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TECHNICAL NOTE
71-2

A REPRINT
OF
USE OF FOUS
(DETAILED PE GUIDANCE)
UNDATED

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Technical Procedure Branch
Weather Analysis and Prediction Division
NOAA

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Purpose

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Distribution

Technical Notes will normally be given the same distribution as AWS Technical Reports which includes all AWS units through detachment level. Additional special distribution may be provided certain issues when the subject matter is believed to warrant wider dissemination within the scientific community. A smaller distribution of the Notes will be made when the area of interest and applicability is considered limited.

PREFACE

This Note is issued to quickly supply field forecasters, especially in the ZI, with guidance for using the National Weather Service FOUS Bulletins that started being transmitted over COMET circuits on 15 February 1971. It includes papers from NWS sources which were intended to provide NWS forecasters with guidance on use of FOUS Bulletins. The AWS is pleased to acknowledge the cooperation of NWS Technical Procedures Branch in making this material available for reprinting.

Introduction

Beginning on 15 February 1971 the FOUS 1 and FOUS 2 KWBC Bulletins are being relayed on all 8 COMET circuits twice daily during the time blocks 0645Z-0715Z and 1845Z-1915Z. These Bulletins contain detailed guidance based on the 6-layer (PE) numerical prediction model. This model supplies the bulk of the forecast fields provided on the NAFAX and FOFAX circuits. Although primarily designed to satisfy National Weather Service requirements, the information contained in these Bulletins has proven useful to AWS forecasters at detachments located near the cities included in the Bulletins.

Reprinted in this Technical Note is a copy of the NWS Forecasters Training Course notes entitled "Use of FOUS (Detailed PE Guidance)" by Mr. Frederick P. Ostby, Jr., of the Technical Procedures Branch, WXAP, National Weather Service. Mr. Ostby's notes describe the Bulletin content, give a breakdown of the format, and discuss some of the special characteristics of the parameters which are included. We call your attention to the Eastern Region Technical Attachment 70-11-9 which Mr. Ostby appended to his notes. This Attachment discusses a systematic procedure for depicting the data available in the form of a time cross-section. Effective assimilation and use of this detailed guidance requires a systematic organization such as the one suggested. The Western Region Technical Attachment No. 70-43, also reprinted in the Technical Note, provides additional guidance on organizing FOUS data.

Thus, AWS ZI units are now receiving detailed guidance derived from three different basic models: the AFGWC multilevel cloud-forecasting model, the AFGWC Boundary-Layer Model, and the National Meteorological Center's 6-layer (PE) model. Also, output data from the AFGWC models are used in computing the AFGWC trajectory bulletins. AWS units are encouraged to quantify their experience with these products. By carefully evaluating the accuracy of the guidance as a function of synoptic situation, the ability of these centralized products to assist in producing more accurate terminal forecasts can be appraised and confidence in their proper use established.

UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

USE OF FOUS
(Detailed PE Guidance)

Frederick P. Ostby, Jr.
Technical Procedures Branch
Weather Analysis and Prediction Division

Forecasters Training Course
1970-71

1. INTRODUCTION

The versatility of the 6-Layer (PE) Numerical Prediction Model has made it practicable to output values of a variety of meteorological parameters at specific geographical locations from its forecast run. Essentially, grid point values are bilinearly interpolated to specific cities to obtain these data.

Evaluation of the forecasts during a test period demonstrated the usefulness of a number of the parameters as guidance in daily local weather forecasting. Transmission of this digital form of guidance over Service C began in October 1969 as "FOUS-1" and "FOUS-2." It is currently transmitted twice daily at 0644Z and 1844Z.

2.0 OPERATIONAL PROGRAM

2.1 Forecast Cities

Forecasts are provided for 62 cities (see Fig. 1), divided into two sets to minimize transmission time. The sets are as follows:

a. FOUS-1 transmitted over Circuits 30, 33, and 34--SEA, GEG, GTF, BIL, PDX, MFR, SFO, BOI, CYS, BIS, FSD, MSP, OMA, LBF, DSM, MKE, INL, ORD, SSM, DET, IND, CLE, BUF, PIT, CRW, ALB, BTV, JFK, BOS, BGR, DCA, and PHL.

b. FOUS-2 transmitted over Circuits 31, 32, and 35--RNO, SLC. LAX, FAT, PHX, ELP, ABQ, LBB, OKC, GSW, SAT, BRO, HOU, NEW, LIT, MEM, JAN, BHM, ATL, TYS, TLH, LAL, MIA, CAE, RDU, HAT, DEN, TOP, STL, SDF, CYS, BOI, MFR, and SFO.

2.2 Parameters

Values of parameters, judged to be the most useful, forecast at 6-hourly intervals from 12 to 48 hours after 0000Z and 1200Z are provided. The parameters include:

RH--Mean relative humidity of the lowest three layers of the PE model (approximately 1000 to 490 mb), in percent.

RI--Mean relative humidity of the 50-mb thick boundary layer, in percent (approximately 1000 to 950 mb).

R2--Mean relative humidity of the lowest tropospheric layer, in percent (approximately 950 to 720 mb).

R3--Mean relative humidity of the middle tropospheric layer, in percent (approximately 720 to 490 mb).

VV--Vertical velocity at 700 mb, in tenths of a microbar per second; a weighted average of three hourly values--at forecast time, one hour before, and one hour after (double weight assigned to value at forecast time).

LI--Lifted index, in degrees Celsius. Negative values are designated by subtracting from 100; e.g., -4 = 96.

HH--1000-500 mb thickness, in decameters with the first digit omitted.

DDFF--Direction, in tens of degrees, and speed (in knots) of the mean wind in the boundary layer of the PE model.

TB--Mean potential temperature of the boundary layer, in degrees Kelvin, with hundreds position omitted.

PB--Mean pressure of the boundary layer, in millibars, with hundreds position omitted.

PPT--6 hour accumulated precipitation, in hundredths of an inch.

2.3 The Guidance Message

The teletypewriter message has the following format:

```
FOUS1 KWBC 191844
TO CIRCUITS 30 33 34
OUTPUT FROM 12Z NOV 19 70
STA RH R1R2R3 VVLI HHDDFF TBPBPTT STA RH R1R2R3 VVLI HHDDFF
TBPBPTT SEA061 976819 -1011 402821 8578001 GEG089 989466 00306
362830 8624005 18055 965228 00811 372927 8479001 18079 988837
01607 342824 8524003 24064 954678 00510 332729 8376001 24083
988659 01507 312724 8421003 30073 935595 02309 302629 8377001
30089 988393 02207 292619 8324005 36084 927598 01807 262731
8174001 36090 988198 02007 272512 8221006 42092 939192 02708
212629 7974002 42093 988698 02707 242511 8121005 48091 929092
02606 152824 7771004 48096 989198 02107 202703 7921006
```

Relative humidities of 98% or more in the individual layers will be indicated by a "98." Three digits are provided for the mean relative humidity averaged over the three layers allowing for forecasts of 100%.

Missing values will be represented by 9's.

3.0 GENERAL DESCRIPTION

The FOUS-1, 2 message provides some of the same kind of information as is contained in the facsimile representation of the output from the 6-Layer (PE) Numerical Prediction Model. Both are derived from the grid point values of the basic parameters carried in the forecast history of the PE Model. Grid point values of the derived parameters are analyzed to provide sets of isopleths which are automatically superimposed on a map base for facsimile representation. For the detailed PE guidance teletypewriter bulletin, values of the derived parameters at specific cities are interpolated from the values at the four surrounding grid points. This bilinear interpolation will often produce slightly different results when compared to "eyeballed" facsimile values.

3.1 Advantages of the Teletypewriter Message

a. Forecast data are provided at 6-hourly intervals out to 48 hours. Facsimile depiction of these parameters are only available to 36 hours except for 1000-500 mb thickness for which there is a 48-hour forecast (on FOFAX only).

b. Forecast data are transmitted about one to two hours earlier than on facsimile.

c. The necessity of interpolating the values from a number of facsimile charts is eliminated.

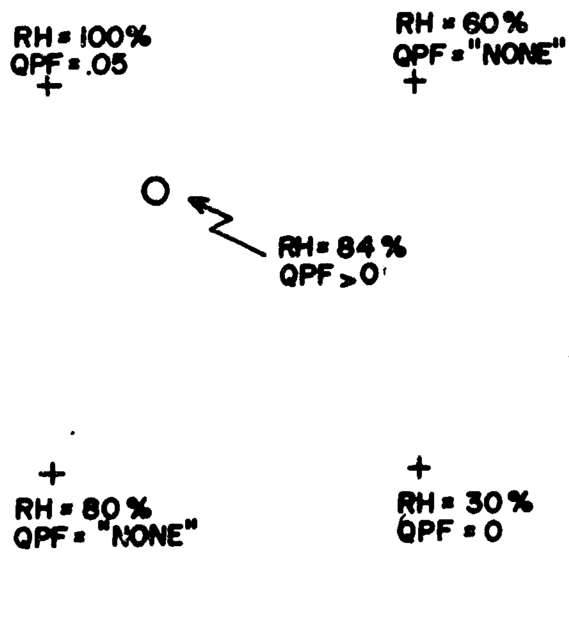
d. Forecast parameters which are not presently available on facsimile charts are included: QPF, RH in layers, and boundary layer wind, temperature and pressure.

3.2 Special Characteristics

Not all differences between "FOUS" guidance and facsimile depiction are caused by differences in interpolation procedures. For example, vertical velocity from the FOUS will often seem inconsistent from the facsimile product. This is because of differences in the way vertical velocity is time-smoothed to reduce the effects of gravity waves in the PE model. On the fax charts (NAFAX 40 and 100) vertical velocities are averaged over six 20-minute intervals (every other time step) during the two hours preceding the valid time. As described previously, the FOUS vertical velocity is a "centered" weighted average of three values; valid time (double weight), one hour prior and one hour subsequent.

The QPF portion of the FOUS message is another parameter that will occasionally appear strange. The PE Model does not forecast precipitation at cities, only grid points (likewise for the other parameters). It turns out that the method to interpolate forecast precipitation to cities from grid points differs from the method to interpolate the other parameters to cities (e.g., relative humidity). Prior to April 1968, precipitation for station locations was computed by the bilinear scheme. However, it was noted that this procedure had the effect of "spreading" the precipitation rather close to those adjacent grid points where "zero" precipitation was forecast. In April 1968 the interpolation system was modified to effectively place the "zero" precipitation isohyet halfway between grid points having "zero" and "non-zero" computed precipitation. This reduces the spreading effect of the interpolation system.

However, the spreading effect is still present to some extent and this will occasionally manifest itself in the FOUS message as a forecast of precipitation in the absence of saturation as shown by the mean RH forecast. Consider the following example in which precipitation is forecast to occur at the upper left grid point but not at the other three. Bilinear interpolation gives a mean relative of about 84% at a hypothetical station, as shown. Note that since the station is closer to the precipitating grid point than the non-precipitating grid points, the FOUS message will indicate precipitation for this station even though the mean RH is only 84%.



4. LOCAL STUDIES USING FOUS

Numerous studies have been and are being conducted both at field stations and Regional Scientific Services Divisions. A sampling of a few of the studies follows. Most of the studies have been directed at deriving relationships between the FOUS parameters and observed measurable precipitation. One study, at Albuquerque, actually evaluated the accuracy of the FOUS parameters themselves. Conclusions of that study were that the errors were generally too large to be useful in forecasting those parameters. This, however, does not necessarily make the FOUS data of little use in developing relationships to forecast other parameters, i.e., precipitation. In fact, these other studies show useful results can be obtained.

a. WR/SSD conducted a study relating forecast RH and vertical velocity to measurable precipitation at three stations: Astoria (wet), Kalispell (moderately dry) and Las Vegas (very dry). The developmental sample included November 1969 through January 1970.

The results for Astoria showed that progged RH and VV values by themselves are useful for forecasting precipitation occurrence, and RH and VV combined are useful for QPF for a "wet station" located in the Pacific Northwest. (WR Tech. Attachment 70-11.)

Results for a moderately dry station (Kalispell) were not as good as for Astoria. A categorical forecast of precipitation if VV ≥ 1.0 microbar/sec grossly underforecasts precipitation. RH alone, or RH and VV combined overforecast precipitation. The Kalispell local forecast was better than the objective for the 12-24 forecast while the objective was better than the local for 24-36 hours (both Brier Score and Threat Score) (WR Tech. Attachment 70-13).

The third part of the study was for the very dry regime (Las Vegas). Discriminating between rain and no-rain cases was very difficult here, but some improvement in Brier Score over Climatology (the only comparison made) was noted (WR Tech. Attachment 70-15).

b. Eastern Region SSD has made extensive use of the FOUS data. In particular is their study relating RH and VV to measurable precipitation at BOS, JFK, and DCA. In addition to these parameters, the trend of RH was found to be important. The details of the application of the technique should be of interest and are appended to these notes (ER Tech. Attachment 70-10-19).

Eastern Region has also expanded on a procedure developed by WSFO, Raleigh, NC, to systematically depict the FOUS parameters (as well as SAM and FMUS data). This information is also appended (ER Tech. Attachment 70-11-9).

c. WSFO - Birmingham, Alabama, has also made a RH/VV vs. precipitation study confirming the desirability of including the trend in relative humidity. They obtained significantly higher PoP values if the RH tendency is steady or increasing and markedly lower probability if humidity is decreasing.

Numerous other studies have been conducted using detailed PE guidance as a source of predictor information. Such things as boundary layer temperature as a predictor for shower activity in the vicinity of the Great Lakes and also as a rain-snow discriminator (see Spar, JAM. Dec. 1969), and relative humidities in layers to assist in aviation forecasts have been attempted with some success.

It is recommended that field stations utilize some of these recently developed techniques that are applicable to their local forecast problems, or initiate studies of their own to determine the usefulness of the FOUS data. An obvious potential drawback of this kind of technique development is that major PE Model changes can render these relationships worthless. However, even with such changes it is often possible to salvage useful results by "recalibrating" the predictors. A case in point is the recent change in saturation criterion for the PE Model. A recalibration of the relative humidity predictor permitted most of the developed relationships to continue to be valid.

BREAKDOWN OF FOUS 1,2 CODE

```
STA RH R1R2R3 VVLI HHDDFF TBPB[illegible]T
SEA061 978119 -1011 402821 8578[illegible]1
```

Station: Seattle

Mean Relative Humidity: 61%

Relative Humidity (layer 1): 97%

Relative Humidity (layer 2): 81%

Relative Humidity (layer 3): 19%

Vertical Velocity (700mb): -1.0 microbar/sec

Lifted Index: 11

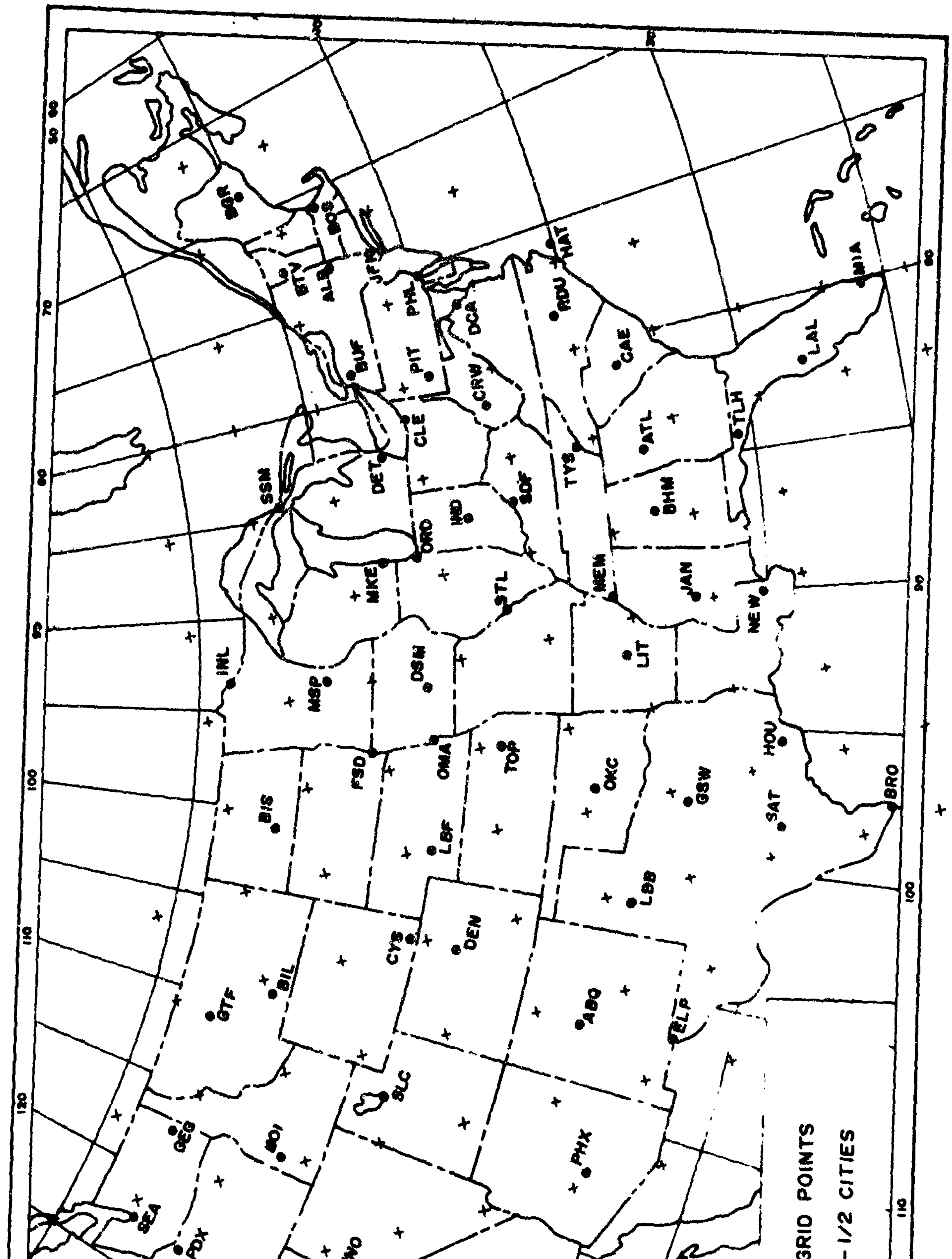
1000-500 mb thickness: 540 decameters

Boundary Layer Wind Direction & Speed: 280°/21 kt

Boundary Layer Temperature: 285°K

Boundary Layer Pressure: 978 mb

6-hr Accumulated Precipitation: .01 inches


NMC GRID POINTS
FOUS - 1/2 CITIES
SEA
PDX
MFR
GEG
BOI
RNO
SFO
FAT
LAX
SLC
PHX
GTF
BIL
CYS
DEN
ABQ
ELP
BIS
FSD
LBF
OMA
TOP
OKC
LBB
GSW
SAT
HOU
BRO
INL
MSP
DSM
STL
LIT
NEW
JAN
MEM
MKE
ORD
IND
SDF
DET
SSM
CLE
CRW
TYS
BHM
ATL
TLH
LAL
MIA
CAE
RDU
HAT
DCA
PIT
PHL
BUF
JFK
ALB
BTV
BOS
BGR

TECHNICAL ATTACHMENT 70-10-19

USE OF PE MODEL OUTPUT TO FORECAST WINTER PRECIPITATION IN THE NORTHEAST COASTAL SECTIONS OF THE UNITED STATES

Scientific Services Division, ERH, has completed a study to assist forecasters in the northeast United States. A procedure has been developed for objectively forecasting precipitation using the National Meteorological Center's Multilayer Primitive Equation Model Output. The technique is applicable to the three consecutive 12-hour forecast periods included in the public weather forecast (i.e., today, tonight, and tomorrow) for the area east of the Appalachian Mountains and north of North Carolina. The technique may be applicable to other areas in the Eastern Region, but tests to determine this have not, as yet, been conducted. A complete report describing the technique will be issued soon as an Eastern Region Technical Memorandum. At this time, we are making the forecasting procedure available for immediate use.

It is suggested that all stations in the Eastern Region use this technique in place of any other procedure previously developed from PE model predictors. The technique presented here has been adjusted to be compatible with the PE model output, as revised on September 8, 1970. These revisions are described in Technical Procedures Bulletin Number 55.

Mean relative humidity from the surface to about 500mb and vertical velocity predictions as they appear in the FOUS-1 or FOUS-2 teletype messages should be used in working with the table presented. In the event that the teletype message is missing but a facsimile presentation of the predictors is available, then the values that appear on the facsimile chart can be used as a back-up.

Examples of Use of Table

The FOUS-1 message reproduced below for DCA was originated from 0000Z data and transmitted at 0644Z. Using the accompanying table, PoP forecasts are determined for today (Example A), tonight (Example B) and tomorrow (Example C).

STA RH	R1R2R3	VVLI	HHDDFF	TBPBPTT
DCA094	979883	00005	402517	8924003
18090	909383	-0305	401812	8927000
24086	898978	00107	421715	8925000
30092	919196	02806	421615	8922004
36099	949898	02604	411612	8920003
42100	989898	03804	402011	8920009
48082	989872	01504	382516	8821010

PoP	1st Period	Hours 12-24	2nd Period	Hours 24-36	3rd Period	Hours 36-48
	Relative* Humidity	Vertical** Velocity	Relative* Humidity	Vertical** Velocity	Relative* Humidity	Vertical** Velocity
	Positive Trend		**Positive Trend**		**Positive Trend**	
85%	100%	2.5	100%	2.5		
75%	99	2.2	99	2.2	100%	2.2
65%	96	1.5	96	1.5	96	1.6
55%	91	1.0	91	1.0	91	1.0
45%	88	0.5	89	0.5	89	0.5
35%	82	0.0	87	0.0	87	0.0
25%	73	-0.4	73	-0.4	73	-0.4
15%	69	-0.7	67	-0.7	53	-0.7
5%	64	-0.9	56	-1.0	44	-1.0
	Steady Trend		**Steady Trend**		**Steady Trend**	
85%	100%	2.5				
75%	96	2.0	100%	3.0		
65%	92	1.6	99	2.3		
55%	89	1.3	97	1.4	97%	1.4
45%	86	1.1	93	1.1	93	1.1
35%	82	0.8	90	0.8	90	0.8
25%	78	0.5	78	0.5	78	0.5
15%	72	0.2	68	-0.7	67	-0.7
5%	67	-0.2	56	-1.0	44	-1.0
	Negative Trend		**Negative Trend**		**Negative Trend**	
55%	100%	3.0	100%	3.0		
45%	93	2.1	93	2.1	100%	3.2
35%	91	1.2	91	1.4	99	2.8
25%	89	0.6	89	1.0	94	1.6
15%	85	0.2	81	0.1	81	0.1
5%	73	-0.2	56	-0.9	44	-1.0

*Mean Relative Humidity Surface to about 500mb. **Microbars per Sec.

TABLE: Probability of Precipitation Determined from 6-hourly PE Forecasts of Relative Humidity and Vertical Velocity. The relative humidity values in this table have been adjusted to account for the 11.1% inflation of relative humidity forecasts effective Sep 8, 1970. To use this table, first determine the forecast relative humidity trend by subtracting the forecast at the beginning of the period from the forecast 12 hours later, at the end of the period. The trend is defined as steady unless there is a change of at least 10% in predicted relative humidity; then the trend is defined as either positive or negative, as appropriate. Enter the proper trend table for the forecast period of interest with the maximum relative humidity and algebraic maximum vertical velocity 6-hourly values that are forecast to occur during the period. PoP is equal to that value on the far left for which both the relative humidity forecast and the vertical velocity forecast are equal to or higher than the values shown in the table. PoP values are indicated in the table for 10% intervals beginning at 5%. This eliminates any need to interpolate to arrive at PoP values rounded to the nearest whole number multiple of 10%.

Example A

For the today period of the forecast (1st period) we look at the mean surface to 500mb relative humidity prediction (RH) and vertical velocity predictors (VV) for hours 12, 18, and 24. Subtracting the RH prediction for hour 12 (94%) from the RH prediction for hour 24 (86%) we find that the predicted trend is steady (less than 10% change). Next, we determine that the maximum relative humidity prediction for hours 12, 18, and 24 is 94% which occurs at hour 12. The maximum algebraic value of vertical velocity predicted is +.01 microbars per second which occurs at forecast hour 24. Using these maximum values and entering the table for the first period, steady trend, we find the PoP to be between 5% and 15%, which is 10% if rounded to the nearest whole-number multiple of 10%. In this example, it can be seen that a 94% relative humidity prediction meets the moisture requirement for PoP between 65% and 75%; however, the vertical velocity prediction required for a PoP to be between 65% and 75% is at least +1.6. PoP is equal to that value on the far left of the table for which both the relative humidity forecast and the vertical velocity forecast are equal to or higher than the values shown in the table.

Example B

For the tonight period of the forecast (2nd period) we subtract RH at hour 24 (85%) from RH at hour 36 (99%) and determine that the predicted trend is positive (an increase of at least 10%). The maximum relative humidity predicted for hours 24, 30, and 36 is 99%, which occurs at forecast hour 36. The maximum, algebraic, vertical velocity predicted is +2.8, which occurs at forecast hour 30. Using these maximum values and entering the table for the second period, positive trend, we find the PoP to be equal to 75% which, when rounded to the nearest whole-number multiple of 10%, is 80% (75% is raised to the higher decile value of 80% rather than the lower value of 70%). In this example the +2.8 vertical velocity forecast value meets the requirement for 85% PoP (which would be rounded to 90% PoP) but the relative humidity prediction of 99% is less than the humidity of 100% required for a PoP forecast of 85%.

Example C

For the tomorrow period of the forecast (3rd period) we subtract RH at forecast hour 36 (99%) from RH at forecast hour 48 (82%) and determine that the predicted trend is negative (a decrease of at least 10%). The maximum relative humidity predicted for forecast hours 36, 42, and 48 is 100%, which occurs at forecast hour 42. The maximum, algebraic, vertical velocity predicted is +3.8, which also occurs at hour 42. Using these maximum values and entering the table for the third period, negative trend, we find the PoP to be 45% which, when rounded to the nearest whole-number multiple of 10%, is 50%.

Conclusions

A technique has been presented for objectively preparing guidance forecasts of precipitation using the National Meteorological Center's Multilayer PE Model Output. This technique can aid forecasters until such time as more data and more sophisticated treatment of the data are used to develop a new and, hopefully, better technique.

Future modifications of the PE model may require new changes in the prediction table presented here. When and if changes are made to the PE model such that the new output cannot be made compatible with the output used in this study as development data, the technique now presented will become obsolete. The fact that, in the past, significant changes have been made to the model is strong reason for starting to utilize the procedure presented here as soon as one is convinced it will contribute positively to the forecasting problem. Testing can be conducted while the procedure is in use.

Incidentally, when SAM/PE PoP values are available for the first forecast period, it is suggested that the SAM/PE PoP value be given more weight than the PoP derived here from PE predictors only.

SCIENTIFIC SERVICES DIVISION, ERH
October 19, 1970

TECHNICAL ATTACHMENT 70-11-9

SYSTEMATIC DEPICTION OF NUMERICAL FORECASTS

Centrally produced objective forecasts are becoming increasingly more accurate and should serve as the base point from which field forecasters make modifications. The following forecasts from three different models are now transmitted on circuit "C": (1) FMUS 1 maximum and minimum temperature forecasts; (2) FOUS SAM forecasts; (3) FOUS 1 and 2 6-hourly PE forecasts. With the increased utilization of these numerical forecasts a need arose for a systematic procedure of depicting and assimilating the information available.

In a technical attachment to the Staff Notes of August 10, 1970, a procedure, developed at WSFO, Raleigh, N.C., was introduced for depicting some of the numerical forecasts available from the PE model. The benefits of the Raleigh technique were immediately recognized and improved upon. Scientific Services expanded the Raleigh procedure into a technique that now enables a forecaster to systematically depict and simultaneously consider the information available from all three models. The expanded version of the Raleigh technique has now been available for several weeks on a test basis to several WSFO's. The technique has been favorably received by these offices. Figure 1 presents a time-cross section, Form SSD 70-1(b), on which is systematically plotted the actual FOUS 1/2, SAM and FMUS data having the initial upper air data time of 1200Z October 10, 1970. A similar form, SSD 70-1(a), has been prepared with slight modification to handle numerical forecasts from 0000Z initial upper air data time. From 4 to 6 FOUS 1/2 cities should be plotted so as to adequately depict the forecast area and its peripheries. The cities plotted may vary from day to day depending upon the direction from which an anticipated change in the weather is approaching.

The SSD 70-1(a) and 70-1(b) FOUS time-cross sections are prepared with time increasing to the left. This procedure enables one to associate forecast weather changes with systems moving in from the left or west as is most often the case. By plotting the information for different periphery cities in approximately the same relative position as they are geographically located, one can see the numerical forecasts not only as they are approaching a particular station or point of interest, but also as they are approaching upstream or downstream points. This procedure also facilitates a visual interpretation for locations between the plotted points.

Processing and analysis of the time-cross sections can be accomplished in the following manner – Isolines for layered relative humidity values can be drawn for every 20% beginning with a value of 10%. Areas of relative humidity $\geq 90\%$ can be shaded green and area $\geq 70\%$ and $<90\%$ shaded in orange (hatching is used in lieu of color in Figure 1). Probable indications of frontal passages can be shown with appropriate symbols.

The plotted data can be used with objective aids to determine PoP, cloud cover, snow vs. freezing precipitation vs. rain, temperature, and surface wind speed and direction. Objective aids are either now available or can be made available, in the future, thru on-station, SSD and National Weather Service HQ development efforts. The circled percentages in Figure 1 are PoPs derived objectively as described in an October 19, 1970 Technical Attachment (70-10-19) to the Eastern Region Staff Notes. SAM PoPs and surface winds plotted on the form are also objectively derived.

The plotted time-cross sections should be saved. Most recent plots should be compared to 12-hour earlier plots to note all inconsistencies and lack of continuity. Determination of errors can be made by comparing observations to those forecasts with expired valid times.

Scientific Services has provided a supply of Forms SSD 70-1(a) and SSD 70-1(b) to several stations. Forms are now available to additional stations upon request. Since these forms are still experimental, SSD would welcome requests for modification and improvement.

SCIENTIFIC SERVICES DIVISION, ERH
November 9, 1970

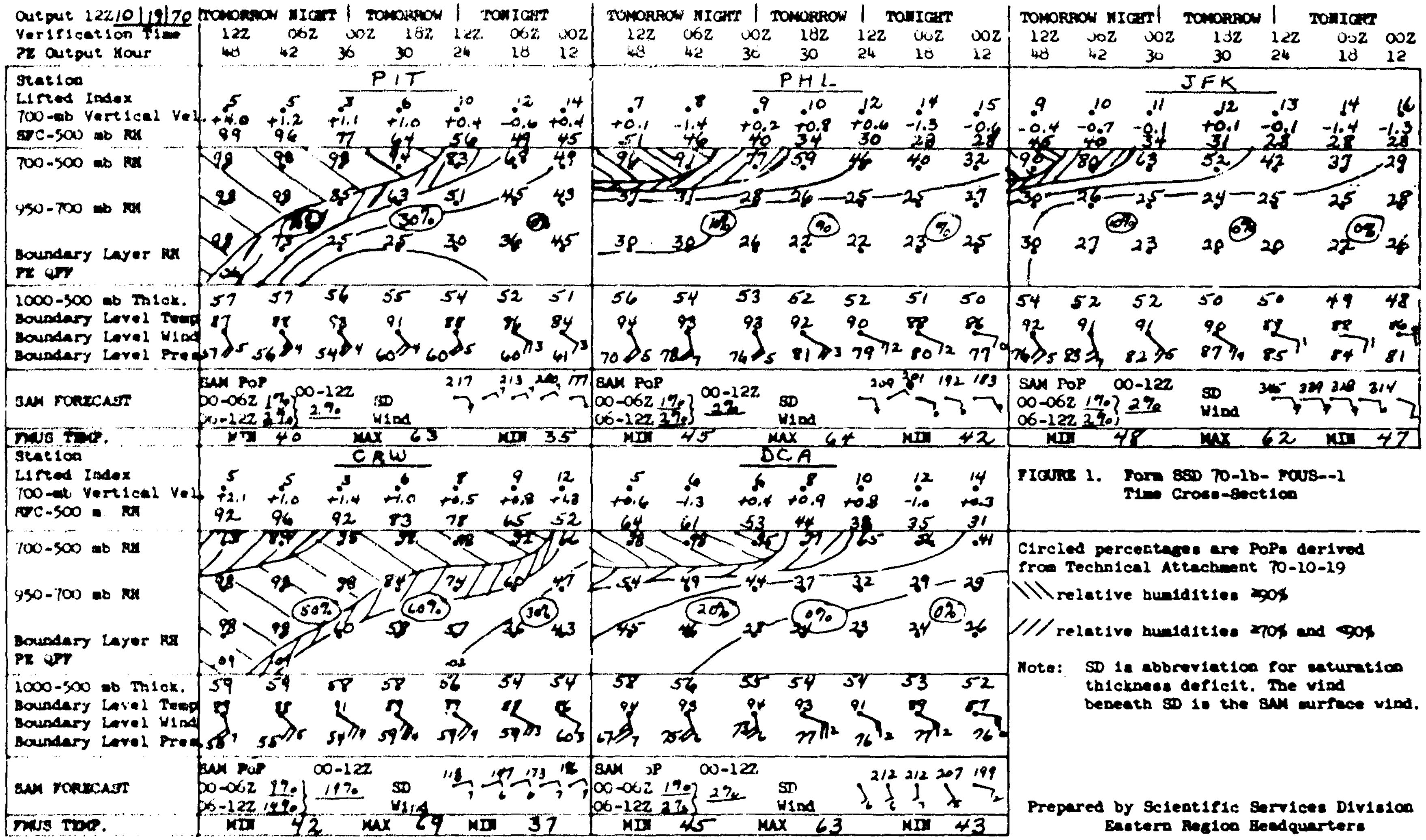


FIGURE 1. Form SSD 70-1b- FOUS--1
Time Cross-Section

Circled percentages are PoPs derived from Technical Attachment 70-10-19

\\\\\\ relative humidities ≥90%

/// relative humidities ≥70% and <90%

Note: SD is abbreviation for saturation thickness deficit. The wind beneath SD is the SAM surface wind.

Prepared by Scientific Services Division
Eastern Region Headquarters

WESTERN REGION TECHNICAL ATTACHMENT
October 27, 1970
No. 70-43

MAKING MORE USE OF FOUS DATA

Winter is the season when the FOUS data should be most useful in preparing local forecasts. The quality of forecast flow patterns by the PE model has reached the point of excellence where forecasters should usually accept them and spend most of their forecast effort relating the local weather to the forecast flow. One of the PE products that is most helpful in local forecasting is the FOUS data; i.e., the 6-hourly printout of PE forecasts of several significant moisture and temperature parameters [1]. The usefulness of these data can be enhanced by graphically displaying them, and also by knowing some of the mechanics used to produce them. Previous Western Region Technical Attachments [2] [3] have suggested uses and plotting schemes. In this Technical Attachment we shall suggest a modification of the plotting scheme and offer some suggestions on interpreting the data.

In June 1970 the FOUS teletype bulletin was expanded to include the mean relative humidities in each of the three lower sigma layers of the PE model [1]. The Eastern Region was responsible for this expansion and has developed a useful way of plotting these new data which we have incorporated into the suggested plotting scheme illustrated in Figure 1. In the new scheme all moisture parameters are consolidated in the upper half of the graph and temperature and wind parameters in the lower half. Provision is made for entering the Klein forecast temperatures based on the same PE forecast run as the FOUS data. As before [3], a graph of 10 gradations to the inch is recommended, and the time axis should run from right to left.

A plot of the mean relative humidities forecast for each of three lowest sigma layers shows implied forecast cloud layers and origin of forecast precipitation. As we gain experience with these additional moisture parameters, other uses may emerge.

At times the forecast precipitation and relative humidities will not appear compatible. This usually occurs when and where the relative humidity gradients are strong. The basic PE forecast is made for grid points. Once the grid-point data are determined, they are interpolated to the location of cities included in FOUS bulletins. Figure 2 shows the grid points and FOUS cities in the Western Region. The closer a city is located to a grid point, the more consistent the forecast data should be. Note that Seattle, Boise, Billings, and Fresno are the only stations that are close to a grid point.

Relative humidities are linearly interpolated to city locations, but the indication of rain or no rain is not. The rain is considered to apply halfway to the next grid point with no rain. Therefore, it is possible to have rain indicated without a very high relative-humidity value (see Figure 3). By interpolation the relative humidity is only 68%, but Great Falls is less than a half grid length from the grid points indicating precipitation, so measurable precipitation would be indicated. This was apparently the situation at Reno on October 23 (see Figure 1). Note that the relative humidities do not indicate saturation for the 42- to 48-hour forecast period, yet rain is indicated. While we have little experience with this problem, we suggest that more weight be given to relative humidity than to precipitation values.

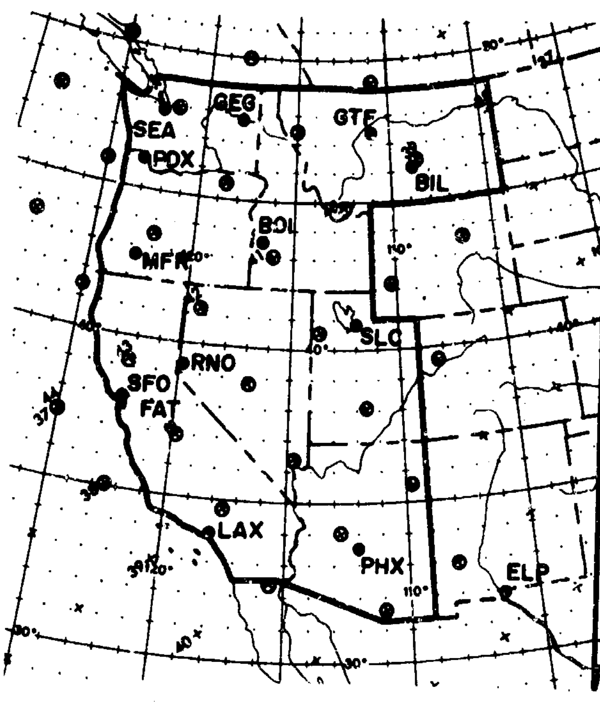


Figure 2. NWP grid points and Western Region FOUS stations. ⊗ indicates grid point.

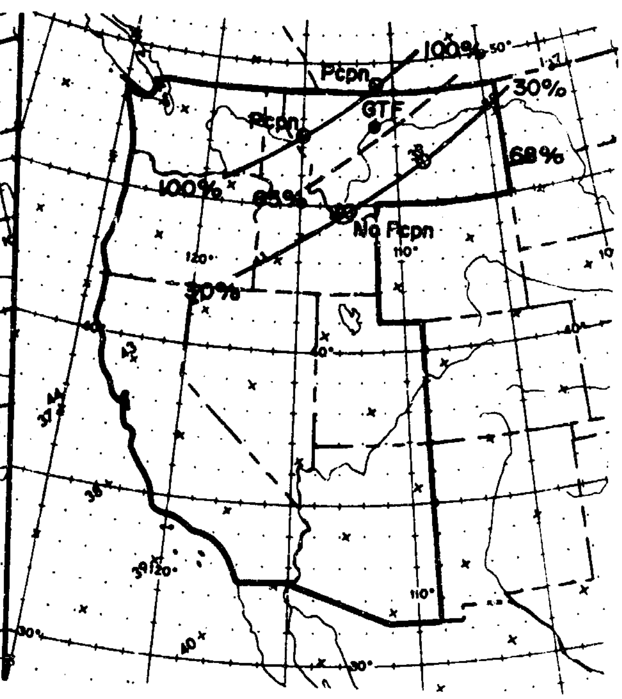


Figure 3. Example of Interpolation scheme used to get relative humidity and precipitation values at GTF.

The surface to 500-mb mean relative humidity values are computed as the sum of forecast precipitable water values in each layer, divided by the sum of saturation precipitable water values. In essence this gives a pressure-weighted mean-relative-humidity value. The highest value permitted for one layer in the bulletin is 98%. Only 2 digits are available for reporting relative humidity in the code, and 99 is reserved for missing data. Consequently, a value of 98% in most cases means saturation (100%). The 3-layer mean value, in contrast, can exceed 100%. First, three digits are available for it in the code. Second, the mean humidity values are computed after the temperature adjustment for convection is made. Since this adjustment results in lowering temperatures in the lower sigma layers, it is possible for relative humidity values to exceed 100%. This usually occurs where precipitation is forecast.

In spite of some of the difficulties encountered, the FOUS data should be thoroughly explored as an input to preparation of local forecasts. It is an excellent source of input data to local conditional climatological studies. Absolute values of some of the parameters, e.g., boundary-layer temperatures, may not be as useful as the trend shown by the values. For example, in Figure 1 both the thickness and boundary-layer temperature forecasts for Friday and Saturday indicate a cooling trend.

If sufficient demand were expressed, we could have forms designed and printed for routine field plotting of FOUS data.

REFERENCES:

[1] Ostby, F. P., "Revisions to Detailed Guidance from the 6-Layer (PE) Numerical Prediction Model," Techniques Procedures Bulletin No. 49, dated June 8, 1970.

[2] "Use of FOUS Data," WR Technical Attachment No. 69-45, dated 11/10/69.

[3] "More on FOUS Data," WR Technical Attachment No. 69-48, dated 11/25/69.

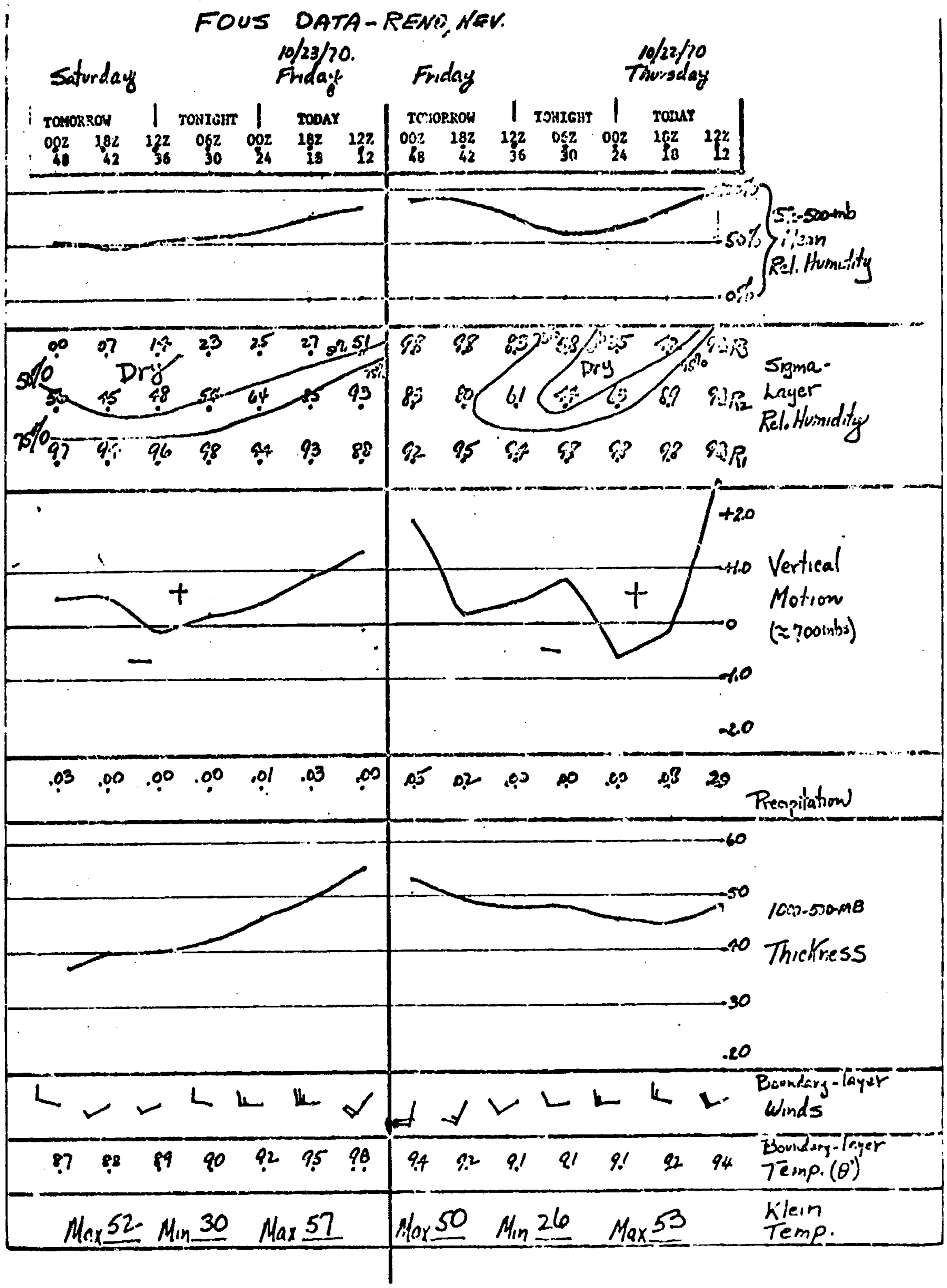


FIGURE 1. SUGGESTED PLOTTING SCHEME FOR FOUS DATA USING THE P.E. MODEL FORECAST FOR RENO, NEVADA, BASED ON OCTOBER 22 AND 23, 1970 0000Z INPUT DATA.

LIST OF USAFETAC TECHNICAL NOTES

Number	Title	Date
70-1	A Selected Annotated Bibliography on Clear Air Turbulence (1964-1969) (AD-700057)	Jan 70
70-2	An Annotated Climatological Bibliography of the BENELUX Countries (1960-1969) (AD-701692)	Feb 70
70-3	Listing of Available Seminars (AWS Wings) (AD-702463)	Mar 70
70-4	A Selected Annotated Bibliography of Environmental Studies of Israel (1960-1969) (AD-705199)	Apr 70
70-5	A Selected Annotated Bibliography of Environmental Studies of Iraq, Jordan, Lebanon, and Syria (AD-707120)	May 70
70-6	A Selected Annotated Bibliography of Environmental Studies of Poland (AD-709762)	Jun 70
70-7	Air Force Eastern Test Range Computer "Printed" Rawinsonde (SKEW-T) Analysis (AWS distribution only) (AD-691228)	Jul 70
70-8	Hook Echoes on Radar (AD-711794)	Aug 70
70-9	The National Air Pollution Potential Forecast Program (AD-714568)	Nov 70
70-10	A Selected Annotated Bibliography of Environmental Studies of Argentina, Chile, and Uruguay (AD-717196)	Dec 70
71-1	Interim Instructions for the Use of the National Meteorological Center Air Pollution Potential (APP) Products (AWS distribution only) (AD-)	Feb 71
71-2	A Reprint of Use of FOUS (Detailed PE Guidance) (AWS distribution only) (AD-)	Mar 71

VV--Vertical velocity at 700 mb, in tenths of a microbar per second; a weighted average of three hourly values--at forecast time, one hour before, and one hour after (double weight assigned to value at forecast time).

LI--Lifted index, in degrees Celsius. Negative values are designated by subtracting from 100; e.g., -4 = 96.

HH--1000-5000 mb thickness, in decameters with the first digit omitted.

DDFF--Direction, in tens of degrees, and speed (in knots) of the mean wind in the boundary layer of the PE model.

TB--Mean potential temperature of the boundary layer, in degrees Kelvin, with hundreds position omitted.

PB--Mean pressure of the boundary layer, in millibars, with hundreds position omitted.

PPT--6 hour accumulated precipitation, in hundredths of an inch.

2.3 The Guidance Message

The teletypewriter message has the following format:

```
FOUS1 KWBC 191844
TO CIRCUITS 30 33 34
OUTPUT FROM 12Z NOV 19 70
STA RH R1R2R3  VVLI HHDDFF TBPBPTT
SEA061 976819 -1011 402821 8578001
 18055 965228 00811 372927 8479001
 24064 954678 00519 332729 8376001
 30073 935595 02309 302629 8377001
 36084 927598 01807 262731 8174001
 42092 939192 02708 212629 7974002
 48091 929092 02606 152824 7771004
```

Relative humidities of 98% or more in the individual layers will be indicated by a "98." Three digits are provided for the mean relative humidity averaged over the three layers allowing for forecasts of 100%.

Missing values will be represented by 9's.

3.0 GENERAL DESCRIPTION

The FOUS-1, 2 message provides some of the same kind of infor-

1. INTRODUCTION

The versatility of the 6-Layer (PE) Numerical Prediction model has made it practicable to output values of a variety of meteorological parameters at specific geographical locations from its forecast run. Essentially, grid point values are bilinearly interpolated to specific cities to obtain these data.

Evaluation of the forecasts during a test period demonstrated the usefulness of a number of the parameters as guidance in daily local weather forecasting. Transmission of this digital form of guidance over Service C began in October 1969 as "FOUS-1" and "FOUS-2." It is currently transmitted twice daily at 0644Z and 1844Z.

2.0 OPERATIONAL PROGRAM

2.1 Forecast Cities

Forecasts are provided for 62 cities (see Fig. 1), divided into two sets to minimize transmission time. The sets are as follows:

a. FOUS-1 transmitted over Circuits 30, 33, and 34--SEA, GEG, GTF, BIL, PDX, MFR, SFO, BOI, CYS, BIS, FSD, MSP, OMA, LBF, DSM, MKE, INL, ORD, SSM, DET, IND, CLE, BUF, PIT, CRW, ALB, BTV, JFK, BOS, BGR, DCA, and PHL.

b. FOUS-2 transmitted over Circuits 31, 32, and 35--RNO, SLC. LAX, FAT, PHX, ELP, ABQ, LBB, OKC, GSW, SAT, BRO, HOU, NEW, LIT, MEM, JAN, BHM, ATL, TYS, TLH, LAL, MIA, CAE, RDU, HAT, DEN, TOP, STL, SDF, CYS, BOI, MFR, and SFO.

2.2 Parameters

Values of parameters, judged to be the most useful, forecast at 6-hourly intervals from 12 to 48 hours after 0000Z and 1200Z are provided. The parameters include:

RH--Mean relative humidity of the lowest three layers of the PE model (approximately 1000 to 490 mb), in percent.

RI--Mean relative humidity of the 50-mb thick boundary layer, in percent (approximately 1000 to 950 mb).

R2--Mean relative humidity of the lowest tropospheric layer, in percent (approximately 950 to 720 mb).

R3--Mean relative humidity of the middle tropospheric layer, in percent (approximately 720 to 490 mb).