NOAA Eastern Region Computer Programs
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AUTOMATED ANALYSIS OF UPPER AIR SOUNDINGS TO SPECIFY PRECIPITATION TYPE

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Scientific Services Division
Eastern Region Headquarters
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NOAA TECHNICAL MEMORANDUM

National Weather Service, Eastern Region Computer Programs and Problems

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I. General Information

A. Summary

The vertical temperature and moisture structure of the atmosphere, as obtained from the radiosonde observation (RAOB), is an important consideration for short-range forecasts of precipitation type. This computer program automatically analyzes a RAOB and computes a number of variables which have been found to be important in discriminating between liquid, freezing, and frozen precipitation (Bocchieri, 1980; see Appendix).

Frozen precipitation is defined as snow, sleet (ice pellets), or snow mixed with sleet; freezing precipitation includes freezing rain, freezing drizzle, or freezing rain or drizzle mixed with snow or sleet; and the liquid category consists of rain or rain mixed with snow or sleet.

The variables computed from the RAOB are input to regression equations which produce the probability of liquid, freezing and frozen precipitation given that precipitation is occurring. It should be emphasized that the regression equations were developed with observations of precipitation type concurrent with the RAOB valid time. Therefore, in operations, the method may be useful only for very short-range forecasting, i.e., if precipitation is expected within 3 to 6 hours and no significant changes are expected in the temperature profile. Other cautions for operational use are given in Section III C.

The development of the regression equations and a meteorological interpretation are given in the Appendix. Verification statistics are also provided. It should be noted that verification statistics were computed from data from 48 RAOB stations combined; the local accuracy of the method may be different from the combined statistics. Also, the verification statistics are valid for cases of precipitation type observed at about the same time as the RAOB valid time. The method may be less accurate when the system is used in a forecast mode.

II. Application

A. Machine Requirements

This program requires 18K core in background. The runtime is about 20 seconds. Disk space required for the program is 35111 bytes (69 RDOS blocks).

B. Database

Products that are referenced:

1. cccSGLxxx : actual RAOB product.

Files/products that are created:

1. The output from the program is stored in AFOS product PRECIPTYP.

C. Structure of Software

PTYPE is the main program. First, the significant level data is read from the RAOB. If dew point is missing below 700mb, the program terminates. If dew point is missing above 700mb, dry conditions are assumed and the temperature-dew point spread is set equal to 30C. For each significant level, the program computes the virtual temperature, height of the level above the station, and wet-bulb temperature. All output is done by PTYPE. All other computations are done by subroutines as described below. All interpolations are done assuming a linear variation of the quantity with respect to height. The variables computed from the RAOB by the following subroutines are explained in the Appendix.

<u>DECOS</u> (Stone, 1983)

Reads the temperature portion of the UJ1 RAOB specified in the array JST, utilizing the AFREAD subroutine (Peroutka, 1981).

<u>TEMP1</u> (Stone, 1983)

This subroutine is called by DECOS for decoding temperature and dew point.

<u>CHECK2</u>

This subroutine establishes a height cutoff of 6000m for the height, temperature, dew point, wet-bulb temperature, and pressure arrays. The values in these arrays are set to missing above 6000m. All predictors are computed below 6000m.

<u>LLAS</u>

This subroutine determines the number of warm and cold layers and gets the height and sense of the crossover points in the RAOB. A warm (cold) layer is a layer in which the temperature is greater (less) than ØC. A crossover point is the height at which the temperature becomes greater or less than ØC.

<u>DMAL</u>

This subroutine determines the depth of the warm or cold layers.

<u>TAAL</u>

This subroutine determines the area between the temperature profile and the ØC isotherm in the warm or cold layers.

ATHICK

This subroutine computes the mean value of a variable in a layer.

ƵRPOT

This subroutine determines if the RAOB is a freezing precipitation type; that is, if the surface temperature is ≤ ØC and a warm layer exists aloft, then a variable ƵR is set equal to 1. Otherwise, ƵR is set equal to Ø.

PPAL

This subroutine determines the depth of the warm layer for ƵR=1 RAOBS.

ƵPFLH

This subroutine determines the depth of the surface based cold layer for ZR=1 RAOBS.

AHAL

This subroutine determines the area between the temperature profile and the ØC isotherm in the surface based cold layer for ƵR=1 RAOBS.

FUNCTION ARF

This function is used in subroutine TAAL to compute area.

EQUINT

This subroutine is called by function ARF to assist in computing area.

FUNCTION AREA

This function is used in function ARF to compute area.

DCV

This subroutine is used to add or subtract a constant from a variable.

FUNCTION XINT

This function performs linear interpolation with respect to height.

III. Procedures

A. Preparation

AFOS product PRECIPTYP must be added to the database (several versions). The program PTYPE.SV must be moved to the main disk DPØ or to DPØF with a link to DPØ. The program can operate on any significant level RAOB stored in the database.

B. Initiating the Program

To run the program for a single RAOB station, at the ADM console type:

```
RUN:PTYPE cccSGLxxx
```

where cccSGLxxx is the actual nine-letter AFOS identifier for the RAOB desired. If running the program for several stations, the results can be stored in the several versions of PRECIPTYP.

C. Output

An ALERT at the ADM signals that the output has been stored (product PRECIPTYP). Sample of the output and the corresponding plotted RAOB are shown in Figures 1 and 2, respectively.

PRECIPTYP
<<<<<<<<<<<<<

PRESSURE	HEIGHT(M)	TEMP(C)	DEW PT(C)	WET BULB(C)
1009.	0.	0.8	-9.2	-2.5
950.	482.	-0.9	-13.9	-4.8
940.	567.	-1.3	-12.3	-4.8
929.	660.	-0.5	-1.6	-0.9
902.	898.	3.8	0.9	2.5
878.	1118.	5.8	0.8	3.5
862.	1269.	6.0	3.0	4.5
822.	1657.	4.2	3.7	4.0
700.	2950.	-2.7	-3.2	-2.9
588.	4315.	-9.7	-11.0	-10.2
562.	4663.	-11.1	-16.1	-12.7
472.	6000.	-20.4	-24.9	-21.4

PROBABILITY OF LIQUID, FREEZING, AND FROZEN
PRECIPITATION FOR IAD/ 28 12Z
LIQUID=105 FREEZING= 16 FROZEN=-20

Figure 1. Example of PRECIPTYP

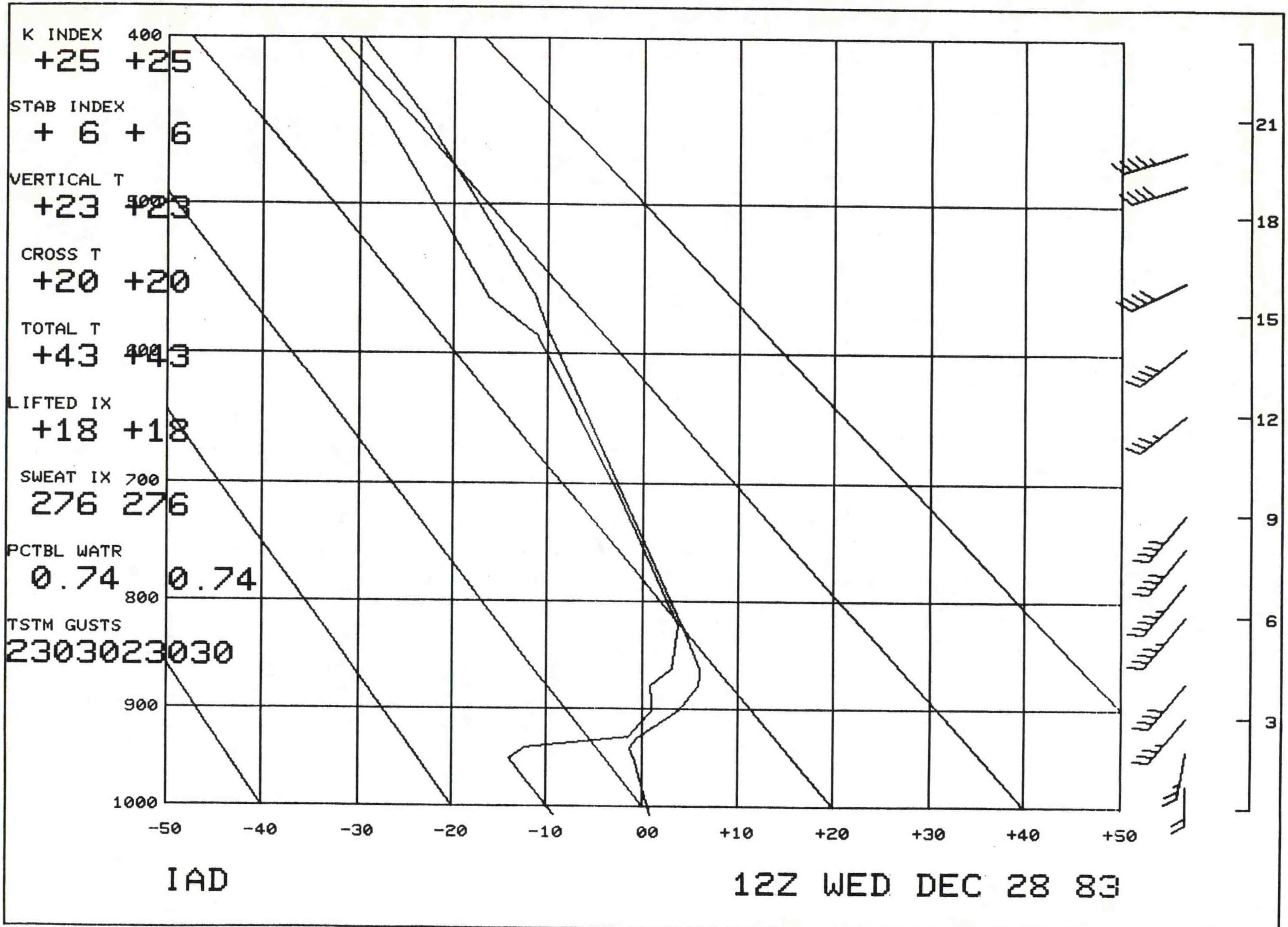

Figure 2. Plotted RAOB for which the output in Figure 1 was computed.

D. Cautions on Use

1. As mentioned previously, the method was developed with observations of precipitation type concurrent with the RAOB valid time. Therefore, in operations, the method may be useful only for very short-range forecasting, let's say, if precipitation is expected within 3 to 6 hours and no significant changes are expected in the RAOB temperature profile.

2. Be alert for evaporational cooling (see Appendix for discussion). The method does compute variables from the wet-bulb temperature profile for the special cases in which the surface wet-bulb temperature is ≤ ØC <u>and</u> the wet-bulb temperature is > ØC for a layer aloft. However, evaporational cooling may still pose a problem. If you expect that evaporational cooling will be a factor, then look at the wet-bulb temperature provided in the PRECIPTYP display. If the wet-bulb temperature is below freezing in a layer in which the temperature is above freezing, then more emphasis of frozen or freezing precipitation may be appropriate even though the method produces the highest probability for the liquid type. An example of this is shown in Figures 1 and 2. Note that the surface temperature at IAD was just above freezing at 1200 GMT. The method indicated liquid precipitation for this RAOB, but note that the wet-bulb temperature was below-freezing near the surface. At 1200 GMT, light rain began to fall at IAD; so the method was correct in its specification of liquid precipitation. However, by 1300 GMT, the surface temperature at IAD dropped to below freezing and the light rain changed to freezing rain.

3. Because of the nature of the statistical equations, it's possible for the probability for a category to be greater than 100% or less than 0%. The sum of the three probabilities will, however, add to 100%, except for round-off error.

4. Watch for the occurrence of freezing drizzle with RAOB's in which the temperature profile is below freezing at all levels. The method will likely indicate frozen precipitation for this type of RAOB, but if the precipitation falls from a moist layer near the surface with relatively dry conditions above, the freezing drizzle may occur. See the Appendix for further discussion.

5. For the purposes of very short-range forecasting, this method will likely give better results than the MOS Probability of Precipitation Type (PoPT) guidance in the FO12 message (Bocchieri and Maglaras, 1983), although no testing was done to confirm this. At the time of the RAOB, the MOS guidance is 9 to 12 hours old. The new MOS guidance based on 0000 GMT (1200 GMT) data is not available until about 0400 GMT (1600 GMT). The 0000 GMT (1200 GMT) RAOB contains updated information which was not available to the MOS guidance from the previous cycle.

E. Program Listings.

See Appendix A2, pages A2-1 through A2-17.

ACKNOWLEDGEMENTS

Portions of this program were taken from programs written by Hugh Stone of Scientific Services Division (SSD, ERH) and by John Januzzi of the Weather Service Forecast Office, Portland, Oregon. Programming advice was also received from Jim Kemper of the Techniques Development Laboratory, Office of Systems Development and Joe Facundo of the Sounding Systems Branch, Office of Technical Services. Fred Zuckerberg and Cynthia Scott of SSD were also very helpful. The support of Jim Travers, DMIC, and Ross LaPorte, MIC, of the Washington DC Weather Service Forecast Office is also appreciated. The original computer program for the IBM 360/195 was written by Mr. Frank Merrem of the Environmental Research Laboratories.

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The Objective Use of Upper Air Soundings to Specify Precipitation Type

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ABSTRACT

Linear screening regression is used to derive relationships between parameters computed from observed upper air soundings (RAOBs) and concurrent observations of precipitation type. Precipitation type is defined as three categories: liquid (rain or drizzle), freezing (freezing rain or freezing drizzle) and frozen (snow or ice pellets). Statistical screening results indicate that of the parameters tried the following are important: the mean temperature in the surface–1000 m and 500–2500 m layers; the depth of the warm layer (temperature > 0°C), if one exists; the area between the temperature profile and the 0°C isotherm in the warm layer; the depth of the surface-based cold layer, if one exists, with respect to the wet-bulb temperature profile; and the area between the wet-bulb temperature profile and the 0°C isotherm in the surface-based cold layer.

Verification of the specification equations on both developmental and independent data samples indicates that the scores are generally stable. The equations show excellent discrimination ability for liquid and frozen precipitation but have some difficulty with freezing precipitation.

Part of the problem with the freezing category is the fact that freezing drizzle, which is included with freezing rain in this category, can occur with a RAOB in which the temperature is ≤0°C at all levels (no warm layer). It is found that about 44% of the freezing drizzle RAOBs examined have no warm layer.

1. Introduction

The vertical temperature and moisture structure of the atmosphere, as obtained from the radiosonde observation (RAOB), is an important consideration for short-range forecasts of precipitation type. In this study, we used statistical methods to determine the characteristics of the RAOB associated with liquid, freezing and frozen precipitation. In this respect, a forward screening technique known as the Regression Estimation of Event Probabilities (REEP) (Miller, 1964) was used to develop linear regression equations that relate parameters from the RAOB with precipitation type observed at about the same time as the RAOB; i.e., the equations "specify" (as opposed to "predict") precipitation type.

The results of this study may be useful in a number of ways. For example, with the implementation of the Automation of Field Operations and Services (AFOS) program (Klein, 1978; Wilkins and Johnson, 1975) the capability will exist to display and analyze the RAOB with a local mini-computer. The specification equations developed in this study can rapidly be evaluated on the AFOS computer for use in a "nowcasting" (very short-range forecast) sense. Also, the parameters used in the equations could be derived from a forecasted RAOB (the perfect-prog approach) to obtain short- to medium-range forecasts of precipitation type. Such prognostic RAOBs are available, for instance, from the Techniques Development Laboratory's (TDL's) boundary-layer model (BLM) (Long *et al.*, 1978). In addition, after BLM prognostic RAOBs have been archived for a suitable period, the parameters found to be important in this study could be used in the Model Output Statistics (MOS) (Glahn and Lowry, 1972) approach to develop precipitation-type prediction equations. Such MOS forecasts are presently available within the National Weather Service (Bocchieri, 1979) based on the Limited-area Fine Mesh (LFM) model (Gerrity, 1977; National Weather Service, 1971). However, since the BLM has greater vertical resolution than the LFM within the lowest 1600 m, MOS precipitation-type forecasts based on the BLM may be more accurate than those based on the LFM.

In this paper, frozen precipitation is defined as snow, sleet (ice pellets), or snow mixed with sleet; freezing precipitation includes freezing rain, freezing drizzle, or freezing rain or drizzle mixed with snow or sleet; and the liquid category consists of rain or rain mixed with snow or sleet.

In Section 2, the predictors[2] derived from the RAOBs are described, and references to authors

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[2] The word predictor is used in this paper even though the equations developed *specify* precipitation type.

TABLE 1. A description of the RAOB predictors.

Predictor	Description
1. Sfc T	Surface temperature
2. $\bar{T}$ (sfc–500)	Mean temperature in the surface–500 m layer
3. $\bar{T}$ (sfc–1000)	Mean temperature in the surface–1000 m layer
4. $\bar{T}$ (sfc–1600)	Mean temperature in the surface–1600 m layer
5. $\bar{T}$ (sfc–3000)	Mean temperature in the surface–3000 m layer
6. $\bar{T}$ (sfc–6000)	Mean temperature in the surface–6000 m layer
7. $\bar{T}$ (500–2500)	Mean temperature in the 500–2500 m layer
8. Sfc T_w	Same as 1 except wet-bulb temperature was used
9. $\bar{T}_w$ (sfc–500)	Same as 2 except wet-bulb temperature was used
10. $\bar{T}_w$ (sfc–1000)	Same as 3 except wet-bulb temperature was used
11. $\bar{T}_w$ (sfc–1600)	Same as 4 except wet-bulb temperature was used
12. $\bar{T}_w$ (sfc–3000)	Same as 5 except wet-bulb temperature was used
13. $\bar{T}_w$ (sfc–6000)	Same as 6 except wet-bulb temperature was used
14. $\bar{T}_w$ (500–2500)	Same as 7 except wet-bulb temperature was used
15. Sfc U	Surface *u* wind component
16. Sfc V	Surface *v* wind component
17. $\bar{U}$ (500–2500)	Mean *u* in the 500–2500 m layer
18. $\bar{V}$ (500–2500)	Mean *v* in the 500–2500 m layer
19. W.L. DEPTH(T)	Warm layer depth with respect to temperature
20. W.L. AREA(T)	Area between the temperature profile and the 0°C isotherm in the warm layer
21. W.L. TOP(T)	Height of top of warm layer with respect to temperature
22. HGT FREEZ LEV(T)	Height of the lowest freezing level with respect to temperature. If the sfc T $\leq$ 0°C, then this parameter is zero
23. W.L. DEPTH(T_w)	Same as 19 except wet-bulb temperature was used
24. W.L. AREA(T_w)	Same as 20 except wet-bulb temperature was used
25. W.L. TOP(T_w)	Same as 21 except wet-bulb temperature was used
26. HGT FREEZ LEV(T_w)	Same as 22 except wet-bulb temperature was used
27. ZR(T)	A binary predictor that equals 1 if sfc T $\leq$ 0°C *and* a warm layer exists aloft; otherwise, it is zero
28. C.L. DEPTH(T)	The depth of the surface-based cold layer, with respect to temperature, when ZR(T) = 1
29. C.L. AREA(T)	Area between temperature profile and the 0°C isotherm in the surface-based cold layer when ZR(T) = 1
30. ZR(T)·W.L. DEPTH(T)	The product of parameters 19 and 27
31. ZR(T)·W.L. AREA(T)	The product of parameters 20 and 27
32. ZR(T_w)	Same as 27 except wet-bulb temperature was used
33. C.L. DEPTH(T_w)	Same as 28 except wet-bulb temperature was used
34. C.L. AREA(T_w)	Same as 29 except wet-bulb temperature was used
35. ZR(T_w)·W.L. DEPTH(T_w)	Same as 30 except wet-bulb temperature was used
36. ZR(T_w)·W.L. AREA(T_w)	Same as 31 except wet-bulb temperature was used

who have used many of these parameters previously are given. Section 3 describes the statistical development of the specification equations, and Section 4 presents verification of the equations for both developmental and independent data samples. The results indicate that specification of the liquid and frozen categories was excellent, but the system had some difficulty with freezing precipitation.

2. The potential RAOB predictors

Table 1 describes the predictors that were derived from the RAOBs. Heights are given in terms of height above station; also, when vertical interpolation was necessary, it was done linearly with respect to height.

Parameters were derived from both the temperature and wet-bulb temperature profiles. The wet-bulb temperature was used to help account for the evaporational cooling effect. As explained by Penn (1957), evaporational cooling takes place as precipitation falls through unsaturated air between the clouds and the ground. The effect is especially pronounced when very dry air is present in low levels. Lumb (1960, 1961, 1963) and Booth (1973) also found the wet-bulb temperature to be important for rain-snow discrimination in the British Isles. Lumb indicated that cooling by evaporation during precipitation of moderate intensity can reduce the wet-bulb depression to a small fraction of its original value within an hour or two; as saturation is approached, the temperature of the air should approach the wet-bulb temperature.

In Table 1, predictors 1–18 are rather simple and include temperature, wet-bulb temperature and wind components at the surface and mean values of these parameters for various layers aloft. The mean temperature within a layer is analogous to a thickness variable such as 1000–500 mb thickness. Many investigators, including Wagner (1957), Younkin (1967) and Glahn and Bocchieri (1975), have used

TABLE 2. The 48 RAOB stations used in this study to compute composite freezing rain and freezing drizzle soundings.

WBAN no.	Station	WBAN no.	Station
3860	Huntington, WV	23044	El Paso, TX
3937	Lake Charles, LA	23047	Amarillo, TX
3940	Jackson, MS	23050	Albuquerque, NM
12912	Victoria, TX	23062	Denver, CO
13723	Greensboro, NC	23066	Grand Junction, CO
13873	Athens, GA	23154	Ely, NV
13880	Charleston, SC	23194	Winslow, AZ
13897	Nashville, TN	24011	Bismarck, ND
13963	Little Rock, AR	24021	Lander, WY
13967	Oklahoma City, OK	24023	North Platte, NB
13985	Dodge City, KS	24090	Rapid City, SD
13996	Topeka, KS	24127	Salt Lake City, UT
14607	Caribou, ME	24128	Winnemucca, NV
14733	Buffalo, NY	24131	Boise, ID
14735	Albany, NY	24143	Great Falls, MT
14764	Portland, ME	24157	Spokane, WA
14826	Flint, MI	24225	Medford, OR
14842	Peoria, IL	24232	Salem, OR
14847	Sault St Marie, MI	93729	Cape Hatteras, NC
14898	Green Bay, WI	93739	Wallops Island, VA
14918	Intl Falls, MN	94008	Glasgow, MT
14936	Huron, SD	94240	Quillayute, WA
22010	Del Rio, TX	94789	New York, NY
23023	Midland, TX	94823	Pittsburgh, PA

various thicknesses as predictors because it's generally easier to predict thickness than, say, temperatures at specific levels. Other studies in which thickness was used are referred to by Brenton (1973) who extensively reviewed the state of the art in snow forecasting.

For predictors 19–26 in Table 1, both the temperature and wet-bulb temperature profiles were examined in relation to the 0°C isotherm to derive parameters defining the warm layer (or layers) and freezing level in the RAOB. In this respect, a warm layer is defined as a layer in which the temperature, or the wet-bulb temperature, is >0°C. Predictors 19 and 23 define the depth of the warm layer, and predictor 20 (24) defines the area between the temperature (wet-bulb temperature) profile and the 0°C isotherm in the warm layer. In cases where more than one warm layer exists, the depths and areas are summed. The areas were computed by a numerical integration technique known as the trapezoidal rule (Kaplan, 1959). Predictors 21 and 25 define the height of the top of the warm layer; for multiple warm layers, the highest warm layer was used. Predictors 22 and 26 define the height of the *lowest* freezing level.

Predictors similar to 20 and 24 were used by Burnash and Hug (1970) and Lumb (1961 and 1963) to help determine the downward penetration of snow. The idea, of course, is that the greater the depth, or area, of the warm layer the greater is the chance that precipitation in the form of snow would melt when falling through the layer. The height of the freezing level has been found to be useful for rain-snow discrimination by a number of investigators including Murray (1952), Boyden (1964), Pandolfo (1957), Booth (1973) and Lumb (1960).

Predictors 27–36 were designed specifically to help discriminate freezing precipitation from other types. The design was based on the conditions generally associated with freezing precipitation: ". . . a shallow wedge of cold air and a sharp rise in temperature aloft to a peak temperature, warmer than freezing, generally at some level between 850 and 700 mb . . ." (Young, 1978). It should be noted that freezing drizzle and freezing rain are both included in the freezing precipitation category in this study. However, the characteristics of a freezing drizzle RAOB can be quite different than those of a freezing rain RAOB. Young, for instance, showed representative RAOBs for freezing rain and freezing drizzle and found that temperatures near the surface and aloft were generally colder for freezing drizzle than for freezing rain.

In this study, we computed composite temperature and dew point profiles for both freezing rain and freezing drizzle. The data sample consisted of 127 freezing drizzle and 94 freezing rain RAOBs from the 48 stations in Table 2 for the period October–April, 1972–73 through 1976–77. The composite RAOBs, shown in Fig. 1, indicate the following: 1) In agreement with Young, freezing drizzle RAOBs were, in the mean, colder than freezing rain RAOBs. 2) The saturated layer for freezing rain was, in the

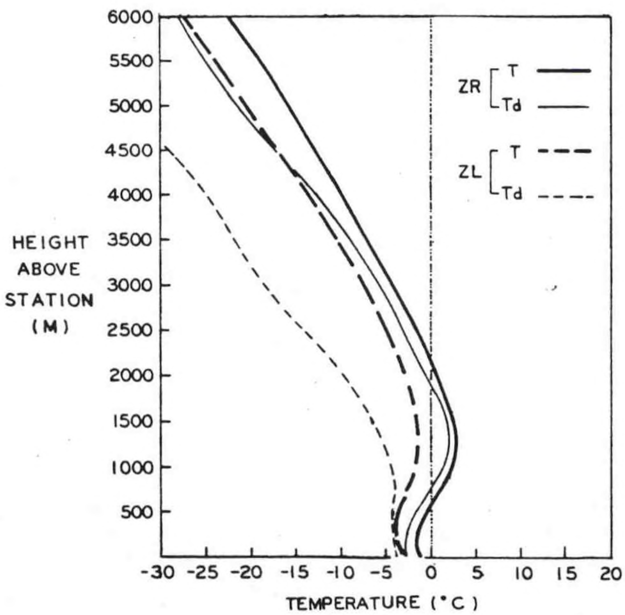

FIG. 1. Composite temperature and dew-point profiles for freezing drizzle (ZL) and freezing rain (ZR). The sample consisted of 127 freezng drizzle and 94 freezing rain RAOB's from the period October through April 1972–73 through 1976–77 for the 48 stations in Table 2.

mean, much deeper than the saturated layer for freezing drizzle. 3) The composite freezing rain RAOB, showing a warm layer over a surface-based cold layer, is similar to the typical freezing rain RAOB shown by Young and other investigators. However, the composite freezing drizzle RAOB shows no warm layer aloft; this differs from the typical freezing drizzle RAOB shown by Young.

With respect to this last result, Young showed a RAOB which, he said, was ". . . an unusual case of freezing drizzle, with no temperature above 0°C at any level." We found that this circumstance was not so unusual. That is, 44% of the freezing drizzle RAOBs used to compute the composite had no temperature above 0°C at any level. Apparently, when freezing drizzle occurs with no temperatures above 0°C at any level, the coalescence of supercooled water drops is predominantly responsible for the growth of drizzle drops, and the clouds are warm enough so that they are unlikely to contain ice crystals (Mason and Howorth, 1952).

In view of the above discussion, predictor 27 is a binary variable that equals 1 if the surface temperature is ≤0°C *and* a warm layer exists aloft; otherwise, this variable is zero. The conditions for ZR(T) to equal 1 were characteristic of almost all freezing-rain RAOBs and a majority of the freezing drizzle RAOBs used to compute the composite soundings. The design of predictors to specifically discriminate freezing drizzle from other precipitation types *when no warm layer exists aloft* was left for future research.

Predictor 28 is the depth of the surface-based cold layer, with respect to temperature, when ZR(T) = 1; and predictor 29 is the area between the temperature profile and the 0°C isotherm in the surface-based cold layer when ZR(T) = 1. If ZR(T) = 0, both of these predictors are zero. Predictors 30 and 31 are interactive or product variables; when ZR(T) = 1, for example, they define the depth and area of the warm layer, respectively, with regard to temperature. Young also experimented with variables similar to predictors 28–31 and found them to have some merit. However, he didn't include them in his forecast method. Also, Mahaffy (1961) emphasized the importance of the depth of the warm layer for the occurrence of freezing rain.

3. Specification equations

To develop the specification equations, the RAOB predictors in Table 1 were included in the REEP screening program. In the REEP procedure, a subset of effective predictors is selected objectively from a large set of potential predictors to use in multiple linear regression equations. The equations developed give estimates of the probabilities of occurrence of a given set of binary predictands. In this application, precipitation type is categorized into three binary predictands: liquid, freezing and frozen. The predictands are called binary because, in the developmental phase, each predictand is assigned a value of 1 or 0 in a given case depending, respectively, upon whether that particular precipitation type occurs or doesn't occur. The potential predictors can be either in binary or continuous form. A good description of the screening procedure can be found in Glahn and Lowry (1972); also, Klein and Glahn (1974) give applications of REEP as developed by TDL.

Two data samples, called samples 1 and 2, were used in the development of the specification equations. Sample 1 was used to develop the equations, and sample 2 was used to determine the number of predictors to include in the equations. Sample 1 consisted of 1200 GMT RAOBs matched with precipitation type observed at 1200 GMT; for sample 2, 0000 GMT data were used. For both samples, data were combined from the 48 RAOB stations listed in Table 2 for the winter seasons (September through April) of 1972–73 through 1976–77 (6067 precipitation cases for sample 1 and 5245 precipitation cases for sample 2). The RAOB data were obtained on magnetic tape from the National Climatic Center in Asheville, North Carolina, and consisted of pressure, temperature, relative humidity and wind measurements at both mandatory and significant levels. Within TDL, these data were error checked and reformatted into a form more acceptable to our statistical analysis programs.

With sample 1, 10 REEP equations were developed containing 2, 4, 6, . . . , 18 and 20 predictors. Each equation was then evaluated with data from sample 2, and the Brier score (Brier, 1950) was computed. The results, shown in Fig. 2, indicate that the Brier score steadily improved (decreased) out to about 12 predictors; after that, there was very little change in the score. Therefore, we included 12 predictors in the specification equations.

Table 3 shows the 12 predictors in the order determined by the REEP screening procedure. The additional reduction of variance (RV) after each predictor was chosen, the total reduction of variance, and the observed relative frequency for each precipitation type are also shown. Note that all the predictors are in binary form, that is, they can have only the values 0 or 1. For example, if the $\bar{T}$(sfc–1000) is ≤ −1.0°C for a particular case, then the first predictor has a value of 1; otherwise, it has a value of 0.

The $\bar{T}$(sfc–1000) was chosen first because of its contribution to the RV of the liquid category. Note that this predictor, by itself, accounted for much of the total RV of the liquid and frozen categories but very little of the total RV of freezing precipitation. Obviously, the $\bar{T}$(sfc–1000) *alone* is not sufficient for discriminating freezing precipitation from other types.

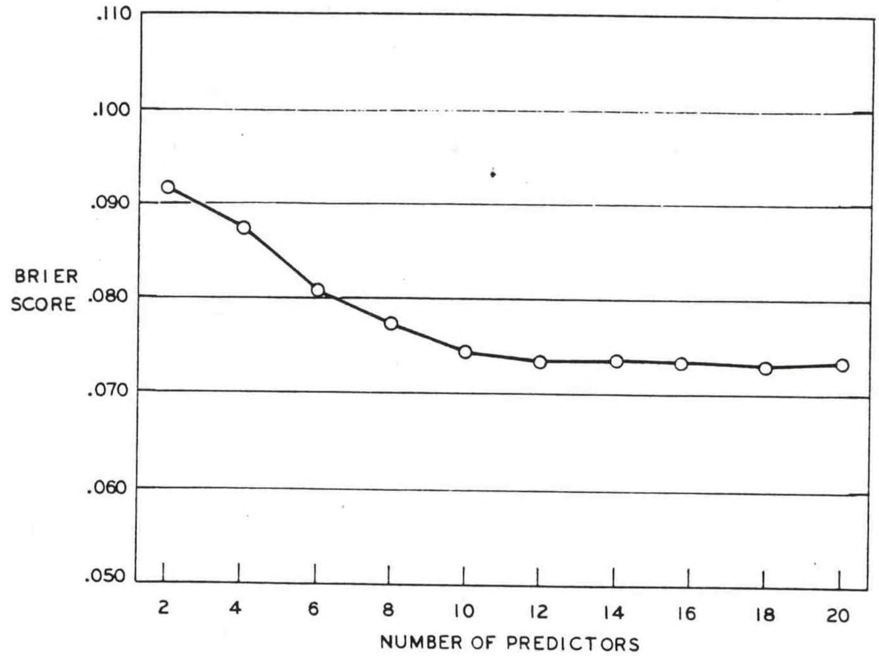

FIG. 2. The Brier score computed for forecasts from each of 10 REEP precipitation type specification equations containing 2, 4, 6, . . . , 18 and 20 predictors. The sample consisted of independent data combined from 48 stations (Table 2) for the winter seasons of 1972–73 through 1976–77.

The second and third predictors, ZR(T)·W.L. DEPTH(T) and C.L. DEPTH(T_w), were chosen because of their contribution to the RV of freezing precipitation. These predictors were designed specifically for the freezing precipitation category, and, together, these two binaries accounted for much of the total RV of freezing precipitation. Note that ZR(T)·W.L. DEPTH(T) was also picked as the sixth and eighth predictors and the C.L. DEPTH(T_w) as the twelfth predictor in the form of different binaries. These results indicate that the depth of the warm layer and, to a lesser degree, the depth of the surface-based cold layer, if such layers exist, are important factors with respect to the occurrence of freezing precipitation.

The fourth predictor, W.L. DEPTH(T), was

TABLE 3. The 12 predictors included in the precipitation type specification equations in the order determined by the REEP procedure. The developmental sample consisted of 1200 GMT data combined from the 48 stations (Table 2) for the winter seasons of 1972–73 through 1976–77. The number in brackets refers to the number of the predictor in Table 1.

Predictor	Binary limit	Additional reduction of variance (%)		
		Liquid	Freezing	Frozen
1. $\bar{T}$ (sfc–1000) [3]	≤ −1.0°C	82.05	1.43	77.44
2. ZR(T)·W.L. DEPTH(T) [30]	≤550 m	1.28	31.85	0.76
3. C.L. DEPTH (T_w) [33]	≤250 m	0.15	5.30	0.18
4. W.L. DEPTH(T) [19]	≤300 m	3.88	0.07	4.43
5. $\bar{T}$ (500–2500) [7]	≤ −6.0°C	0.28	1.04	0.83
6. ZR(T)·W.L. DEPTH(T) [30]	≤300 m	0.86	0.10	0.69
7. W.L. DEPTH(T) [19]	≤150 m	0.58	0.08	0.45
8. ZR(T)·W.L. DEPTH(T) [30]	≤1200 m	0.00	0.49	0.05
9. W.L. AREA(T) [20]	≤750°C m	0.34	0.00	0.35
10. ZR(T)·W.L. AREA(T) [31]	≤50°C m	0.05	0.32	0.00
11. C.L. AREA(T_w) [34]	≤4000°C m	0.00	0.35	0.06
12. C.L. DEPTH(T_w) [33]	≤800 m	0.01	0.43	0.11
Total reduction of variance		89.47	41.47	85.36
Relative frequency of occurrence (%)		62.83	2.98	34.18

TABLE 4. The constants and coefficients in the REEP specification equations for liquid, freezing and frozen precipitation. The number in brackets refers to the number of the predictor in Table 1. The predictors are arranged by type.

Predictor	Binary limit	Coefficients		
		Liquid	Freezing	Frozen
Constant		20.19	63.35	16.46
1. $\bar{T}$ (sfc−1000) [3]	≤ −1.0°C	−17.93	+7.99	+9.94
2. $\bar{T}$ (500−2500) [7]	≤ −6.0°C	−5.83	−6.82	+12.65
3. W.L. DEPTH(T) [19]	≤150 m	−28.48	+4.88	+23.60
4. W.L. DEPTH(T) [19]	≤300 m	−30.27	−4.56	+34.83
5. W.L. AREA(T) [20]	≤750°C m	−16.04	−0.13	+16.17
6. ZR(T)·W.L. DEPTH(T) [30]	≤300 m	+34.90	+18.72	−53.62
7. ZR(T)·W.L. DEPTH(T) [30]	≤550 m	−6.38	−22.35	+28.73
8. ZR(T)·W.L. DEPTH(T) [30]	≤1200 m	+6.55	−13.84	+7.29
9. ZR(T)·W.L. AREA(T) [31]	≤50°C m	+23.83	−27.23	+3.40
10. C.L. DEPTH(T_w) [33]	≤50 m	+20.95	−25.82	+4.87
11. C.L. DEPTH(T_w) [33]	≤800 m	−5.88	−15.60	+21.49
12. C.L. AREA(T_w) [34]	≤4000°C m	+5.04	+22.96	−28.01

chosen because of its contribution to the RV of frozen precipitation; it also makes a significant contribution to the liquid category. Remember that this predictor defines the depth of the warm layer, if one exists, *irrespective of whether the sfc T is ≤0°C*. It's also chosen as the seventh predictor in the equation. As indicated previously, the depth of the warm layer is a factor in determining whether precipitation in the form of snow would melt when falling through the layer.

Each of the other predictors chosen made relatively smaller contributions to the reductions of variance and included $\bar{T}$(500−2500), W.L. AREA(T), ZR(T)·W.L. AREA(T) and C.L. AREA(T_w). Note that the predictors defining the areas of the warm and cold layers were among the last several predictors chosen. Apparently, these area-type predictors could contribute relatively little once predictors defining the depths of the warm and cold layers and mean temperatures for specific layers were already in the equations.

The total RV was very high for liquid and frozen precipitation, about 89% and 85% respectively, but much lower for freezing precipitation, about 41%. The relatively low frequency of occurrence of freezing precipitation, about 3%, contributes to the difficulty in its specification. Also, part of the problem is due to the fact that many of the RAOBs associated with freezing drizzle, which was included with freezing rain in the freezing category, had temperatures ≤ 0°C at all levels (see discussion for Fig. 1 in Section 2). The predictors used in this study would have difficulty in discriminating between freezing drizzle and frozen precipitation for such RAOBs.

Table 4 shows the constants and coefficients in the specification equations. With this information, the probability of liquid, freezing and frozen precipitation can be computed for any given case. From Table 4, we can determine those atmospheric conditions which would provide the maximum possible probability of each precipitation type; however, it should be noted that there is no guarantee that this set of conditions would exist simultaneously in reality. For instance, with regard to freezing precipitation, if ZR(T) = 0 and ZR(T_w) = 0 for a particular case, then predictors 6–12 are automatically zero. This would result in about a −63% contribution to the probability of freezing precipitation. In fact, for this case, the maximum possible probability of freezing precipitation would be only about 9%. On the other hand, if ZR(T) = 1 and ZR(T_w) = 1 for a particular case, then the maximum possible probability of freezing precipitation would be about 94% under the following conditions: $\bar{T}$(sfc−1000) ≤ −1.0°C, $\bar{T}$(500−2500) > −6.0°C, W.L. DEPTH(T) > 1200 m, W.L. AREA(T) > 750°C m, C.L. DEPTH(T_w) > 800 m and C.L. AREA(T_w) ≤ 4000°C m. This last condition seems to put a limit on how cold the wet-bulb temperature in the surface-based cold layer can be, given the C.L. DEPTH(T_w) > 800 m. The reason may be that the colder and deeper this layer is the greater is the chance that the water drops would freeze before hitting the surface, i.e., sleet might result.

In a similar manner, conditions giving the maximum or minimum possible probability of frozen or liquid precipitation could also be deduced from Table 4.

4. Verification

We verified the REEP specification equations for both developmental and independent data samples. For this verification, the developmental sample consisted of samples 1 and 2 (see Section 3) combined. Remember that sample 1 was used to develop the equations, and sample 2 was used to determine the number of predictors to include. The independent

TABLE 5. Verification scores of the REEP specification equations. The developmental sample (D) consisted of samples 1 and 2 combined (see Section 3). The independent sample (I) consisted of data combined from 0000 and 1200 GMT for the 48 stations in Table 2 for the winter season of 1977–78. The number of precipitation cases for each sample is shown in parentheses.

	Category					
	Liquid		Freezing		Frozen	
	D (7282)	I (1605)	D (277)	I (78)	D (3753)	I (976)
Bias	0.99	0.99	0.88	0.79	1.02	1.04
Post-agreement	0.98	0.98	0.62	0.60	0.92	0.92
Prefigurance	0.97	0.97	0.54	0.47	0.95	0.96

sample consisted of 0000 and 1200 GMT data combined from the 48 stations in Table 2 for the winter season of 1977–78.

The REEP equations specify the probability of each of the precipitation types given that precipitation occurs. For this verification, the probability estimates were transformed into a best category by picking the precipitation type category with the highest probability. The verification scores included the bias, post-agreement and prefigurance.[3]

The verification results for both developmental and independent samples, shown in Table 5, indicate that the scores were generally similar for both samples except for some deterioration in the scores for freezing precipitation. For the purposes of further discussion, verification scores were computed for the developmental and independent data samples combined. The contingency table and verification scores for the combined sample, shown in Tables 6 and 7, respectively, indicate the following:

1) The bias shows that the liquid and frozen categories were specified to occur about as often as they did occur. However, the system tended to slightly underestimate the frequency of freezing precipitation.

2) The post-agreement indicates that, when the system specified liquid and frozen precipitation, it was correct 98 and 92% of the time, respectively. However, for freezing precipitation, it was correct 61% of the time.

3) The prefigurance shows that, when liquid and frozen precipitation occurred, they were correctly specified 97 and 95% of the time, respectively. When freezing precipitation occurred, it was correctly specified 53% of the time.

It's interesting to note in Table 6 that ~42% of the observed freezing precipitation cases were specified as frozen by the system. Many of these cases were freezing drizzle cases that occurred with RAOBs which had temperatures ≤ 0°C at all levels. For such RAOBs, the specification equations in Table 4 would give a *maximum* probability of ~8% for freezing precipitation, and a *minimum* probability of ~75% for frozen precipitation!

[3] The bias = B/C, the post-agreement = A/B, and the prefigurance = A/C, where A is the number of correct specifications of the event, B the total number of specifications of the event, and C the number of observations of the event.

TABLE 6. The contingency table resulting from evaluation of the REEP specification equations for the developmental and independent samples (see Table 5) combined.

	Specified			
Observed	Liquid	Freezing	Frozen	Total
Liquid	8615	51	221	8887
Freezing	18	188	149	355
Frozen	173	67	4489	4729
Total	8806	306	4859	13971

TABLE 7. The verification scores computed from the contingency table in Table 6.

Verification scores	Category		
	Liquid	Freezing	Frozen
Bias	0.99	0.86	1.03
Post-agreement	0.98	0.61	0.92
Prefigurance	0.97	0.53	0.95

5. Summary and conclusions

Linear screening regression was used to derive relationships between predictors computed from RAOBs and concurrent observations of precipitation type (liquid, freezing and frozen). Statistical screening indicated that the following parameters were important: the mean temperature in the surface–1000 m and 500–2500 m layers; the depth of the warm layer, if one exists, with respect to the temperature profile; the area between the temperature profile and the 0°C isotherm in the warm layer; the depth of the surface-based cold layer, if one exists, with respect to the wet-bulb temperature profile; and the area between the wet-bulb temperature profile and the 0°C isotherm in the surface-based cold layer.

Verification of the specification equations on both developmental and independent data samples indicated that the scores were generally stable, except that some deterioration of the scores occurred for freezing precipitation. The system showed excellent discrimination ability for liquid and frozen precipitation but had some difficulty with freezing precipitation.

Part of the problem with the freezing precipitation category was due to the fact that freezing drizzle, which was included with freezing rain in this category, can occur with a RAOB in which the temperature is ≤0°C at all levels (no warm layer). In part of this study, it was found that about 44% of freezing drizzle RAOBs examined had no warm layer. For such "cold" RAOBs, the specification equations produce a very low probability of freezing precipitation and a very high probability of frozen precipitation. Further research needs to be done to develop predictors to help discriminate between freezing drizzle and frozen precipitation in cases when the RAOB has no warm layer.

In addition to being interesting in an academic sense, the results obtained in this study should be useful in the following ways:

1) At stations that routinely take RAOBs, or nearby stations, the regression equations in Table 4 can be rather easily evaluated in real time (for instance, on an AFOS minicomputer) for the purpose of "nowcasting."

2) The regression equations can be used in the perfect-prog sense to obtain short-range to medium-range forecasts of precipitation type from prognostic soundings made, for instance, from TDL's BLM. Also, after BLM prognostic soundings have been archived for a suitable period, the MOS approach can be used to develop precipitation type prediction equations.

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```
C       PROGAM PTYPE
C       COMPUTES PROBABILITY OF PRECIPITATION TYPES FROM AN OBSERVED RAOB.
C
C       FROZEN PRECIP...IS DEFINED AS SNOW,ICE PELLETS,OR SNOW MIXED WITH ICE
C       PELLETS.
C       FREEZING PRECIP... IS DEFINED AS FREEZING RAIN,FREEZING DRIZZLE,OR
C       FREEZING RAIN OR DRIZZLE MIXED WITH SNOW OR ICE PELLETS.
C       LIQUID PRECIP....IS DEFINED AS RAIN OR RAIN MIXED WITH SNOW OR ICE
C       PELLETS.
C       THE SYSTEM WAS DEVELOPED WITH PRECIPITATION CASES THAT OCCURRED AT
C       ABOUT THE SAME TIME AS THE RAOB VALID TIME.
C
C       VARIABLES...
C       T( )        = TEMPERATURE IN DEG C AT EACH SIG LVL.
C       PP( )        = PRESSURE IN MB AT EACH SIG LVL.
C       D( )        = DEW POINT IN DEG C AT EACH SIG LVL.
C       NLVLS       = NUMBER OF SIG LVLS IN RAOB.
C       TK( )       = TEMPERATURE IN KELVIN AT EACH SIG LVL.
C       TV( )       = VIRTUAL TEMPERATURE AT EACH SIG LVL IN KELVIN.
C       H( )        = HEIGHT OF EACH SIG LVL ABOVE STATION(M).
C       W( )        = WET BULB TEMPERATURE AT EACH SIG LVL IN DEG C.
C       ICC         = NUMBER OF SIG LVLS AT AND BELOW HEIGHT CUTOFF(COFF).
C       COFF        = HEIGHT CUTOFF. SOUNDING NOT ANALYZED ABOVE COFF.
C       HHT( )      = HEIGHTS OF CROSSOVER POINTS(ACROSS 0 DEG C) FOR
C                     TEMPERATURE.
C       SST( )      = SENSE OF EACH CROSSOVER POINT.
C       NNNT        = NUMBER OF LAYERS IN WHICH TEMPERATURE LESS THAN 0C
C                     (COLD LAYERS).
C       NNPT        = NUMBER OF LAYERS IN WHICH TEMPERATURES GREATER THAN
C                     0C (WARM LAYERS).
C       HHW( )      = SAME AS HHT EXCEPT FOR WET BULB TEMPERATURE.
C       SSW( )      = SAME AS SST EXCEPT FOR WET BULB TEMPERATURE.
C       NNNW        = SAME AS NNNT EXCEPT FOR WET BULB TEMPERATURE.
C       NNPW        = SAME AS NNPT EXCEPT FOR WET BULB TEMPERATURE.
C       TEMP( )     = ARRAY CONTAINING VARIABLES COMPUTED FROM SOUNDING
C                     AND USED AS PREDICTORS.
C       BL( )       = ARRAY CONTAINING 1 OR 0 FOR EACH PREDICTOR DEPENDING
C                     ON WHETHER BINARY LIMIT IS SATISFIED.
C       ALIQ( )     = ARRAY CONTAINING PREDICTOR COEFFICIENTS FOR THE LIQUID
C                     PROBABILITY EQUATION.
C       AFRZG( )    = ARRAY CONTAINING PREDICTOR COEFFICIENTS FOR THE FREEZING
C                     PROBABILITY EQUATION.
C       AFRZN( )    = ARRAY CONTAINING PREDICTOR COEFFICIENTS FOR THE
C                     FROZEN PROBABILITY EQUATION.
C       ILIQU       = PROBABILITY OF LIQUID PRECIP IN PERCENT.
C       IFRZG       = PROBABILITY OF FREEZING PRECIP IN PERCENT.
C       IFRZN       = PROBABILITY OF FROZEN PRECIP IN PERCENT.
C       JST         = STATION AFOS ID.
C       JDATE       = 2 DIGIT DAY OF MONTH.
C       JHOUR       = 2 DIGIT GMT TIME, 00 OR 12Z.
       DIMENSION T(51),PP(51),D(51),H(51),W(51),HHT(10),SST(10),
      1HHW(10),SSW(10),TEMP(10),BL(12),TK(51),TV(51)
       COMMON/TRASH/ALIQU(12),AFRZG(12),AFRZN(12)
       COMMON/S/JST(5),JDATE,JHOUR,JNO,JJNO,P(0:50),TS(0:50),TSD(0:50)
       INTEGER DAT(32),SW(2)
```

```
      DATA ALIQU/-17.93,-5.83,-28.48,-30.27,-16.04,34.90,-6.38,6.55,
     123.83,20.95,-5.88,5.04/
      DATA AFRZG/7.99,-6.82,4.88,-4.56,-0.13,18.72,-22.35,-13.84,
     1-27.23,-25.82,-15.6,22.96/
      DATA AFRZN/9.94,12.65,23.60,34.83,16.17,-53.62,28.73,7.29,
     13.40,4.87,21.49,-28.01/
C       READ SIG LVL DATA FROM RAOB.
C       DEFINE STATION HEIGHT AS 0M.
      H(1)=0
      COFF=6000.
      CALL FCOM(IC,IER)
      CALL COMCM(IC,DAT,11,SW,IER)
      CALL COMCM(IC,DAT,11,SW,IER)
      CALL KLOSE(IC,IER)
      DO 50 I=1,5
 50   JST(I)=DAT(I)
      CALL DECOS(10,$520)
      NLVLS=JNO+1
      DO 100 I=1,NLVLS
      T(I)=TS(I-1)
      D(I)=TSD(I-1)
      PP(I)=P(I-1)
 100  CONTINUE
C
C       CHECK FOR MISSING DEW POINT AT OR BELOW 700 MBS. EXIT PROGRAM
C       IF DEW POINT MISSING AT OR BELOW 700 MB. IF DEW POINT MISSING
C       ABOVE 700 MB ASSUME DRY.
      DO 270 I=1,NLVLS
      IF(D(I).NE.999.)GO TO 270
      IF(PP(I).GE.700.)GO TO 500
      D(I)=T(I)-30.
 270  CONTINUE
C       COMPUTE KELVIN TEMPERATURE
      DO 280 I=1,NLVLS
      TK(I)=T(I)+273.16
 280  CONTINUE
C       NOW COMPUTE VIRTUAL TEMPERATURE
      DO 300 I=1,NLVLS
      E=6.11*(10.**((7.5*D(I))/(D(I)+237.3)))
      W1=(.622*E)/(PP(I)-E)
      TV(I)=TK(I)*((1.+(1.609*W1))/(1.+W1))
 300  CONTINUE
C
C       NOW GET HEIGHT ABOVE STATION OF EACH SIG LVL IN METERS.
      DO 350 I=2,NLVLS
C       GET MEAN TV BETWEEN LEVELS
      TBAR=(TV(I)+TV(I-1))*.5
      H(I)=H(I-1)+(TBAR/.034163)*ALOG(PP(I-1)/PP(I))
 350  CONTINUE
C       NOW COMPUTE WET BULB TEMPERATURE AT EACH SIG LVL
      DO 360 I=1,NLVLS
      C=(T(I)-D(I))*0.18
      W(I)=T(I)-(.035*C-.00072*C*(C-1.0))*(T(I)+D(I)+95.556-
     1(PP(I)/30.474))
      IF(W(I).LT.D(I))W(I)=D(I)
 360  CONTINUE
C       CREATE FILE "PRECIPTYP" IN DATABASE
      CALL DELETE("PRECIPTYP",IER)
      CALL CRAND("PRECIPTYP",IER)
      CALL GCHN(ICHN1,IER)
```

```
      CALL OPEN(ICHN1,"PRECIPTYP",2,IER)
      WRITE(ICHN1,5)
 5    FORMAT(1X,"PRECIPTYP000","<177777><177777>","<177777>
     1<177777>","50","<305><200>",/1X)
      WRITE(ICHN1,6)
 6    FORMAT(/1X,"<12>","<<<<<<<<<<<<",/1X)
C     ESTABLISH HEIGHT CUTOFF FOR RAOB
      CALL CHECK2(H,T,D,W,PP,COFF,NLVLS,ICC)
      WRITE(ICHN1,362)
 362  FORMAT(1X,"<12>",1X,"PRESSURE",2X,"HEIGHT(M)",2X,"TEMP(C)",
     12X,"DEW PT(C)",2X,"WET BULB(C)")
      DO 370 I=1,ICC
      WRITE(ICHN1,363)PP(I),H(I),T(I),D(I),W(I)
 363  FORMAT(1X,"<12>",F7.0,3X,F7.0,4X,F5.1,5X,F5.1,5X,F5.1)
 370  CONTINUE
      CALL LLAS(H,T,10,ICC,HHT,SST,ILST,NNNT,NNPT)
      CALL LLAS(H,W,10,ICC,HHW,SSW,ILSW,NNNW,NNPW)
C     COMPUTE DEPTH OF LAYERS > 0C
      CALL DMAL(T,H,+1.0,TEMP,1,NLVLS)
C     COMPUTE AREA OF LAYERS > 0C
      CALL TAAL(T,H,+1.0,ICC,TEMP,2)
C     COMPUTE MEAN TEMP 0-1000 M
      CALL ATHICK(T,H,0.0,1000.0,ICC,TEMP,3)
C     COMPUTE MEAN TEMP 500-2500 M
      CALL ATHICK(T,H,500.0,2500.0,ICC,TEMP,4)
C     DETERMINE IF RAOB IS FREEZING RAIN TYPE(ZR=1)
      CALL ZRPOT(T,NNNT,TEMP,5)
      CALL ZRPOT(W,NNNW,TEMP,6)
C     FOR ZR=1 RAOB COMPUTE DEPTH OF WARM LAYERS
      CALL PPAL(TEMP(1),TEMP(5),TEMP,7)
C     COMPUTE AREA OF WARM LAYERS FOR ZR=1 RAOB
      CALL PPAL(TEMP(2),TEMP(5),TEMP,8)
C     COMPUTE HEIGHT OF SURFACE BASED COLD LAYER FOR ZR=1 RAOB
      CALL ZPFLH(TEMP(6),HHW,ILSW,TEMP,9)
C     COMPUTE AREA OF SURFACE BASED COLD LAYER FOR ZR=1 RAOB
      CALL AHAL(SSW,HHW,TEMP(6),ILSW,W,H,ICC,-1.0,+1.0,TEMP,10)
C
C      AT THIS POINT, NECESSARY PREDICTORS HAVE BEEN COMPUTED.
C
C     NOW DETERMINE IF BINARY LIMITS ARE SATISFIED FOR EACH PREDICTOR.
C     PUT ANSWERS IN BL( ). FIRST SET BL( ) TO 0.
      DO 400 I=1,12
      BL(I)=0.
 400  CONTINUE
      IF(TEMP(3).LE.-1.0)BL(1)=1.
      IF(TEMP(4).LE.-6.0)BL(2)=1.
      IF(TEMP(1).LE.150.)BL(3)=1.
      IF(TEMP(1).LE.300.)BL(4)=1.
      IF(TEMP(2).LE.75.)BL(5)=1.
      IF(TEMP(7).LE.300.)BL(6)=1.
      IF(TEMP(7).LE.550.)BL(7)=1.
      IF(TEMP(7).LE.1200.)BL(8)=1.
      IF(TEMP(8).LE.5.)BL(9)=1.
      IF(TEMP(9).LE.50.)BL(10)=1.
      IF(TEMP(9).LE.800.)BL(11)=1.
      IF(TEMP(10).LE.400.)BL(12)=1.
C     SET THE CONSTANTS FOR THE THREE EQUATIONS.
      PLIQU=20.19
      PFRZG=63.35
      PFRZN=16.46
```

```
C      NOW COMPUTE THE PROBABILITIES.
       DO 405 I=1,12
       PLIQU=PLIQU+(BL(I)*ALIQU(I))
       PFRZG=PFRZG+(BL(I)*AFRZG(I))
       PFRZN=PFRZN+(BL(I)*AFRZN(I))
 405   CONTINUE
       ILIQU=IFIX(PLIQU+0.5)
       IFRZG=IFIX(PFRZG+0.5)
       IFRZN=IFIX(PFRZN+0.5)
C      THE DATA IS NOW OUTPUT TO A DATA FILE NAMED "PRECIPTYP"
C      THIS FILE CAN BE DISPLAYED ON AN ADM FOR REVIEW.
       WRITE(ICHN1,410)
       WRITE(ICHN1,420)(JST(I),I=4,5),JDATE,JHOUR
       WRITE(ICHN1,430)ILIQU,IFRZG,IFRZN
       WRITE(ICHN1,440)
 410   FORMAT(1X,"<12>",///," PROBABILITY OF LIQUID, FREEZING, AND
      1 FROZEN","<15><15>","<12>",Z)
 420   FORMAT(1X,"<12>","PRECIPITATION FOR ",2A2,"/",I3,1X,I3,"Z",
      1"<15><15>","<12><15>","<15><12>",Z)
 430   FORMAT(1X,"<12>","LIQUID=",I3,2X,"FREEZING=",I3,2X,"FROZEN=",I3)
 440   FORMAT(1X,"<12><203>")
       CALL CLOSE(ICHN1,IER)
       CALL FSTORE("PRECIPTYP",0,IER)
       CALL FORKP("PTYPE","PRECIPTYP",IER)
       GO TO 920
 500   CALL FORKE("PTYPE","MISS DEW PTS.",IER)
       WRITE(10,510)(JST(I),I=4,5)
 510   FORMAT("<15><12>",1X," MISS. DEW PTS. BLO 700 MB STATION
      1 =",2A2)
       GO TO 920
 520   CALL FORKE("PTYPE","ERROR READING",IER)
 920   CONTINUE
       STOP
       END
```

```
      SUBROUTINE DECOS (IFC,Q)
C   DECODES RAOB SIGNIFICANT LEVELS UP TO 100MB
      COMMON/S/JST(5),JDATE,JHOUR,JNO,JJNO,P(0:50),TS(0:50),TSD(0:50)
      DIMENSION IOUT(40)
      INTEGER Q
      K=0
      CALL AFREAD (1,JST,$100)
      CALL AFREAD (2,IOUT,$50,$125)
C   TEST FOR NEW RAOB CODE FORMAT
      IF (IOUT(4).EQ."TT".AND.IOUT(5).EQ."BB") GO TO 9
      GO TO 10   ;   OLD RAOB CODE
9     IF (IOUT(6).EQ." 5".OR.IOUT(6).EQ." 6".OR.IOUT(6).EQ." 7".
     1 OR.IOUT(6).EQ." 8") GO TO 11
      K=-5          ;   DOUBLE SPACE AFTER TTBB
      K1=-3
      K2=-2
      GO TO 12
11    K=-6          ;   SINGLE SPACE AFTER TTBB
      K1=-3
      K2=-2
      GO TO 12
C   OLD RAOB CODE FORMAT
10    IF (IOUT(6).EQ." U".AND.IOUT(7).EQ."J1") K=K+4
      K1=K/2
      K2=K1
      IF (IOUT(9+K1).EQ." 5".OR.IOUT(9+K1).EQ." 6".OR.IOUT(9+K1).EQ." 7".
     1 OR.IOUT(9+K1).EQ." 8") GO TO 12  ;  TESTING FOR DOUBLE SPACE AFTER TTBB
      K=K-1
C
C   TEST FOR MISSING RAOB 10142
12    IIA=ITCVT(30+K,4,$900)
      IIB=ITCVT(34+K,1,$900)
      IIIA=ITCVT(36+K,4,$900)
      IF (IIA.EQ.5151.AND.IIB.EQ.5.AND.IIIA.EQ.1014) GO TO 126
C
      JDATE=ITCVT(18+K,2,$900)-50
      JHOUR=ITCVT(20+K,2,$900)
      JNO=0
      DO 1 I=0,2
      I1=6*I
      I2=I1+I1
      II=ITCVT(30+K+I2,2,$900)
      IJJ=I*11
      IF (IJJ.NE.II) GO TO 127  ;  TEST FOR IMPROPER FORMAT
      IF (IOUT(17+K1+I1).EQ."//".OR.IOUT(17+K1+I1).EQ."/ ") GO TO 1 ; SIG LVL PRS MISG
      P(JNO)=FTCVT(32+K+I2,3,$901)
      IF (P(JNO).LT.100.) P(JNO)=P(JNO)+1000.
      TS(JNO)=FTCVT(36+K+I2,3,$901)
      IF (IOUT(20+K1+I1).EQ."//".OR.IOUT(20+K2+I1).EQ."/ ") GO TO 2  ;  DEWPT MISG
      TSD(JNO)=FTCVT(39+K+I2,2,$901)
      GO TO 3
2     TSD(JNO)=999.
3     CALL TEMP1(TS(JNO),TSD(JNO))  ;  TEMPERATURE DECODER
      JNO=JNO+1
1     CONTINUE
```

```
C    FIRST LINE OF RAOB IS FINISHED HERE
C    STATEMENT 4 STARTS 2ND AND SUBSEQUENT LINES
          JNO=JNO-1
          IJK=22
4         CALL AFREAD (2,IOUT,$50,$125)
          DO 5 I=0,4
          I1=6*I
          I2=I1+I1
          IJK=IJK+11
          IF (IJK.EQ.110) IJK=11
          IJK1=I2+1
          IF (IOUT(I1+2).EQ."//") GO TO 5  ;  SIG LVL PRESSURE MISG
          I515=ITCVT(I2+1,3,$900)
          IF (I515.EQ.515) GO TO 53  ;  TEST FOR 51515 101XX GROUP ENDING MSG
          JI=ITCVT(IJK1,2,$900)
          IF (IJK.NE.JI) GO TO 128  ;  TEST FOR IMPROPER FORMAT
          IF (JNO.EQ.50) GO TO 51
          JNO=JNO+1
          P(JNO)=FTCVT(I2+3,3,$901)
          IF (P(JNO).LT.100.) P(JNO)=P(JNO)+1000.
          TS(JNO)=FTCVT(I2+7,3,$901)
          IO=IOUT(I1+6)
          IF (IO.EQ."/ ".OR.IO.EQ."/=") GO TO 6
          TSD(JNO)=FTCVT(I2+10,2,$901)
          GO TO 7
6         TSD(JNO)=999.
7         CALL TEMP1(TS(JNO),TSD(JNO))
          IF (IO.EQ."/=".OR.IO.EQ."0=".OR.IO.EQ."1=".OR.IO.EQ."2=".OR.IO.EQ.
     1    "3=".OR.IO.EQ."4=".OR.IO.EQ."5=".OR.IO.EQ."6=".OR.IO.EQ."7=".OR.IO.
     2    EQ."8=".OR.IO.EQ."9=") GO TO 53  ;  TEMPERATURES FINISHED
5         CONTINUE
          GO TO 4   ;   RETURNS TO 4 TO DO 3RD AND SUBSEQUENT LINES
53        CONTINUE
C    IF WIND DATA REQUIRED, READ IT HERE...
          RETURN
51        WRITE (IFC,52) (JST(I),I=4,5),P(JNO)
52        FORMAT ("<15><12>",1X,2A2,1X,"51 SIGNIFICANT LEVELS HAVE BEEN DECOD
     1    ED, LEVELS ABOVE ",F5.0,"MB DISREGARDED.")
          RETURN
50        WRITE (IFC,54) (JST(I),I=4,5)
54        FORMAT ("<15><12>",3X,2A2," AFREAD ERROR 50 - DECOS")
          RETURN Q
100       WRITE (IFC,55) (JST(I),I=4,5)
55        FORMAT ("<15><12>",3X,2A2," AFREAD ERROR 100 - DECOS")
          RETURN Q
125       WRITE (IFC,56) (JST(I),I=4,5)
56        FORMAT ("<15><12>",3X,2A2," AFREAD ERROR 125 - DECOS")
          RETURN Q
126       WRITE (IFC,57) (JST(I),I=4,5)
57        FORMAT ("<15><12>",3X,2A2," STATION MISSING - DECOS")
          RETURN Q
127       WRITE (IFC,129) (JST(I),I=4,5),IJJ,II
129       FORMAT ("<15><12>",3X,2A2," IMPROPER FORMAT (1ST LINE) LOOKING FOR:
     1    ",I3," FOUND: ",I3," DECOS")
          RETURN Q
128       WRITE (IFC,130) (JST(I),I=4,5),IJK,JI
130       FORMAT ("<15><12>",3X,2A2," IMPROPER FORMAT (2ND + LINE) LOOKING FOR:
     1    ",I3," FOUND: ",I3," DECOS")
          RETURN Q
900       WRITE (IFC,131) (JST(I),I=4,5)
```

```
131     FORMAT ("<15><12>",3X,2A2," SGL RAOB ERROR - SUBROUTINE ITCVT")
        RETURN Q
901     WRITE (IFC,132) (JST(I),I=4,5)
132     FORMAT ("<15><12>",3X,2A2," SGL RAOB ERROR - SUBROUTINE FTCVT")
        RETURN Q
        END
```

DP3:ITCVT.FR 08/05/83 18:24

```
        FUNCTION ITCVT(IBGN,N,Q)
C
C   THIS FUNCTION IS USED WITH SUBROUTINE AFREAD.  ASCII
C   CHARACTERS IN THE CURRENT LINE ARE SCANNED AND INTERPRETED
C   AS INTEGERS.  THE SCAN BEGINS WITH CHARACTER IBGN AND N
C   CHARACTERS ARE SCANNED.  ABNORMAL RETURN TO STATEMENT ~Q~.
C   THIS IS A MODIFICATION OF FUNCTION INTCVT IN AFREAD.LB
C
        COMMON/QARDQ/IOUTU(80)
        INTEGER Q
        LOGICAL NEG
        ITCVT=0
        NEG=.FALSE.
        IEND=IBGN+N-1
100     IF (IOUTU(IEND).NE.32) GO TO 200
        IF (IEND.EQ.IBGN) RETURN
        IEND=IEND-1
        GO TO 100
200     DO 250 I=IBGN,IEND
        IF (IOUTU(I).NE.32) GO TO 300
250     CONTINUE
        RETURN
300     IF (IOUTU(I).EQ.43) GO TO 400
        IF (IOUTU(I).NE.45) GO TO 500
        NEG=.TRUE.
400     I=I+1
500     J=I
        DO 600 I=J,IEND
        IF (IOUTU(I).EQ.32) IOUTU(I)=48
        IF (IOUTU(I).LT.48.OR.IOUTU(I).GT.57) GO TO 800
        ITCVT=ITCVT*10+IOUTU(I)-48
600     CONTINUE
        IF (NEG) ITCVT=-ITCVT
        RETURN
800     RETURN Q
        END
```

```
      FUNCTION FTCVT(IBGN,N,Q)
C
C   THIS FUNCTION IS USED WITH SUBROUTINE AFREAD.  ASCII
C   CHARACTERS IN THE CURRENT LINE ARE SCANNED AND INTERPRETED
C   AS REAL NUMBERS.  IF NO DECIMAL POINT IS DETECTED, IT IS ASSUMED
C   TO FOLLOW THE LAST NUMERAL IN THE FIELD.  THE SCAN BEGINS
C   WITH CHARACTER IBGN.   N CHARACTERS ARE SCANNED.
C   ABNORMAL RETURN TO STATEMENT ~Q~.
C   THIS IS A MODIFICATION OF FUNCTION FLTCVT IN AFREAD.LB
C
      COMMON/QARDQ/IOUTU(80)
      INTEGER Q
      LOGICAL NEG
      FTCVT=0.
      NEG=.FALSE.
      IEND=IBGN+N-1
100   IF (IOUTU(IEND).NE.32) GO TO 200
      IF (IEND.EQ.IBGN) RETURN
      IEND=IEND-1
      GO TO 100
200   DO 250 I=IBGN,IEND
      IF (IOUTU(I).NE.32) GO TO 300
250   CONTINUE
      RETURN
300   IF (IOUTU(I).EQ.43) GO TO 400
      IF (IOUTU(I).NE.45) GO TO 500
      NEG=.TRUE.
400   I=I+1
500   J=I
      DO 600 I=J,IEND
      IF (IOUTU(I).EQ.32) IOUTU(I)=48
      IF (IOUTU(I).LT.48.OR.IOUTU(I).GT.57) GO TO 700
      FTCVT=FTCVT*10+IOUTU(I)-48
600   CONTINUE
      IF (NEG) FTCVT=-FTCVT
      RETURN
700   IF (IOUTU(I).NE.46) GO TO 800
      J=I+1
      DIV=10.
      DO 750 I=J,IEND
      IF (IOUTU(I).EQ.32) IOUTU(I)=48
      IF (IOUTU(I).LT.48.OR.IOUTU(I).GT.57) GO TO 800
      FTCVT=FTCVT+(IOUTU(I)-48)/DIV
      DIV=DIV*10.
750   CONTINUE
      IF (NEG) FTCVT=-FTCVT
      RETURN
800   RETURN Q
      END
```

```
      SUBROUTINE TEMP1 (T,TD)
C   COMPUTES + OR - TEMPERATURE, AND COMPUTES DEWPOINT
      TT=AMOD(T,2.)
      IF (TT.EQ.1.) T=-T
      T=T*.1
      IF (TD.EQ.999.) RETURN
      IF (TD.LE.50.) GO TO 1
      TD=T-(TD-50.)
      RETURN
1     TD=T-TD*.1
      RETURN
      END
```

DP3:CHECK2.FR 12/07/83 22:44

```
      SUBROUTINE CHECK2(H,T,D,W,PP,COFF,NLVLS,IJ)
C     THIS ROUTINE IS USED TO ESTABLISH A HEIGHT CUTOFF "COFF" ON
C     ARRAYS T,D,W,PP,AND H.VALUES IN THESE ARRAYS ARE SET TO 9999.
C     ABOVE LEVEL COFF.
      DIMENSION H(1),T(1),D(1),W(1),PP(1)
      FN=9999.
      ISW=0
      DO 160 I=2,NLVLS
      IF(H(I).LT.COFF)GO TO 160
      IF(ISW.EQ.1)GO TO 100
C
C     INTERPOLATE TO HEIGHT "COFF"
      T(I)=XINT(H(I-1),T(I-1),H(I),T(I),COFF)
      D(I)=XINT(H(I-1),D(I-1),H(I),D(I),COFF)
      W(I)=XINT(H(I-1),W(I-1),H(I),W(I),COFF)
      PP(I)=XINT(H(I-1),PP(I-1),H(I),PP(I),COFF)
      H(I)=COFF
      IJ=I
C     IJ IS NUMBER OF LEVELS IN RAOB UP TO AND INCLUDONG COFF.
      ISW=1
      GO TO 160
 100  T(I)=FN
      D(I)=FN
      W(I)=FN
      PP(I)=FN
      H(I)=FN
 160  CONTINUE
      RETURN
      END
```

DP3:XINT.FR 08/06/83 22:58

```
      FUNCTION XINT(X1,Y1,X2,Y2,X3)
C     THIS FUNCTION INTERPOLATES TO A VALUE "X3" BETWEEN "X1","X2",
C     AND "Y1","Y2"

      FN=9999.
      IF(X1.EQ.FN.OR.X2.EQ.FN.OR.Y1.EQ.FN.OR.Y2.EQ.FN)GO TO 20
      X13=X1-X3
      X23=X2-X3
      IF((X13.LE.0.0.AND.X23.GE.0.0).OR.(X13.GE.0.0.AND.X23.LE.0.0))
     1GO TO 40
 20   XINT=9999.
      RETURN
 40   IF(X3.NE.X1)GO TO 70
      XINT=Y1
 70   IF(X3.NE.X2)GO TO 100
      XINT=Y2
      RETURN
 100  AM=(Y1-Y2)/(X1-X2)
      XINT=AM*(X3-X1)+Y1
      RETURN
      END
```

```
      SUBROUTINE LLAS(VAR1,VAR2,MIC,NLVS,H,S,IC,NN,NP)
C     THIS SUBROUTINE DETERMINES THE NUMBER OF WARM AND COLD LAYERS
C     AND GETS HEIGHT AND SENSE OF CROSSOVER POINTS IN RAOB
C     NP = NO. OF LAYERS TEMP. GT 0C
C     NN = NO. OF LAYERS TEMP. LT 0C
C     H(1) = 0 ELEVATION ABOVE STATION
C     S(1) = + FOR SFC TEMP GT 0C, = - FOR SFC TEMP. LT OR EQ TO 0C
C     H(2) = HEIGHT OF 1ST CROSSOVER POINT IF ONE EXISTS.
C     S(2) = SENSE OF CROSSOVER, - MEANS GT 0C TO LE 0C, + MEANS LE 0C
C            TO GE 0C.
C     H(3,4,ETC.) = HEIGHT OF SUCCESSIVE CROSSOVER POINTS IF ANY
C     S(3,4,ETC.) = SENSE OF EACH SUCCESSIVE CROSSOVER POINTS
C     NLVS = NUMBER OF SIG LVLS WITHIN HEIGHT CUTOFF.
C
      DIMENSION VAR1(1),VAR2(1),H(1),S(1)
      NN=0
      NP=0
      IC=1
      II=1
      IF(VAR2(1)-0.0)42,42,43
 42   XX=-1.0
      GO TO 44
 43   XX=+1.0
 44   S1=SIGN(1.0,XX)
      H(IC)=VAR1(1)
      GO TO 140
 70   II=II+1
      IF(II.GT.NLVS)RETURN
      IF(VAR2(II)-0.0)72,72,73
 72   XX=-1.0
      GO TO 74
 73   XX=+1.0
 74   S1=SIGN(1.0,XX)
      IF(S1.EQ.S0)GO TO 70
      IC=IC+1
      IF(IC.GT.MIC)RETURN
      H(IC)=XINT(VAR2(II-1),VAR1(II-1),VAR2(II),VAR1(II),0.0)
 140  S(IC)=S1
      IF(S1.EQ.+1.0)GO TO 180
      NN=NN+1
      GO TO 190
 180  NP=NP+1
 190  S0=S1
      GO TO 70
      END
```

```
      SUBROUTINE DMAL(VAR1,VAR2,SGN,TEMP,INPR,NLVLS)
C     THIS SUBROUTINE FINDS THE DEPTH OF THE LAYERS OF SIGN "SGN" AND
C     USES IT AS A PREDICTOR.
C
      DIMENSION VAR1(1),VAR2(1),TEMP(1),H(10)
      ISW=0
      TEMP(INPR)=0.0
      IC=0
      DO 220 I=1,NLVLS
      IF(VAR1(I).EQ.9999.)GO TO 210
      IF(VAR1(I)-0.0)20,20,30
 20   XX=-1.0
      GO TO 40
 30   XX=+1.0
 40   S0=SIGN(1.0,XX)
C     CORRECT SIGN
      IF(S0.NE.SGN)GO TO 160
C     HAS IT BEEN USED
      IF(ISW.EQ.1)GO TO 220
C     NO..GET HEIGHT
      IF(I.NE.1)GO TO 130
      H1=VAR2(1)
      GO TO 140
 130  H1=XINT(VAR1(I),VAR2(I),VAR1(I-1),VAR2(I-1),0.0)
C     SET THE HAS BEEN USED FLAG
 140  ISW=1
      GO TO 220
C     WAS THERE A SIGN CHANGE
 160  IF(ISW.EQ.0)GO TO 220
C     YES..GET THE HEIGHT
      H2=XINT(VAR1(I),VAR2(I),VAR1(I-1),VAR2(I-1),0.0)
      IC=IC+1
      IF(IC.GT.10)GO TO 240
C     SAVE THE DEPTH
      H(IC)=H2-H1
 210  ISW=0
 220  CONTINUE
      IF(IC.EQ.0)RETURN
C     FIND TOTAL DEPTH
 240  TEMP(INPR)=H(1)
      IF(IC.LT.2)RETURN
      DO 290 I=2,IC
      TEMP(INPR)=TEMP(INPR)+H(I)
 290  CONTINUE
      RETURN
      END
```

```
      SUBROUTINE TAAL(VAR1,VAR2,SGN,NLVS,TEMP,INPR)
C     THIS SUBROUTINE FINDS TOTAL AREA OF LAYERS OF SIGN "SGN"
      DIMENSION VAR1(1),VAR2(1),TEMP(1)
      ISW=0
      AA=0.0
      NHS=100
      DO 280 I=1,NLVS
      IF(VAR1(I)-0.0)50,50,60
 50   XX=-1.0
      GO TO 70
 60   XX=+1.0
 70   S0=SIGN(1.0,XX)
C     CORRECT SIGN
      IF(S0.NE.SGN)GO TO 160
C     HAS IT BEEN USED
      IF(ISW.EQ.1)GO TO 280
C     NO..GET HEIGHT
      IF(I.NE.1)GO TO 130
      H1=VAR2(1)
      GO TO 140
 130  H1=XINT(VAR1(I),VAR2(I),VAR1(I-1),VAR2(I-1),0.0)
C     SET THE HAS BEEN USED FLAG
 140  ISW=1
      GO TO 280
C     WAS THERE A SIGN CHANGE
 160  IF(ISW.EQ.0)GO TO 280
C     YES..GET THE HEIGHT
      H2=XINT(VAR1(I),VAR2(I),VAR1(I-1),VAR2(I-1),0.0)
C     FIND THE AREA
      AA=AA+ARF(H1,H2,VAR1,VAR2,NLVS,0.0)
      ISW=0
 280  CONTINUE
      TEMP(INPR)=0.0
      AA=ABS(AA/10.)
      IF(AA.GT.0.0)TEMP(INPR)=AA
      RETURN
      END
```

DP3:ARF.FR 12/07/83 22:35

```
      FUNCTION ARF(B,E,V1,V2,NR,CON)
C     COMPUTES AREA THROUGH FUNCTION "AREA". THE INTERVAL
C     BETWEEN ALL DATA POINTS MUST BE EQUAL TO EACH OTHER.
      DIMENSION V1(1),V2(1),HH(101),AA(101)
      ARF=0.0
      IF(B.EQ.E)RETURN
      CH=(E-B)/100.0
      DO 60 I=2,100
      HH(I)=B+(I-1)*CH
 60   CONTINUE
      HH(1)=B
      HH(101)=E
      CALL EQUINT(V2,V1,NR,9999.0,HH,AA,101,9999.0)
      CALL DCV(AA,AA,-CON,101)
      ARF=AREA(AA,101,CH)
      RETURN
      END
```

DP3:DCV.FR 08/08/83 12:23

```
      SUBROUTINE DCV(A,B,CON,NR)
      DIMENSION A(1),B(1)
      DO 30 I=1,NR
      IF(A(I).EQ.9999.0)GO TO 30
      B(I)=A(I)+CON
 30   CONTINUE
      RETURN
      END
```

DP3:AREA.FR 08/08/83 12:18

```
      FUNCTION AREA(H,N,D)
C     THIS FUNCTION FINDS THE AREA UNDER A CURVE BY SIMPSONS RULE
C     THE INTERVAL BETWEEN ALL DATA POINTS MUST BE EQUAL TO EACH OTHER
      DIMENSION H(1)
      M=N-1
      S=0.0
      DO 60 I=1,M
      S=S+H(I)
 60   CONTINUE
      AREA=D*(S+(H(N)-H(1))/2.0)
      RETURN
      END
```

DP3:ATHICK.FR 08/09/83 11:32

```
      SUBROUTINE ATHICK(VAR1,VAR2,ALEV1,ALEV2,NLVS,TEMP,INPR)
C
C     FINDS MEAN VALUE OF VARIABLE IN VAR1 BETWEEN LEVELS ALEV1 AND
C     ALEV2
C
      DIMENSION VAR1(1),VAR2(1),TEMP(1),HH(101),AA(101)
      TEMP(INPR)=0.0
      IF(ALEV1.EQ.ALEV2)RETURN
      CH=(ALEV2-ALEV1)/100.0
      DO 70 I=2,100
      HH(I)=ALEV1+(I-1)*CH
 70   CONTINUE
      HH(1)=ALEV1
      HH(101)=ALEV2
      CALL EQUINT(VAR2,VAR1,NLVS,9999.0,HH,AA,101,9999.0)
      S=0.0
      IS=0
      DO 140 I=1,101
      IF(AA(I).EQ.9999.)GO TO 140
      IS=IS+1
      S=S+AA(I)
 140  CONTINUE
      IF(IS.EQ.0)GO TO 141
      TEMP(INPR)=S/FLOAT(IS)
      GO TO 142
 141  TEMP(INPR)=9999.
 142  CONTINUE
      RETURN
      END
```

DP3:EQUINT.FR 08/08/83 11:39

```
      SUBROUTINE EQUINT(A,B,JMAX,DM1,AP,BP,IMAX,DM2)
C     THIS SUBROUTINE RETURNS AN ARRAY "BP" OF POINTS INTERPOLATED
C     AT POINTS DEFINED BY ARRAY "AP" BETWEEN POINTS DEFINED BY
C     ARRAYS "A" AND "B". CHECKS FOR MISSING DATA ARE MADE.
      DIMENSION A(1),B(1),AP(1),BP(1)
      DO 90 I=1,IMAX
      DO 70 J=2,JMAX
      IF(A(J-1).EQ.DM1.OR.A(J).EQ.DM1.OR.B(J-1).EQ.DM1.OR.B(J).EQ.DM1)
     1GO TO 80
      IF(AP(I).LT.A(J-1).OR.AP(I).GT.A(J))GO TO 70
      BP(I)=XINT(A(J-1),B(J-1),A(J),B(J),AP(I))
      GO TO 90
 70   CONTINUE
 80   BP(I)=DM2
 90   CONTINUE
      RETURN
      END
```

DP3:ZRPOT.FR 08/26/83 12:06

```
      SUBROUTINE ZRPOT(VAR1,INFL,TEMP,INPR)
C
C     DETERMINES IF ZR=1 COND EXISTS: SFT TEMP LE 0C AND WARM LAYER
C     EXISTS ALOFT. SOUNDING FAVORABLE FOR FREEZING RAIN.
      DIMENSION TEMP(1),VAR1(1)
      TEMP(INPR)=9999.
      IF(INFL.EQ.9999.OR.VAR1(1).EQ.9999.)RETURN
      TEMP(INPR)=1.0
      AST=VAR1(1)
      IF(AST.LE.0.0.AND.INFL.GT.1)RETURN
      TEMP(INPR)=0.0
      RETURN
      END
```

DP3:PPAL.FR 08/09/83 11:44

```
      SUBROUTINE PPAL(AL,PZ,TEMP,INPR)
C     MULTIPLIES AL AND PZ
      DIMENSION TEMP(1)
      TEMP(INPR)=9999.
      IF(AL.EQ.9999..OR.PZ.EQ.9999.)RETURN
      TEMP(INPR)=AL*PZ
      RETURN
      END
```

DP3:ZPFLH.FR 08/09/83 11:49

```
      SUBROUTINE ZPFLH(ZR,H,NR,TEMP,INPR)
C     FINDS THE HEIGHT OF THE TOP OF THE SURFACE BASED COLD LAYER FOR
C     ZR=1 CONDITION.
      DIMENSION H(1),TEMP(1)
      TEMP(INPR)=9999.
      IF(ZR.EQ.9999.)RETURN
      TEMP(INPR)=0.0
      IF(ZR.LT.1.0)RETURN
      TEMP(INPR)=H(2)
      RETURN
      END
```

EASTERN REGION CP NO. 18

AUTOMATED ANALYSIS OF UPPER AIR SOUNDINGS TO SPECIFY PRECIPITATION TYPE

PART A: PROGRAM INFORMATION AND INSTALLATION PROCEDURE

PROGRAM NAME: PTYPE.SV

AAL ID:
REVISION NO. 1.00

PURPOSE: Performs an automated analysis of upper air soundings to specify liquid, freezing, or frozen precipitation, given that precipitation occurs. Creates a local use product stored on the AFOS database.

PROGRAM INFORMATION:

Development Programmers:
Joseph R. Bocchieri
Gerald G. Rigdon

Maintenance Programmer:
Joseph R. Bocchieri

Location: WSFO Washington, DC
Phone: (FTS) 763-8088
Language: FORTRAN IV/5.20
Date: March 2, 1984
Running Time: About 20 seconds
Disk Space: 69 RDOS blocks

Type: Normal
Revision Date: NA

PROGRAM REQUIREMENTS:

Program Files: PTYPE.SV

Data Files:

Name	DP Location	Read/Write
PRECIPTYP	DPØ	Write

AFOS Products:

ID	Action	Comments
cccSGLxxx	Input	Specified in run line
PRECIPTYP	Output	Displayed on ADM

LOAD LINE:

```
PTYPE:  RLDR PTYPE DECOS TEMP1 AFREAD.LB ITCVT FTCVT
        AHAL AREA ARF ATHICK CHECK2 DCV DMAL EQUINT
        LLAS PPAL TAAL XINT ƵPFLH ƵRPOT BG.LB
        UTIL.LB FORT.LB AFOSE.LB
```

PROGRAM INSTALLATION:

1. PTYPE.SV should be on DPØ or on DPØF with link to DPØ.

2. The significant level data, cccSGLxxx, must be stored in database before the program can be run for a specific station.

3. Add key "PRECIPTYP" to your database or wish list.

AUTOMATED ANALYSIS OF UPPER AIR SOUNDINGS TO SPECIFY PRECIPITATION TYPE

PART B: PROGRAM EXECUTION AND ERROR CONDITIONS

PROGRAM NAME: PTYPE.SV

AAL ID:
REVISION NO. 1.00

PROGRAM EXECUTION

1. From an ADM, enter: RUN: PTYPE cccSGLxxx.

   cccSGLxxx is the nine-letter AFOS identifier for the RAOB desired. Repeat the command to obtain results for a different RAOB station.

   The file PRECIPTYP is created on DPØ by the program and the contents are stored into the AFOS database under AFOS identifier PRECIPTYP.

ERROR CONDITIONS

ADM Messages	Meaning
1. "JOB PTYPE ABORTED-- ERROR CONDITION: ERROR READING"	Indicates an error was encountered by subroutine DECOS in decoding the RAOB.
2. "JOB PTYPE ABORTED-- ERROR CONDITION: MISS DEW PTS."	Indicates dew point data were missing below 700mb and program terminates as a result.

Dasher Messages

If problems are encountered in decoding the RAOB data, anyone of a number of messages (depending on the error) is written to the dasher by subroutine DECOS.

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