to compute the PWC for each 500 foot layer. First, overlay the transformed profile with the merged profile. Second, calculate the PWC for each layer of the overlayed profiles from the pressures at the boundary levels, the mixing ratios at the boundary levels, and the gravitational acceleration at the mean height of the layer (appendix A.8). Third, add the PWC of the appropriate layers of the overlayed profiles to get the PWC of the 500 foot layers of the transformed profile.

3.11 Extension of Profile Above 100,000 Feet

For points in the Northern Hemisphere, the pressure values are extended to 200,000 feet. Temperature and density values are extended to 400,000 feet. Values of these parameters are determined for each 20,000 foot level. For points in the Southern Hemisphere, no extension above 100,000 feet is attempted.

3.11.1 Extension of Pressure to 200,000 Feet

If ROCOB data are not included, pressures are extended to 200,000 feet using a hydrostatic extrapolation coupled with climatology (appendix B). If ROCOB data are included the pressure profile will normally already extend above 200,000 feet.

3.11.2 Extension of Temperature and Density to 400,000 Feet

Temperature and density values (above the highest data) are calculated using climatological parameters derived from the U.S. Standard Atmospheric Supplements, 1966 (appendix C). The temperature and density profiles join smoothly with the Jacchia Model boundary conditions at 120 KM (Part 3, Atmospheric Models Above 120 KM, U.S. Standard Atmospheric Supplements, 1966).

3.12 Summary of the Vertical Profile

Only specific levels from the completed profile are included in the final Point Analysis output (Figure 9b). For points in the Northern Hemisphere, the following physical properties are included: (1) pressure up to 200,000 feet AGL. (2) horizontal wind components (highest level dependent upon available data), (3) temperature up to 400,000 feet AGL, (4) absolute humidity up to 100,000 feet AGL, (5) density up to 400,000 feet AGL, and (6) precipitable water content for each layer below 100,000 feet AGL. For points in the Southern Hemisphere the same physical properties are included up to 100,000 feet AGL.

4. CLOUD DEPICTION

A Cloud Depiction (CD) is provided for the area surrounding the input point. The CD displays values of low, middle, high and total cloud amounts in eighths of coverage. These values are displayed at the grid points of a polar stereographic projection (data grid), displayed for a map scale of 1:1, 875,000. The data grid is true at 60°N or 60°S latitude (where the data grid spacing is approximately 25 nm). The display is centered on the input point and covers a square area with sides equal to six times the grid spacing at the input point. A reference grid (equally spaced in earth distance) is superimposed on the data grid. The reference grid is always 100 nautical miles on a side with grid spacing of 25 nautical miles. It is centered on the input point and squared to the printed page. In the northern hemisphere, north is towards the top of the grid. In the southern hemisphere, south is at the top of the grid. The cloud coverage amounts are plotted top to bottom; high through low, respectively. The total cloud amount is plotted to the right of the middle cloud amount (figure 9a).

4.1 Source Data for the CD

Data for the CD are extracted from the Three Dimensional Nephanalysis (3DNEPH) portion of the AFGWC data base. The 3DNEPH (AFGWC TM 70-9 and AFGWC TM 71-2) is generated every three hours (beginning with 00Z). It is produced from a combination of meteorological satellite observations and conventionally sensed data. The 3DNEPH provides percent of cloud cover for 15 vertical layers of variable thickness. The lower six layers are terrain following, while the upper nine layers are referenced to mean sea level (MSL). The actual layers are:

(1) 0 - 150 FT AGL,

(2) 150 - 300 FT AGL,

(3) 300 - 600 FT AGL,

(4) 600 - 1000 (1M) FT AGL,

(5) 1M - 2M FT AGL,

(6) 2M - 3.5M FT AGL,

(7) 3.5M - 5M FT MSL,

(8) 5M - 6.5M FT MSL,

(9) 6.5M - 10M FT MSL,

(10) 10M - 14M FT MSL,

(11) 14M - 18M FT MSL,

(12) 18M - 22M FT MSL,

(13) 22M - 26M FT MSL,

(14) 26M - 35M FT MSL, and

(15) 35M FT MSL and above.

The 3DNEPH also provides a total percent of cloud coverage for all layers.

4.2 Combination of 3DNEPH Layers to Determine Low, Middle and High Cloud Amounts

The 15 layers of the 3DNEPH are combined to determine the amounts of low, middle and high clouds. The limits of these three cloud categories vary somewhat with surface elevation. The approximate limits are: (1) 0 to 6000 feet AGL for low clouds, (2) 6000 to 20000 feet AGL for middle clouds, and (3) above 20,000 feet AGL for high clouds. The combining process is an approximation which makes use of a "stacking" factor (appendix A.10). This factor is a measure of the degree to which individual cloud layers are vertically separated.

5. SURFACE OBSERVATIONS

Data from the four closest surface observations may be tabulated in paragraph G. of the final product. The maximum distance from the site to any tabulated surface observation is approximately 375 nm. Figure 9c has an example of such a table.

6. SITE WEATHER PSEUDO OBSERVATION

A pseudo surface observation is created by using data available from the 3DNEPH and the four closest surface observations described in section 5. (See also 8.2)

6.1 Surface Visibility

The surface visibility is a distance weighted average of the visibilities reported at the four closest stations. If no surface observation data is available, the visibility is reported as 99.99. Visibility is in nautical miles.

6.2 Cloud Types (low, middle, high)

The cloud types present in the 3DNEPH data base at the closest grid point are assumed to be present at the input site.

6.3 Cloud cover (in eighths) for Each cloud category (low, middle, high)

The low, middle and high cloud amounts calculated in section 5 (for the nearest 3DNEPH grid point) are assumed to be valid for the input site.

6.4 Layer Limits (minimum bases and maximum tops)

The 3DNEPH layers for the nearest 3DNEPH grid point are examined to determine which layers make a non zero contribution to the cloud amounts for each cloud category (low, middle, high). The extremes of the highest and lowest layers used for each category are used as the layer limits for that category. the heights are in hundreds of feet.

6.5 Present Weather (for the input time)

The weather reported at the nearest surface reporting station is assumed to be the weather at the site.

6.6 Surface Wind

Wind direction, speed, and gust speed are distance weighted averages of the four closest surface stations. If no wind data is available, direction and speed will both be "999". Missing gust data or no gusts are both coded as "***". Wind direction is in degrees. Wind speed and gust speed are in knots.

7. FINAL PRODUCT

The final product contains seven paragraphs.

7.1 Paragraphs A through F.

Paragraphs A through F contain the following: (A) -either a six character site code or the latitude and longitude; (B) -either blank or the input time of interest; (C) -cloud depiction discussed in section 4; (D) -the site weather pseudo observation; (E) the precipatible water information from the vertical profile discussed in section 3; (F) -all the remaining parameters from the vertical profile.

7.2 Paragraph G.

Paragraph G begins with a number of plain language automated remarks. These remarks describe the types and times of the data used to create the vertical profile. If a RAOB was used, the distance and bearing to the RAOB will appear. The RAOB station number may also appear. The last automated remark has the characters "MARK" in columns 75 through 78. This line may be followed by the surface observations table. The surface observation table can be further controlled to display or not display station identification information. The next record to appear is the solar flux and geomagnetic field intensity parameters. Then comes manual forecaster remarks in plain launguage. These manual remarks may discuss the representativeness of the RAOB or any other information the forecaster wants the PA customer to know. The last record of the PA gives the vertical-profile-software version number.

8.0 FORECASTER MODIFICATIONS

There are two basic categories of action the forecaster can take to control the production process.

8.1 Control of Automated Process

The options which the forecaster can exercise to control the automated process are:

(1) Remove a maximum of five upper air stations from consideration as a suitable RAOB.

(2) Specify the upper air station to use as the suitable RAOB.

(3) Change the size of the radius within which the search for a suitable RAOB is conducted.

(4) Change the pressure level above which a suitable RAOB must extend.

(5) Specify that analysis fields are not to be used.

(6) Specify that only analysis fields are to be used.

8.2 Manual Changes

The forecaster can adjust the site weather pseudo surface observation in any way he feels necessary. He may also insert, in paragraph G., any plain language remarks that he feels may help the customer in using the PA product.

9. SUMMARY

The PA is an approximation of the atmospheric structure and the weather phenomena surrounding a given point. Exactly how well the PA represents truth is unknown. However, it is the best estimate available. The total PA process makes optimum use of data automation; while providing the capability for a trained weather analyst to control and/or modify the automated process. The result is a final product of higher quality than either the analyst or the computer could produce separately.

RAOB FOUND AT A DISTANCE OF .42 NAUTICAL MILES FROM A BEARING OF 27.00 DEGREES.

PRESSURE (MB.)	HEIGHT (METERS)	WIND DIR. (DEGREES)	WIND SPEED (M./SEC.)	TEMPERATURE (DEG. K)	DEW PT. DEP. (DEG. K)
1015.00	18.00	55.00	8.20	298.20	4.60
1000.00	134.00	55.00	9.20	297.40	4.30
928.00	********	********	********	291.60	1.60
850.00	1532.00	70.00	19.50	285.80	1.70
799.00	********	********	********	284.40	2.50
798.00	********	********	********	283.20	1.10
790.00	********	********	********	287.20	30.00
721.00	********	********	********	285.60	30.00
700.00	3159.00	70.00	10.30	284.40	30.00
697.00	********	********	********	284.20	30.00
675.00	********	********	********	281.40	30.00
568.00	********	********	********	272.90	30.00
500.00	5870.00	50.00	15.40	264.70	30.00
433.00	********	********	********	254.90	30.00
400.00	7550.00	60.00	12.30	250.70	30.00
313.00	********	********	********	239.10	30.00
300.00	9600.00	330.00	5.10	236.70	30.00
250.00	10850.00	255.00	27.30	229.10	********
218.00	********	********	********	222.50	********
209.00	********	********	********	220.30	********
200.00	12310.00	260.00	31.40	218.50	********
169.00	********	********	********	213.50	********
157.00	********	********	********	212.10	********
150.00	14120.00	360.00	13.40	212.70	********
111.00	********	********	********	201.10	********
100.00	16560.00	40.00	9.20	201.50	********
98.10	********	********	********	201.30	********
79.50	********	********	********	194.10	********
75.20	********	********	********	198.50	********
70.00	18630.00	50.00	5.10	198.70	********
64.10	********	********	********	200.10	********
57.90	********	********	********	209.10	********
50.00	20660.00	80.00	8.70	212.90	********
47.60	********	********	********	213.90	********
42.80	********	********	********	213.10	********
30.00	23880.00	85.00	19.50	219.50	********
25.40	********	********	********	224.10	********
24.70	********	********	********	223.70	********
20.00	26540.00	100.00	12.80	225.70	********
18.80	********	********	********	224.10	********
12.90	********	********	********	235.70	********
10.90	********	********	********	235.10	********
10.00	********	********	********	232.10	********
10.00	31230.00	95.00	4.10	232.50	********
7.90	********	********	********	237.30	********
7.00	33690.00	25.00	10.80	236.30	********
6.80	********	********	********	234.10	********

Figure 1. This is an example of suitable Rawinsonde data.

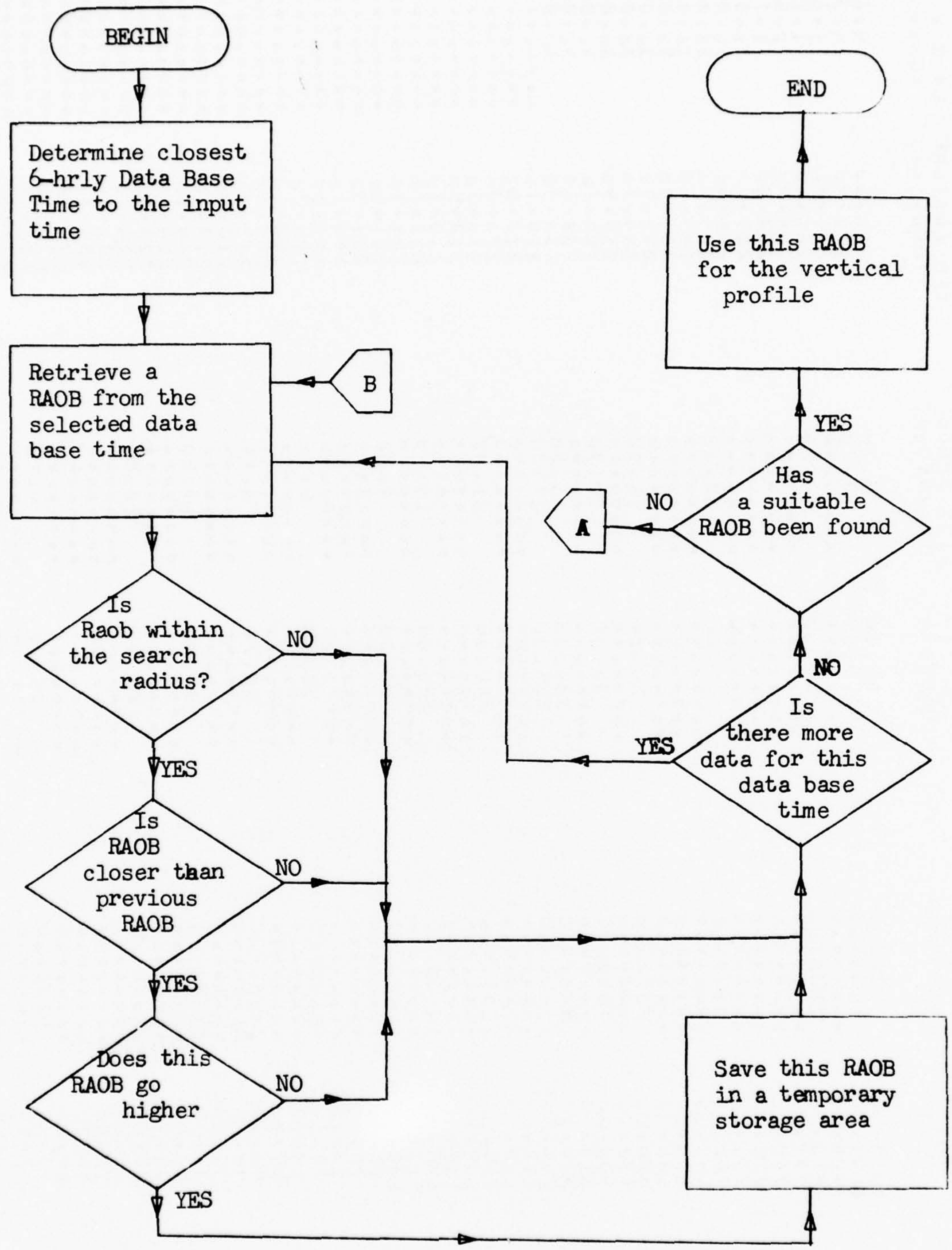


FIGURE 2: Decision logic for selecting the best available RAOB.

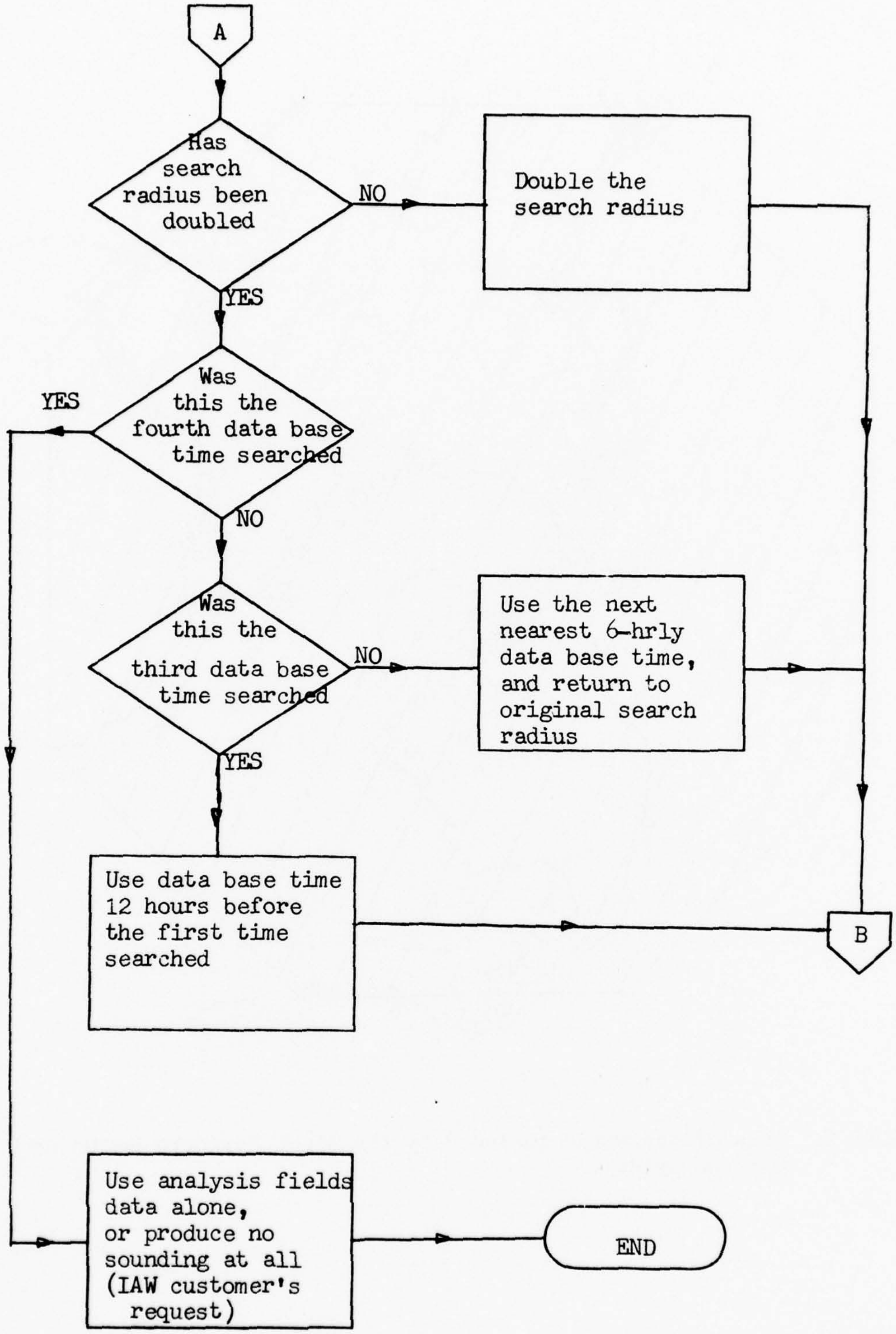


FIGURE 2 (continued):

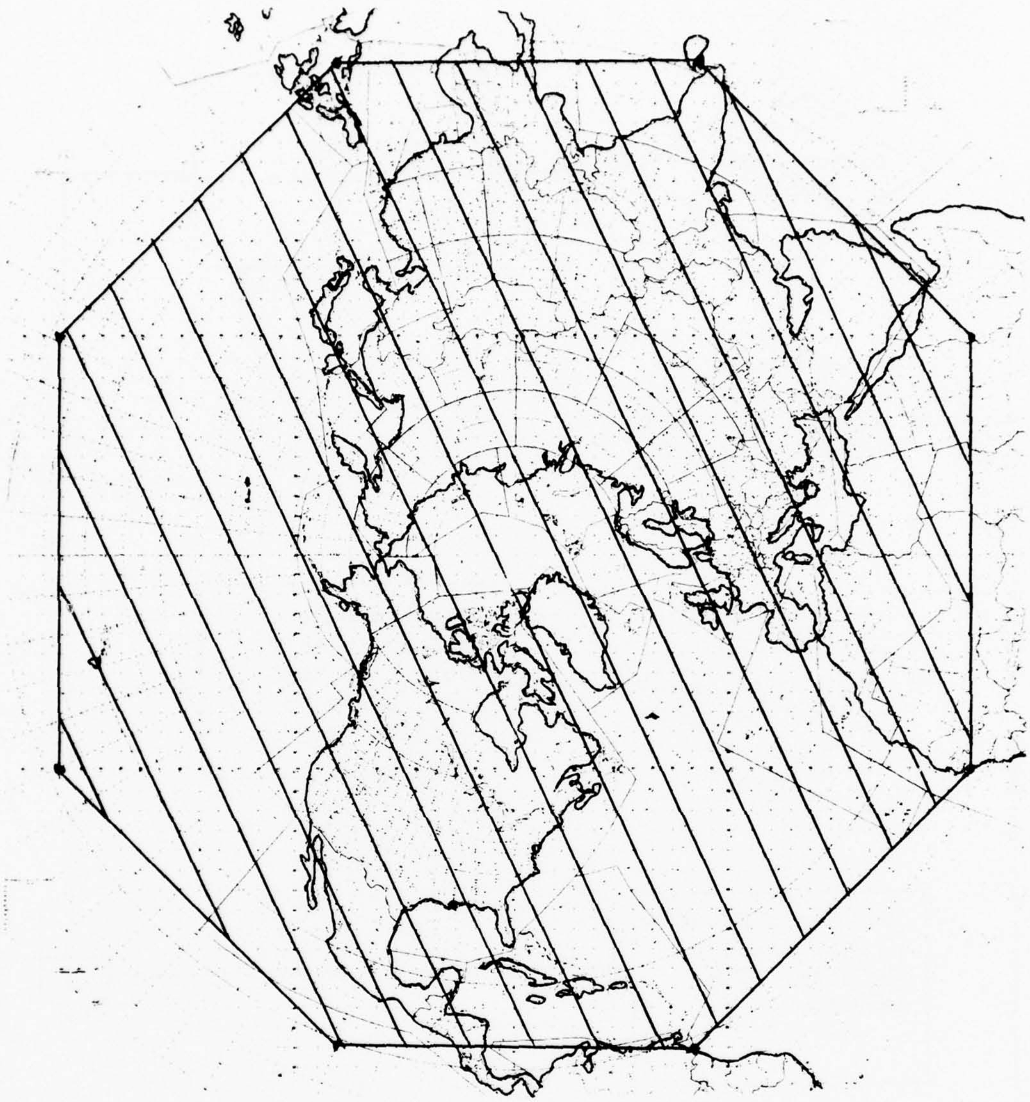


FIGURE 3: Area of the world included by the AFGWC Northern Hemispheric Octagon grid.

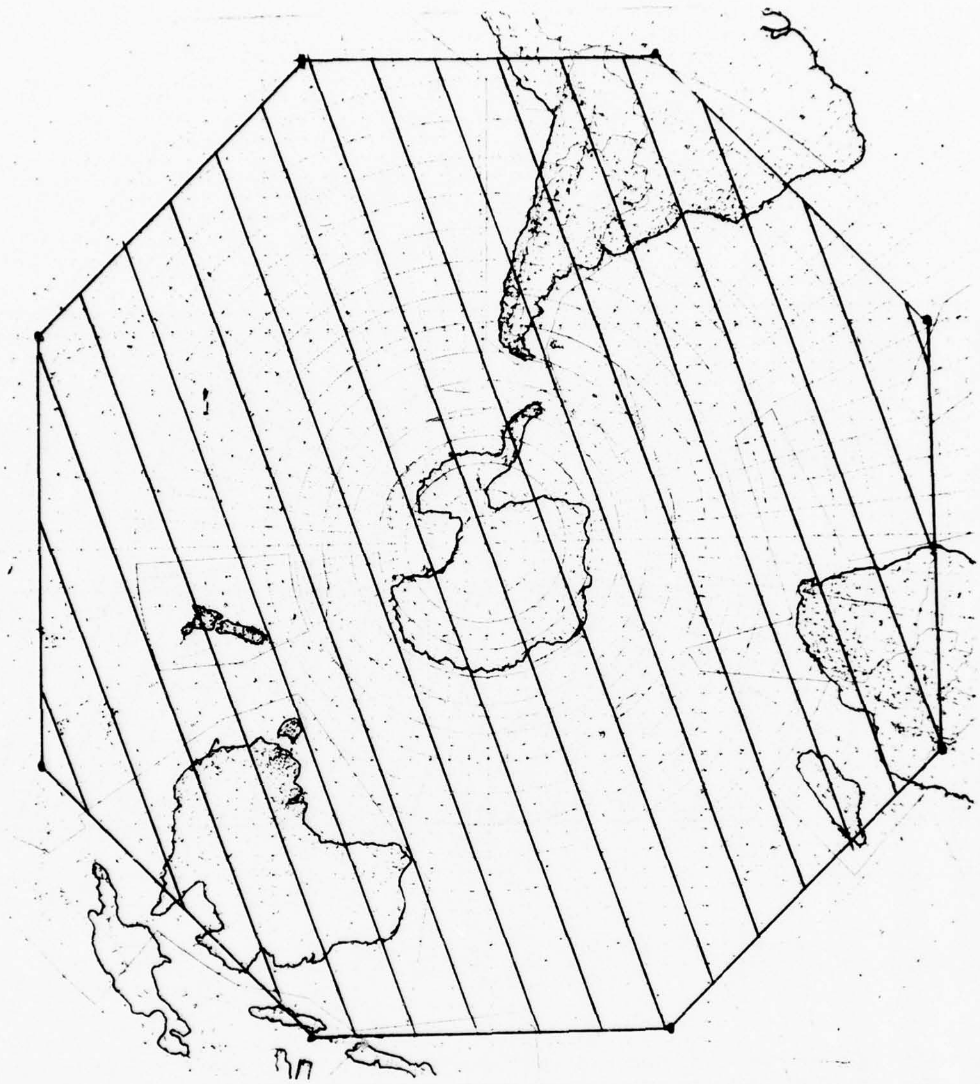


FIGURE 4: Area of the world included by the AFGWC Southern Hemispheric Octagon grid.

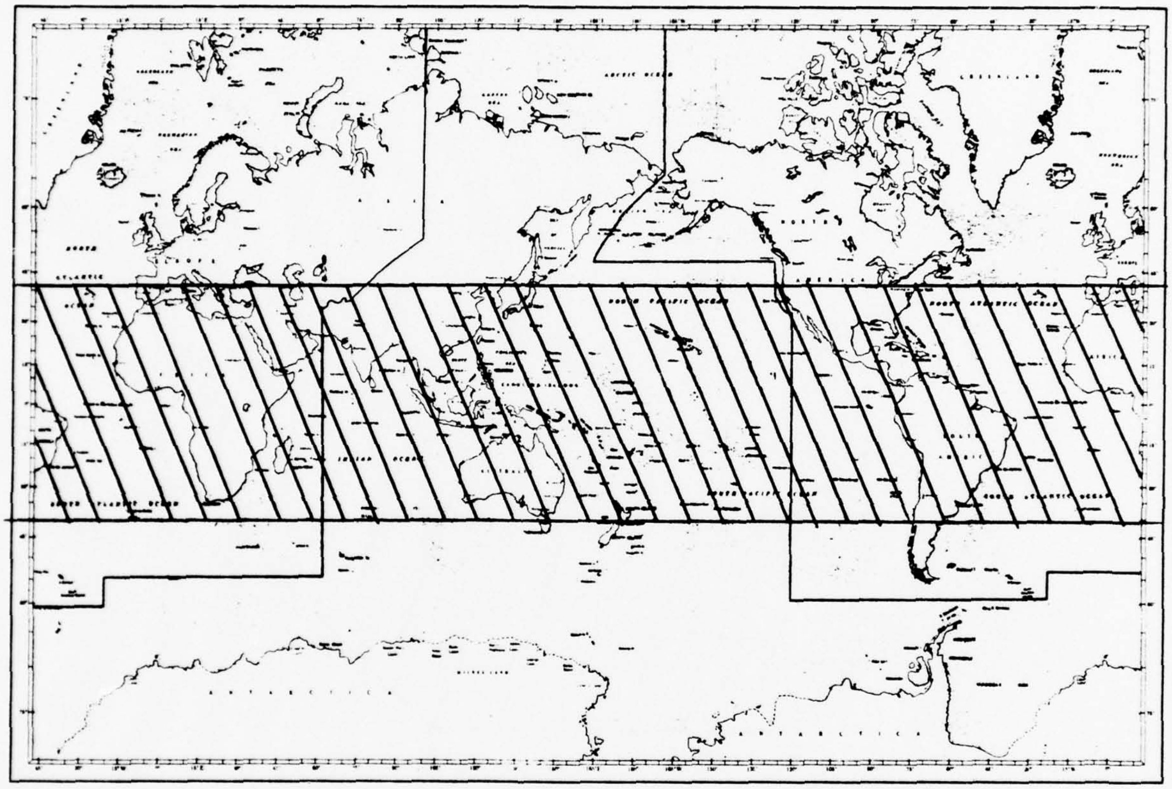


FIGURE 5: Area of the world included by the AFGWC Tropical grid.

Pressure (mb)	Height	Wind Dir	Wind Speed	Temperature	Dewpoint Depression
1000	*	*	*	*	
850	*	*	*	*	*
700	*	*	*	*	*
500	*	*	*	*	*
400	*	*	*	*	
300	*	*	*	*	*
250	*	*	*	*	
200	*	*	*	*	
Trop	*	*	*	*	
150	*	*	*	*	
100	*	*	*	*	
70	*	*	*	*	
50	*	*	*	*	
30	*	*	*	*	
20	*	*	*	*	
10	*	*	*	*	

FIGURE 6: DATA AVAILABLE IN THE AFGWC ANALYSIS FIELDS.

HEIGHT (METERS)	WIND DIR. (DEGREES)	WIND SPEED (M./SEC.)
30.00	120.00	7.70
144.00	125.00	9.20
300.00	130.00	11.80
600.00	140.00	12.80
900.00	150.00	10.30
1200.00	180.00	5.60
1339.00	185.00	5.10
1800.00	170.00	5.60
2100.00	165.00	7.70
2400.00	175.00	9.20
2700.00	185.00	10.80
2729.00	185.00	10.80
3600.00	205.00	8.20
4200.00	215.00	5.10
4800.00	210.00	5.10
5080.00	210.00	5.10
5700.00	215.00	7.20
6000.00	230.00	6.10
6560.00	265.00	4.60
7500.00	250.00	5.60
7849.00	250.00	6.70
8410.00	245.00	8.70
9000.00	235.00	8.70
9600.00	230.00	8.20
10520.00	235.00	7.20
11090.00	240.00	6.10
12600.00	230.00	7.70
13020.00	240.00	6.70
13200.00	255.00	5.60
15000.00	230.00	8.20
15750.00	235.00	7.70
17400.00	225.00	5.60
18140.00	235.00	5.60
20400.00	175.00	1.50
21000.00	185.00	1.50
22800.00	110.00	2.50

FIGURE 7: This is an example of Pibal data

FIRING TIME = 1450Z.

PRESSURE (MB.)	HEIGHT (METERS)	WIND DIR. (DEGREES)	WIND SPEED (M./SEC.)	TEMPERATURE (DEG. K)	DENSITY (GM./CM.3)
********	22000.00	80.00	11.00	212.20	6.750-05
********	25000.00	160.00	21.00	223.20	4.030-05
********	30000.00	230.00	********	228.20	1.860-05
********	35000.00	330.00	8.00	242.20	8.560-06
********	36000.00	330.00	15.00	246.20	7.310-06
********	40000.00	292.00	10.00	254.20	4.140-06
********	41000.00	260.00	11.00	260.20	3.560-06
********	42000.00	252.00	15.00	265.20	3.070-06
********	45000.00	260.00	16.00	265.20	2.100-06
********	50000.00	290.00	24.00	270.20	1.100-06
********	52000.00	272.00	20.00	264.20	8.770-07
********	55000.00	253.00	31.00	259.20	6.090-07
********	56000.00	250.00	22.00	254.20	5.450-07
********	57000.00	240.00	26.00	250.20	4.850-07
********	58000.00	222.00	34.00	251.20	4.210-07
********	60000.00	240.00	52.00	253.20	3.210-07
********	61000.00	250.00	51.00	249.20	2.860-07
********	62000.00	250.00	34.00	245.20	2.540-07
********	65000.00	300.00	38.00	232.20	1.760-07
********	66000.00	300.00	27.00	227.20	1.550-07
********	67000.00	330.00	20.00	229.20	1.330-07
********	69000.00	350.00	22.00	225.20	1.010-07
********	70000.00	90.00	9.00	219.20	8.950-08

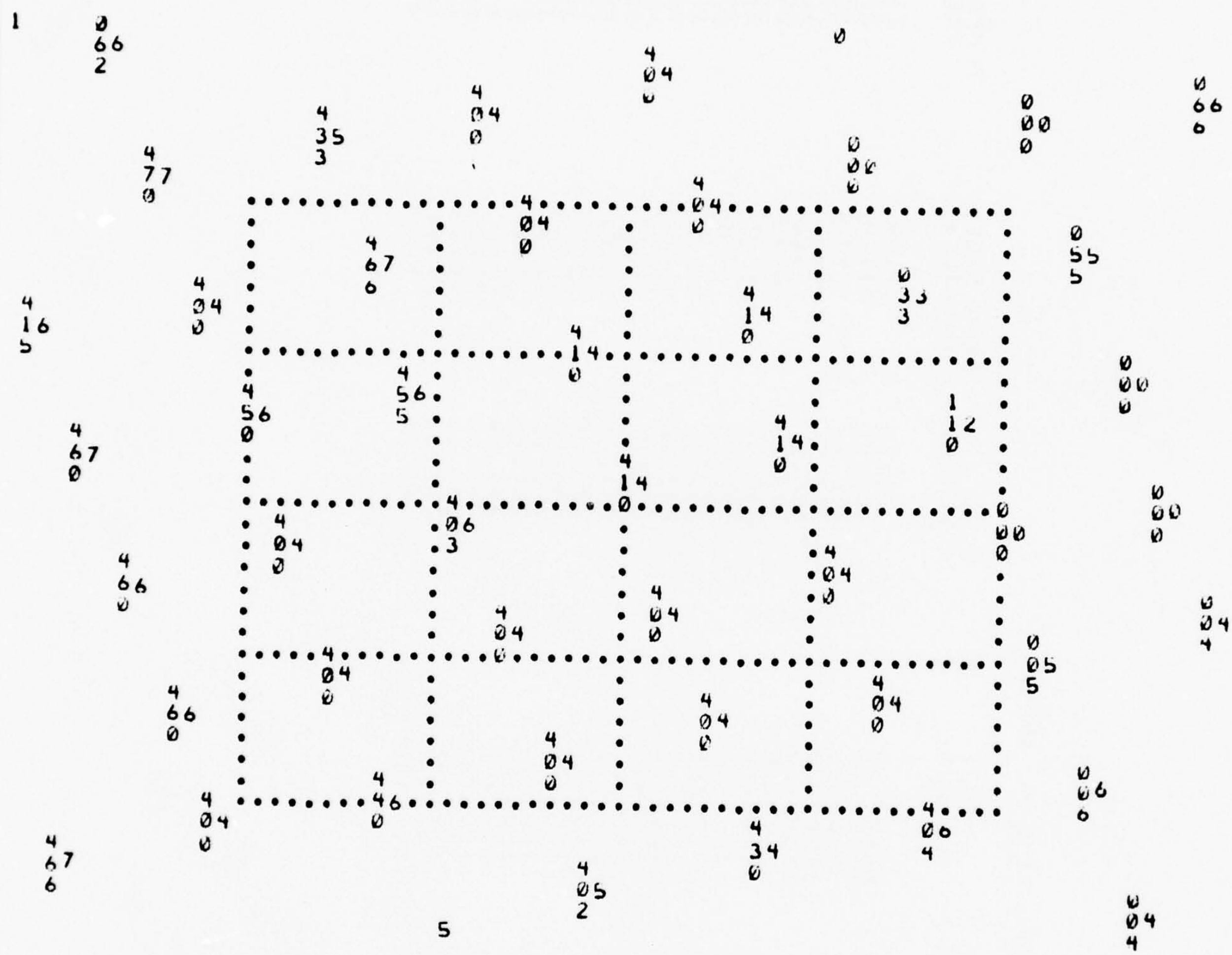
Figure 8. This is an example of useable Rocob data.

A. SITE 41.50 -96.00

B. TIME 1200Z 14 AUG 78

C. CLOUD COVER

(3-D NEPH FOR 1200Z ON 14/08/78 USED IN CLOUD DEPICTION)



D. WEATHER AT SITE

VSBY 11.11 NM 0/8 **/**/** ***/***,1/8 AS/**/** 089/129,4/8 CI/**/** 209/249
WIND 160007G***   CLD BLDG ,

FIGURE 9A: Paragraphs A. - D. of an example PA.

E. PRECIPITABLE WATER (CM) -

SFC - 1M FT	4.70-01	10M - 12M FT	3.13-01	40M - 45M FT	2.81-04
1M - 2M FT	3.49-01	12M - 14M FT	1.19-01	45M - 50M FT	1.67-04
2M - 3M FT	3.27-01	14M - 16M FT	2.51-02	50M - 60M FT	1.55-04
3M - 4M FT	3.00-01	16M - 18M FT	1.50-02	60M - 70M FT	6.62-05
4M - 5M FT	2.85-01	18M - 20M FT	9.99-03	70M - 80M FT	5.27-05
5M - 6M FT	2.61-01	20M - 25M FT	1.23-02	80M - 90M FT	3.22-05
6M - 7M FT	2.41-01	25M - 30M FT	3.57-03	90M -100M FT	1.97-05
7M - 8M FT	2.18-01	30M - 35M FT	8.85-04		
8M - 10M FT	3.84-01	35M - 40M FT	4.61-04		

F. WINDS, TEMPERATURE, ABS HUMIDITY, DENSITY, PRESSURE -

	DIR (DEG)	SPEED (M/SEC)	TEMP (DEG C)	A HUM (GM/M3)	DEN (GM/CM3)	PRES (MB)
SFC	0.	0.	25.	1.835+01	1.117-03	965.00
1M	227.	17.	28.	1.284+01	1.070-03	932.00
2M	230.	19.	29.	1.079+01	1.034-03	901.00
3M	230.	17.	27.	1.018+01	1.004-03	870.00
4M	227.	14.	25.	9.551+00	9.772-04	840.00
5M	217.	12.	22.	6.813+00	9.511-04	811.00
6M	208.	11.	20.	8.134+00	9.257-04	783.00
7M	203.	11.	17.	7.500+00	9.008-04	755.00
8M	198.	12.	15.	6.922+00	8.769-04	729.00
10M	193.	14.	10.	5.755+00	8.314-04	678.00
12M	207.	15.	5.	4.073+00	7.879-04	630.00
14M	213.	14.	1.	6.962-01	7.417-04	584.00
16M	212.	11.	-3.	3.024-01	6.979-04	541.00
18M	200.	14.	-8.	1.980-01	6.569-04	501.00
20M	169.	12.	-12.	1.310-01	6.160-04	463.00
25M	168.	10.	-22.	4.265-02	5.241-04	378.00
30M	204.	9.	-33.	1.080-02	4.439-04	305.00
35M	260.	9.	-45.	3.776-03	3.737-04	245.00
40M	272.	11.	-54.	2.330-03	3.085-04	194.00
45M	228.	8.	-63.	1.408-03	2.523-04	152.00
50M	245.	5.	-66.	6.131-04	1.990-04	118.00
60M	****	****	-63.	3.585-04	1.195-04	72.00
70M	****	****	-63.	2.191-04	7.304-05	44.00
80M	****	****	-63.	1.340-04	4.467-05	27.00
90M	****	****	-63.	8.197-05	2.732-05	16.00
100M	****	****	-63.	5.015-05	1.672-05	10.00
120M	****	****	-24.	********	6.942-06	4.60
140M	****	****	-9.	********	2.863-06	2.10
160M	****	****	2.	********	1.301-06	.98
180M	****	****	-3.	********	6.180-07	.45
200M	****	****	-18.	********	2.935-07	.21
220M	****	****	-42.	********	1.394-07	*******
240M	****	****	-69.	********	6.097-08	*******
260M	****	****	-96.	********	2.466-08	*******
280M	****	****	-108.	********	8.174-09	*******
300M	****	****	-105.	********	2.573-09	*******
320M	****	****	-88.	********	7.526-10	*******
340M	****	****	-62.	********	2.343-10	*******
360M	****	****	-13.	********	8.202-11	*******
380M	****	****	54.	********	3.472-11	*******
400M	****	****	130.	********	1.470-11	*******

FIGURE 9B: Paragraphs E. & F. of an example PA.

G. REMARKS -
DISTANCE AND BEARING TO NEAREST RAOB -- 39.0 NM AT 85.0 DEG
RAOB STATION NUMBER -- 724330
SURFACE ELEVATION -- 574 FT
SOME ANALYSIS FIELDS DATA USED TO FILL IN 6 STANDARD PRESSURE LEVELS
RAOB BASE TIME -- 1200Z

				MARK
SURFACE OBSERVATIONS	1	2	3	4
BLOCK/STATION NUMBER	72434	72439	72433	72433
CALL LETTERS	STL	SPI	MDH	BLV
ZULU TIME	1200Z	1200Z	1200Z	1200Z
BEARING (DEG)	289	005	152	218
DISTANCE (NM)	29	74	56	4
WIND DIRECTION (DEG)	360	330	CALM	350
WIND SPEED (KTS)	8	7		3
SEA LEVEL PRESSURE (MB)	1016.4	1016.5		1015.5
3-HRLY PRES CHANGE (MB)	+ 1.2	+ 2.0		+ 1.2
ALTIMETER SETTING (IN)	30.03	30.02	29.99	30.00
VISIBILITY (NM)	6.9	4.3	1.7	6.0
TEMPERATURE (DEG C)	20	17	22	20
DEWPOINT (DEG C)	18	15	21	18
PRESENT WEATHER	CLD BLDG	MIST	NOSKY FOG	
PAST WEATHER	GT 1/2 CLDY	PRT 1/2 CLDY		
CLOUDS	0,AC7,CS7 8/8 MIS, 200 8/8 TOTL CLD CIG E200	0, 0,CS8 7/8 MIS, 220 6/8 TOTL CLD CIG E220	8/8 MIS, 100 8/8 TOTL CLD CIG E100	0,AC7,CS7 7/8 MIS, 100 6/8 019 000 8/8 TOTL CLD CIG E100

MF=130. F=107. A=050.

Figure 9C. Paragraph G of an example PA.

APPENDIX A.

BASIC THEORY

The theoretical development in this appendix is confined to formulas utilized below 100,000 feet. Formulas used to obtain values above 100,000 feet are discussed in Appendices B and C.

A.1 Definitions

$A = \frac{g}{R_d}$ . . . . auto-convective temperature gradient, the temperature gradient of a constant density atmosphere ($^{o}K.cm^{-1}$)

α . . . . direction form which wind is blowing (degrees measured from north)

e . . . . partial pressure due to water vapor

e_i . . . . saturation vapor pressure at the icepoint temperature (p=6.1071 mb)

e_s . . . . saturation vapor pressure (100% relative humidity)

e_v . . . . saturation vapor pressure at the steampoint temperature (p=1031.246 mb)

$\varepsilon = \frac{R_d}{R_v} = 0.62197$ . . . ratio of dry air gas contant to water vapor gas constant

Φ . . . . latitude

g . . . . acceleration due to gravity (cm/sec^2) (a function of latitude and height)

$G = \; = 3.085462(10)^{-6}+2.27(10)^{-9} \cos (2I)^{-2} (10)^{-12} \cos (4I)$

. . . . gravity gradient at z=0 (List 1963)

$g(\Phi) = 978.0356(1.+0.0052885 \sin^2 \Phi - 0.0000059 \sin^2 (2\Phi)$ . . . .

. . . . g at latitude Φ, Z=0 ($m.sec^{-2}$) (List 1963)

$\gamma = -\frac{\partial T_v}{\partial z}$ . . . . vertical temperature gradient in the direction of a decreasing temperature ($^{o}K/km$)

$H = \frac{T_v}{\gamma_A}$	height scaling parameter (cm)
L	latent heat (erg.gm^{-1} or cal gm^{-1})
M	Molecular weight of dry air (28.96(10^{-3}) Kg/mole below 80Km)
P	atmospheric pressure (mb)
PWC	precipitable water content (CM)
$Q = \frac{w}{w_s}(100)$	**relative humidity (percent)**
$q = \frac{\rho_v}{\rho}$	specific humidity (gm H_2O vapor/Kg moist air)
ρ	total atmospheric density (gm.cm^{-3})
ρ_d	dry air density (gm.cm^{-3})
ρ_v	**water vapor density or absolute humidity** (gm.cm^{-3})
$r = \frac{2g(\Phi)}{G}$	effective earth radius
R_d	gas constant for dry air (2.8704(10)^6 erg.gm^{-1}.$^{\circ}$K^{-1})
R_m	gas constant for moist air
R_v	gas constant for H_2O vapor (4.6150(10)^6 erg.gm^{-1}.$^{\circ}$K^{-1})
T	**absolute temperature** ($^{\circ}$K=Ti+$^{\circ}$C)
T_d	dewpoint, the temperature to which moist air must be cooled at constant pressure to reach saturation ($^{\circ}$K)

T_i . . . . ice-point temperture (273.16°K or 0°C)

$T_p = T-T_d$ . . . . . . dewpoint depression (°K)

T_s . . . . steam-point

T_v . . . . virtual temperature (°K or°C) the temperature that dry air would have if it's pressure and density were equal to the same sample of moist air (°K)

$u = -\vec{V}\sin\alpha$ . . . . . East-West horizontal wind component ($m.sec^{-1}$)

$v = -\vec{V}\cos\alpha$ . . . . North-South horizontal wind comonent ($m.sec^{-1}$)

$\vec{V}$ . . . . horizontal wind velocity ($m.sec^{-1}$)

$w = \frac{\rho_v}{\rho_d}$ . . . . water vapor mixing ratio (gm H_2O/Kgm dry air)

w_s, q_s . . . . saturation mixing ratio

Z . . . . height

A.2 <u>Pressure/Height Interpolation</u>

Geopotential altitude, H, is defined:

$$H = \frac{1}{G_p}\int_0^z g\,dz, \text{ where } G_p = 9.80665\ m^2 sec^{-2} \quad (1)$$

But $g = g_\phi r^2/(r+z)^2$, where r is the effective earth's radious for latitude, , as given by Lambert's equation (List, 1963) and g_ϕ is the acceleration due to gravity at the earth's surface for latitude, ϕ.

Note: $g_\phi = 9.78035\ (1+.0052285 \sin^2\phi - .0000059 \sin^2 2\phi)\ M/sec^2$.

therefore,

$$H = \frac{1}{G_p}\int_0^z \frac{g_o r^2}{(r+z)^2}\,dz$$

$$H = \frac{-g_o r^2}{G_p(r+z)} + \frac{g_o r^2}{G_p\, r}$$

$$H = \frac{-g_o r^2}{G_p (r+z)} + \frac{g_o r^2}{G_p (r+z)} + \frac{g_o r z}{G_p (r+z)} \qquad (2)$$

or

$$Z = \frac{rH}{\frac{g_o r}{G_p} - H} \qquad (3)$$

where Z is geometric altitude.

The perfect gas law yields:

$$\rho = \frac{M\, P}{R^* T_v}$$

(where M is the molecular weight of dry air = $28.96(10^{-3})\frac{Kg}{mole}$ below 80Km.)

While the hydrostatic equation can be expressed:

$$dP = -\bar{\rho}\, \bar{g} dz, \qquad (4)$$

therefore,

$$dP = -\frac{MP}{R^* T_v} g\, dZ.$$

Once again, substituting for g yields,

$$dP = -\frac{MP}{R^* T_v} \frac{g_o r^2}{(r+z)^2} dz$$

$$\frac{R^* T_v}{P} dP = -\frac{M g_o r^2}{(r+Z)^2} dz$$

Assuming $\bar{T}$ for a layer is a good approximation to Tv, we integrate over the layer to get:

$$R^*\bar{T}\int_{P_1}^{P_2}\frac{1}{P}\,dp = -Mg_\phi r^2\int_{z_1}^{z_2}\frac{1}{(r+z)^2}\,dz$$

$$R^*\bar{T}\int_{P_1}^{P_2}\frac{1}{P}\,dp = -\left[Mg_\phi r^2\int_0^{z_2}\frac{1}{(r+z)^2}\,dz - Mg_\phi r\int_0^{z_1}\frac{1}{(r+z)^2}\,dz\right]$$

$$R^*\bar{T}\ln\left(\frac{P_2}{P_1}\right) = \frac{-Mg_\phi r^2}{(r+z_1)} + \frac{Mg_\phi r(r+z_1)}{(r+z_1)} + \frac{Mg_\phi r}{(r+z_2)} - \frac{Mg_\phi r(r+z_2)}{(r+z_2)}$$

$$R^*\bar{T}\ln\left(\frac{P_2}{P_1}\right) = -G_p M\left[\frac{g_0 r z_2}{G_p(r+z_2)} - \frac{g_0 r z_1}{G_p(r+z_1)}\right]$$

Substituting (2) into the equation above yields

$$R^*T\ln(P_2/P_1) = -G_pM(H_2-H_1) \qquad (5)$$

Let $H_2 - H_1 = h$, then

$$\ln(P_2/P_1) = -G_pMh/R^*\bar{T}$$

or

$$(P_2/P_1) = \exp(-G_pMh/R^*\bar{T}) \qquad (6)$$

If we approximate G_p with g_ϕ, (6) can be rewritten as

$$P_2/P_1 = \exp(-g_\phi M_o h / R^* \bar{T}_m),$$ which

is identically equation (1.13) from the U.S. STANDARD ATMOSPHERIC SUPPLEMENTS, 1966. Equation (6) is used to extrapolate missing surface pressure.

Equation (6) may be written:

$$H_2 = H_1 - \frac{R^* \bar{T}}{G_p M} \ln\left(\frac{P_2}{P_1}\right) \quad (7)$$

or

$$H_1 = H_2 - \frac{R^* \bar{T}}{G_p M} \ln\left(\frac{P_1}{P_2}\right) \quad (8)$$

(7) or (8) is used to extrapolate geopotential height to a level where height is missing. Equation (3) is used to convert the extrapolated geopotential height to geometric height.

A.3 Temperature Extrapolation

let: climo temp @ 120,000 ft = T_{120}

height in meters of 120,000 ft = Z_{120}

height in last temp level = Z_L

temperature at last temp level = T_L

pressure at last temp level = P_L

pressure at 120,000 ft = P_{120}

Equation of State for Moist Air is: $p = \rho R_d T_v$ (9)

Rewriting (9) and substituting into (4) for ρ gives:

$$\partial p = -\frac{p}{R_d T_v} g \, \partial z$$

or

$$\frac{\partial p}{p} = \frac{-g}{R_d T_v} \partial z \quad (10)$$

Now assuming g and T_v constant, integrate (10) to obtain:

$$\ln p = \frac{-g}{R_d T_v} z + C \qquad (11)$$

Then take partial of (11) with respect to $\ln p$ to obtain:

$$\partial(\ln p) = \frac{-g}{R_d T_v} \partial z \qquad (12)$$

Now assume $\partial T/\partial(\ln p)$ = constant over interval Z_L to Z_{120} (this is analagous to drawing a straight line on a thermodynamic diagram), and obtain:

$$\frac{T - T_L}{\ln(P/P_L)} = \frac{\partial T}{\partial \ln P}$$

or $T = \ln (P/P_L) \dfrac{\partial T}{\partial(\ln P)} + T_L$, (13)

but from (12):

$$\frac{\partial T}{\partial(\ln P)} = \frac{-R_d T_v}{g} \frac{\partial T}{\partial z} \qquad (14)$$

However, (11), (12) and therefore, (14) are based on the assumption that g and T_v are constant throughout the layer. If we assume g_m at mean layer height is representative of the entire layer, and assume that $(T_L + T_{120})/2$ represents T_v for the entire layer, then

$$\frac{\partial T}{\partial(\ln P)} = \frac{-R_d (T_{120} + T_L)}{2 g_m} \frac{\partial T}{\partial z} \qquad (15)$$

Now assume

$$\frac{\partial T}{\partial z} \approx \frac{\Delta T}{\Delta z}$$

Then

$$\frac{\partial T}{\partial(\ln P)} = \frac{R_d}{2g_m}\left(T_L^2 - T_{120}^2\right)/\left(Z_{120} - Z_L\right) \tag{16}$$

Substituting (16) into (13) yields:

$$T = \ln\left(\frac{P}{P_L}\right)\frac{R_d}{2g_m}\frac{\left(T_L^2 - T_{120}^2\right)}{\left(Z_{120} - Z_L\right)} + T_L \tag{17}$$

A.4 MIXING RATIO INTERPOLATION:

Assume the change in natural log of mixing ratio is inversely proportional to change in height; then

$$C_1\partial(\ln w) = \partial Z \tag{18}$$

It has been shown that (12)

$$\partial(\ln P) = \frac{-g}{R_d T_v}\partial Z$$

Assumming g/T_v constant yields,

$$C[\partial(\ln p)] = \partial Z \tag{19}$$

Combining (18) and (19) obtains

$$\frac{C_2}{C_1} = \frac{\partial(\ln W)}{\partial(\ln p)} = K$$

or

$$\frac{\Delta \ln w}{\Delta \ln p} = K \tag{20}$$

Let subscript, t, denote the upper boundry level for a layer and subscript, b, denote the lower boundary level of the same layer.

Then, $\frac{\Delta \ln w}{\Delta \ln p} = \frac{\ln w_t - \ln w_b}{\ln p_t - \ln p_b} = \frac{\ln (w_t/w_b)}{\ln (p_t/p_b)} = C$

Now for any level in the layer

$$\frac{\ln(w/w_b)}{\ln(p/p_b)} = C$$

or $$w = w_b \left(p/p_b\right)^C \tag{21}$$

A.4.1 Tropopause Dewpoint

Let: T_{dt} = Tropopause Dew Point, ^{o}C.

G1A = Average Lapse Rate for 1Km above the tropopause.

G1B = Average Lapse Rate for 1Km below the tropopause.

G3B = Average Lapse Rate for 3Km below the tropopause.

T_t = Tropopause temperature, ^{o}C.

$PLOG_t$ = Natural Log of tropopause pressure in mb.

The regression equation used to fill the tropopause dewpoint is

$T_t = RI + CT * G1A + E * G1B + F*G3B + R * T_t + S * PLOG_t$.

where the constants are:

RI = -88.05397

T = 0.45038

E = - 0.84287

F = - 1.1 8564

R = 0.41794

S = 6.384336

* = multiplication

For information concerning the development of this regression equation see USAF ETAC Report 7584, 20 Aug 1975 and USAF ETAC Report 8035, Aug 1976.

A.4.2 Calculate Saturation Vapor Pressure

Computations based on Goff-Gratch equations for saturation vapor pressure over ice or water - see Smithsonian METEOROLOGICAL TABLES, LIST, 6th Edition, page 350.

Over water the vapor pressure equation is:

$$e_s = 10^{LOG10W\ (373.16/T_d)}, \tag{22}$$

where T_d is in ^oK, e is in mb, and

$$LOG10W\ (F) = -7.90298\ (F-1) + 5.02808\ LOG_{10}F - 1.3816(10^{-7})\ (10^{(11.344(1-1/F))}-1) + 8.1328(10^{-3})\ (10^{(3.49149(1-F))}-1) + LOG_{10}\ (1013.246). \tag{23}$$

Over ice the vapor pressure equation is:

$$e_s = 10^{LOG10I\ (273.16/T_d)}, \tag{24}$$

Where

$$LOG10I\ (F) = -9.09718(F-1) - 3.56654\ LOG_{10}(F) + .876793(1-1/F) + LOG_{10}(6.1071). \tag{25}$$

Vapor Pressure is calculated over water for temperatures above -40^o to be consistent with raob measurements.

A.4.3 Calculate Mixing Ratio

The equation of state of water vapor is $e = \rho_v R_v T$. (26)

The equation of state of dry air is $p_d = \rho_d R_d T$ (27)

The total pressure is the sum of partial pressures

$$p = e + p_d, \tag{28}$$

or $p - e = p_d$.

Dividing (26) by (27) yields

$$e/p_d = \frac{\rho_v R_v T}{\rho_d R_d T},$$

$$\text{or } e/p_d = \frac{(\rho_v)\ (R_v)}{\rho_d\ \ R_d}. \tag{29}$$

Let M_v = Mass of vapor for volume V,

M_d = Mass of dry air for volume V.

Then $\rho_v = M_v/V$,

and $\rho_d = M_d/V$.

Therefore, (29) becomes

$$e/p_d = \frac{(M_v/V)}{(M_d/V)} \left(\frac{1}{R_d/R_v} \right), \tag{30}$$

but $M_v/M_d = W$,

and $P_d = P-e$.

If R_d/R_v = GASRAT,

then (30) becomes

$$\frac{e}{P-e} = (w) \left(\frac{1}{\text{GASRAT}} \right),$$

$$\text{or} \quad \frac{(e) \quad (\text{GASRAT})}{(p-e)} = w . \tag{31}$$

A.5 Calculate Dewpoint

$$R_m = \left(\frac{M_v}{M_v + M_d} \right) R_v + \left(\frac{M_d}{M_v + M_d} \right) R_d \tag{32}$$

(Haltiner and Martin (1957), Page 24.)

where R_m = gas constant for moist air,

R_d = gas constant for dry air,

R_v = gas constant for water vapor,

M_v = mass of water vapor,

M_d = mass of dry air.

Multiplying each term of (32) by $\left(\frac{1/M_d}{1/M_d} \right)$ yields

$$R_m = \frac{(M_v/M_d)}{M_v/M_d+1} R_v + \left(\frac{1}{M_v/M_d+1} \right) R_d .$$

Since $w = M_v/M_d$,

$$R_m = \left(\frac{w}{w+1}\right) R_v + \left(\frac{1}{w+1}\right) R_d . \quad (33)$$

The Equation of State of Moist Air is $p = \rho_s R_m T$, (34)

or $\rho = R_m T/p$. (35)

For any volume (V) w can be alternately defined as $w = \left(\frac{M_v/V}{M_d/V}\right) = \frac{\rho_v}{\rho_d}$ (36)

Since the total density equals the sum of the densities, we have:

$$\rho_d = \rho - \rho_v$$

Therefore, (36) yields

$$\rho_v = \frac{w\rho}{(1+w)} \quad (37)$$

then (26) yields vapor pressure, e.

Saturation vapor pressure (e_s) is calculated from (22) or (24) using the temperature T as a first approximation to T_d. The equation which relates these two values is the Clausius-Clapeyron Equation (LIST, 1963)

$$\frac{1}{e_s}\frac{de_s}{dT} = \frac{L}{R_v T^2}. \quad (38) \quad (38)$$

By approximating de_s/dT with $\Delta e_s / \Delta T$ and using a value for latent heat, (L) based on the temperature, (38) becomes

$$\Delta T = \frac{R_v T^2 \Delta e_s}{e_s L} \quad (39)$$

Then $T_d = T_d + \Delta T$. Iteration continues until successive values of T_d differ by 1% or less.

A.6 Height Extrapolation

A.6.1 Method 1

$$\text{Let } \underline{TTLAP} = -2 \frac{\partial T_v}{\partial (\ln P)} \left(g/R_d \right) \tag{40}$$

Rearranging (12) and substituting into (40) gives

$$\underline{TTLAP} = -2 \frac{\partial T_v}{\partial (\ln P)} \left(\frac{R_d T_v \partial (\ln P)}{\partial z \, R_d} \right) \tag{41}$$

Assuming T_v and $\partial T_v / \partial z$ are constant, intergrating (41) from Z_1 to Z_2 yields

$$\underline{TTLAP} \, (z_2 - z_1) = T_{v2}^2 - T_{v1}^2 \tag{42}$$

By approximating $\partial T_v / \partial (\ln P)$ with $\Delta T_v / \Delta \ln p$, (40) yields

$$\underline{TTLAP} = \frac{2g}{R_d} \frac{(T_{v1} - T_{v2})}{(\ln p_2 - \ln p_1)} \tag{43}$$

Equation (43) can be solved for TTLAP using acceleration due to gravity at Z_1. Then (42) yields

$$z_2 = \left(T_{v2}^2 - T_{v1}^2 \right) / \underline{TTLAP} + z_1 \tag{44}$$

which can be used to extrapolate the missing height Z_2.

The final two steps, (43) and (44), are repeated until the change in height is less than 10^{-5} meter.

A.6.2 Method 2

If TTLAP in (44) is zero, method 2 is used to extrapolate heights.

It has been previously shown that (12)

$$\partial(\ln p) = \frac{-g}{R_d T_v} \partial Z$$

Using the delta approximation yields

$$\Delta \ln p = \frac{-g}{R_d T_v} \Delta Z$$

Approximating g for the layer by g at p_1 and T_v for the layer by T_v at p_1 we have:

$$\Delta \ln p = \frac{g_1}{R_d T_{v1}} \Delta Z$$

$$\text{or} \qquad Z_2 = Z_1 - \frac{T_{v1} R_d \ln(p_2/p_1)}{g_1} \qquad (45)$$

The value of Z_2 obtained from (45) is used to calculate a new value for g and equation (43) is solved for TTLAP. Then method 1 is used to obtain a new value of Z_2.

A.7 Absolute Humidity

The definition of mixing ratio is

$$w = \frac{\rho_v}{\rho_d} \qquad (46)$$

Total density equals the sum of the densities of the constituents.

$$\rho = \rho_d + \rho_v \tag{47}$$

Equation (47) may be rewritten

$$\rho_d = \rho - \rho_v \tag{48}$$

Substituting (48) into (46) yields

$$\frac{w\rho}{(1+w)} = \rho_v$$

However, $w/1+w$ is specific humidity, q . Therefore,

$$q\rho = \rho_v$$

and, averaged over a layer, $\bar{q}\,\bar{\rho} = \bar{\rho}_v$

Then letting q = $\frac{(\rho_T + \rho_B)}{2}$,

we have

$$\frac{\left[\dfrac{w_T}{1+w_T} + \dfrac{w_B}{1+w_B}\right]}{2}\,\bar{\rho} = \bar{\rho}_v \tag{49}$$

A.8 <u>Computation of Preciptable Water Content</u>

Let $\bar{\rho}_v =$ average density of water vapor in a column of air through a given layer (gm/cm^3).

Assume a horizontal cross section of 1 cm^2 for the column.

Then $m_v = \bar{\rho}_v \Delta z \, (1)$ (50)

Where, m_v = mass of water vapor in the column of air for this layer (gm), and
Δz = the thickness of the layer (cm).

$$\bar{\rho}_v = (\rho_{vT} + \rho_{vB})/2$$

If the water vapor in the column (m_v) is condensed into a vessel of equal cross section, we know that

$m_v = \rho_w \Delta z_L (1)$ (51)

Where, ρ_w = density of liquid water (1gm/cm^3), and

Δz_L = height of the liquid water in the vessel (precipitable water content).

Use <u>PWC</u> for Δz_L, then combining (50) and (51) yields;

$$\bar{\rho}_v \Delta z = \rho_w \underline{PWC} \tag{52}$$

or
$$\underline{PWC} = \frac{\bar{\rho}_v}{\rho_w} \Delta z \tag{53}$$

However, integrating (4) yields

$$\Delta p = -\bar{\rho}\,\bar{g}\,\Delta z \tag{54}$$

Substituting (54) into (53) yields

$$\underline{PWC} = \frac{\bar{\rho}_v}{\rho_w} \left(\frac{-\Delta p}{\bar{\rho}\,\bar{g}} \right) \tag{55}$$

or
Substituting (49) into (55) and using average values over the layer yields

$$\underline{PWC} = \frac{\left[\frac{W_T}{1+W_T} + \frac{W_B}{1+W_B} \right] (p_B - p_T)}{2 \rho_w \bar{g}} \tag{56}$$

Given Δp in mb and $\bar{g}$ in m/sec^2 and noting that ρ_w = 1 gm cm $^{-3}$

after clearing units

$$\underline{PWC} = \frac{5\left[\frac{W_T}{1+W_T} + \frac{W_B}{1+W_B} \right] (p_B - p_T)}{\bar{g}} \quad \text{cm} \tag{57}$$

A.9 Interpolation for Site Pseudo Surface Observation Visibility and Wind

Interpolation from the four surrounding surface observations is done by a distance weighted average. The weight factor is

$$F = \exp\left[-\left(\frac{d}{25}\right)^2\right],$$

where F is the weight factor and d is the distance from the station to the point. Notice that if a station is at the input point, d would be zero and F would be one. As d becomes larger F decreases, with zero as a limit. Distance is divided by 25 to keep F significantly larger than zero for the expected range of distance values.

Visibility is calculated with the following equation:

$$V = \frac{\sum_{i=1}^{n} (V_i F_i)}{\sum_{i=1}^{n} F_i},$$

where V is the calculated visibility, V_i is the visibility reported by a station, and F_i is the weight factor for a station. Variable n can vary from 1 to 4, depending on how many surface reports are tabulated. If there is no data available, visibility is set at 99.99.

The wind reported by each surface station is broken into east-west components (ui) and north-south components (v_i). Then a weighted average is determined for both.

$$u = \frac{\sum_{i=1}^{n} (u_i F_i)}{\sum_{i=1}^{n} F_i} \qquad v = \frac{\sum_{i=1}^{n} (v_i F_i)}{\sum_{i=1}^{n} F_i}$$

These average components are used to recreate a final direction and speed. If wind gust data is available, average gust is determined using an analogous equation. However, gust data is reported and available only for North America.

Users should be aware that the surface wind in paragraphs D and F are determined in completely different ways. Therefore, significant differences should be expected.

If no wind data is available, the direction and speed both become 999.

A.10 Low, Middle, and High Cloud Amounts

There are 15 layers in the 3DNEPH cloud analysis. These layers are grouped into low, middle, and high layer groups. Then the layers within a group are combined. First, the two lowest layers in a group are combined. Then, the next layer up is combined into the result of the first combination, and so on until all the layers of a group are combined into a final result for the group.

The process of combining two layers, or of combining a combination with the next layer up, uses a dimensionless stacking factor, R. R equal to zero indicates that the clouds in the next layer up are all stacked directly above the clouds below. R equal to one indicates that the clouds in the next layer up are totally random in relation to the clouds below.

The difference in height between two layers (D) is used to determine R. If D is less than 610 meters, R is set at zero. For D greater than 610 meters,

$$R = \frac{D-610}{6100}$$

The equation used to determine the total cloud coverage for the combination of any two layers is

$$T = MAX + (1-MAX)(MIN)R.$$

where T is the total coverage, MAX is the larger of the two coverages, and MIN is the smaller of the two coverages.

APPENDIX B

EXTENSION OF PRESSURE TO 200,000 FEET

The hydrostatic equation can be expressed by

$$\ln(p) = -\frac{z}{H} + C$$

where C is a constant of integration and the other symbols are defined in Appendix A. Changing the logarithm base from natural to common yields

$$\log_{10} P = Az + B, \quad \text{where } A = -\frac{\log_{10} e}{H}, \text{ and } B = C \log_{10} e$$

Given values for A, which is essentially the inverse of the scale height, p can be extrapolated to any height.

The technique programmed for the PA process computes B for the pressure at 100,000 feet and then computes the pressure for each 20,000 feet to 200,000 feet. Values for A, taken from the COSPAR International Reference Atmosphere (1965) for 60° North latitude are tabulated below.

Month	A ($\times 10^{-5}$)
Jan	-1.924
Feb	-1.918
Mar	-1.874
Apr	-1.789
May	-1.705
Jun	-1.651
Jul	-1.645
Aug	-1.690
Sep	-1.733
Oct	-1.800
Nov	-1.847
Dec	-1.896

APPENDIX C

EXTENSION OF DENSITY AND

TEMPERATURE TO 400,000 FEET

This appendix presents a method for extending the temperature and density profiles from 100,000 feet to 400,000 feet, using climatological parameters.

To extend the density profiles from 100,000 feet to 400,000 feet, mean scale heights were derived from the U.S. Standard Atmospheric Supplements (1966), the equation used is:

$$\rho(Z) = \rho(Z_o)\exp\left(-\frac{(Z - Z_o)}{H}\right) \qquad (1)$$

where

$\rho(z_o)$ is the density at height z_o,

$\rho(Z)$ is the density at height Z ($Z > Z_o$), and

H is the scale height.

The density profiles are broken into layers for which (1) is valid (Figures C1 and C2). Table C1 presents the calculated scale heights for the appropriate layers for given months and latitudes. The error in reproducing the densities from 30-120 Km in the U.S. Standard Atmospheric Supplements (1966) by using (1) and the scale heights in Table C1, is less than 10 percent.

There is contradictory evidence concerning the existence of an isopycnic (constant density) layer in the vicinity of 90 Km. For this development the presence of this isopycnic layer is accepted. The value for density at 90 Km is set equal to 3.44 (10^{-9}) $gm.cm^{-3}$ for all months and latitudes.

Table C2 depicts how the January, July and Spring/Fall data for 30°N, 45°N and 60°N latitudes are applied to other months and latitudes. The choices are somewhat arbitrary, but necessary due to a lack of additional data.

The extension of the density to 400,000 feet is now direct. The density at 100,000 feet and Table C1 are used to extend the density profile to the isopycnic value at 90 Km, and then upward to 400,000 feet.

The temperature data are extracted directly from the U.S. Standard Atmospheric Supplements (1966) at 20,000 feet increments (Table C3).

The temperature and density profiles join smoothly with the Jacchia Model at 120 Km. Temperatures and densities above 120 Km can be determined from the Jacchia Model using three parameters: (1) the 10.7-cm solar radio flux averaged over three solar rotations, (2) the daily average of the 10.7-cm solar radio flux, and (3) the applicable planetary magnetic index, Ap. All three of these solar parameters are provided in the Point Analysis.

A graph of three actual mid-latitude extended PAs is presented in Figure C3. Similar graphs for extended density profiles are presented in Figures C4, C5 and C6. Note that both the extended temperature and density profiles join the PA smoothly at 100K feet.

TABLE C1

MONTHLY MEAN SCALE HEIGHTS (KM)

JANUARY

	30N	45N	60N
30-45km	6.810	6.448	6.383
45-70km	6.944	7.797	7.542
70-80km	6.806	7.032	7.501
90-104km	5.882	5.979	6.079
104-122km	7.358	7.162	7.020

JULY

	30N	45N	60N
30-45km	6.894	6.937	6.991
45-70km	8.058	8.189	8.298
70-80km	6.701	6.740	6.687
90-100km	5.178	4.959	4.862
100-108km	5.459	5.420	5.375
108-122km	6.800	7.091	7.302

SPRING/FALL

30-45km	6.706
45-70km	8.031
70-80km	6.733
90-100k	5.678
100-122km	6.281

ALL MONTHS

	15N
30-45km	6.922
45-70km	7.999
70-80km	6.738
90-108km	5.384
108-122km	6.346

TABLE C2

DECEMBER JANUARY FEBRUARY	JANUARY SCALE HEIGHTS
JUNE JULY AUGUST	JULY SCALE HEIGHTS
20N - 35N	30N SCALE HEIGHTS
35N - 55N	45N SCALE HEIGHTS
55N - 90N	60N SCALE HEIGHTS
MARCH APRIL MAY SEPTEMBER OCTOBER NOVEMBER	SPRING/FALL SCALE HEIGHTS
20N - 90N	SPRING/FALL SCALE HEIGHTS
20S - 20N	ALL MONTHS, 15N SCALE HEIGHTS

TABLE C3

MONTHLY MEAN TEMPERATURES (^{o}C)

(10^3 Feet)	JANUARY 30N	JANUARY 45N	JANUARY 60N	SPRING/FALL
120	-29.4	-40.1	-46.7	-32.3
140	-15.1	-21.8	-31.9	-15.4
160	- 4.0	- 7.5	-16.8	- 2.5
180	-10.6	-12.3	-13.9	- 7.3
200	-24.0	-24.3	-22.8	-15.5
220	-42.5	-36.5	-25.7	-41.9
240	-61.0	-49.0	-34.5	-62.5
260	-79.4	-61.5	-47.6	-80.3
280	-82.1	-73.4	-60.8	-82.6
300	-75.4	-72.6	-68.5	-82.0
320	-57.3	-59.5	-58.2	-73.5
340	-37.0	-41.7	-44.3	-61.4
360	- 7.7	-14.8	-21.3	-40.5
380	+30.0	+26.5	+22.7	+22.7
400	+74.3	+75.9	+77.6	+109.0

TABLE C3 (contd)

(10³Feet)	JULY 30N	JULY 45N	JULY 60N	ALL MONTHS 15N
120	-26.6	-24.1	-21.2	-27
140	-12.2	- 9.0	- 3.2	-13
160	- 1.0	+ 2.5	+ 3.9	- 3
180	- 7.6	- 3.5	+ 1.1	-10
200	-21.9	-18.5	-14.9	-23
220	-44.6	-42.1	-43.0	-44
240	-67.2	-68.9	-71.0	-65
260	-89.8	-95.7	-99.1	-86
280	-100.7	-108.7	-111.5	-96
300	-98.4	-104.6	-107.3	-95
320	-87.1	-88.5	-89.3	-85
340	-66.7	-62.3	-59.4	-69
360	-23.3	-12.9	- 5.4	-33
380	+47.0	+54.0	+58.9	+40
400	+134.0	+130.5	+128.5	+138

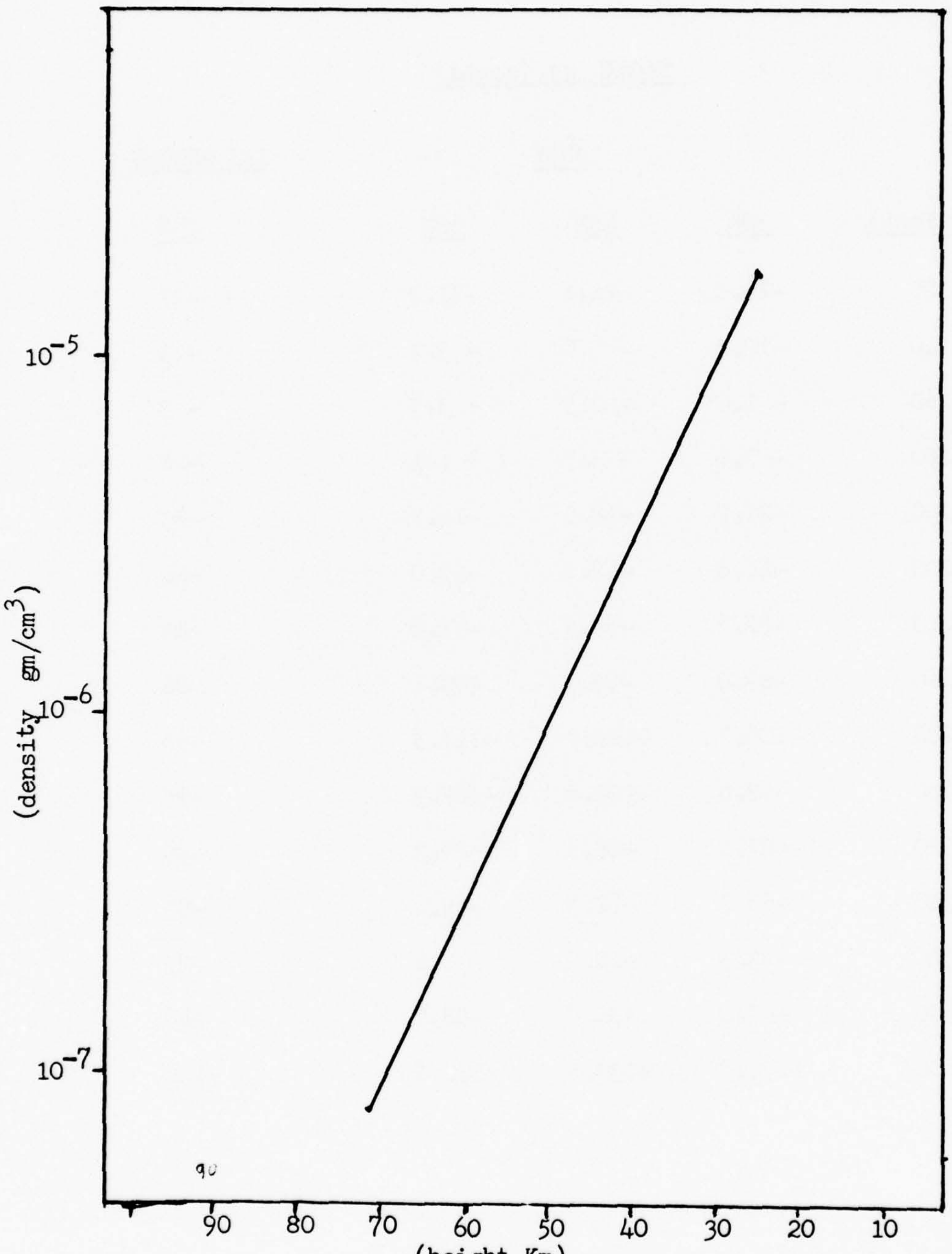


FIGURE C1: Density profile generated by using scale height of 7.797 Km from 30 to 45 Km height and a scale height of 6.448 Km from 45 to 70 Km height.

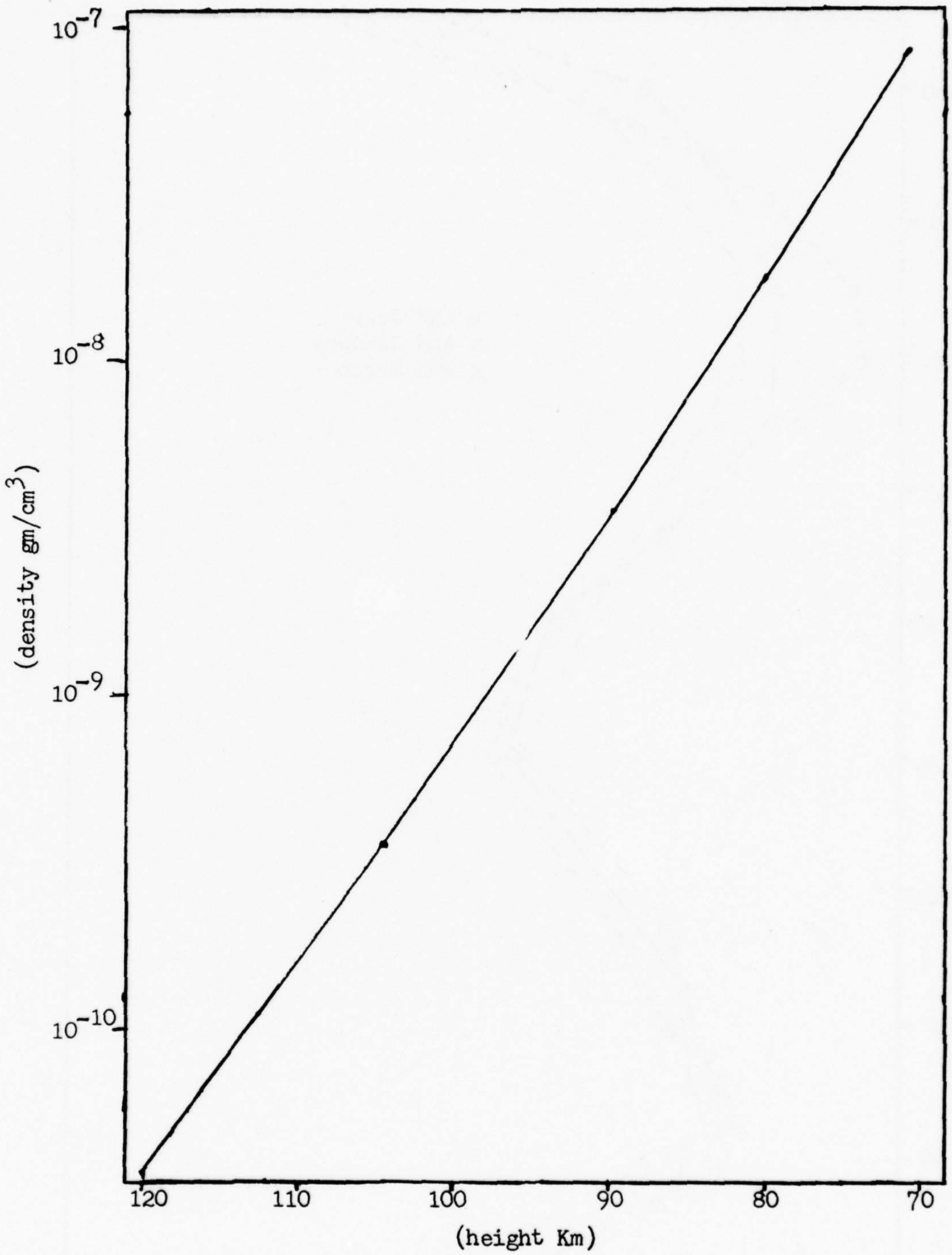


FIGURE C2: Density profile generated using the following constant scale heights - 7.032Km from 70 to 80 Km - 5.979Km from 80 to 104 Km - 7.162Km from 104 to 120 Km.

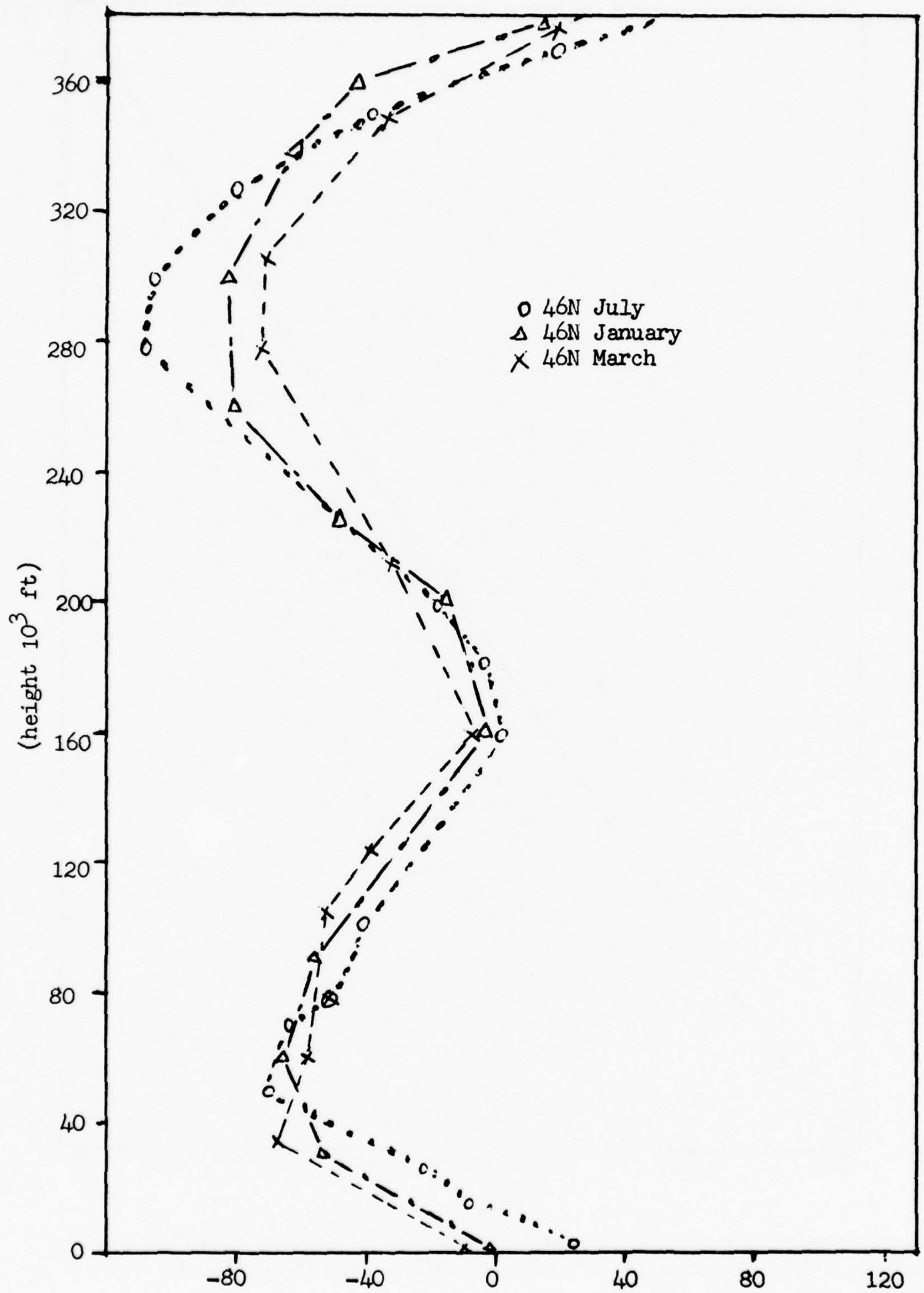


FIGURE C3: Three sample extended temperature profiles from midlatitude Point Analyses.

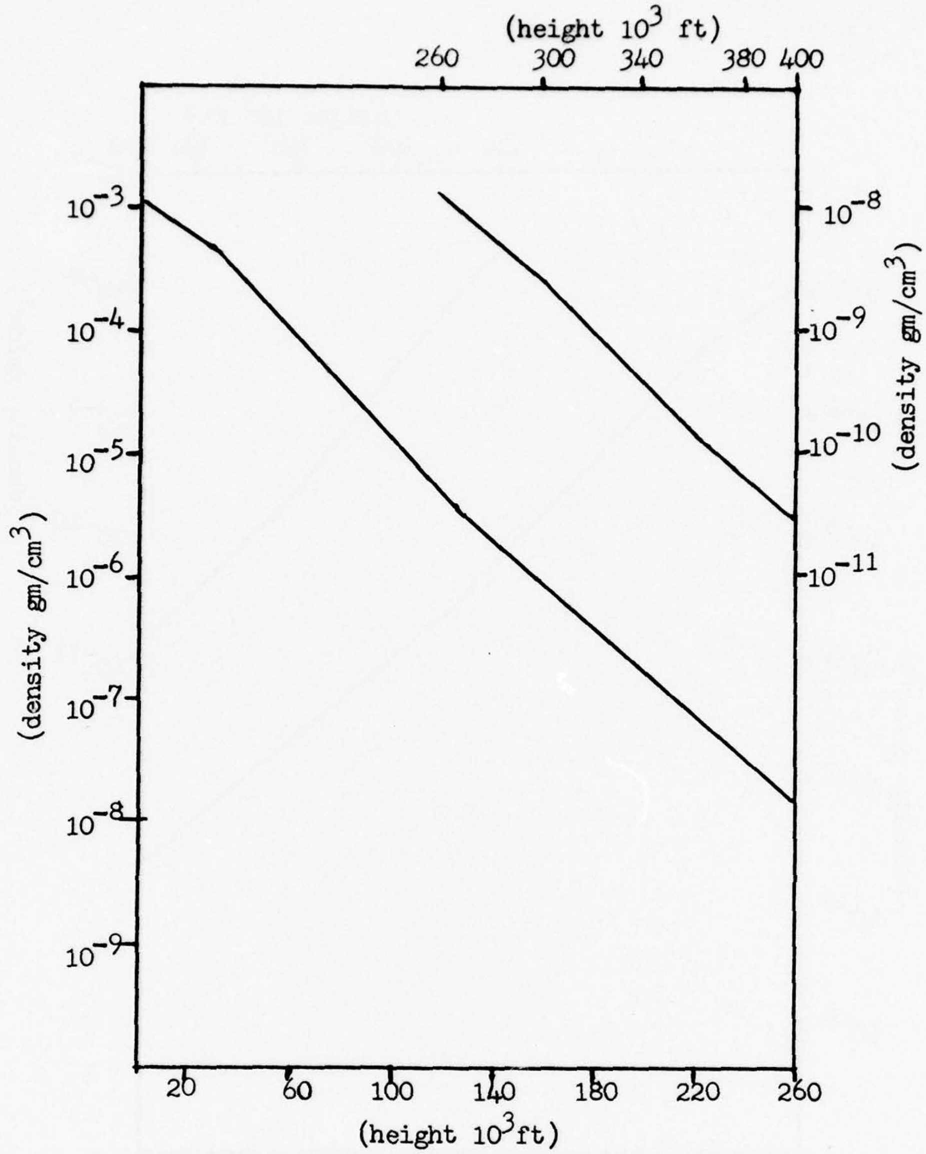


FIGURE C4: Example of an extended density profile (46N, January).

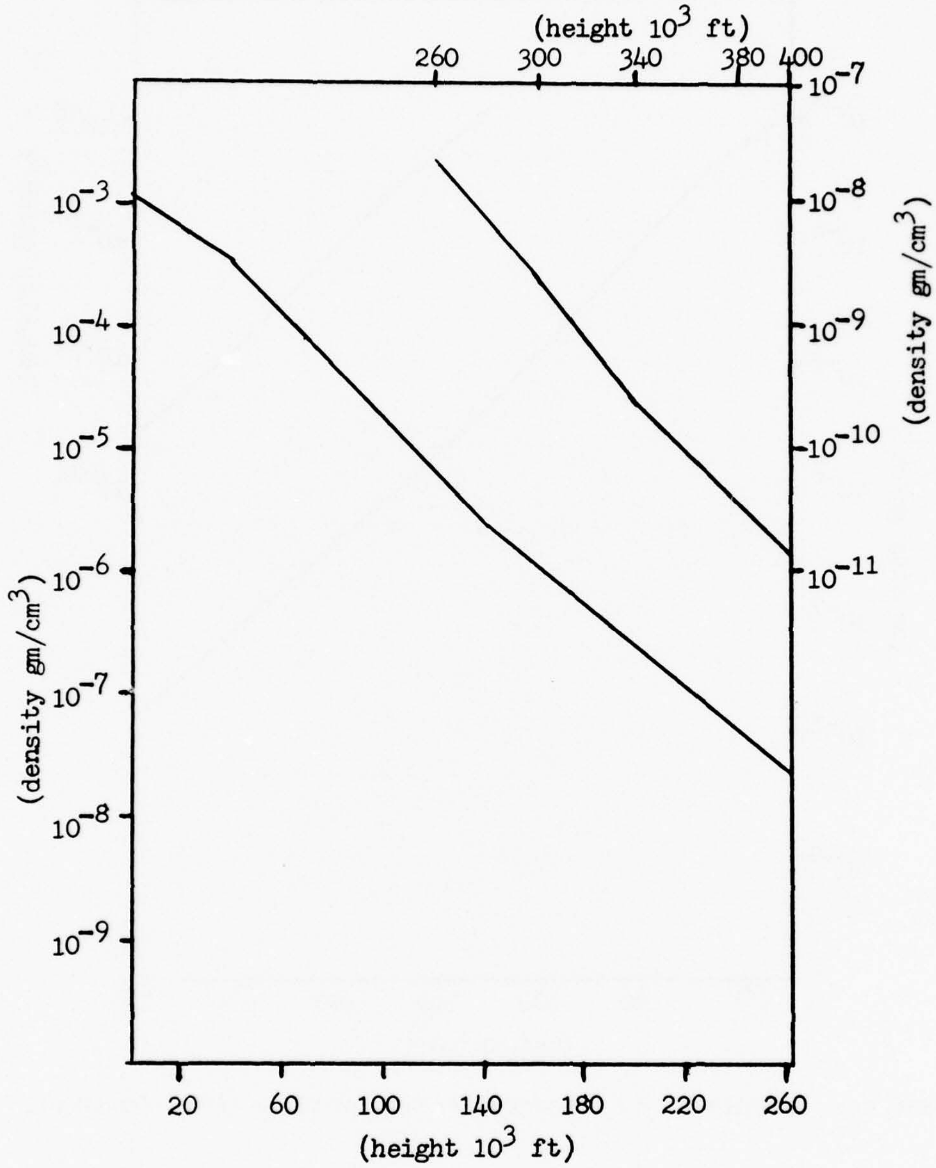


FIGURE C5: Example of an extended density profile (46N, July).

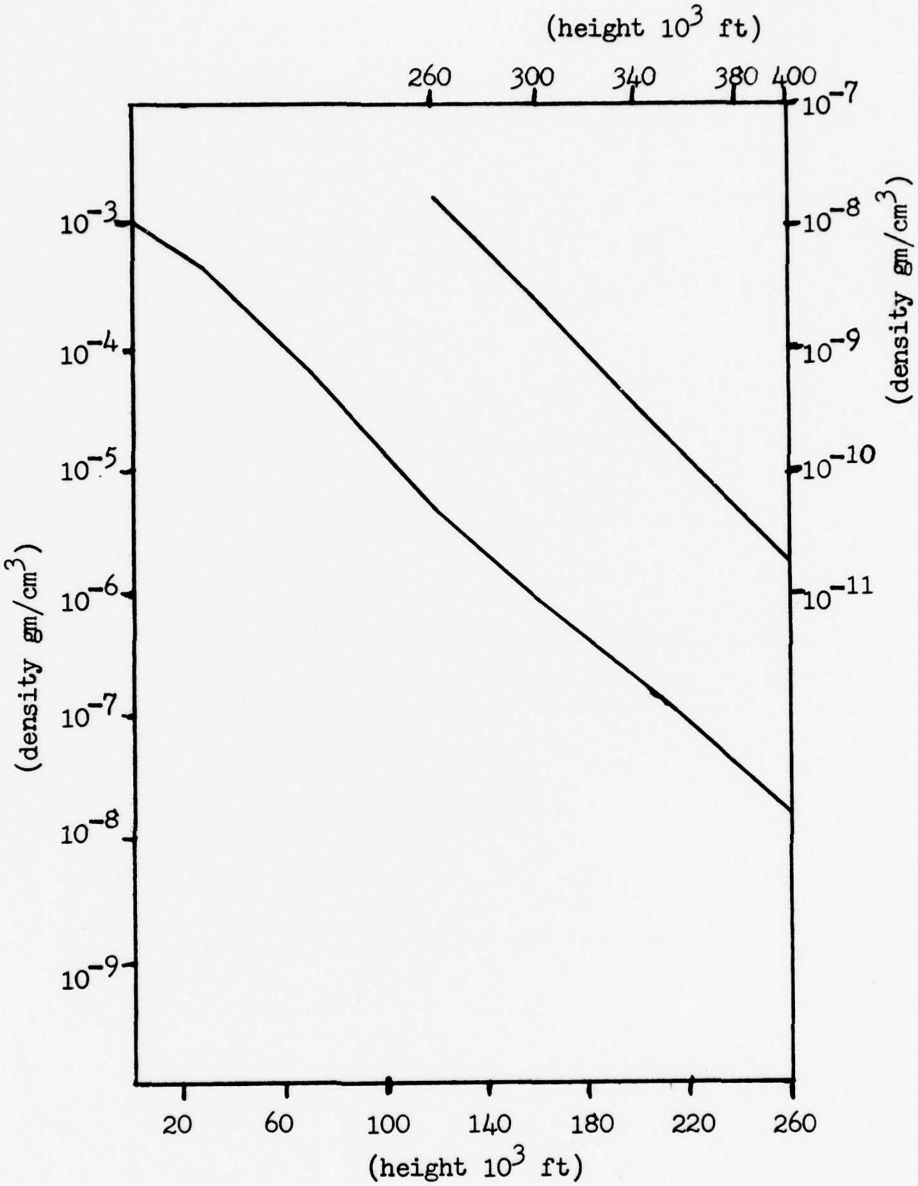


FIGURE C6: Example of an extended density profile (46N, March)

APPENDIX D

INTERPRETING

SITE PSEUDO-SURFACE OBSERVATION

(Paragraph D.)

D.1 The First Record of Site Pseudo-Surface Observation

The first nonblank record of paragraph D. contains visibility and cloud data. Visibility is interpolated from surrounding surface data (interpolation technique is described in Appendix A). The cloud data is taken from the nearest 3DNEPH cloud analysis grid point. Table D1 is a column by column description of the first record.

Unless there is no surface data, the visibility will range from 00.00 to 15.00 nm. When there is no surface data available, 99.99 is encoded.

The cloud data is broken into low, middle, and high cloud groups. The cloud coverage, types, and heights are presented in each group. Cloud coverage is first and is given in eighths. For example, "2/8." Eight columns are reserved for cloud types. In these eight columns, three two-character types are separated by the character "/" Table D2 presents all the possible cloud types that may appear. An example cloud type code for low clouds is "CU/SC/**". This example means there are cumulus and stratocumulus clouds present. Seven columns are used to give minimum bases and maximum tops of clouds in a layer. Three digits are used to give bases in hundreds of feet. These digits are followed by the character "/" and three more digits for tops of clouds in hundreds of feet. The characters "***/***" mean missing height data or no clouds in layer.

D.2 The Second Record of the Site Pseudo-Surface Observation

The second record of paragraph D. contains wind and present weather data. Wind data in interpolated from the surrounding surface observations (interpolation technique is described in Appendix A.). The present weather is taken from the closest surface observation. Table D3 is a column by column description of the second record.

Wind data is presented in 10 columns. The first three digits give direction in degrees. These are immediately followed by three digits for speed in knots. Missing wind data is encoded as "999999". Calm winds are encoded as "000000". These six columns are followed by the character "G" and three digits for gust speed in knots. Missing gust data is encoded as "***". (Gust data is available only for North America.)

Zero to four 12-character present weather contractions may also appear in the second record. Table D4 presents all the possible contractions and their equivalent in World Meteorological Organization (WMO) code 4677 WW. A complete definition may be found by referencing Air Weather Service Manual 105-24, Vol. III. The 12-character contractions are followed by commas.

Table D1. Format for first Data Record of Point Analysis

Paragraph D.

-cols 1-3: three blanks

-cols 4-7: the four characters "VSBY"

-col 8 : a blank

-cols 9-13: a four digit decimal number with the decimal point (period) in col 11

-col 14 : a blank

-cols 15-16: the two characters "NM"

-col 17 : a blank

-col 18 : one digit for eights of low cloud coverage.

-cols 19-20: the two characters "/8"

-col 21 : one blank

-cols 22-29: Three two-letter cloud type codes separated the character "/". Columns 22-29 contain types for low clouds.

-col 30 : blank

-cols 31-33: three digit number for minimum low cloud bases in hundreds of feet above ground level.

-col 34 : the character "/"

-cols 35-37: three digit number for the maximum low cloud tops.

-col 38 : a comma

-cols 39-58: same as columns 18-37 except that the data refers to middle clouds

-col 59 : a comma

-cols 60-79: same as column 18-37, except that data refers to high clouds

-col 80 : blank

Table D2. Possible cloud types

Type	Meaning
SC	Stratocumulus
ST	Stratus
CU	Cumulus
CB	Cumulonimbus
AC	Altocumulus
AS	Altostratus
NS	Nimbostratus
CI	Cirrus
CC	Cirrocumulus
CS	Cirrostratus
**	Missing data, or no other cloud type in layer or no clouds at all in layer
UN	Unknown (the 3DNEPH cloud analysis program was not able to determine the cloud type)

Table D3. Format for the Second Data Record of Paragraph D. in the Point Analysis Product

-cols 1-3: three blanks

-cols 4-7: the four characters "WIND"

-col 8 : a blank

-cols 9-11: three digits giving wind direction in degrees.

-cols 12-14: three digits giving wind speed in knots

-col 15 : the character "G"

-cols 16-18: three digits giving gust speed in knots

-cols 19-21: three blanks

-cols 22-73: one to four 12-character present weather contractions, each one followed by a comma

-cols 74-80: seven blanks

Table D4. List of All Possible Twelve Character Present Weather Contractions and their Equivalent in WMO Code 4677 WW.

(Reference AWSM 105-24, Vol. III)

CONTRACTION	WMO 4677	CONTRACTION	WMO 4677
- -	00	-LGT INT DRZL-	50
- CLD DCRSG -	01	-LGT CON DRZL-	51
- CLD SAME -	02	-MOD INT DRZL-	52
- CLD BLDG -	03	-MOD CON DRZL-	53
- SMOKE -	04	-HVY INT DRZL-	54
- HAZE -	05	-HVY CON DRZL-	55
- DUST -	06	-LGT FRZ DRZL-	56
- BLWG DUST -	07	-MOD FRZ DRZL-	57
- DUST DEVILS-	08	-LT DRZL+RAIN-	58
- DUST STORM -	09	-MD DRZL+RAIN-	59
- MIST -	10	-LGT INT RAIN-	60
-PCHY GRN FOG-	11	-LGT CON RAIN-	61
- GROUND FOG -	12	-MOD INT RAIN-	62
- LTG SEEN -	13	-MOD CON RAIN-	63
- VIRGA -	14	-HVY INT RAIN-	64
-DISTANT PRCP-	15	-HVY CON RAIN-	65
- CLOSE PRCP -	16	-LGT FRZ RAIN-	66
-THNDR HEARD -	17	-MOD FRZ RAIN-	67
- SQUALLS -	18	-LT RAIN+SNOW-	68
- FUNNEL CLD -	19	-MD RAIN+SNOW-	69
-DRZL/SNW GRN-	20	-LGT INT SNOW-	70
- RAIN -	21	-LGT CON SNOW-	71
- SNOW -	22	-MOD INT SNOW-	72
-RN/SNW/ICEPL-	23	-MOD CON SNOW-	73
- FRZG PRCP -	24	-HVY INT SNOW-	74
- RAIN SHWRS -	25	-HVY CON SNOW-	75
-RN/SNW SHWR -	26	-ICE CRYSTALS-	76
-RN/HAIL MXD -	27	-SNOW GRAINS -	77
- FOG/ICE FOG-	28	-ISLTD CRYSTL-	78
-THUNDERSTORM-	29	-ICE PELLETS -	79
-DCRSG MDUST -	30	-LT RAIN SHWR-	80
- MOD DUST -	31	-MDH RAIN SHW-	81
-INCRSG MDUST-	32	-SVR RAIN SHW-	82
-DCRSG SDUST -	33	-LT RAIN+SNOW-	83
- SVR DUST -	34	-MD RAIN+SNOW-	84
-INCRSG SDUST-	35	-LT SNOW SHWR-	85
-MD DRFTG SNW-	36	-MDH SNW SHWR-	86
-HV DRFTG SNW-	37	-LT SNOW PLT -	87
-MOD BLWG SNW-	38	-MDH SNOW PLT-	88
-HVY BLWG SNW-	39	-LT HAIL SHWR-	89
- DSTNT FOG -	40	-MDH HAIL SHW-	90
- PTCHY FOG -	41	-LT RAIN OBT -	91
- SKY/DC FOG -	42	-MDH RAIN OBT-	92
-NOSKY/DC FOG-	43	-LT SNOW OBT -	93
- SKY FOG -	44	-MDH SNOW OBT-	94
- NOSKY FOG -	45	-THDSTM+RAIN -	95
-SKY/IN FOG -	46	-THDSTM+RN+HL-	96
-NOSKY/IN FOG-	47	-HVY THDSTM -	97
- SKY/RM FOG -	48	-THDSTM+DUST -	98
-NOSKY/RM FOG-	49	-HV THDSTM+HL-	99

APPENDIX E

INTERPRETING THE SURFACE OBSERVATIONS TABLE

(Paragraph G.)

E.1 Inclusion of Surface Observation Table

The PA user may request that data from surface observation stations surrounding the input site be included in Paragraph G. The stations chosen are as close as possible to the user's input site and time.

E.2 Table Entries

All possible types of data are listed in TableE1. Each line of the observation table in paragraph G. is labeled as shown in Table E1. Entries for which no data is available are deleted.

The entries for "BLOCK/STATION NUMBER" through "DEWPOINT (DEG C)" are self-explanatory. The user may request inclusion of the surface observation table with the entries for "BLOCK/STATION NUMBER" through "BEARING (DEG)" deleted.

E.2.1 Present Weather

Up to four present weather contractions may appear for each station. The contractions are exactly the same as those shown in Appendix D, Table D4

E.2.2 Past Weather

One twelve-character past weather contraction may appear for each station. Table E2 lists all the possible contractions and their equivalent in WMO code 4500 (reference AWSM 105-24, Vol. III).

E.2.3 Clouds

There are four possible kinds of entries under the data type "CLOUDS"

The first type is the principal cloud type the observer reported for low, middle and high clouds. The distinguishing trait of this type is that two commas appear in it. Two characters and a digit are encoded for each layer. The single digit is from WMO code 513 for low clouds, WMO code 515 for middle clouds and WMO code 509 for high clouds (reference AWSM 105-24, Vol. III). The characters "MIS" indicate missing data.

The second type of "CLOUDS" entry gives cloud coverage, cloud type, height of cloud bases for important cloud layers reported by the observer. The distinguishing trait of this type is the presence of one comma. There may be zero to six entries of this type for each station. The cloud coverage may vary from zero to eight eights. If the sky is obscured "9/8" will appear. The cloud type code is identical to that used above. Three digits give cloud bases in hundreds of feet above ground level.

The third type of "CLOUDS" entry gives the total fraction of the sky covered by clouds. Its distinguishing trait is the characters "TOTL CLD". The cloud coverage is given in eighths. If the cloud ceiling is indefinite "9/8" will appear. If the observer reported a sky obscuration, the characters "SKY OBSCURED" will replace this entry.

The last type of "CLOUDS" entry gives the lowest reported ceiling. Its distinguishing trait is that it begins with the characters "CIG". The height of the lowest ceiling is given in hundreds. The three digits for height may be preceded by a single letter which either indicates how the ceiling height was determined (M-measured, E-estimated, A-aircraft, or B-ballon), or characterizes the ceiling (W-indefinite, X-obscuration). If the ceiling is "variable" or "thin", then the last four characters of the entry will be "VRBL" or "THIN", respectively.

TABLE E1

LIST OF ALL POSSIBLE DATA TYPES
IN THE SURFACE OBSERVATIONS TABLE OF PARAGRAPH G.

BLOCK/STATION NUMBER
CALL LETTERS
ZULU TIME
BEARING (DEG)
DISTANCE (NM)
WIND DIRECTION (DEG)
WIND SPEED (KTS)
WIND GUSTS (KTS)
SEA LEVEL PRESSURE (MB)
3-HRLY PRES CHANGE (MB)
ALTIMETER SETTING (IN)
VISIBILITY (NM)
6-HR PRECIPITATION (IN)
TEMPERATURE (DEG C)
DEWPOINT (DEG C)
PRESENT WEATHER
PAST WEATHER
CLOUDS

TABLE E2

LIST OF ALL POSSIBLE TWELVE CHARACTER PAST WEATHER CONTRACTIONS AND THEIR EQUIVALENT IN WMO CODE 4500. (REF AWSM 105-24, VOL III)

CONTRACTION	WMO 4500
-LT 1/2 CLDY -	0
-FRT 1/2 CLDY-	1
-GT 1/2 CLDY -	2
- DUSTSTORM -	3
- FOG -	4
- DRIZZLE -	5
- RAIN -	6
- SNOW -	7
- SHOWERS -	8
-THUNDERSTORM-	9

APPENDIX F.

USER CONSIDERATIONS

F.1 Protecting Input Site and Time

The basic Point Analysis message format clearly reveals the user's input site and time. If the user wants the site and time protected, then the following changes are made:

Para. A. - Site latitude and longitude are replaced by a six character identification code provided by the user at the time of his request.

Para. B. - Paragraph B. is left blank.

Para. G. - If a rawinsonde was used to create the vertical profile the rawinsonde station number will be deleted.

Para. G. - If the user has requested inclusion of the Surface Observations Table, the entries for BLOCK/STATION NUMBER through "BEARING (DEG)" are deleted.

F.2 Analysis Only Versus Rawinsonde

The users of Point Analysis products desire a vertical profile that is as representative as possible. For some applications, and for some areas of the world where data is sparse, it is advisable to force the PA program to ignore rawinsonde data and build the vertical profile based on data at the closest GWC analysis fields grid point.

However, the GWC Analysis Fields used by the PA program are the worldwide whole mesh fields. The grid spacing for these fields is approximately 200 nautical miles at 60^{o} latitude. Therefore, the closest grid point can be a maximum of 150 nm away, and average about 70 nm away. Furthermore, only the standard pressure levels have data and never more than four levels have moisture data (see Figure 6 in manual).

Most PA runs find a rawinsonde with at least four levels of moisture data within 150 nm of the input site. Therefore, allowing the PA program to search for Rawinsonde before falling back to Analysis Fields data is recommended. This is especially so for applications which require the vertical stratification of density and moisture available in the Rawinsonde significant levels data.

F.3 Summary of Forecaster Capabilities

Because some human judgement of what is or is not representative of a given site and time is useful, the PA production process was designed to allow GWC forecaster to intervene in the process.

F.3.1 Selection of Data for the Vertical Profile

The forecaster can force the PA program to ignore 1 to 5 rawinsondes which he feels are not representative. He can also look at a listing of available rawinsondes and force the PA program to use a particular rawinsonde which the forecaster feels is representative. Frequently, the program determines there is no rawinsonde available and falls back to GWC Analysis Fields data on its own. However, the forecaster can also decide to ignore rawinsonde data and force the program to do so.

F.3.2 Change the Pseudo-Surface Observation

The GWC forecaster may review the contents of paragraph D. and determine some part of, or all of, the Pseudo-surface Observation not representative. He may change any part of this paragraph to whatever he feels is representative.

F.3.3 Paragragh G Remarks

The GWC forecaster is free to include whatever plain language remarks he desires. This will include any special information requested by the user, information which the forecaster feels the user ought to be aware of, or general remarks about the representativeness of the vertical profile.

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