NOAA Western Region Computer Programs and
Problems NWS WRCP - No. 4

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PRECIPITABLE WATER ESTIMATE

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Great Falls, Montana

October 1979

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This Western Region publication series is considered as a subset of our Technical Memorandum series. This series will be devoted exclusively to the exchange of information on and documentation of computer programs and related subjects. This series was initiated because it did not seem appropriate to publish computer program papers as Technical Memoranda; yet, we wanted to share this type of information with all Western Region forecasters in a systematic way. Another reason was our concern that in the developing AFOS-era there will be unnecessary and wasteful duplication of effort in writing computer programs in National Weather Service (NWS). Documentation and exchange of ideas and programs envisioned in this series hopefully will reduce such duplication. We also believe that by publishing the programming work of our forecasters, we will stimulate others to use these programs or develop their own programs to take advantage of the computing capabilities AFOS makes available.

We solicit computer-oriented papers and computer programs from forecasters for us to publish in this series. Simple and short programs should not be prejudged as unsuitable.

The great potential of the AFOS-era is strongly related to local computer facilities permitting meteorologists to practice in a more scientific environment. It is our hope that this new series will help in developing this potential into reality.

NOAA Western Region Computer Programs and Problems NWS WRCP

1 Standard Format for Computer Series. June 1979
2 AFOS Crop and Soil Information Report Program. Ken Mielke, July 1979
3 Decoder for Significant Level Transmission of Raobs. John Jannuzzi, August 1979

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PRECIPITABLE WATER ESTIMATE

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I. GENERAL INFORMATION

Precipitable water is an important - and often neglected - forecast tool. The delay between receipt of initial radiosonde data and the printed precipitable water chart over the facsimile network greatly reduces the usefulness of the product. To counteract the delay, a "quick and dirty" estimate of precipitable water was worked up at the Great Falls WSFO using data from the mandatory RAOB message.

The program was created for use with a programmable calculator, but recently was translated into Fortran for use with the Eclipse computer. Input and output are accomplished via the AFOS dasher.

II. APPLICATION

A. Program Purpose and Function

The program gives a reliable estimate of precipitable water in Montana and has been used successfully in thunderstorm forecasting. It will be an integral part of an objective scheme to determine flash flood watch issuance. The values have been helpful in tracking the flow of moisture into Montana. This additional information comes at the time of minimum NMC forecast model output, yet is the critical time for flash flood alert or watch issuances as well as for consultation with SELS with regard to severe thunderstorm watch issuances.

The program sums the precipitable water in three layers: from the surface to 775 MB, 775 to 625 MB and 625 to 500 MB. Data are input at the AFOS dasher and include surface pressure, and the dewpoint temperature at the surface, 850,700 and 500 MB levels. The calculated value for precipitable water is printed on the dasher.

B. Derivation

Briefly, precipitable water is defined as the mass of water vapor in a vertical column of air with horizontal area 1 cm^2 between two given height or pressure surfaces. For the purposes of this study pressure levels were used, so that (variables defined in Table 1):

$$P_w = -\frac{1}{g}\int_{P_1}^{P_2} q\,dp. \qquad (1)$$

Since $q \sim r$,

$$P_w \sim \frac{1}{g}\,\bar{r}\,(p_1 - p_2). \qquad (2)$$

By definition,

$$r = \varepsilon\, e/(p - e), \qquad (3)$$

so

$$P_w \sim \frac{1}{g}\,\varepsilon\left(\frac{e}{p-e}\right)(P_1 - P_2) \qquad (4)$$

Manipulation of the value of e yields:

$$P_w \sim \frac{1}{g}\,\varepsilon\left(\frac{e^{(56.815 - 6885.06/\bar{T}_d - 5.31\ \ln \bar{T}_d)}}{p-e^{(56.815 - 6885.06/\bar{T}_d - 5.31\ \ln \bar{T}_d)}}\right)(P_1 - P_2)$$

for $P_1 - P_2$ the relation $\Delta Z \sim K\bar{T}_d \ln\left(P_1/P_2\right)$ was used.

Thus, to find the precipitable water of a layer, the only variables are the two pressure levels forming the boundaries and the average dewpoint temperature between the levels.

Table 1

P_w = precipitable water

e = partial pressure
ε = constant .622
g = force of gravity
K = .2929 gpm/degree
p = pressure
q = specific humidity
r = relative humidity
T_d = dewpoint temperature

C. Machine Requirements

The program requires less than 10K memory. Computer run time is less than one second.

D. Comments and Restrictions

Technically, the program can be used at any location. A necessary assumption, however, is that the dewpoint temperature at the midpoint of a layer is also the average dewpoint temperature of the layer. When this is true, the calculated precipitable water value is accurate to about one hundreth of an inch. Unfortunately, the calculated value is rarely the exact figure and occasionally is not close to the actual average dewpoint temperature.

A related problem is that the program was created to suit the needs of the Montana forecaster. Thus, no effort was made to account for the type of moisture profile frequently found along the coast with abundant moisture concentrated in the very lowest levels of the atmosphere. This program could easily be adapted to access "SOUNDING.W" file created by significant level raob decoder (See WRCP-2). This would make preicpitable water calculation more accurate.

III. PROCEDURES

A. Input

Program is initiated by typing "MCPWTR" at the dasher. Prompts from the dasher individually request the following information: surface pressure and dewpoints at the surface, 850, 700 and 500 MB. Values are read directly from the mandatory level (TTAA) raob message. The only restriction is that the dewpoint temperature of the surface and 850 MB levels must not be the same. When the two temperatures are entered with the same value, the computer will be unable to compute a value for the layer between the surface and 775 MB.

B. Output

Entering the dewpoint temperature for 500 MB triggers computation of the precipitable water. Output on the AFOS dasher is the precipitable water estimate in inches. Sample input and output is shown in Figure I.

C. Program Listing

```
  $$
C PRECIPITABLE WATER PROGRAM
      DIMENSION P(3), T(3), PW(3), PSRDF(3)
      P(3)=500.
      PSRDF(2)=1.24
      PSRDF(3)=1.25
      PCPWTR = 0.0
      P(2) = 700.
C SFC PRESSURE,TD SFC,TD850,TD700,TD500
      ACCEPT "SURFACE PRESSURE=",P(1),
     1"SURFACE DEWPOINT=",TS,
     2"850MB DEWPOINT=",T(1),
     3"700MB DEWPOINT=",T(2),
     4"500MB DEWPOINT=",T(3)
      T(1) = T(1) + 273
      T(2) = T(2) + 273
```

```
C CREATE NEW MIDPOINT TD TO REPLACE 850 AND 500 MB TDS
      SLP = (850-P(1))/(T(1)-(TS+273))
      P(1) = (P(1) - 925)/2 + 850
      T(1) = (P(1)+(T(1)*SLP-850))/SLP
      T(3) = (2 * (T(3) + 273) + T(2))/3
C CALCULATE EACH LAYER AND ADD
      PSRDF(1) = P(1)/775
      DO 50 I = 1,3
      PRTLMR = EXP(56.815 - 6885.06/T(I) - 5.31*ALOG(T(I)))
      PW(I) = .732*(PRTLMR/(P(I) - PRTLMR))*T(I)*ALOG(PSRDF(I))
50    PCPWTR = PCPWTR + PW(I)
      WRITE(10,60)PCPWTR
60     FORMAT(" PRECIPITABLE WATER = ",F5.2)
      STOP
      END
```

```
MPCPWTR
SURFACE PRESSURE=886
SURFACE DEWPOINT=8.2
850MB DEWPOINT=7.2
700MB DEWPOINT=-2.0
500MB DEWPOINT=-18.1
PRECIPITABLE WATER =  0.67
STOP
R
```

Figure I. Sample Input/output

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