OBJECTIVE ANALYSIS OF MEAN MOISTURE ALOFT UTILIZING RADIOSONDE AND SURFACE DATA

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PREFACE

The work reported here has been jointly supported by the National Severe Storms Laboratory, ESSA Research Laboratories, and the Techniques Development Laboratory, ESSA Weather Bureau. It has involved facilities at the National Severe Storms Laboratory, Norman, Oklahoma and at the National Severe Storms Forecast Center, Kansas City, Missouri, and personnel of these organizations working together to develop improved techniques for severe storm forecasting.

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ABSTRACT

A procedure of objective analysis for the mean mixing ratio in the 100 mb layer adjacent to the earth's surface utilizes radiosonde data and surface observations of humidity. An estimation, based on the observed data, of the relationship between the surface mixing ratio and the mean mixing ratio in the 100 mb layer provides a bogus value of mean mixing ratio at the location of each surface station. These values are then used with the mean mixing ratios determined at each upper air station to produce the final objective analysis of the mean low-level moisture. The method incorporates procedures for the detection of errors in both surface and upper air data and is presently being used operationally at the National Severe Storm Forecast Center (NSSFC), Kansas City, Missouri.

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by

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1. INTRODUCTION

Determination of the three dimensional distribution of moisture in the atmosphere is of prime importance in the prediction of precipitation. The problem is extremely acute in the forecasting of areas where severe thunderstorms are most likely to occur. An effort must be made to predict thunderstorm events on a smaller scale than is normally possible with upper air data alone. Since the precipitable water in a column in the atmosphere is highly correlated with the surface dew-point, temperature severe thunderstorm forecasters have long used the surface dew point to aid in the delineation of areas where severe convective activity is likely to develop.

This note describes a simple method of utilizing surface humidity observations to better define the field of mean mixing ratio in the lowest 100 mb layer of the atmosphere. The objective analysis utilizes both surface data and radiosonde data.

2. RELATIONSHIPS BETWEEN SURFACE HUMIDITY AND VERTICALLY INTEGRATED MOISTURE

In the past few years several investigators have attempted to find linear relationships between the natural logarithm of precipitable water in a column and the surface dew-point temperature. Reitan (1963) determined a linear correlation of 0.98 between the logarithm of mean monthly total precipitable water and mean monthly surface dew point from a total of 540 observations. Bolsenga (1965) found correlation coefficients of 0.85 and 0.80 for mean daily and hourly observations, respectively. Lowry and Glahn (1969) collected a total of 33,134 1200 GMT observations, made at 56 U. S. stations east of the Rocky Mountains for the period December 1965 through November 1967. They determined multiple regression equations which relate the natural logarithm of precipitable water in the column between the surface and 500 mb, to surface dew-point temperature and 10 other variables. They found that when the data

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were stratified by month and dew point used as a specifier, a total of 83.9 per cent of the variance of the natural logarithm of precipitable water was explained. Another 2.7 per cent was explained by two additional variables, surface weather and total sky cover. The remaining predictors were shown to be of little additional value.

It is hardly surprising that the precipitable water in a column is highly correlated to surface dew-point temperatures since it is well known that an approximate expression of the form

$$\ln w_o = A + Bt_d \ ,$$

can easily be derived by combining Tetens' (1930) empirical formula for vapor pressure with the definition of water vapor mixing ratio. Here w_o is surface mixing ratio and t_d is surface dew point. Thus, one can always expect the surface dew point and the mean mixing ratio, $\bar{w}$, in an atmospheric column to be highly correlated because (for almost any grouping of the data) there will be a dominant range of values of the ratio, $\bar{w}/w_o$. Stratification of the data should be accomplished to separate cases characterized by similar values of the ratio $k = \bar{w}/w_o$. Other investigators (Lowry and Glahn, 1969) have done this by stratifying the data by month, season, geographical location, etc., or by averaging the data over a period of time so that at least a portion of the variability of $\bar{w}/w_o$ is removed.

Smith (1966) derived a theoretical relationship between total precipitable water and surface dew-point temperature by assuming that the average decrease of moisture with height through the atmospheric column may be described by the power law

$$w = w_o \left(\frac{p}{p_o}\right)^{\lambda} \ , \qquad (1)$$

where w is mixing ratio, w_o is the mixing ratio at $p = p_o$, p is pressure and λ is a parameter. The mean mixing ratio in a vertical column in the atmosphere is

$$\bar{w} = \frac{1}{p_o} \int_o^{p_o} w_o \left(\frac{p}{p_o}\right)^{\lambda} dp = \frac{w_o}{\lambda + 1} \ . \qquad (2)$$

Since the total precipitable water in the column is related to the mean mixing ratio by

$$U = \frac{p_o}{g} \bar{w} \ , \qquad (3)$$

where g is the acceleration of gravity, Smith wrote the equation in the form

$$\ln U = \ln\left(\frac{p_o}{g}\right) + \ln \bar{w}$$

$$= \ln\left(\frac{p_o}{g}\right) - \ln(\lambda + 1) + \ln w_o \quad . \tag{4}$$

Of course w_o can be related to the surface dew-point temperature by use of Tetens' empirical formula (1930) for saturation vapor pressure and the definition of mixing ratio.

A better understanding of Smith's relationship can be obtained by transforming the equation to a slightly different form. Remembering that

$$(\lambda + 1)^{-1} = \frac{\bar{w}}{w_o} \quad , \tag{5}$$

we see that the term $\ln(\lambda+1)$ in (4), the only one which depends on the vertical distribution of moisture in Smith's equation may be written simply as $\ln(\bar{w}/w_o)$. That is, if one desires to estimate mean moisture aloft from surface data, he simply should have information concerning the variability of $\bar{w}/w_o$. There is no need to be concerned with the parameter λ. If we write

$$\bar{w} = k\, w_o \quad , \tag{6}$$

where k is an independent estimate of $\bar{w}/w_o$, we have a more sensible type of assumed relationship; note that this is equivalent to the type of relationship sought by the previously mentioned investigators. Here, however, we characterize the actual moisture profile with the realistic ratio $k\ (=\bar{w}/w_o)$ instead of a parameter associated with an assumed power law. Naturally we can expect that this ratio will vary considerably spatially as well as with time. It will also depend greatly on the synoptic situation, i.e., the type of air mass involved.

The variability of mean values of k can be illustrated by reexamining some of the previous work in this area. Here k is the ratio of the mean mixing ratio in the column between p_o and $p = 0$, to the mixing ratio at the surface. Smith (1966) presented a table showing the seasonal latitudinal mean values of the parameter λ defined in (1). Since $k = \bar{w}/w_o = (\lambda+1)^{-1}$, we can easily transform Smith's results to show variations of the mean values of k with season and latitude. Smith utilized mean Northern Hemisphere soundings tabulated by London (1957) in his evaluations of λ. The Northern Hemisphere averages were derived by weighting each latitude band equally.

Table 1. Seasonal and latitudinal mean values of $k = \overline{w}/w_o$ (after Smith, 1966).

Latitudinal Zone (deg N)	Winter	Spring	Summer	Fall	Annual Average
0-10	.23	.26	.26	.27	.26
10-20	.25	.25	.27	.25	.26
20-30	.22	.25	.25	.25	.24
30-40	.25	.24	.26	.25	.25
40-50	.27	.25	.27	.27	.26
50-60	.28	.25	.27	.25	.26
60-70	.36	.27	.28	.28	.29
70-80	.38	.37	.31	.28	.33
80-90	.47	.41	.34	.33	.38
Northern Hemisphere Average	.28	.27	.28	.27	.28

Table 1 shows that the seasonal and latitudinal variations of the mean values of k are rather insignificant in the low and middle latitudes. Very significant variations occur, however, in the latitude band, 60-90 deg N.

During the past several years NSSL has operated a mesonetwork of rawinsonde stations, usually during portions of the months of April, May and June. Most of these soundings were made during the period 1100 - 0300 CST. From data collected during 1966 and 1967, a total of 776 soundings have been processed for the purpose of investigating the variability of the ratio, $\overline{w}/w_o$, where $\overline{w}$ is the mean mixing ratio in the 100 mb layer adjacent to the surface of the earth, and w_o is the surface mixing ratio. Table 2 shows the frequency distribution of $\overline{w}/w_o$. Note that in over half of the soundings $\overline{w}/w_o$ has a value between 0.90 and 1.03 and in almost 80 per cent of the cases has a value between 0.83 and 1.10. In about 69 per cent of the soundings $\overline{w}$ is less than or equal to the surface value, w_o.

Table 2. Frequency distribution of $\bar{w}/w_o$ based on 1966-1967 data from NSSL rawinsonde network.

Class Interval, $\bar{w}/w_o$	f	%	Cum. Freq. (%)
.55 - .61	1	.13	.13
.62 - .68	7	.90	1.03
.69 - .75	17	2.19	3.22
.76 - .82	42	5.41	8.63
.83 - .89	114	14.69	23.32
.90 - .96	213	27.44	50.76
.97 - 1.03	196	25.26	76.02
1.04 - 1.10	96	12.37	88.39
1.11 - 1.17	48	6.19	94.58
1.18 - 1.24	30	3.87	98.45
1.25 - 1.31	6	.77	99.22
1.32 - 1.38	5	.64	99.86
1.39 - 1.45	0	.00	99.86
1.46 - 1.52	1	.13	100.00
	776		

3. ANALYSIS PROCEDURE

The analysis procedure is summarized as follows and detailed in following paragraphs:

a. Consistent values of surface mixing ratio, w_o, at radiosonde stations, are determined.

b. The mean mixing ratio in the lowest 100 mb layer at each radiosonde station is calculated and $R\ (=\bar{w}/w_o)$ is computed, where w_o is the surface mixing ratio evaluated in the first step rather than the reported surface mixing ratio.

c. The distribution of R is defined objectively so that R may be estimated at each surface station.

d. A bogus value of $\bar{w}\ (=Rw_o)$ is computed for each surface station.

e. An objective analysis of $\bar{w}$ is performed utilizing the two sets of data, i.e., the observed values of $\bar{w}$ at radiosonde stations and the bogus values of $\bar{w}$ at surface stations.

The basic objective analysis method employed in this study is similar to that devised by Cressman (1959); the particular scheme, as well as others available for operational use at NSSFC, has been described by Inman (1970). One modification has been added to facilitate its use for the analysis of moisture, i.e., the routine has been redesigned to use two sets of data of different reliability in a single analysis. Reports from the two sets are given different weights depending on their relative accuracy. Specifically, in the application of the successive approximations technique the correction made at the grid point (i,j) is

$$C_{i,j} = \frac{\sum_{k=1}^{K} W_k D_k + \alpha \sum_{m=1}^{M} W_m D_m}{\sum_{k=1}^{K} W_k + \alpha \sum_{m=1}^{M} W_m} , \qquad (7)$$

where W is the Cressman distance-dependent weight function, D is the deviation between the observation and the current analysis at the location of the report (interpolated) and α is the relative reliability factor of the second set of data.

An objective analysis of the field of surface mixing ratio, w_o, is first accomplished with observations of surface humidity from both surface stations and radiosonde stations. On each pass through the data, as the analysis is successively corrected, each piece of data, $\hat{Z}$, is compared with the current analysis, Z, at the location of the observing station. If $|Z - \hat{Z}|$ is greater than some predetermined number (different from each pass) the datum is assumed to be bad and is discarded. This technique requires a first approximation available at all grid points; in the analysis of the surface mixing ratio the first-guess field is assumed to be zero.

The analyzed values of surface mixing ratio are then utilized in the calculation of $R = \bar{w}/w_o$, where w_o is the interpolated surface mixing ratio at the upper air station and $\bar{w}$ is the mean mixing ratio in the lowest 100 mb layer at the upper air station. The calculation of $\bar{w}$ is defined by

$$\bar{w} = \frac{1}{100} \int_{P_s-100}^{P_s} w\,dp , \qquad (8)$$

where P_s is the surface pressure. The integral is evaluated with the trapezoidal rule utilizing significant level data from rawinsonde reports. If the value of R determined at a radiosonde station is greater than 1.25, R is set equal to 1.25; also, if the value is less than 0.5, R is set equal to 0.5. These arbitrary limits were placed on R to insure

that the analysis would not be spoiled by an unrepresentative surface dew-point temperature. It is seldom necessary to make this adjustment.

Next an objective analysis of R is performed to provide estimates of R at each surface station. An initial guess of 0.9 at all grid points is used in this analysis. After this is completed, one could produce a final analysis of the mean mixing ratio by simply multiplying R at each grid point by the corresponding previously analyzed values of surface mixing ratio. In practice, however, it has been found to be desirable to control the influence of the surface data; thus, we have proceeded by first interpolating a value of R for each surface station. Then a bogus value of $\bar{w}$ ($=Rw_o$) is calculated for each surface station. At this point two sets of data are available; (1) the mean mixing ratios determined at each radiosonde station, and (2) the bogus values of $\bar{w}$ estimated for each surface station. Certainly the former set of data should be considered to be the most reliable. Consequently, the analysis scheme is designed so that the upper air data is given greater weight than the bogus values of mean mixing ratio. By proper adjustment of the relative weights assigned to the two sets of data, one can obtain a final analysis of the mean mixing ratio that reflects, to the degree desired, the smaller scale variations present in the surface data. For operational analysis at NSSFC the upper air data is given a weight three times that given to the bogus data.

4. APPLICATION OF THE ANALYSIS PROCEDURE

The area of analysis, shown in figure 1, is covered by a 21 x 27 grid which has a gridlength of approximately 68.5 n mi. Radiosonde stations in the United States also are shown in figure 1; the average distance between stations is about three times the gridlength. Roughly ten times as many surface stations as upper air reporting stations are positioned within the grid.

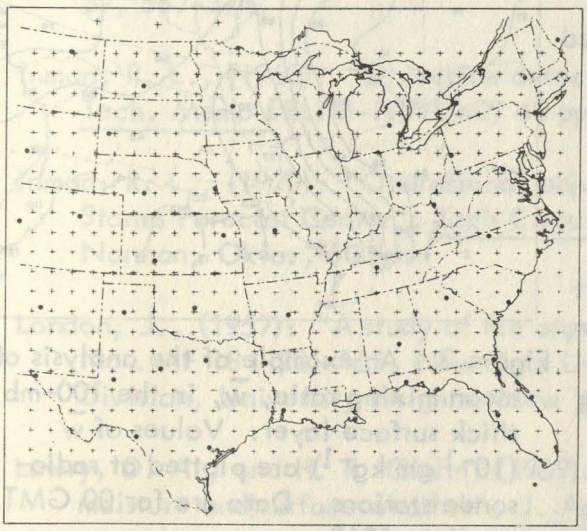

Figure 1. The area of analysis of the 21 x 27 grid. United States rawinsonde stations are shown by black dots.

The data employed include the radiosonde reports processed at the National Severe Storm Forecast Center; these data are checked for hydrostatic consistency (Inman, 1968) before they are stored on magnetic tape. Surface data from the surface observation network are placed on a separate magnetic tape.

An example of the analysis of R, the ratio of $\bar{w}$ to w_o, is shown in figure 2 for 00 GMT, April 4, 1968. Important features include a minimum in the field of R located in eastern Kansas to the west of the surface position of a cold front. (The surface map

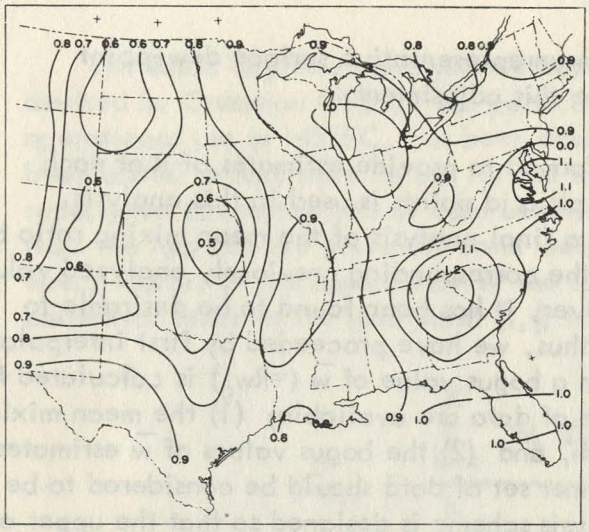

Figure 2. An example of the analysis of R, the ratio of mean mixing ratio, $\bar{w}$, to the surface mixing ratio, w_o. Data are for 00 GMT, April 4, 1968.

is shown in figure 3.) Also, a maximum in the field of R is located in southeastern Missouri east of the surface position of the cold front. The continuity of dominant features such as these is usually rather good as frontal systems move across the United States.

An example of the analysis of $\bar{w}$ obtained by the techniques described in the previous sections is shown in figure 4. A moist tongue extends from the Texas Gulf coast region northeastward through northern Louisiana and eastern Arkansas and then northward to southeastern Iowa. Similar configurations of the moisture field often develop as a low-level low-pressure system develops in the central United States. That is, a tongue of low-level moisture develops east of the surface front and usually extends northward and then northwestward around the surface position of the low-level Low.

Accurate determination of the position of the axis of such moist tongues is extremely important in severe thunderstorm forecasting. If an analysis of low-level moisture is attempted utilizing only radiosonde data, often the analysis is constructed so that the axis of the moist tongue passes through the location of one or more radiosonde stations. However, there is a strong probability that the axis should be located up to a hundred miles from the radiosonde station(s). Such errors may be particularly large when a radiosonde report happens to be missing in a critical location, i.e., in the vicinity of the true position of the moist axis. Obviously, by utilizing the surface observations as described in this report, one has a better change of accurately describing the low-level moisture field.

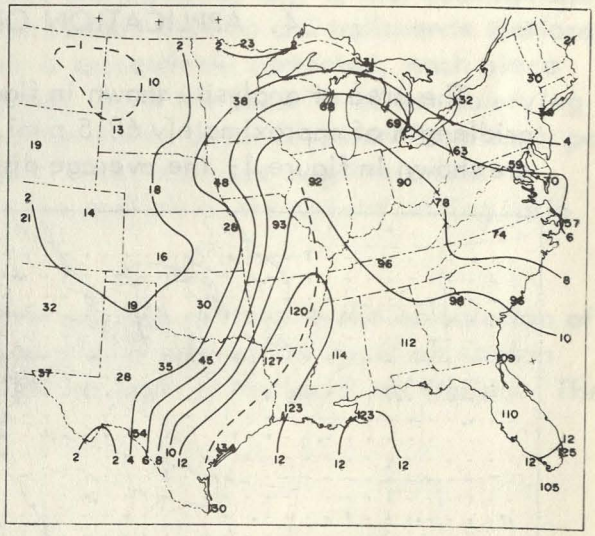

Figure 3. An example of the analysis of mean mixing ratio, $\bar{w}$, in the 100-mb thick surface layer. Values of $\bar{w}$ (10^{-1} gm kg^{-1}) are plotted at radiosonde stations. Data are for 00 GMT, April 4, 1968.

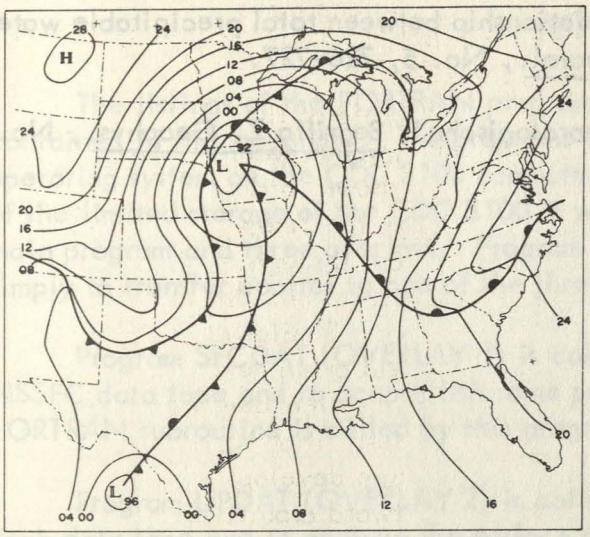

Figure 4. Surface map for 00 GMT, April 4, 1968.

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APPENDIX

The listings of the FORTRAN programs which perform the described analyses are contained in this appendix. The programs are in the form necessary for use with the operating system on the CDC 3100 computer at NSSFC, Kansas City, Missouri. Because of the limited storage of the CDC 3100 it was necessary to separate the program into a main program and three overlays. Program MOIST is the main program; its purpose is simply to transfer control to one of the three overlay programs.

Program SFCDAT (OVERLAY 1) is called by MOIST to read surface data from the NSSFC data tape and to accomplish some preliminary processing of these data. No FORTRAN subroutine is called by this program.

Program UPDAT (OVERLAY 2) is called to read radiosonde data from the NSSFC Raob data tape and to analyze the surface mixing ratio, w_o. FORTRAN subroutines SORTOB and BOBAN are called by this program to analyze w_o.

Program FINAL (OVERLAY 3) is called to analyze the field of R ($=\bar{w}/w_o$), interpolate a value of R for each surface station, calculate a bogus value of $\bar{w}$ at each surface station and perform the objective analysis of $\bar{w}$ using the two sets of data, i.e., the observed $\bar{w}$'s and the bogus values. Several FORTRAN subroutines are called by this program. SORTOB and BOBAN are called to accomplish the objective analyses. PRTFLD is a simple output routine utilized to print analyzed values at grid points; no contouring is done. Subroutine MAPONE is called to print station values of $\bar{w}$ on the NSSFC sectional map. Subroutine CONTUR is called to print analyzed values at grid points and to contour the analyzed field.

```
      PROGRAM MOIST
C     ...CALCULATES AND OBJECTIVELY ANALYZES THE MEAN MIXING RATIO IN
C        THE LOWEST 100MB USING A COMBINATION OF UPPER AIR AND SFC
C        STATIONS
C     (1)  WBAR/WSFC IS CALCULATED AND ANALYZED USING UPPER AIR DATA
C     (2)  A VALUE OF THE RATIO IS INTERPOLATED FOR EACH SFC
C          STATION WITHIN THE GRID
C     (3)  WSFC IS CALCULATED FOR EACH SFC STATION
C     (4)  WBOGUS(BOGUS MEAN MIXING RATIO) = RATIO*WSFC
C     (5)  BOTH WBAR AND WBOGUS ARE ANALYZED
C     ...SENSE SWITCH 1 ON - PRINTS ANALYZED RATIO FIELD
C     ...SENSE SWITCH 2 ON - PRINTS INTERMEDIATE MIXING RATIOS,ETC FOR
C                            UPPER AIR STATIONS
C     ...SENSE SWITCH 3 ON - PRINTS INTERMEDIATE MIXING RATIOS,ETC
C                            FOR SFC STATIONS
C     ...SENSE SWITCH 4 ON - PRINTS WBAR USING RAOB DATA ONLY
C     ...SENSE SWITCH 5 ON - COMPUTES (WBAR)=(WZERO)(RATIO) PRINTS FLD
C     ...ORDER OF OVERLAYS * SFCDAT, UPDAT, FINAL
C     ...TAPES **** RAOB ON 2,  SFC ON 3
      COMMON NI,NJ,IDX,IDY,IXFO,IYFO,IXO,IYO,IXGP(21),IYGP(27)
      COMMON NWEG,NSFC,NRAOB,NOPSF,NOPUA,KOUT(4)
      COMMON DATE(4),SDATE(4),IRSF(4),IRUA(4),IX(485),IY(485),IZX(485)
      COMMON IZGY(21,27),IXS(86),IYS(86),IZXT(86),IXQ(86),IYQ(86),
     *  IZXQ(86)
      INTEGER DATE,SDATE
  100 CALL OVERLAY(1,0,55)
      CALL OVERLAY(2,0,55)
      CALL OVERLAY(3,0,55)
      PAUSE 7
      GO TO 100
      END
```

```
      PROGRAM SFCDAT
      DIMENSION DATA(2680),CDATA(10720)
      CHARACTER CDATA
      EQUIVALENCE(DATA,CDATA)
      INTEGER DATE,SDATE
      COMMON NI,NJ,IDX,IDY,IXFO,IYFO,IXO,IYO,IXGP(21),IYGP(27)
      COMMON NWEG,NSFC,NRAOB,NOPSF,NOPUA,KOUT(4)
      COMMON DATE(4),SDATE(4),IRSF(4),IRUA(4),IX(485),IY(485),IZX(485)
      COMMON/DATA/NLAT(536),NLONG(536),NALTC(536)
      DATA(( NLAT(I),I=  1, 86)=     55183, 54917, 55117, 53883, 54417,  NLAT   1
     *   54133, 53967, 53033, 53583, 53667, 52883, 53350, 53217, 51983,  NLAT   2
     *   52183, 52767, 52383, 50683, 52167, 52100, 50000, 51267, 51100,  NLAT   3
     *   50700, 50633, 51100, 49383, 49800, 49817, 54617, 49900, 50250,  NLAT   4
     *   50017, 49083, 49967, 50333, 49183, 50283, 49383, 50017, 49467,  NLAT   5
     *   49450, 49533, 48800, 49500, 49633, 49067, 47950, 48133, 48267,  NLAT   6
     *   47950, 48600, 48550, 47450, 48300, 48217, 48167, 46967, 47400,  NLAT   7
     *   47633, 46900, 47467, 46917, 47483, 46150, 46567, 47050, 46783,  NLAT   8
     *   46767, 46917, 46100, 46383, 45600, 46600, 46433, 45617, 45450,  NLAT   9
     *   45683, 44917, 45950, 45800, 44917, 45700, 44117, 44833, 45250)  NLAT  10
      DATA(( NLAT(I),I= 87,172)=     44383, 44267, 44767, 44383, 43417,  NLAT  11
     *   44517, 44050, 43567, 44050, 43583, 43967, 43567, 43517, 42367,  NLAT  12
     *   43050, 41783, 42917, 42833, 42583, 42150, 42917, 41983, 42917,  NLAT  13
     *   42817, 41783, 42533, 42050, 41433, 40983, 41317, 42167, 41867,  NLAT  14
     *   40967, 41800, 41133, 41317, 41600, 41100, 40600, 40900, 41183,  NLAT  15
     *   40150, 40833, 41300, 41150, 40517, 40617, 40733, 40217, 40767,  NLAT  16
     *   40067, 40167, 39133, 39500, 40183, 39100, 39950, 39383, 39767,  NLAT  17
     *   39367, 39650, 38867, 38517, 39283, 39383, 39600, 39117, 38817,  NLAT  18
     *   37733, 38283, 37767, 37367, 38067, 38433, 38417, 37933, 38050,  NLAT  19
     *   37367, 37367, 36583, 37700, 37700, 37450, 37250, 36767, 36683)  NLAT  20
      DATA(( NLAT(I),I=173,258)=     36300, 36333, 36750, 36750, 36017,  NLAT  21
     *   36083, 35350, 35683, 35417, 34900, 35617, 35650, 35233, 35000,  NLAT  22
     *   35183, 34583, 34567, 34750, 34650, 34867, 35133, 35167, 35050,  NLAT  23
     *   34433, 35017, 35100, 34433, 34767, 34200, 34650, 34383, 33933,  NLAT  24
     *   33933, 33650, 33617, 33617, 33400, 33433, 33233, 32433, 32733,  NLAT  25
     *   32833, 32683, 32850, 32667, 32300, 32633, 32333, 31933, 32250,  NLAT  26
     *   32117, 31783, 31367, 31800, 31833, 31350, 31583, 31450, 30967,  NLAT  27
     *   29367, 27850, 46867, 48333, 46133, 45650, 53833, 46800, 44950,  NLAT  28
     *   52233, 44317, 48050, 49417, 45467, 51467, 43650, 48567, 50183,  NLAT  29
     *   47700, 50283, 44467, 44933, 43200, 43633, 46367, 42367, 50117)  NLAT  30
      DATA(( NLAT(I),I=259,344)=     48583, 45567, 43350, 41250, 46617,  NLAT  31
     *   49267, 42200, 41733, 44000, 42750, 41933, 41167, 44967, 43150,  NLAT  32
     *   48367, 44117, 45883, 41267, 46467, 43117, 48567, 41633, 47167,  NLAT  33
     *   44750, 43117, 42217, 40450, 43683, 46533, 45567, 45067, 43983,  NLAT  34
     *   40700, 47383, 42933, 42167, 41333, 47500, 46833, 40650, 40033,  NLAT  35
     *   44733, 42850, 41250, 44367, 43300, 41800, 39883, 39450, 42083,  NLAT  36
     *   43533, 40883, 39667, 40217, 44917, 44483, 45867, 42967, 39133,  NLAT  37
     *   45583, 44867, 41267, 40300, 44000, 41400, 43167, 42217, 39183,  NLAT  38
     *   44883, 42267, 43933, 40500, 39400, 38333, 40917, 43867, 42950,  NLAT  39
     *   42233, 41600, 38950, 44550, 43133, 40183, 43917, 40817, 43200)  NLAT  40
      DATA(( NLAT(I),I=345,430)=     41017, 39650, 41700, 39950, 41983,  NLAT  41
     *   41000, 38883, 43150, 42200, 40000, 38133, 37500, 42400, 39350,  NLAT  42
     *   36900, 41500, 42550, 39900, 37083, 36267, 41883, 41450, 40417,  NLAT  43
     *   39433, 38367, 35267, 40300, 37317, 42400, 39733, 38367, 37783,  NLAT  44
     *   40667, 39067, 41533, 40050, 36567, 35967, 41100, 40783, 39267,  NLAT  45
     *   37300, 39450, 35867, 35083, 41300, 39833, 36083, 38183, 38033,  NLAT  46
     *   40617, 39933, 40100, 40850, 35000, 38983, 36483, 37083, 35733,  NLAT  47
     *   34267, 38050, 40317, 38750, 39767, 35217, 38967, 35433, 39550,  NLAT  48
     *   39117, 36967, 34183, 33683, 38733, 35817, 39067, 38133, 39150,  NLAT  49
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*   37067, 36667, 35950, 34900, 37233, 36117, 33950, 38817, 37800)  NLAT  50
 DATA(( NLAT(I),I=431,516)=     34500, 38333, 35033, 32900, 38067,  NLAT  51
*   37667, 36017, 37233, 33950, 33367, 37650, 37167, 35600, 34700,  NLAT  52
*   34350, 36133, 36267, 35350, 34750, 33650, 32133, 36733, 35050,  NLAT  53
*   33583, 32700, 36000, 36183, 34267, 36333, 33567, 31150, 35333,  NLAT  54
*   34733, 32517, 31533, 33233, 33633, 35400, 34483, 34167, 32300,  NLAT  55
*   31533, 30417, 34883, 33500, 30783, 30233, 31317, 34650, 32333,  NLAT  56
*   29183, 34300, 29700, 33217, 30383, 33450, 32317, 33717, 30783,  NLAT  57
*   29633, 33967, 28550, 28100, 32517, 30067, 32467, 27650, 30467,  NLAT  58
*   31267, 30683, 32833, 32783, 32350, 27967, 31400, 30400, 26683,  NLAT  59
*   31050, 30533, 26067, 31233, 31617, 29983, 26583, 25800, 30200)  NLAT  60
 DATA(( NLAT(I),I=517,536)=     29333, 31067, 30117, 30583, 29950,  NLAT  61
*   30300, 30500, 29650, 24550, 29300, 29533, 28717, 28850, 28367,  NLAT  62
*    28450, 27683, 27733, 27500, 26183, 25900)                      NLAT  63
 DATA((NLONG(I),I=  1, 86)=    118883, 98633,105300,122683,110283,  NLONG   1
*  115667,101100,122517,116417,113467,118067,110833,105683,124933,  NLONG   2
*  122050,108250,114917,127367,106683,111450,127417,102467,100050,  NLONG   3
*  121317, 97050,114017,126533, 94367,124500,101350, 97233,102533,  NLONG   4
*  100317,125767,119383,105550,123167,107683,121433,110717,119600,  NLONG   5
*  117567,115767,122533,113950,112800,103000,124550,123400,101283,  NLONG   6
*   97183,112367,109767,122300,114267,106617,103633,123933,120200,  NLONG   7
*  117533, 96800,115767, 98683,111350,123883,120533,109450,102800,  NLONG   8
*  100750,114083,118283,117017,122600,112000,105867,121150, 98433,  NLONG   9
*  118850,123017,112500,108533, 97150,110433,123217,117817,112550)  NLONG  10
 DATA((NLONG(I),I= 87,172)=     98217,121150,106967,100283,124250,  NLONG  11
*  109017,101600, 96733,103067,119050,107950,116217,112067,122867,  NLONG  12
*  115850,124233,114767,103083, 99983,121733,106467, 97433,112600,  NLONG  13
*  108733,122467,113767,102800, 97350,124100,122317,112317,103600,  NLONG  14
*   98317,107200,100683,105683,109067,102983, 98433,117800,112017,  NLONG  15
*  122250,115783,110983,104817,101617,116867,114033,100583,111967,  NLONG  16
*  118550,103217,123200,119783,112933,121567,105833, 99833,104883,  NLONG  17
*  101700,106917, 98817,121500,114850,112517,110750,108533,104700,  NLONG  18
*  122200,104517, 99967,121917,117083,113017,110683,100717,103517,  NLONG  19
*  120567,118367,121850,113100,112150,105867,104333,119717,121767)  NLONG  20
 DATA((NLONG(I),I=173,258)=     99767,119950,104500,108250,102550,  NLONG  21
*  115167, 99200,117683,119050,120450,106083,105150,101700, 99050,  NLONG  22
*  103600,117900,120667,118733, 99267,116783,111667,107900,106617,  NLONG  23
*  100283,110733,108783,119833,114617,118367,112433,103317,118383,  NLONG  24
*  116950,101817,116167,114717,104533,112017,107267, 99683,117167,  NLONG  25
*  115567,103200,106083,114600,101450,108167,104267,102200,107700,  NLONG  26
*  110933,103200,100500,106400,104800,113667,110333,109600,110300,  NLONG  27
*  100917,110917, 68017, 71000, 67783, 68683, 89867, 71383, 68667,  NLONG  28
*   87883, 69800, 77783, 82467, 73750, 90250, 70317, 81367, 86700,  NLONG  29
*   79850, 88900, 73150, 74833, 71500, 72317, 79417, 71033, 91900)  NLONG  30
 DATA((NLONG(I),I=259,344)=     85283, 77417, 73617, 70067, 80800,  NLONG  31
*   90583, 72533, 71433, 76017, 73800, 72683, 71583, 79300, 75383,  NLONG  32
*   89317, 77533, 82567, 72883, 84367, 76117, 93383, 73883, 83017,  NLONG  33
*   81100, 77667, 75983, 73117, 79650, 87567, 84800, 83567, 80750,  NLONG  34
*   74167, 92850, 78733, 76900, 75733, 94933, 92183, 75433, 74350,  NLONG  35
*   85583, 80267, 76917, 84683, 81517, 78633, 75250, 74583, 80183,  NLONG  36
*   84083, 78083, 75600, 76850, 89617, 88133, 95383, 83733, 75467,  NLONG  37
*   94183, 91483, 80667, 78317, 88567, 81850, 86233, 83350, 76667,  NLONG  38
*   93217, 84467, 90267, 80217, 77983, 75500, 81433, 91250, 87900,  NLONG  39
*   85550, 83800, 77450, 95083, 89333, 80650, 92500, 82517, 90183)  NLONG  40
 DATA((NLONG(I),I=345,430)=     83667, 79917, 86317, 81900, 87900,  NLONG  41
*   85200, 79850, 93333, 89100, 82883, 78450, 77333, 90700, 81433,  NLONG  42
*   76200, 88167, 92400, 84217, 77950, 76183, 91700, 90517, 86933,  NLONG  43
*   83800, 81600, 75550, 88150, 79967, 96383, 86283, 82550, 81117,  NLONG  44
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*    89683,  84667,  93650,  88267,  79333,  77800,  92450,  91117,  85900,  NLONG 45
*    81217,  87300,  78783,  77033,  95900,  89667,  79950,  85733,  84600,  NLONG 46
*    93933,  91200,  92550,  96750,  78883,  89167,  82400,  84083,  81383,  NLONG 47
*    77917,  87533,  96750,  90383,  94917,  80933,  92367,  82533,  97650,  NLONG 48
*    94583,  86433,  79717,  78933,  93567,  83983,  95633,  91767,  96667,  NLONG 49
*    88767,  87500,  85083,  82217,  89583,  86683,  81117,  97567,  92100)  NLONG 50
 DATA((NLONG(I),I=431,516)=      82717,  96200,  85200,  80033,  97867,  NLONG 51
*    95483,  89400,  93383,  83317,  81967,  97417,  94500,  88917,  86583,  NLONG 52
*    85167,  90933,  93150,  89867,  87617,  84433,  81200,  97100,  89983,  NLONG 53
*    85850,  83650,  94167,  95900,  88767,  97900,  86750,  81383,  94367,  NLONG 54
*    92233,  84933,  82517,  87617,  88450,  97600,  93100,  91933,  86400,  NLONG 55
*    84183,  81650,  95783,  90200,  83283,  81667,  85450,  98400,  88750,  NLONG 56
*    81050,  97017,  82267,  92800,  84367,  94000,  90083,  96667,  86517,  NLONG 57
*    83100,  98483,  81333,  80633,  92050,  85583,  93817,  80417,  87200,  NLONG 58
*    90467,  88250,  97050,  98067,  95400,  82533,  92300,  88917,  80100,  NLONG 59
*    93183,  91150,  80150,  94750,  97217,  90250,  81867,  80267,  91983)  NLONG 60
 DATA((NLONG(I),I=517,536)=      89400,  97833,  93217,  96350,  94017,  NLONG 61
*    97700,  99767,  95283,  81750,  94800,  98467,  96250,  96917,  97667,  NLONG 62
*     99217,  97283,  98033,  99500,  98233,  97433)                          NLONG 63
 DATA((NALTC(I),I=  1, 86)=      2293,   817,   1286,   2322,   1879,  NALTC  1
*     2536,   954,   1882,   3137,   2398,   3576,   2138,   1498,   3055,  NALTC  2
*     3192,   1892,   3430,   80,   1736,   2724,   0,   1745,   1065,  NALTC  3
*     1690,   776,   3635,   0,   1426,   457,   1070,   840,   2134,  NALTC  4
*     1642,   0,   1492,   1954,   0,   2783,   164,   2470,   1192,  NALTC  5
*     2100,   3117,   172,   3877,   3122,   1982,   221,   31,   1807,  NALTC  6
*     889,   3924,   2705,   483,   3078,   2403,   2003,   16,   1332,  NALTC  7
*     2470,   959,   3690,   1581,   3748,   24,   1135,   4219,   2689,  NALTC  8
*     1752,   3291,   1282,   1520,   42,   3981,   2740,   226,   1379,  NALTC  9
*     1582,   217,   5518,   3664,   1834,   4667,   401,   3472,   5219)  NALTC 10
 DATA((NALTC(I),I= 87,172)=      1368,   3188,   4049,   1820,   18,  NALTC 11
*     5124,   2316,   1511,   3270,   4242,   4280,   2964,   4786,   1409,  NALTC 12
*     3118,   62,   3759,   3415,   2686,   4160,   5294,   1639,   4535,  NALTC 13
*     5541,   2761,   4230,   4012,   1524,   242,   3680,   4551,   4039,  NALTC 14
*     1953,   6607,   2893,   7071,   6609,   4372,   2043,   4403,   4513,  NALTC 15
*     380,   5097,   6829,   6070,   3384,   4586,   4308,   2676,   4297,  NALTC 16
*     3987,   4670,   664,   4461,   4422,   79,   8168,   2325,   5333,  NALTC 17
*     3778,   6403,   1966,   27,   6179,   4802,   5853,   4875,   6096,  NALTC 18
*     8,   4763,   2698,   60,   5427,   5056,   4520,   2988,   4285,  NALTC 19
*     212,   4218,   237,   5596,   7345,   7303,   5710,   352,   155)  NALTC 20
 DATA((NALTC(I),I=173,258)=      2306,   256,   6281,   5490,   4077,  NALTC 21
*     2283,   2032,   2342,   528,   256,   6220,   6723,   3697,   1659,  NALTC 22
*     4117,   2417,   82,   4578,   1460,   2028,   6849,   6413,   5317,  NALTC 23
*     2051,   4916,   6344,   22,   947,   776,   5046,   4370,   112,  NALTC 24
*     2706,   3342,   -120,   421,   3711,   1178,   4893,   1848,   30,  NALTC 25
*     -51,   3757,   4179,   222,   2670,   5374,   3362,   2968,   4389,  NALTC 26
*     2661,   2926,   2006,   3999,   5451,   54,   4731,   4182,   5211,  NALTC 27
*     1094,   29,   673,   575,   511,   444,   770,   264,   145,  NALTC 28
*     897,   387,   1179,   804,   106,   1285,   68,   1029,   1134,  NALTC 29
*     860,   1134,   366,   224,   372,   611,   1285,   31,   1303)  NALTC 30
 DATA((NALTC(I),I=259,344)=      1320,   612,   358,   13,   1192,  NALTC 31
*     1743,   266,   67,   358,   314,   193,   127,   988,   796,  NALTC 32
*     690,   286,   669,   14,   775,   439,   1257,   175,   844,  NALTC 33
*     770,   595,   1729,   117,   620,   1509,   765,   742,   1442,  NALTC 34
*     32,   1438,   756,   1017,   1011,   1459,   1501,   414,   119,  NALTC 35
*     675,   843,   563,   1233,   887,   2253,   30,   72,   788,  NALTC 36
*     717,   2012,   86,   378,   1271,   751,   1515,   819,   41,  NALTC 37
*     1111,   955,   1260,   1555,   850,   860,   678,   711,   167,  NALTC 38
*     895,   1087,   976,   1301,   573,   65,   1313,   720,   742,  NALTC 39
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     *      933.    741.    348.   1097.    925.   1270.   1400.   1392.    771) NALTC 40
      DATA((NALTC(I),I=345,430)=                  858.   1330.    826.    963.    722. NALTC 41
     *      885.   2106.   1197.    795.    890.    690.    177.   1149.    922. NALTC 42
     *       32.    630.    937.   1069.    471.     14.    930.    637.    682. NALTC 43
     *     1141.   1014.     12.    799.   1250.   1174.    863.    895.   2620. NALTC 44
     *      709.    936.   1027.    816.    632.    132.    908.    751.    712. NALTC 45
     *     2973.    636.    474.     26.   1047.    657.    946.    524.   1054. NALTC 46
     *     1193.    819.   1029.   1263.    211.    579.   1613.   1286.   1262. NALTC 47
     *       41.    417.   1398.    605.    874.    822.    839.   2273.   1570. NALTC 48
     *      802.    575.    163.     38.    938.   1045.    945.   1209.   1139. NALTC 49
     *      444.    623.   1967.   1035.    379.    648.    242.   1332.   1170) NALTC 50
      DATA((NALTC(I),I=431,516)=                  826.   1287.    736.     52.   1612. NALTC 51
     *     1046.    371.   1348.    867.    160.   1421.   1050.    453.    690. NALTC 52
     *      689.    305.   1468.    318.    603.   1101.     55.   1063.    306. NALTC 53
     *      662.    389.   1336.    724.    388.   1397.    675.     26.    497. NALTC 54
     *      285.    424.    222.    201.    241.   1383.    595.    231.    218. NALTC 55
     *      208.     33.    796.    144.    240.     62.    380.   1272.    334. NALTC 56
     *       44.    825.    178.    307.     73.    396.    356.    816.    199. NALTC 57
     *       48.   1097.    128.     29.     87.     30.    279.     30.    127. NALTC 58
     *      503.    238.    618.   1036.    591.     12.    127.     39.     23. NALTC 59
     *      355.     82.     11.    340.    545.     32.     13.     13.     45) NALTC 60
      DATA((NALTC(I),I=517,536)=                    1.   1081.     35.    353.     24. NALTC 61
     *      665.   1806.     67.     23.     58.    849.     16.    126.    211. NALTC 62
     *       514.     21.    194.    447.    121.     22)                        NALTC 63
      NOS=0
      DIST=2508.263*1.8660254
      CINTMB=(1013.25/29.92119696)/1000.
      DDTR=.0174532925E-3
      WRITE(59,750)
  750 FORMAT(30HMOUNT RAOB DATA TAPE ON UNIT 2,/34HAND SFC HOURLY DATA T
     -1APE ON UNIT 3)
      PAUSE 1111
    2 CONTINUE
C     ...READ OBAN PARAMETERS
      READ 701,NI,NJ,NOPUA,IXO,IYO,IRUA,IDX,IDY,NWEG,KOUT
      READ 701,NI,NJ,NOPSF,IXO,IYO,IRSF,IDX,IDY
  701 FORMAT(1615)
      DO 65 I=1,NI
   65 IXGP(I)=IXO+(I-1)*IDX
      DO 66 J=1,NJ
   66 IYGP(J)=IYO+(J-1)*IDY
      IXFO=IXGP(NI)
      IYFO=IYGP(NJ)
      READ 700,SDATE
  700 FORMAT(4A4)
      IF(SDATE(1).EQ.4H9999)50,5
   50 WRITE(59,751)
  751 FORMAT(40HLAST DATE PROCESSED,HIT GO TO START OVER)
      PAUSE 5555
      GO TO 2
C     ...SEARCH SFC TAPE
    5 BUFFER IN(2,1) (DATE(1),DATE(4))
    6 GO TO (6,7,5) ,UNITSTF(2)
    7 IF(DATE(1).EQ.9999)52,8
   52 WRITE(59,753) SDATE
  753 FORMAT(4A4,47H NOT ON SFC TAPE,MOUNT CORRECT TAPE ON 2,HIT GO)
      REWIND 2 $ PAUSE 3333 $ REWIND 2 $ GO TO 5
    8 IF(DATE(1).NE.SDATE(1).OR.DATE(2).NE.SDATE(2).OR.DATE(3).NE.
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     *  SDATE(3).OR.DATE(4).NE.SDATE(4))9,11
    9 BUFFER IN(2,1) (DATA(1),DATA(2680))
   10 GO TO (10,9,5),UNITSTF(2)
C       ...BOTH DATES FOUND AND READ
   11 BUFFER IN(2,1) (DATA(1),DATA(2680))
C       ...SCAN SFC DATA
 8105 GO TO (8105,8106),UNITSTF(2)
 8106 ITWC=1
  124 DO 105 K=1,10681,40
      IF(CDATA(K+3).EQ.60B.OR.CDATA(K+34).EQ.60B.OR.CDATA(K+27).EQ.60B)
     *  105,106
C       ...REJECT IF Y COORD. IS LE 075
  106 IF(CDATA(K+7).GT.00B)109,107
  107 IF(CDATA(K+8)-07B)105,108,109
  108 IF(CDATA(K+9).LE.05B)105,109
C       ...DATA IS NOT MISSING AND IS EAST OF 110 DEGREES
  109 LSUB=(K-1)/40+ITWC
      A=DDTR*(100000-NLONG(LSUB))
      PHI=DDTR*NLAT(LSUB)
      RA=DIST*COS(PHI)/(1.+SIN(PHI))
      IXT=RA*COS(A)
      IF(IXT.LT.IXO.OR.IXT.GT.IXFO)105,110
  110 IYT=RA*SIN(A)
      IF(IYT.LT.IYO.OR.IYT.GT.IYFO)105,111
C       ...STATION IS INSIDE GRID
C       ...FORM STATION PRESSURE
  111 N1=CDATA(K+32) $ N2=CDATA(K+33) $ N3=CDATA(K+34)
      IF(N1.LT.4)112,113
  112 N1=N1+30 $ GO TO 114
  113 N1=N1+20
  114 SPRES=CINTMB*(N1*1000+N2*100+N3*10-NALTC(LSUB))
      N2=CDATA(K+27)
      IF(CDATA(K+26).EQ.60B)115,116
  115 STEMP=N2 $ GO TO 117
  116 N1=CDATA(K+26)
      STEMP=N1*10+N2
  117 IF(CDATA(K+25).EQ.40B)118,119
  118 STEMP=-STEMP
C       ...CALCULATE SFC MIXING RATIO
  119 CTEMP=(STEMP-32.0)*.55555556
      VAP=6.108*EXP((17.269388*CTEMP)/(237.3+CTEMP))
      WZERO=(622.*VAP)/(SPRES-VAP)
      IF(WZERO.GT.35.0.OR.WZERO.LE.0.0)105,130
  130 NOS=NOS+1
      IX(NOS)=IXT
      IY(NOS)=IYT
C       SURFACE MIXING RATIO (SURFACE DATA)
      IZX(NOS)=WZERO*100.+.5
      GO TO (120,105),SSWTCHF(3)
  120 PRINT 905,DATE
  905 FORMAT(1H1,4A4 //)
      PRINT 903,CDATA(K),CDATA(K+1),CDATA(K+2),IX(NOS),IY(NOS),IZX(NOS),
     1  SPRES,STEMP
  903 FORMAT(1H ,3R1,2X,3I6,F7.0,F6.0)
  105 CONTINUE
      IF(ITWC.EQ.1)122,121
  122 BUFFER IN(2,1) (DATA(1),DATA(2680))
      ITWC=269
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123 GO TO (123,124),UNITSTF(2)
121 CONTINUE
    NSFC=NOS
    END
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      PROGRAM UPDAT
      COMMON NI,NJ,IDX,IDY,IXFO,IYFO,IXO,IYO,IXGP(21),IYGP(27)
      COMMON NWEG,NSFC,NRAOB,NOPSF,NOPUA,KOUT(4)
      COMMON DATE(4),SDATE(4),IRSF(4),IRUA(4),IX(485),IY(485),IZX(485)
      COMMON IZGY(21,27),IXS(86),IYS(86),IZXT(86),IXQ(86),IYQ(86),
     *  IZXQ(86)
      INTEGER DATE,SDATE,T,D,P
      DIMENSION NH(11),T(22),D(22),ND(28),NS(28),MMM(9),P(22),W(22)
      DDTR=.0174532925E-3
  905 FORMAT(1H )
  754 FORMAT(44HMOUNT SECTIONAL MAP, SET AT 6 LINES PER INCH    )
C     ...SEARCH RAOB TAPE
    3 READ(1) DATE
      IF(DATE(1).EQ.9999)51,4
   51 WRITE(59,752) SDATE
  752 FORMAT(4A4,48H NOT ON RAOB TAPE,MOUNT CORRECT TAPE ON 1,HIT GO)
      REWIND 1 $ PAUSE 2222 $ REWIND 1 $ GO TO 3
    4 IF(DATE(1).NE.SDATE(1).OR.DATE(2).NE.SDATE(2).OR.DATE(3).NE.
     2  SDATE(3).OR.DATE(4).NE.SDATE(4))823,5
  823 READ(1)
      GO TO (3,823),EOFCKF(1)
C     ...READ RAOB DATA
    5 NOS=0
   12 DO 812 L=1,6
  812 P(L)=0
  813 READ(1) ISTN,(NH(I),T(I),D(I),ND(I),NS(I),I=1,11),(MMM(J),
     1  J=1,9),(P(K),T(K),D(K),K=7,21),(ND(L),NS(L),L=12,28),LAD,LOD,
     2  IHS,LAMBDA,LBETA,I150
      GO TO (100,13),EOFCKF(1)
   13 IF(I150.EQ.47B)813,10013
10013 IF(NH(1).EQ.32767.OR.D(1).EQ.32767)813,14
   14 P(1)=NH(1)
      LX=P(22)=P(1)-100
      MLEV=850
      IF(LX.LT.850)817,816
  817 MLEV=700
      IF(LX.LT.700) 818,816
  818 MLEV=500
  816 IF(I150.LE.MLEV)333,813
  333 D(22)=32767
      IF(P(1).LE.850)15,16
   16 IF(P(1).LE.1000)17,18
   18 P(2)=1000
   17 P(3)=850
   15 P(4)=700
      P(5)=500
      DO 19 I=1,21
      IF(P(I).EQ.32767.OR.D(I).EQ.32767)20,21
   20 P(I)=0
      GO TO 19
   21 IF(P(I).EQ.0)19,22
   22 IF(P(I).EQ.P(22))23,19
   23 P(22)=0
   19 CONTINUE
C     ...ARRAY PRESSURES IN DESCENDING ORDER
   24 DO 25 I=1,21
      K=22-I
      DO 25 N=1,K
```

```
      IF(P(N).GT.0)26,27
   26 IF(P(N+1)-P(N))25,28,27
   28 P(N+1)=0
      GO TO 24
   27 NSV=P(N+1) $ P(N+1)=P(N) $ P(N)=NSV
      NSV=D(N+1) $ D(N+1)=D(N) $ D(N)=NSV
   25 CONTINUE
      DO 29 K=1,22
      IF(P(K).EQ.0) 30,31
   31 IF(P(K).LT.500)30,29
   29 CONTINUE
      NL=22 $ GO TO 32
   30 NL=K-1
   32 DO 33 IPA=1,NL
      IF(P(IPA).EQ.LX)34,33
   33 CONTINUE
   34 IF(D(IPA).NE.32767)36,37
   37 DLP=P(IPA-1)
      D(IPA)=D(IPA-1)+(D(IPA+1)-D(IPA-1))*(ALOG(DLP/P(IPA))/
     *  ALOG(DLP/P(IPA+1)))
   36 DO 35 K=1,IPA
      VAP=6.108*EXP((17.269388*D(K))/(2373+D(K)))
   35 W(K)=(622.*VAP)/(P(K)-VAP)
C     ...INTEGRATE TO FIND WBAR
      WBAR=0.0
      DO 38 K=2,IPA
   38 WBAR=WBAR+(W(K-1)+W(K))*(P(K-1)-P(K))
      WBAR=.005*WBAR
      IF(WBAR.GT.35..OR.WBAR.LE.0.)12,2780
 2780 CONTINUE
C     ...COMPUTE STATION COORDINATES
      RA=.2508263*LBETA*COS(LAD*DDTR)
      DLO=1.E-5*LAMBDA
      NOS=NOS+1
      IXQ(NOS)=IXS(NOS)=RA*COS(DLO)
      IYQ(NOS)=IYS(NOS)=RA*SIN(DLO)
      IZXT(NOS)=WBAR*100.+.5
      IZXQ(NOS)=W(1)*100.+.5
      GO TO (39,12),SSWTCHF(2)
   39 RRR=WBAR/W(1)
      PRINT 900,ISTN,IXQ(NOS),IYQ(NOS),P(1),D(1),WBAR,W(1),RRR
  900 FORMAT(1H ,I5,3I6,I5,3F8.2)
      GO TO 12
C     RAOB COMPUTATIONS COMPLETE
  100 NRAOB=NOS
      NACT=NSFC+NRAOB
      CALL SORTOB(IXS,IYS,IZXT,NRAOB,IXO,IDX)
      CALL SORTOB(IXQ,IYQ,IZXQ,NRAOB,IXO,IDX)
      NWEGS=NWEG $ NWEG=100
      DO 150 L=1,NRAOB
      LSUB=NSFC+L
      IX(LSUB)=IXQ(L) $ IY(LSUB)=IYQ(L)
  150 IZX(LSUB)=-IZXQ(L)
      CALL SORTOB(IX,IY,IZX,NACT,IXO,IDX)
      CALL BOBAN(IX,IY,IZX,IZGY,NACT,IRSF,NOPSF,0)
      NWEG=NWEGS
      GO TO(10150,10152),SSWTCHF(1)
C     ...PRINT ANALYZED SFC MIXING RATIOS
```

```
10150 WRITE(59,754)
      PAUSE 1234
      DO 8101 L=1,5
 8101 PRINT 905
      PRINT 906,(IZGY(I,L),L=1,NJ)
  906 FORMAT(1H ,I4,2615)
      DO 102 I=2,NI
  102 PRINT 902,(IZGY(I,L),L=1,NJ)
  902 FORMAT(/1H0,I4,2615)
      PRINT 911,DATE,(IRSF(L),L=1,NOPSF)
  911 FORMAT(/1H0,19H SFC MIXING RATIOS ,4A4,5X,415)
      DO 8102 L=1,15
 8102 PRINT 905
10152 CONTINUE
      END
```

```
      SUBROUTINE SORTOB(IX,IY,IZX,NOS,IXO,IDX)
C     ...PREPARES DATA IN BANDS OF IDX FOR BOBAN
C     ...SORTS ON IX, THEN IY IN BANDS OF IDX
      DIMENSION IX(1),IY(1),IZX(1)
      NOSM=NOS-1
      DO 1 I=1,NOSM
      IS=I
      IMX=IX(I)
      K=I+1
      DO 2 J=K,NOS
      IF(IMX-IX(J))2,2,3
    3 IS=J
      IMX=IX(J)
    2 CONTINUE
      IF(IS-I)4,1,4
    4 IX(IS)=IX(I)
      IX(I)=IMX
      IMX=IY(IS)
      IY(IS)=IY(I)
      IY(I)=IMX
      IMX=IZX(IS)
      IZX(IS)=IZX(I)
      IZX(I)=IMX
    1 CONTINUE
C     ...SORT ON IY IN BANDS OF IDX
      IF(IX(1)-IXO)5,6,6
    5 IXI=IXO-IDX*(1+(IXO-IX(1)-1)/IDX)
      GO TO 7
    6 IXI=IXO+IDX*((IX(1)-IXO)/IDX)
    7 IS=1
      N=0
      IXB=IXI+IDX
   10 IE=IS
   11 IF(IX(IE)-IXB)12,13,13
   12 IE=IE+1
      IF(IE-NOS)11,11,13
   13 IE=IE-1
      IF(IS-IE)14,15,15
   14 IEE=IE-1
C     ...SORT ON IY
      DO 20 I=IS,IEE
      IQ=I
      IMX=IY(I)
      K=I+1
      DO 21 J=K,IE
      IF(IMX-IY(J))21,21,22
   22 IQ=J
      IMX=IY(J)
   21 CONTINUE
      IF(IQ-I)23,20,23
   23 IY(IQ)=IY(I)
      IY(I)=IMX
      IMX=IX(IQ)
      IX(IQ)=IX(I)
      IX(I)=IMX
      IMX=IZX(IQ)
      IZX(IQ)=IZX(I)
```

```
      IZX(I)=IMX
   20 CONTINUE
   15 IS=IE+1
      IXB=IXB+IDX
      IF(IS-NOS)10,10,30
   30 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE BOBAN(IX,IY,IZX,IZGX,NOS,IR,NOP,LLL)
C     INMAN  4/28/69
C     ...BANDED OBAN VERSION...MISSING DATA PROVISION
C     ...LLL=0, !ZGX ZEROED
C     ...LLL=1, INITIAL VALUES FOR IZGX PROVIDED OUTSIDE SUBROUTINE
C     ...VERSION FOR POSITIVE VALUES ONLY
C     ...IZX HOLDS OBS AND IS UNCHANGED
C     ...IZH HOLDS DEVIATION
C     ...ICA HOLDS ANALYZED VALUE OF EACH STATION
C     ...NEG. IZX ARE GIVEN A WEIGHT OF NWEG AND IABS(IZX) IS USED
      DIMENSION IX(485),IY(485),IZX(485),IZGX(21,27),
     *IR(4),IZH(485),ICA(485),ICALL(485),JCALL(485),IPOS(55),IPOE(55)
      COMMON NI,NJ,IDX,IDY,IXFO,IYFO,IXO,IYO,IXGP(21),IYGP(27)
      COMMON NWEG,NSFC,NRAOB,NOPSF,NCPUA,KOUT(4)
      IF(LLL)2000,1000,2000
 1000 DO 1010 J=1,NJ
      DO 1010 I=1,NI
 1010 IZGX(I,J)=0
 2000 NNS=2
      IF(IX(1)-IXO)1,2,2
    1 IXI=IXO-IDX*(1+(IXO-IX(1)-1)/IDX)
      GO TO 3
    2 IXI=IXO+IDX*((IX(1)-IXO)/IDX)
    3 ICONST=(IXO-IX(1))/IDX+1
      NBAN=0
      IS=1
      IXB=IXI+IDX
      IE=IS
    5 IF(IX(IE)-IXB)6,7,7
    6 IE=IE+1
      IF(IE-NOS)5,5,10
    7 IF(IS-IE)8,9,9
    9 IS=0
    8 NBAN=NBAN+1
      IPOS(NBAN)=IS
      IPOE(NBAN)=IE-1
      IS=IE
      IXB=IXB+IDX
      GO TO 5
   10 NBAN=NBAN+1
      IPOS(NBAN)=IS
      IPOE(NBAN)=IE-1
C     ...NR IS THE RADIUS FOR STATIONS OUTSIDE THE GIRD
      NR=300
      NR2=NR*NR
C  LOCATES GRID SQUARE CONTAINING OBSERVATION STATION
      DO 50 K=1,NOS
      IF(IX(K)-IXO)16,17,18
   18 IF(IX(K)-IXFO)17,16,16
   17 IF(IY(K)-IYO)16,15,19
   19 IF(IY(K)-IYFO)15,16,16
C     ...STATION IS OUTSIDE GRID
   16 ICALL(K)=999
      GO TO 50
   15 ICALL(K)=1+(IX(K)-IXO)/IDX
      JCALL(K)=1+(IY(K)-IYO)/IDY
   50 CONTINUE
```

```
C  INITIALIZATION OF ARRAYS FOR GRID
      DO 14 K=1,NOS
      ICA(K)=0
   14 IZH(K)=IABS(IZX(K))
      DO 199 L=1,NOP
      KR=IR(L)
      IR2=KR*KR
      JGRDL=KR/IDX
      IF(LLL)1030,1020,1030
 1020 IF(L-1)1030,23,1030
C  INTERPOLATION
 1030 DO 22 K=1,NOS
      IF(IZX(K)-32767)10022,22,22
10022 IXK=IX(K)
      IYK=IY(K)
      IF(ICALL(K)-999)52,516,52
C     CALCULATE DEVIATION AT STATION WHEN STATION IS OUTSIDE GRID
  516 IA1=0
      IA2=0
      DO 524 I= 1,NOS
      IF(IZX(I)-32767)10524,524,10524
10524 M1=IABS(IXK-IX(I))
      IF(M1-NR)525,524,524
  525 M2=IABS(IYK-IY(I))
      IF(M2-NR)526,524,524
  526 M3=M1*M1+M2*M2
      IB1=NR2-M3
      IF(IB1)524,524,536
  536 B2=NR2+M3
      IF(IZX(I))637,636,636
  637 KW=(IB1/B2)*NWEG
      GO TO 638
  636 KW=(IB1/B2)*100.
  638 IA1=IA1+KW*IZH(I)
      IA2=IA2+KW
  524 CONTINUE
      ICA(K)=(ICA(K)+IA1/IA2+IABS(IZX(K)))/2
      GO TO 22
C  CALCULATION OF DEVIATION WHEN STATION IS WITHIN GRID
   52 M=ICALL(K)
      N=JCALL(K)
      M1=IXK-IXGP(M)
      M2=IYK-IYGP(N)
      IZ1=IZGX(M,N)
      IZ2=IZGX(M,N+1)
      IZ4=IZGX(M+1,N)
      ICA(K)=IZ1+((M1*(IZ4-IZ1))/IDX+(M2*(IZ2-IZ1))/IDY+
     1 (((M1*M2)/IDX)*(IZGX(M+1,N+1)-IZ4+IZ1-IZ2))/IDY)
   22 CONTINUE
      DO 950 K=1,NOS
      IZH(K)=IABS(IZX(K))-ICA(K)
      IF(IZH(K)-32767)10948,950,10948
10948 IF(IABS(IZH(K))-KOUT(L))950,950,10950
10950 WRITE(59,75)IX(K),IY(K),L,IZX(K)
      IZX(K)=32767
      IZH(K)=32767
      ICA(K)=0
   75 FORMAT(1X,8HDATA AT ,2I10,2X,17HREJECTED ON PASS ,I1,2X,9HVALUE IS
```

```
     * ,I5)
  950 CONTINUE
C     ...BAND VERSION FOR ANALYZED VALUE AT GRID POINTS
   23 DO 198 J=1,NJ
      IYK=IYGP(J)
      DO 198 I=1,NI
      JR=KR
      JR2=IR2
      IGRDL=JGRDL
      IXK=IXGP(I)
 1136 IA1=0
      IA2=0
      NN=0
      IONE=100
      IBGRD=I+ICONST
      IBT=IBGRD-IGRDL
      IBB=IBGRD+IGRDL-1
      IF(IBT)400,400,401
  400 IF(IBB)198,198,402
  402 IBT=1
  401 IF(IBB-NBAN)405,405,404
  404 IBB=NBAN
  405 DO 410 KB=IBT,IBB
      IS=IPOS(KB)
      IF(IS)410,410,411
  411 IE=IPOE(KB)
      NB=0
      DO 424 K=IS,IE
      IF(IZX(K)-32767)10024,424,10024
10024 M1=IABS(IX(K)-IXK)
      IF(M1-JR)425,430,430
  425 M2=IABS(IY(K)-IYK)
      IF(M2-JR)426,430,430
  426 M3=M1*M1+M2*M2
      IB1=JR2-M3
      IF(IB1)424,424,436
  436 B2=JR2+M3
      IF(IZX(K))737,736,736
  737 KW=(IB1/B2)*NWEG
      IONE=NWEG
      GO TO 738
  736 KW=(IB1/B2)*100.
  738 IA1=IA1+KW*IZH(K)
      IA2=IA2+KW
      NN=NN+1
      NB=1
      GO TO 424
  430 IF(NB)424,424,410
  424 CONTINUE
  410 CONTINUE
C     TWO STATIONS ARE REQUIRED WITHIN JR ON FIRST SCAN ONLY
      IF(NN-NNS)398,201,201
  201 IF(NN-1)198,202,200
C     NO STATIONS WITHIN JR-INCREASE JR AND TRY AGAIN
  398 JR=JR+IDX
      JR2=JR*JR
      IGRDL=IGRDL+1
      GO TO 1136
```

```
200  IF(IA2)398,398,27
202  IA2=IONE
 27  IZGX(I,J)=IZGX(I,J)+IA1/IA2
198  CONTINUE
     NNS=0
199  CONTINUE
     RETURN
     END
```

```
      PROGRAM FINAL
      INTEGER DATE,SDATE
      DIMENSION IZGX(21,27)
      COMMON NI,NJ,IDX,IDY,IXFO,IYFO,IXO,IYO,IXGP(21),IYGP(27)
      COMMON NWEG,NSFC,NRAOB,NOPSF,NOPUA,KOUT(4)
      COMMON DATE(4),SDATE(4),IRSF(4),IRUA(4),IX(485),IY(485),IZX(485)
      COMMON IZGY(21,27),IXS(86),IYS(86),IZXT(86),IXQ(86),IYQ(86),
     *  IZXQ(86)
C     ...SET CONTOURING SYMBOLS
      COMMON/DATA/KALP(16)
      DATA(KALP=1HA,1H ,1HB,13(1H ))
C     ...INTERPOLATE A VALUE OF WZERO FOR EACH UA STAT I/S GRID
      NACT=NSFC+NRAOB
      DO 120 L=1,NRAOB
      IXT=IXQ(L)  $  IYT=IYQ(L)
      IF(IXT.LT.IXO.OR.IXT.GT.IXFO)121,122
  122 IF(IYT.LT.IYO.OR.IYT.GT.IYFO)121,123
  123 M=(IXT-IXO)/IDX+1 $ N=(IYT-IYO)/IDY+1
      M1=IXT-IXGP(M) $ M2=IYT-IYGP(N)
      IZ1=IZGY(M,N) $ IZ2=IZGY(M,N+1) $ IZ4=IZGY(M+1,N)
      NZERO=IZ1+((M1*(IZ4-IZ1))/IDX+(M2*(IZ2-IZ1))/IDY+
     *  (((M1*M2)/IDX)*(IZGY(M+1,N+1)-IZ4+IZ1-IZ2))/IDY)
      IZXQ(L)=(IZXT(L)*1000)/NZERO
      GO TO (125,170),SSWTCHF(2)
  125 PRINT 901,IXQ(L),IYQ(L),IZXQ(L),NZERO
  901 FORMAT(6H WZERO,4I7)
      GO TO 170
  121 IZXQ(L)=(IZXT(L)*1000)/IZXQ(L)
  170 IF(IZXQ(L).GT.1250)171,172
  171 IZXQ(L)=1250 $ GO TO 120
  172 IF(IZXQ(L).LT.500)173,120
  173 IZXQ(L)=500
  120 CONTINUE
C     ...ANALYZE THE RATIOS (IZXQ)
      DO 10120 J=1,NJ
      DO 10120 I=1,NI
10120 IZGX(I,J)=900
      CALL BOBAN(IXQ,IYQ,IZXQ,IZGX,NRAOB,IRUA,NOPUA,1)
      DO 10125 J=1,NJ
      DO 10125 I=1,NI
      IF(IZGX(I,J)-500)10123,10125,10125
10123 IZGX(I,J)=500
10125 CONTINUE
      GO TO (126,127),SSWTCHF(1)
  126 WRITE(59,754)
      PAUSE 1234
  754 FORMAT(44HMOUNT SECTIONAL MAP, SET AT 6 LINES PER INCH    )
      CALL PRTFLD(IZGX,NI,NJ)
      PRINT 902,DATE,(IRUA(L),L=1,NOPUA)
  902 FORMAT(/1H0,36HRATIO OF MEAN AND SFC MIXING RATIOS ,4A4,5X,4I5)
      DO 128 L=1,15
  128 PRINT 903
  903 FORMAT(1H )
  127 CONTINUE
C     ...INTERPOLATE A RATIO FOR THE SFC STATIONS
      LS=0
      DO 136 L=1,NACT
      IF(IZX(L).LT.0 .OR.IZX(L).EQ.32767)136,137
```

```
  137 LS=LS+1
      IXT=IX(L) $ IYT=IY(L)
      M=(IXT-IXO)/IDX+1 $ N=(IYT-IYO)/IDY+1
      M1=IXT-IXGP(M) $ M2=IYT-IYGP(N)
      IZ1=IZGX(M,N) $ IZ2=IZGX(M,N+1) $ IZ4=IZGX(M+1,N)
      NRAT=IZ1+((M1*(IZ4-IZ1))/IDX+(M2*(IZ2-IZ1))/IDY+
     *   (((M1*M2)/IDX)*(IZGX(M+1,N+1)-IZ4+IZ1-IZ2))/IDY)
      IZX(LS)=(IZX(L)*NRAT+500)/1000
      IX(LS)=IX(L) $ IY(LS)=IY(L)
  136 CONTINUE
C     ...MOVE (WBAR)UA INTO LIST
      DO 138 L=1,NRAOB
      LSUB=NSFC+L
      IX(LSUB)=IXS(L)
      IY(LSUB)=IYS(L)
  138 IZX(LSUB)=-IZXT(L)
      GO TO (400,401)SSWTCHF(2)
  400 PRINT 920,(IX(L),IY(L),IZX(L),L=1,NACT)
  920 FORMAT(4H ***,3I10)
  401 CONTINUE
C     ...COMPUTE WBAR FIELD BY MULT OF GRID PTS OF WZERO AND RATIO
  129 DO 130 I=1,NI
      DO 130 J=1,NJ
  130 IZGX(I,J)=(IZGY(I,J)*IZGX(I,J)+500)/1000
      GO TO(10129,141),SSWTCHF(5)
10129 CALL PRTFLD(IZGX,NI,NJ)
      PRINT 904,DATE
  904 FORMAT(/1H0,18HMEAN MIXING RATIO ,4A4)
      DO 131 L=1,15
  131 PRINT 903
  141 CALL SORTOB(IX,IY,IZX,NACT,IXO,IDX)
C     MEAN MIXING RATIO
      CALL BOBAN(IX,IY,IZX,IZGX,NACT,IRSF,NOPSF,1)
      DO 2000 I=1,NI
      DO 2000 J=1,NJ
 2000 IZGX(I,J)=(IZGX(I,J)+5)/10
      DO 2001 K=1,5
 2001 PRINT 903
      CALL CONTUR(IZGX,NI,NJ,60,40,KALP)
      PRINT 910,DATE,NWEG,(IRSF(L),L=1,NOPSF)
  910 FORMAT(/1H0,47HMEAN MIXING RATIO IN 100MB THICK SURFACE LAYER ,
     *4A4,5X,5HNWEG=,I5,5X,4I5)
      DO 142 L=1,18
  142 PRINT 903
      GO TO(160,150)SSWTCHF(4)
  160 NWEG=100
      CALL BOBAN(IXS,IYS,IZXT,IZGY,NRAOB,IRUA,NOPUA,0)
      DO 9923 J=1,NJ
      DO 9923 I=1,NI
 9923 IZGY(I,J) =(IZGY(I,J)+5)/10
      CALL PRTFLD(IZGY,NI,NJ)
      PRINT 913,DATE,(IRUA(L),L=1,NOPUA),NRAOB
  913 FORMAT(/1H0,21HMEAN USING RAOB ONLY    ,5X,4A4,5X,4I5,2X,I5)
      DO 162 L=1,15
  162 PRINT 903
      DO 163 I=1,NI
      DO 163 J=1,NJ
  163 IZGX(I,J)=IZGX(I,J)-IZGY(I,J)
```

```
      CALL PRTFLD(IZGX,NI,NJ)
      PRINT 914 ,DATE
  914 FORMAT(/1H0,10HMEAN-RAOB    ,5X,4A4)
      DO 164 L=1,15
  164 PRINT 903
  150 WRITE(59,912)
  912 FORMAT(32HSET PRINTER AT 10 LINES PER INCH)
      PAUSE 4321
      DO 3000 I=1,NRAOB
 3000 IZXT(I)=(IZXT(I)+5)/10
      PRINT 915,DATE
  915 FORMAT(37X,47HMEAN MIXING RATIO IN 100MB THICK SURFACE LAYER ,4A4)
      CALL MAPONE(IXS,IYS,NRAOB,IZXT)
      CONTINUE
      END
```

```
      SUBROUTINE PRTFLD(IAR,NI,NJ)
C     ...PRINTS OBAN FIELD - PROVIDES SPACING AT TOP ONLY
      DIMENSION IAR(21,27)
      DO 1 L=1,5
    1 PRINT 901
  901 FORMAT(1H )
      PRINT 902,(IAR(1,L),L=1,NJ)
  902 FORMAT(1H ,3X,26I5)
      DO 2 I=2,18
    2 PRINT 903,(IAR(I,L),L=1,NJ)
  903 FORMAT(/1H0,3X,26I5)
      PRINT 10,(IAR(19,L),L=1,17),(IAR(19,L),L=23,26)
   10 FORMAT(/1H0,3X,17I5,25X,4I5)
      PRINT 12,(IAR(20,L),L=1,12),(IAR(20,L),L=23,26)
   12 FORMAT(/1H0,3X,12I5,50X,4I5)
      PRINT 14,(IAR(21,L),L=1,11),(IAR(21,L),L=24,26)
   14 FORMAT(/1H0,3X,11I5,60X,3I5)
      RETURN
      END
```

```
      SUBROUTINE MAPONE(IX,IY,NOS,IZX)
C  PRINTS STATION VALUES ON SECTIONAL MAP
C  TO USE * ENTRY    POSITION MAP AT STANDARD POSITION, SET PRINTER AT
C                    10 LPI, PRINT A ONE LINE HEADER, AND CALL THIS SUB
C           EXIT     MAP IS LEFT AT STANDARD MAP POS
C  RESULTS * 4 DIGITS OF IZX ARE PRINTED TO THE LEFT OF THE STATION
C             ASTERISK. IF THE NUMBER EXCEEDS 4 CHARACTERS, $$$$ IS INSERTED
C  IX,IY,IZX,NOS ARE NOT MODIFIED IN ANY WAY
C      FORM  XXXX*  OR  -XXX*
      CHARACTER LINE
      DIMENSION IZX(1),IX(1),IY(1),IS(86),IT(86),LINE(135)
      IXC=1689 $ IYC=-342
      DO 1 L=1,NOS
      IS(L)=(IX(L)-IXC)/10
    1 IT(L)=(IY(L)-IYC)/10
      DO 4 IR=1,126
      DO 3 L=1,135
    3 LINE(L)=60B
      DO 5 I=1,NOS
      IF(IR.EQ.IS(I))6,5
    6 K=IT(I)
      IF(K.LT.1.OR.K.GT.135) 5,930
  930 IF(K.LT.5)30,31
   30 K=5
   31 KK=IZX(I)
      IF(KK.GT.9999.OR.KK.LT.-999)25,21
   25 NS=NH=NT=NU=53B
      GO TO 518
   21 JJ=IABS(KK)
      NS=JJ/1000 $ NX=JJ-NS*1000 $ NH=NX/100 $ NX=NX-NH*100 $ NT=NX/10
      NU=NX-NT*10
      IF(NS.EQ.0)517,518
  517 NS=60B
      IF(KK.LT.0)521,522
  521 NS=40B
  522 IF(NH.EQ.0)519,518
  519 NH=NS
      IF(NT.EQ.0)523,524
  523 NT=NH $ GO TO 525
  518 LINE(K-4)=NS
  524 LINE(K-3)=NH
  525 LINE(K-2)=NT
      LINE(K-1)=NU
      LINE(K)=54B
    5 CONTINUE
      PRINT 901,LINE
  901 FORMAT(1H ,135R1)
    4 CONTINUE
      PRINT 902
  902 FORMAT(12(/))
      RETURN
      END
```

```
      SUBROUTINE CONTUR(IZ,NI,NJ,MIN,INT,KALP)
C     ...PRINTS STANDARD NI X NJ GRID WITH CONTOURING BETWEEN LINES
C     ...MIN IS THE MINIMUM VALUE, INT IS THE CONTOURING INTERVAL
C     ...KALP IS AN ARRAY CONTAINING THE CONTOURING SYMBOLS
C     ...NJ MUST BE LE 27
      DIMENSION IZ(21,27),KALP(16),LINE(131),LIN(27)
      LTOT=INT*16
      NJM=NJ-1
      NUM=5*NJM-4
      PRINT 900,(IZ(1,J),J=1,NJ)
  900 FORMAT(1H,I3,26I5)
      DO 1 IR=2,NI
      DO 2 JD=1,2
      DO 3 L=1,NJ
    3 LIN(L)=((IZ(IR,L)-IZ(IR-1,L))*JD)/3+IZ(IR-1,L)
      K=1
      DO 4 J=1,NJM
      LINE(K)=LINJ=LIN(J)
      NDZ=LIN(J+1)-LINJ
      DO 5 L=1,4
      K=K+1
    5 LINE(K)=(NDZ*L)/5+LINJ
      K=K+1
    4 CONTINUE
      LINE(K)=LIN(NJ)
      DO 6 L=1,NUM
      JDF=LINE(L)-MIN
    7 IF(JDF)8,9,9
    8 JDF=JDF+LTOT
      GO TO 7
    9 J=JDF/INT
      IS=J-(J/16)*16+1
    6 LINE(L)=KALP(IS)
      PRINT 901,(LINE(L),L=1,NUM)
  901 FORMAT(1H,2X,131A1)
    2 CONTINUE
      PRINT 900,(IZ(IR,J),J=1,NJ)
    1 CONTINUE
      RETURN
      END
```

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