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FORECAST WORKSHEET - A NEW APPROACH.(U)

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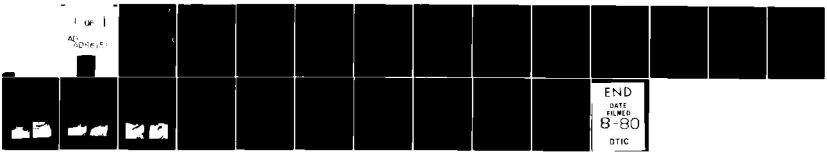

TECHNICAL NOTE
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FORECAST WORKSHEET: A NEW APPROACH

Thomas L. Rish, Lt Col, USAF
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1 MAY 1980

7TH WEATHER WING (MAC)
SCOTT AFB, ILLINOIS 62225

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Forecasters are given mixtures of centralized forecasting guidance for various models, techniques, and data bases; valid for varying times or time intervals; and presented in many different ways. But to produce an operationally sound forecast, they must logically assemble the various bits and pieces, resolve all inconsistencies, and visualize the interactive changes that will be taking place in the atmosphere. This report describes the results of a study of worksheets normally used by Air Weather Service units to prepare forecasts. It identifies weaknesses that exists in many worksheets and describes a new worksheet format which provides a more logical step-by-step process for preparing forecasts.

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FORECAST WORKSHEETS - A NEW APPROACH

1. INTRODUCTION. One of the most perplexing problems forecasters face today is how to effectively use the myriad of available information in preparing forecasts. Even if time was abundant, the task would be difficult because forecasting aids are mixtures of products from different models, techniques, and data bases; valid for different times or time intervals; and presented in many different ways. Simply put, forecasters are given numerous bits and pieces of data that never fit together perfectly; yet, they must assemble all the various parts, interpret implications of each bit of information, resolve all inconsistencies, and put everything together as an operationally sound forecast.

Through years of experience, forecasters generally learn to do most of these things in their head and still derive a fairly clear picture of what's happening. However, new forecasters usually don't have that ability and frequently develop the bad habit of relying too heavily on only a few centralized aids and ignoring the rest. This has become a critical problem in many units because there is no real "pro" around to teach good habits or procedures, and it's getting worse as the experience level declines.

In an attempt to resolve this problem, we conducted a study which focused primarily on methods for improving use of centralized guidance. The study began with an evaluation of worksheets used by 7WW units and guidance available for developing them. Our search lead to a thorough review of worksheets, and their effectiveness. This technical note describes our findings and recommendations.

1.1. Common Weaknesses in Worksheets. Several different publications furnish guidelines for designing worksheets, but the primary source available to all units is AWS TR 218, Preparation of Terminal Forecast Worksheets. It contains an excellent description of the objective of worksheets and features they should contain. This guidance also promotes two serious deficiencies which thwart the objective: Insufficient detail and poor organization.

1.1.1. Insufficient Detail. This deficiency refers to inadequate information concerning when major changes in key predictors will take place and how significant those changes will be. Substantial changes in predictors such as temperature, stability, moisture, vorticity, etc., frequently occur during a 24-hour period, but very few worksheets require more than one entry for each element. Furthermore, the significance or magnitude of change is usually missing because oversimplified entries, such as "increasing/decreasing" or "yes/no", are used. Many aids available to forecasters give predictions of various elements in 6 or 12-hour intervals, but such detail is rarely recorded on worksheets. Omission of this essential guidance encourages forecasters to overlook a detailed analysis of timing and significance of major changes that should be considered.

1.1.2. Poor Organization. The other major deficiency arises because little thought is given to arranging the data in a format that helps digest the information recorded. Entries are usually scattered all over the page, different types of entries are made for the same element (e.g. moisture indicated by dewpoint, temperature/dewpoint, dewpoint spread, or relative humidity), and when valid times are recorded, they often vary. This lack of organization makes most worksheets distasteful to use and of limited value in deriving conclusions.

1.2. Guidelines for Designing Worksheets. The following features were used as guidelines for designing a better format for worksheets. The objective was to eliminate the two problems cited above and to improve use of available information. These features include the best of those listed in AWSTR 218 plus others believed necessary to achieve the objective:

a. Provide a logical step-by-step process for preparing forecasts.

b. Aid review and collating essential information.

c. Promote evaluation of data as it is received rather than just prior to forecast deadlines.

d. Depict data in a format that is easily derived, rapidly entered, and quickly digested.

e. Minimize rechecks of data evaluated earlier.

f. Minimize oversight by focusing attention on key predictors.

g. Provide continuity and consistency in time and space.

h. Provide detailed information on timing and significance of expected changes in predictors.

i. Flag times for intensifying local met watch or use of local forecast studies.

j. Provide a record of rationale used in producing forecasts.

k. Aid identification of procedual problems and development of improved techniques through forecast reviews, case studies, and technical studies.

2. DESCRIPTION. This section describes the new format for displaying data recorded on forecast worksheets. Emphasis is on format only since it is impossible to design a standard worksheet that satisfies the needs of all units. Figure 1 shows a basic worksheet designed for Scott AFB, IL. This format is not really new; in fact, it is very similar to the standard time cross-section with two exceptions. First, all information beyond the first time group is a forecast. Second, symbols instead of numerical values or graphical plots are used to give a visual display of the magnitude or "importance" of various predictors. The time cross-section format was chosen because it provides a logical method for evaluating interactive changes which take place in the atmosphere.

2.1. Selection of Times. The data to be recorded begins with the latest (0000Z or 1200Z) available analysis package. This starting point was chosen because accurate predictions of future conditions are directly related to the extent of knowledge about the initial state. Subsequent data consists of progs of key predictors in six-hour increments spanning the valid period of the forecast. Times listed are geared to the normal valid times of most centralized progs and forecast aids. For some parameters, centralized guidance will be available only in 12-hour increments: in these cases, intermediate entries must be interpolated.

2.2 Selection of Predictors. When making a forecast, the first step is to identify major synoptic scale features, such as ridges, troughs, fronts, jets, etc., that will be influencing terminal weather. Next, various sources of data are studied to develop conclusions about the significance of moisture, temperature advection, stability, vorticity advection and other key predictors that will prevail throughout the forecast period. Predictors shown in Figure 1 are the ones most frequently used to make general forecasts of ceiling and visibility. Others could be added, but these were chosen to illustrate the principle involved.

2.3. Symbol Definitions. Symbols, rather than raw values, were chosen as the means for depicting the significance of most key predictors. This was done because their influence can be adequately described by such terms as strong, moderate, weak, or neutral. These are the same terms we routinely use in verbal and written explanations of why certain conditions occurred or were forecast. Table 1 shows the symbols and corresponding verbal equivalents. Also shown are typical ranges of values for each symbol; this subject will be discussed later.

Table 1. Symbol Definitions

	SYMBOLS				
PREDICTOR	=	-	N	+	‡
Vorticity Advection (Units per 12hrs)	Strong NVA (≥ 5)	Moderate NVA (2-4)	Weak/Neutral (± 1)	Moderate PVA (2-4)	Strong PVA (≥ 5)
Cold Advection (^{o}C Per 6-Hrs)	Strong Warm ($\geq 3^{o}$C)	Moderate Warm (1-2^{o}C)	Weak/Neutral (0^{o}C)	Moderate Cold (1-2^{o}C)	Strong Cold ($\geq 3^{o}$C)
Warm Advection	Strong Cold	Moderate Cold	Weak/Neutral	Moderate Warm	Strong Warm
Moisture (RH%)	Very Dry ($\leq$ 65%)	Moderately Dry ($>$65 $<$ 78%)	Slightly Moist ($\geq$78 $<$ 82%)	Moderately Moist ($\geq$ 82 $<$ 90%)	Very Moist ($\geq$ 90%)

Carefully note the subtle but very important order in which the symbols and terms appear. The intent is to define the predictors such that "N" represents the threshold between non weather-producing (= or -) and weather-producing (+ or ‡) influences. In effect, the symbols visually portray the "importance" role or significance of each predictor. The symbol which best represents conditions expected at each time would be marked by placing a circle or square around it. This allows the forecaster to scan all the data and quickly determine the combined effect on future weather conditions. Thus, a worksheet on which all the double-plus symbols (‡) are marked implies that it's going to be a hectic shift. Conversely, all double-minus symbols (=) probably means that there will be time to catch up on those additional duties and technical training. Since the atmosphere rarely lines everything up so perfectly, most situations will be represented by a mix of symbols ranging from one extreme to the other.

Figure 1. Basic Worksheet for Scott AFB, IL.

The ranges of numbers assigned to each symbol are merely "ball park" figures to get everyone thinking alike and to provide uniform meanings for the symbols. In some cases, these values may need adjustment for individual locations. Don't get "wrapped around the axle" and waste time in trying to calculate precise values of temperature and vorticity advection. For most applications, visual inspection of the angle between the contours and isopleth gradient will usually suffice for estimating the strength of advection. This will be easy after a little practice. The same goes for other predictors; use symbols unless actual values are needed for objective rules or other specific reasons.

Relative humidity (RH), rather than dewpoint depression, was chosen as the standard for describing moisture content. It was selected primarily for two major reasons. First, generally reliable progs of relative humidity for several layers in the lower atmosphere are available in FOUS KWBC bulletins. Secondly, comparisons of the amount of saturation between levels of the atmosphere are easier when relative humidity is used because dewpoint depression varies with temperature for a given degree of saturation (RH). However, use of relative humidity does not eliminate a complication that arises when dealing with clouds composed of ice crystals. Figure 2 graphically shows the significance of this problem and variations in dewpoint depressions. Note especially the large differences in relative humidities with respect to ice and with respect to water for equivalent dewpoint depressions (all with respect to water). For example, a dewpoint depression of $3^{\circ}C$ at an ambient temperature of $0^{\circ}C$ equates to a relative humidity of 80% with respect to both water and ice. However, at air temperatures of $-30^{\circ}C$, the $3^{\circ}C$ dewpoint depression equates to 75% RH with respect to water and 98% RH with respect to ice.

Figure 2 can be used to quickly convert progs of dewpoint depression to relative humdities. Dashed lines were added to illustrate saturation differences between water and ice when forecasting clouds composed of ice crystals. Air containing a mixture of water droplets and ice crystals will likely have a relative humidity somewhere between the two pure states; relative humidities in pure ice clouds are indicated by the dashed portion of the dewpoint depression lines. Note that dewpoint, dewpoint depression, and relative humidities used operationally are normally given with respect to water. This is the relative humidity that should be recorded on worksheets - account for the ice versus water differences mentally.

2.4 Data Sources. Figures 3a and 3b are two examples of worksheets completed for Scott AFB, IL. Normally worksheets should be prepared each time a scheduled forecast is issued, but the 03/1200Z Oct 79 worksheet was omitted here for brevity. This section only discusses data sources in general; a later section gives a more complete discussion of the two examples shown.

CONUS forecasters normally have several possible data sources help complete most prog entries. Sources used in these two examples are shown under the column labeled "Prog Sources". Unfortunately, entries for most predictors must be gleaned from more than one centralized aid to obtain a complete picture for the entire 24-hour period. In some cases, the data are in terms of pressure layers or heights versus pressure surfaces. Other aids depict temperature, moisture, and winds in terms of heights or pressure layers rather than standard pressure surfaces. In addition, moisture is quantified in four different ways (relative humidity, dew point depression, temperature/dew point, and quantitative precipitation). For these situations, the data must be converted to some common standard and mentally interpolated or extrapolated to the desired level before a representative symbol can be assigned. When none of the centralized aids are representative of expected conditions, they should be modified based on all available clues.

In practice, units should establish local policy as to which predictor sources should be studied by listing them directly on their local worksheet in a format similar to the example. The source used should be indicated by placing a check in the parenthesis to the right of the source listed. For situations in which tne forecaster modifies centralized guidance, the source labeled "Personal" would also be checked along with any other sources used. When the centralized guidance is modified, cross out (X) the prog entry and place a square box around the prog entry which best reflects your personal belief of what will happen. Modifications should be based on reanalyses of centralized products, local analyses, satellite data, upstream observations, discussion bulletins, or any other met watch information which indicates that the centralized guidance is unrepresentative.

3. EXAMPLES. This section provides further discussions of the two completed worksheets examples (Figures 3a and 3b). Corresponding satellite photos and analyses for the surface and 500mb level in Figures 4a through 9b show synoptic conditions that existed during that period.

3.1. Worksheet Entries. The remarks section of the two examples describes specific sources actually used and how the entries were derived. Circles around symbols indicate that the information was derived, inferred, or interpolated directly from the prog source checked. Some of the symbols originally circled were later crossed (X) out and a square placed around another symbol. This indicates

DEW POINT — RELATIVE HUMIDITY CONVERSION CHART

NOTE: ADAPTED FROM AWSTR 105-72. DASHED LINES WERE ADDED TO REFLECT APPROXIMATE RELATIVE HUMIDITIES WITH RESPECT TO ICE FOR CORRESPONDING DEW POINT DEPRESSIONS WITH RESPECT TO WATER.

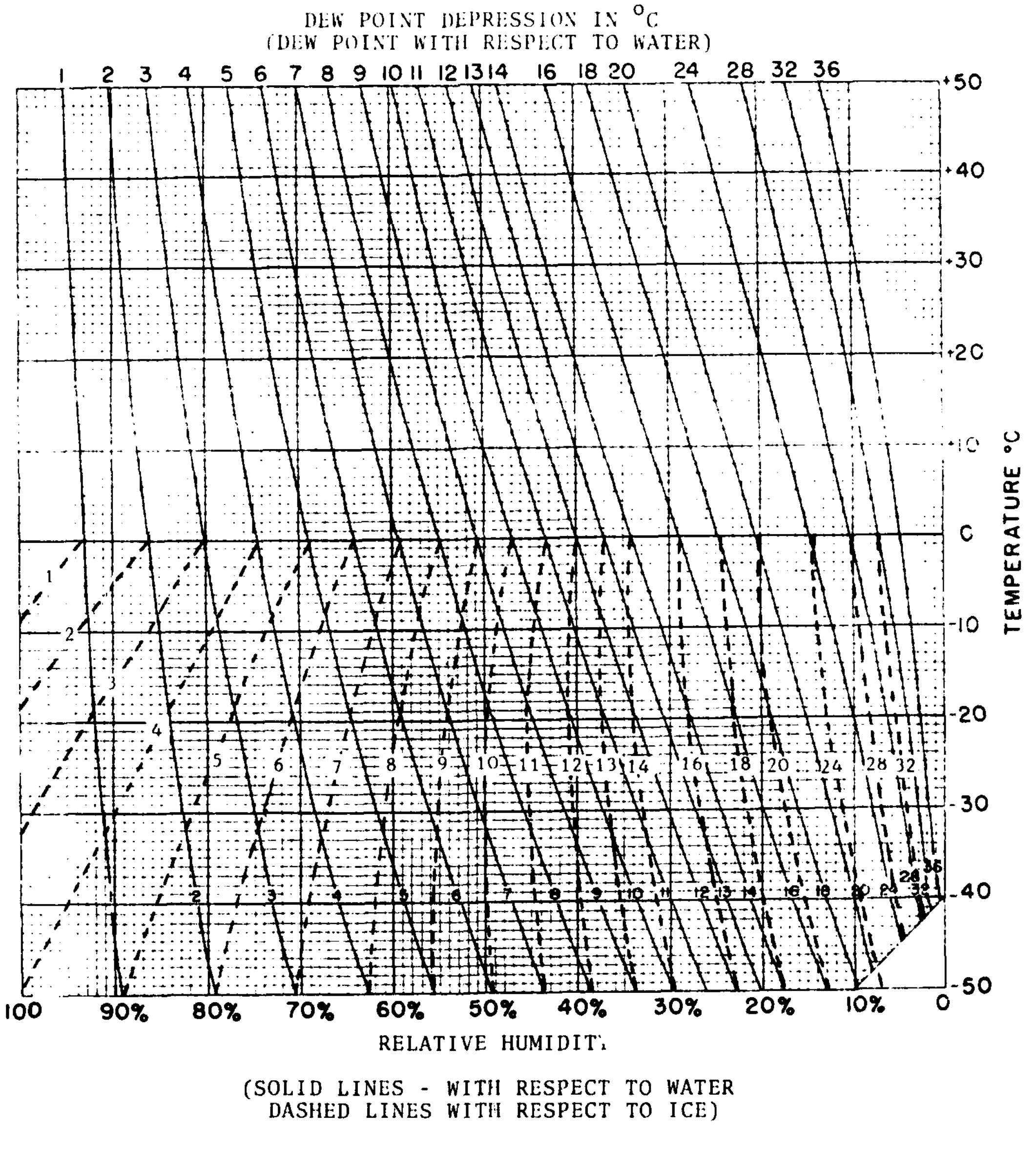
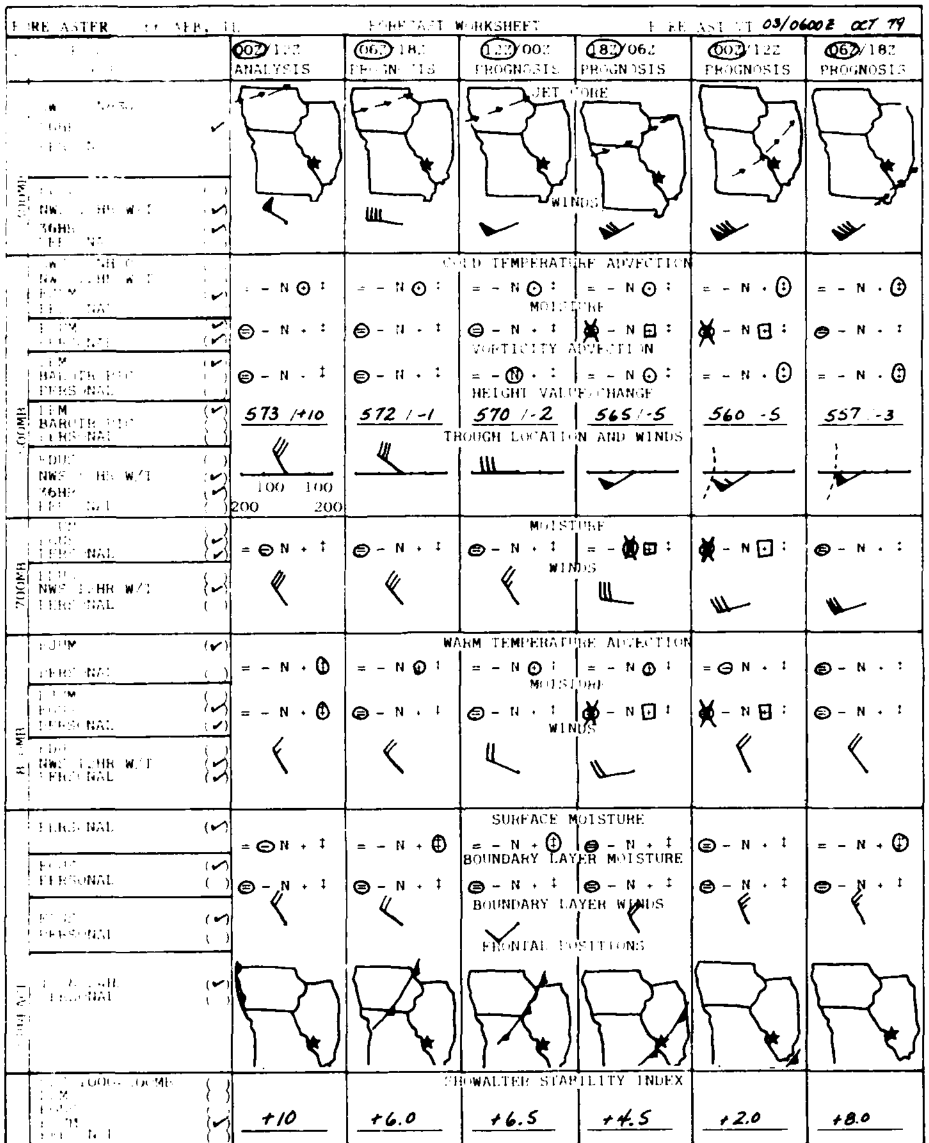
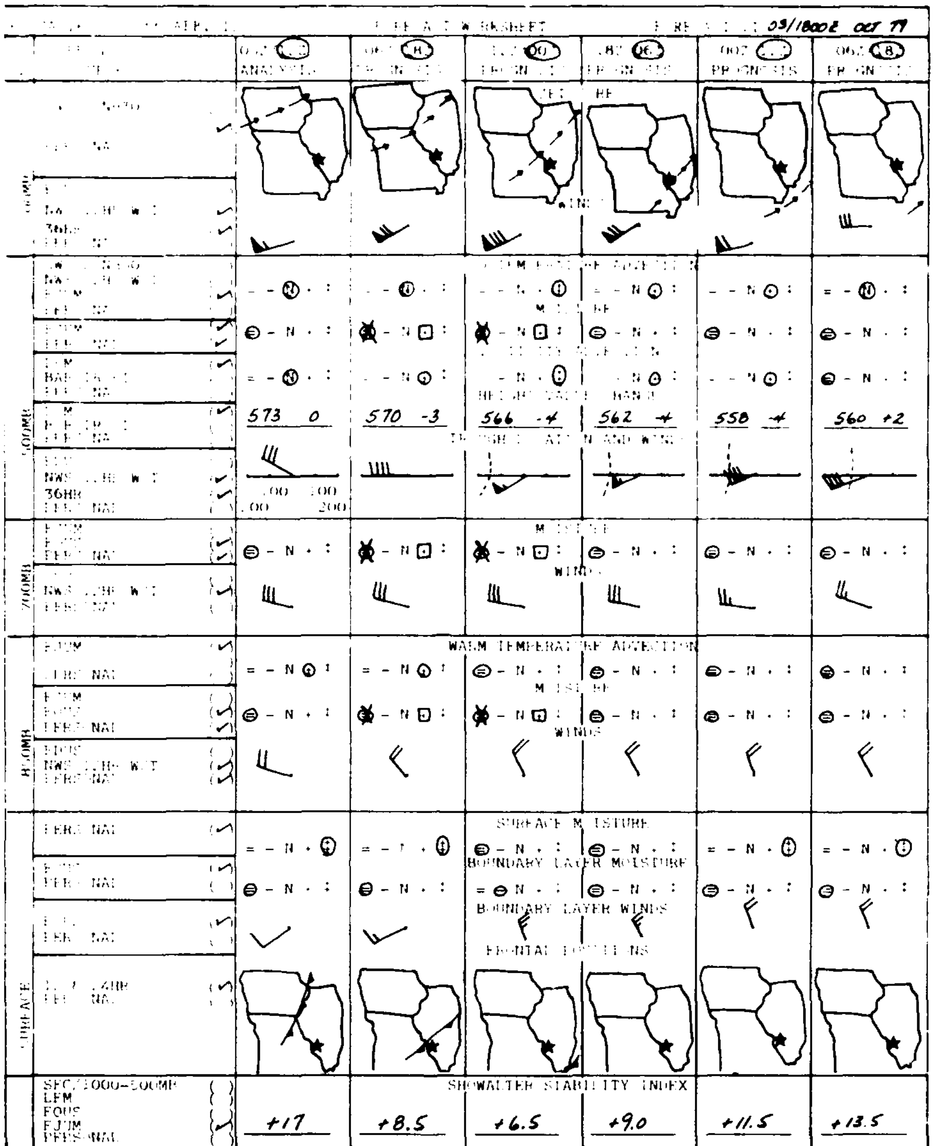


Figure 2. Dew Point - Relative Humidity Conversion Chart.



REMARKS: These comments identify the data sources and procedures used to complete prog entries above. Interpolated or estimated entries were made when no centralized guidance was available for a particular time. JET CORE & 300MB WINDS: NWS 12-hour upper wind and temperature (W/T) progs, 24-hour 850MB and 700MB progs, and 36-hour 500MB progs. 500MB TROUGH LOCATION: Trough position is indicated by the dashed line. Dots along the horizontal solid line are 100 and 200nm up and downstream from Scott AFB (center dot). BOUNDARY LAYER WINDS: FOUS KWBC. TEMPERATURE ADVECTION: Derived from FJUM KGWC by computing the temperature change predicted for the previous six hours. Temperature change converted to symbols using Table 1. MOISTURE: FJUM KGWC used to derive 500MB dewpoint depressions which were converted to relative humidities and then to symbols using Table 1. FOUS KWBC used to infer relative humidities at the boundary layer, 850MB and 700MB using the mean values for the layers R1, R2, and R3, respectively. Corresponding symbols selected from Table 1. The centralized guidance was modified at 03/18Z and 04/00Z (squares around symbols) to more accurately reflect moisture expected during that period.

Figure 3a. Completed Worksheet (03/0600Z Oct 79).



REMARKS: (Con't from Figure 3a): Modifications were based on observations from upstream stations and satellite data which indicated existence of a narrow band of clouds near the 500, 700 and 850MB levels associated with the frontal system moving in from the northwest. Surface moisture entries are subjective forecasts since no centralized aids were available to use directly. <u>VORTICITY ADVECTION</u>: LFM progs used since they handled the expected movement and development of the upstream system better than the barotropic progs. Vorticity advection was "eyeballed" and corresponding symbols chosen from Table 1. <u>HEIGHT VALUE/CHANGES</u>: LFM used for reasons explained above. Height changes were computed for the six hours prior to each valid time. <u>FRONTAL POSITIONS</u>: NWS 12, 24, and 36-hour progs used. <u>SHOWALTER STABILITY INDEX</u>: Taken from the SI column of the FJUM KGWC.

Figure 3b. Completed Worksheet (03/1800Z Oct 79).

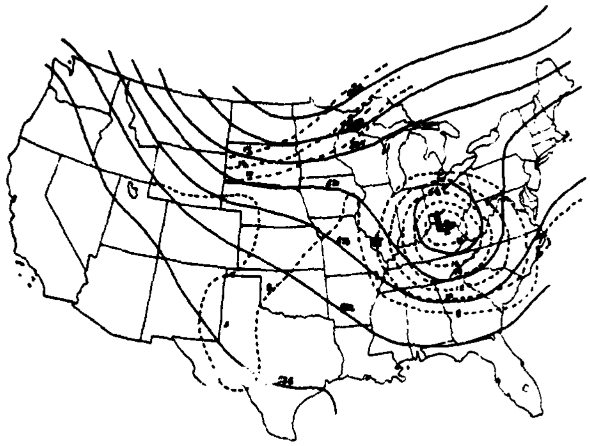


Figure 4a. 500MB Analysis, 3 Oct 79, 0000Z

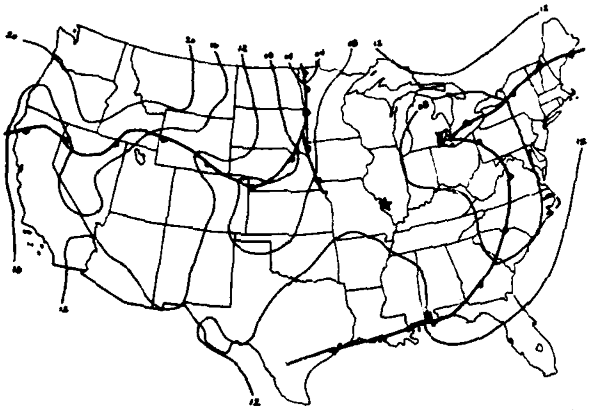


Figure 4b. Surface Analysis, 3 Oct 79, 0000Z

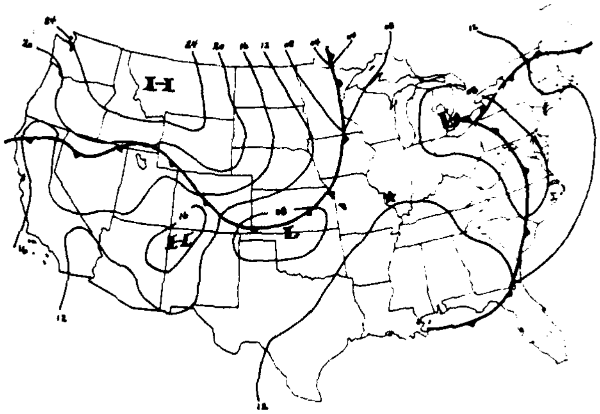


Figure 5a. Surface Analysis, 3 Oct 79, 0600Z

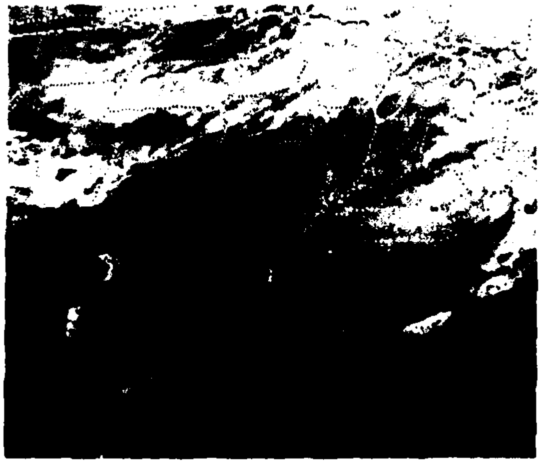


Figure 4c. Satellite, 3 Oct 79, 0000Z

Figure 5b. Satellite, 3 Oct 79, 0600Z

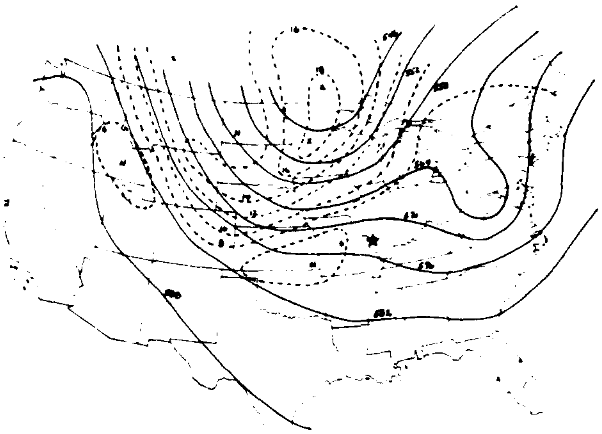


Figure 6a. 500MB Analysis, 3 Oct 79, 1200Z

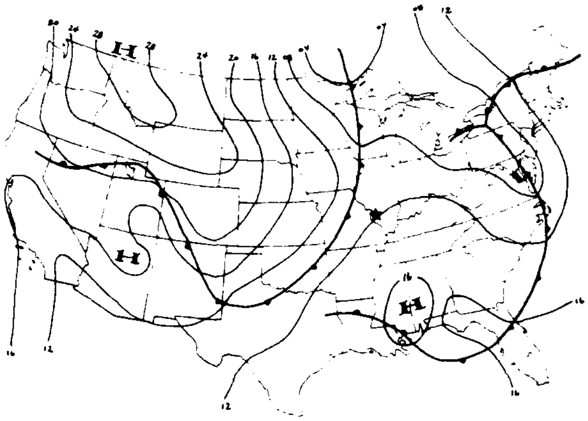


Figure 6b. Surface Analysis, 3 Oct 79, 1200Z

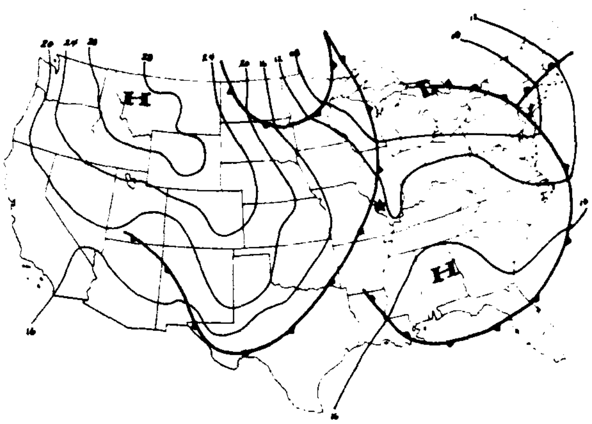


Figure 7a. Surface Analysis, 3 Oct 79, 1800Z

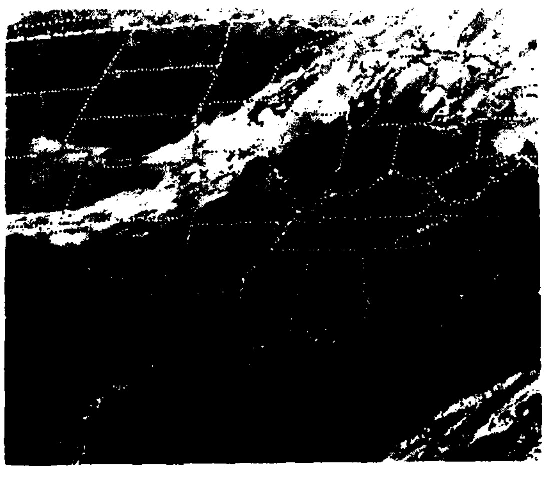


Figure 6c. Satellite, 3 Oct 79, 1200Z

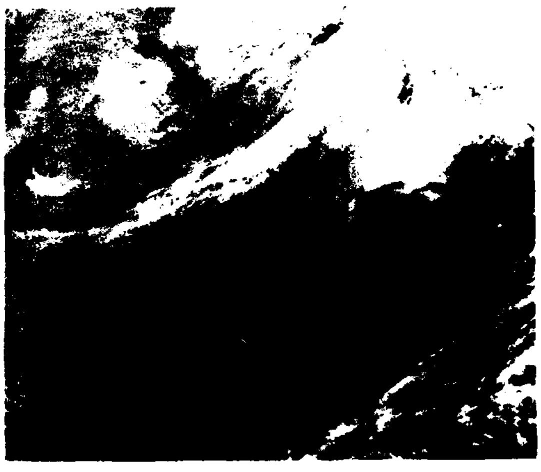


Figure 7b. Satellite, 3 Oct 79, 1800Z

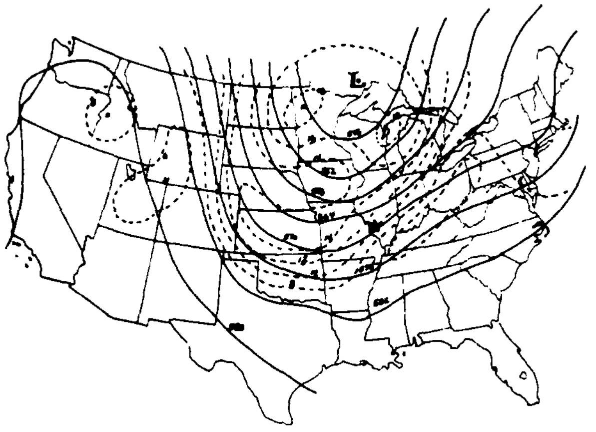


Figure 8a. 500MB Analysis, 4 Oct 79, 0000Z

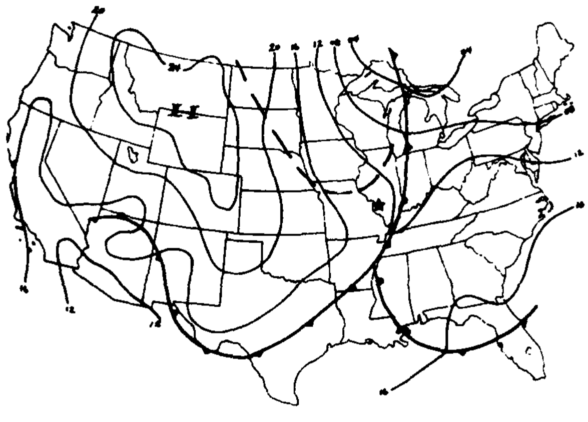


Figure 8b. Surface Analysis, 4 Oct 79, 0000Z

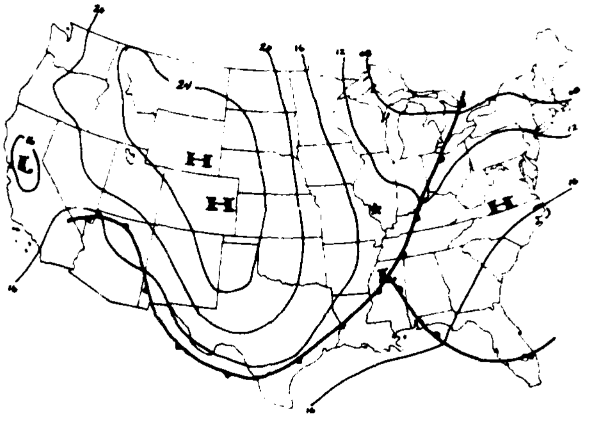


Figure 9a. Surface Analysis, 4 Oct 79, 0600Z

Figure 8c. Satellite, 4 Oct 79, 0000Z

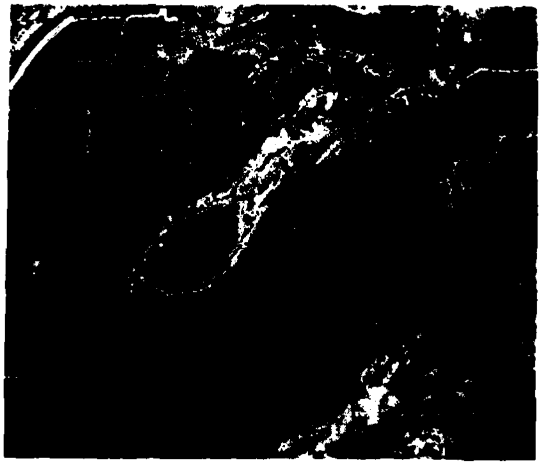


Figure 9b. Satellite, 4 Oct 79, 0600Z

where the forecaster disagreed with the centralized guidance and how the guidance was personally modified and considered in the forecast. It also provides an audit trail of rationale used to make the forecast. Thus, worksheets completed in this manner contain much of the basic information needed for conducting shift change briefings, forecast discussions, forecast reviews, and case studies.

3.2. Forecasting from the Worksheet. Predictors listed in the two worksheet examples (Figures 3a and 3b) were chosen to reflect synoptic scale features. Therefore, a forecast made from this information alone will be rather general in nature. To obtain the precision in timing and other refinements needed for operational forecasts, this information must be supplemented with local techniques, rules-of-thumb, analyses, satellite data, and clues derived from other met watch procedures. Recommendations for adding local predictors will be given later.

Try your hand at making a general forecast from the two example worksheets and see how well it guides you to a conclusion. After you reach a decision, look at Figure 10 and compare your forecast with verifying observations shown at the bottom. Worksheet entries shown in this figure are actual observed conditions for the times when data sources were available. Entries for other times are interpolated to provide a complete picture. Overall, the two worksheet examples (Figures 3a and 3b) handled the situation quite well when compared with the post analysis (Figure 10). Using the worksheet alone, one could produce a reasonably accurate forecast of the events that followed with one exception: The morning fog. Even then the worksheet gave several clues: strong stability, light upslope boundary-layer winds, increasing surface moisture, and prefrontal conditions. These signals alone should be enough to trigger a closer look in deciding on prediction of fog restrictions and timing. This is where supplemental met watch procedures mentioned above come into play.

3.3. Alternate Format. Several variations of the worksheet format and different predictors were examined during consultant visits and at the local base weather station. Although the original version shown does a fairly good job of portraying the predictors in the vertical, one still has to search the data when looking at the vertical distribution of a specific item (e.g., moisture, temperature advection, etc.). An alternate format which groups and vertically stacks like or related predictors is shown in Figure 11. This example contains the same information as shown in Figure 10, except trough positions were added for three levels. Since this format was developed after the initial version was tested, feedback is limited concerning forecaster preferences. Some people say that it is slightly more difficult to fill out since data for the different levels are separated; others think the message portrayed is clearer.

This alternate format also contains one other change involving the analysis and prog time sequences to be used in completing the entries. This change was necessary because one of three prog sequences will be used for each analysis package. The combination actually used depends upon receipt times for the analysis packages and schedules for issuing forecasts. Additional guidance on this subject is given later.

4. APPLICATIONS. When the original guidelines for designing this worksheet format were developed, we tried to satisfy as many of the requirements in AWSR 105-22, Local Analysis and Forecast Program (LAFP), as possible. In testing the new format, we found that it does achieve many of those objectives. We also found several other possible uses not originally envisioned. Potential applications are summarized below.

a. Terminal Aerodrome Forecasts (TAFs). Example worksheets illustrated earlier were designed primarily for recording essential synoptic-scale predictors needed to produce TAFs. Other predictors and rules used locally must be added to achieve the precision required for operational forecasts.

b. Weather Warnings (WWs) and Met Watch Advisories (MWAs). Add all key predictors routinely used to forecast WW and MWA phenomenon. See the next section for details.

c. Forecasts for Drop Zones, Targets, and Other Terminals or Areas. Detachments and Weather Support Units can use this same principle to produce or met watch forecasts for other points or areas. See the next section for details.

d. Local Met Watch. By closely studying the data as it is received and recorded, one can generally tell when the local met watch should be intensified (monitor radar and other data more closely, prepare additional analyses, or complete other specialized worksheets, checklists, etc.). It will also help forecasters stay abreast of developments and be better prepared to deal with bum forecasts.

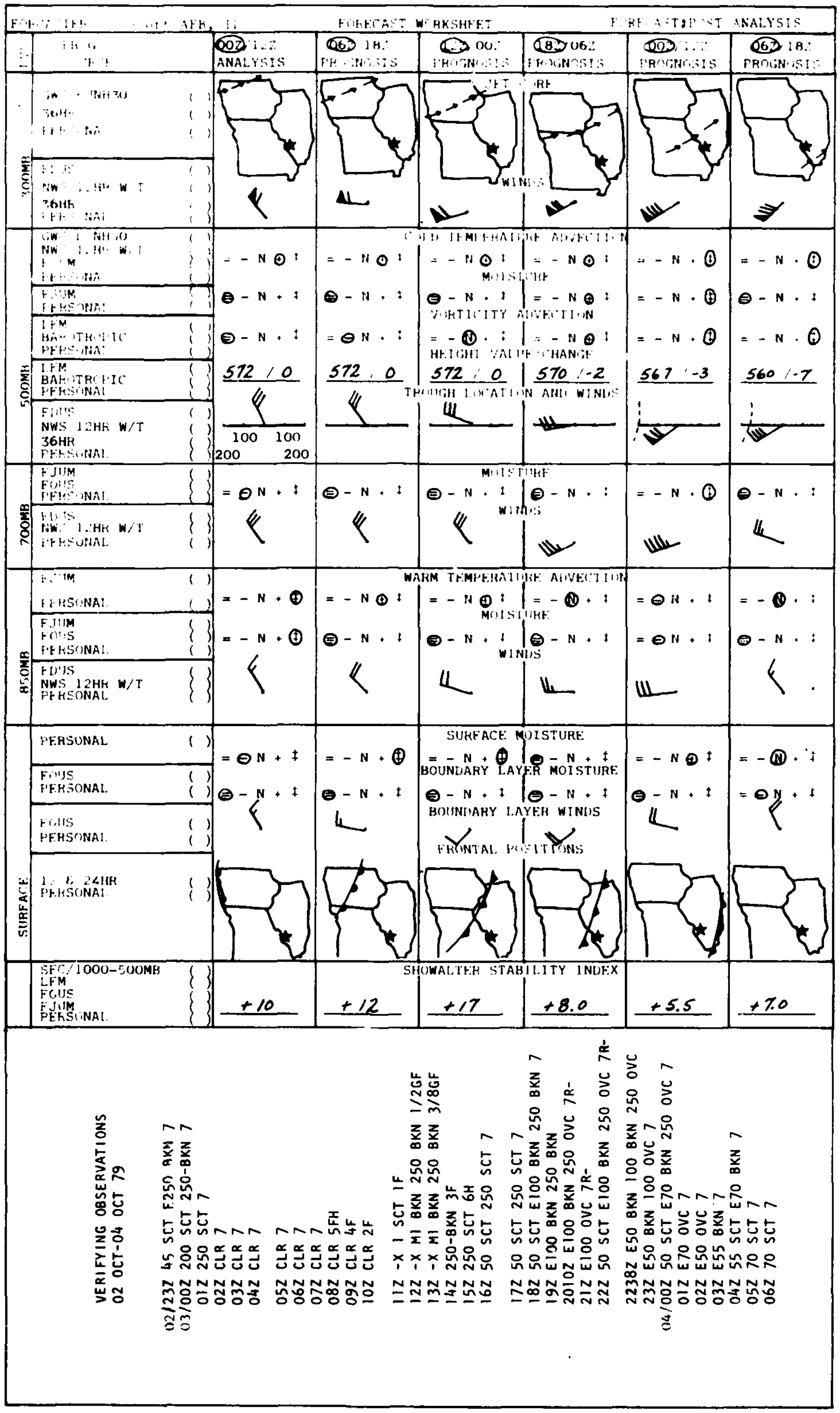


Figure 10. Basic Worksheet Post Analysis (02/2300Z - 04/0600Z Oct 79)

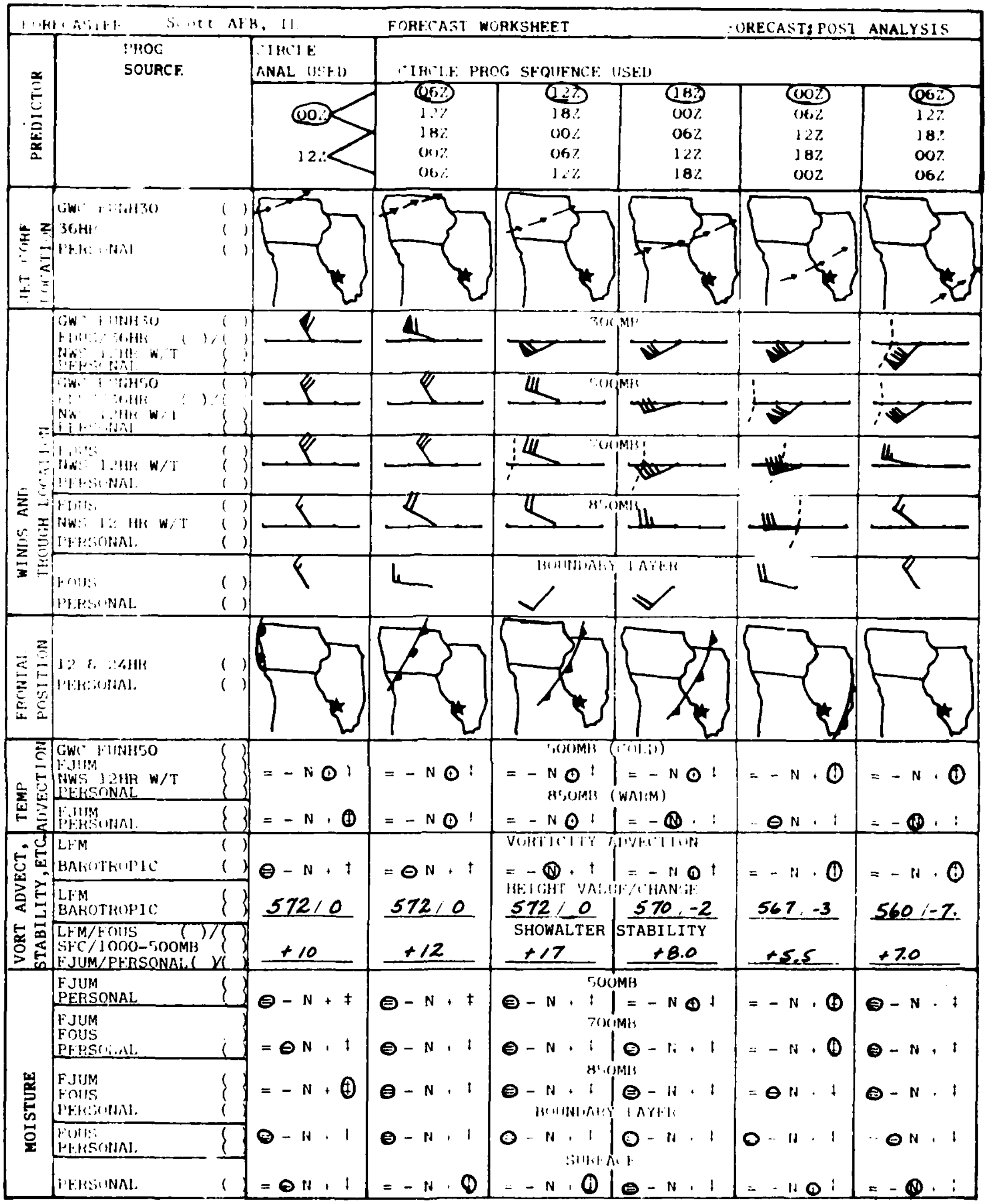


Figure 11. Alternate Worksheet Post Analysis (02/2300Z - 04/0600Z Oct 79)

e. Forecast Discussions and Shift Change Briefings. The worksheet provides an excellent tool for leading forecast discussions and briefings since it contains the rationale used to prepare the latest forecast and current thoughts concerning the next one.

f. Forecast Reviews. Reviews are simplified because most of the original rationale is included on the worksheet. Thus, review efforts can focus on why the original reasoning was erroneous.

g. Supervisor Reviews. By routinely reviewing unit worksheets, supervisors can quickly update themselves on current developments to help with peak workloads or prepare for briefings and to identify soft spots in individual and unit forecast procedures.

h. Forecast Studies/Case Studies. Observed data (0000Z or 1200Z) that is recorded in the first column can be used to evaluate local and centralized progs and to develop and refine local forecasting techniques.

i. Forecaster Training. Trainees can learn good habits initially if they practice with the worksheet because it teaches the basic principles of organizing and studying the data in a logical manner. This applies to new forecasters and also to observers participating in the forecaster preparatory program.

5. DESIGN TIPS: This section describes some pitfalls to avoid and provides suggestions for designing worksheets tailored to local requirements.

5.1. Forecast Schedules and Prog Sequences. Each unit will need to determine the proper analysis (00Z or 12Z) packages and prog sequences to use for their TAF schedule. This can be done by carefully studying forecast deadlines and data receipt times. Actual combinations to be used for each TAF can then be overprinted on the worksheets. Table 2 is a rough guide for the analysis and prog sequences that will apply to most TAFs schedules for the windows shown.

Table 2. Forecast Deadlines Versus Analysis/Prog Sequence.

FORECAST DEADLINE	ANALYSIS	PROG SEQUENCE
$>$ 04Z $\leq$ 06Z	00Z	06Z - 12Z - 18Z - 00Z - 06Z
$>$ 06Z $\leq$ 12Z	00Z	12Z - 18Z - 00Z - 06Z - 12Z
$>$ 12Z $\leq$ 16Z	00Z	18Z - 00Z - 06Z - 12Z - 18Z
$>$ 16Z $\leq$ 18Z	12Z	18Z - 00Z - 06Z - 12Z - 18Z
$>$ 18Z $\leq$ 00Z	12Z	00Z - 06Z - 12Z - 18Z - 00Z
$>$ 00Z $\leq$ 04Z	12Z	06Z - 12Z - 18Z - 00Z - 06Z

Design the worksheet so that a new one must be completed for each scheduled TAF. Since several data sources are transmitted only once or twice daily, there will be many instances in which the same source must be used for two or more consecutive TAFs. In these cases, the data should be reevaluated each time to ensure that it is still representative of expected conditions. Forecasters must avoid the temptation to blindly copy entries from previous worksheets.

5.2. Choosing Predictors. In choosing predictors, the worksheet designer must compromise between two extremes. One is the ideal case which gives only the absolute minimum data needed to make the current forecast. The other is inclusion of every conceivable predictors that could be used. A practical approach is to develop a combination of basic seasonal worksheets and supplemental worksheets, checklists, or other procedures. Basic seasonal worksheets should contain all predictors needed to forecast routine or typical weather conditions plus "trigger" predictors carefully chosen to function as flags for intensifying the met watch and accomplishing supplemental procedures for forecasting special phenomena (e.g. thunderstorms, fog, stratus, snow, freezing precipitation, etc.). Examples of trigger predictors would be a reliable stability index which initiates use of a thunderstorm checklist below a certain threshold or a selected 1000-500mb thickness value which initiates preparation of additional analyses and completion of a local snow versus freezing precipitation forecasting technique.

Avoid the temptation to require entry of actual values for all predictors. A page full of numbers just postpones the key thought process of interpreting the significance of each value until forecast deadlines when least time is available. Unless actual values are needed for a specific purpose, symbol entries are usually easier to derive and digest.

5.2.1. Synoptic Scale Predictors. Here is a list of predictors recommended for basic seasonal worksheets at most mid-latitude stations. It includes the primary synoptic scale conditions that should be considered in most forecasts:

a. Jet Core Location: Recommend all seasons.

b. Winds: 300mb: Recommended all seasons.
500mb; 700mb, and 850mb: Recommended all seasons when troughs are expected within 200nm. Optional other times.
Boundary Layer: Recommended all season.

c. Frontal Position: Recommended all seasons.

d. Temperature Advection: Recommended all seasons.

e. Vorticity Advection: Recommended all seasons.

f. Height Value/Change (500mb): Recommended fall, winter, and spring seasons. Optional summer.

g. Stability: Recommend at least one stability index be evaluated routinely. Choose indexes for which progs are available or which can be computed and which give the best indication of impending significant weather for your area.

h. Moisture (All levels shown): Recommend all seasons.

5.2.2. Local Predictors. In addition to the general predictors mentioned earlier, worksheets should also contain other predictors used locally on a routine basis. They would consist of trigger predictors discussed above plus others geared to local forecasting techniques, studies, and rules-of-thumb. When the latter are not used on a daily basis and space on the basic worksheet is limited, these special predictors could be included on supplemental worksheets. Blank spaces, rather than symbols, should be provided for entries when specific values are needed for a particular forecasting technique. Some examples of special predictors frequently used in forecasting fog, stratus, thunderstorms, snow, freezing precipitation, etc. are given below:

Low Level Jet	Freezing Level	Inversion Height
Thickness Values	Tropopause Height	Sea Sfc Temperature
Temperature (Sfc/Aloft)	Dewpoint/Depression (Sfc/Aloft)	

5.2.3. Guidance Forecasts. Guidance forecasts such as model output statistics (MOS), conditional climatology (CC), etc. can also be recorded on the worksheet. Comparisons with predictors are much easier when these forecasts are displayed in original form for the same valid time. Entries for the "analysis" column should be omitted since they will be of little value.

5.3. Data Sources. This is a list of major data sources available to most CONUS units:

a. Winds (Aloft): 00/12Z Analyses, Skew-T 00/12Z Observed Winds, NWS 12hr Upper Wind Prog, AFGWC 109 Progs, and FDUS KWBC.

b. Winds (Boundary Layer): FOUS KWBC, Skew-T.

c. Temperature Advection (All levels): 00/12Z Analyses, 00/12Z Observed Winds/Temps, AFGWC 109 Progs, and FJUM KGWC.

d. Moisture (All levels): 00/12Z Analyses, FJUM KGWC, FOUS KWBC, New Composite Chart, LFM Anal/Progs, Mean RH/Vertical Velocity Prog.

e. Vorticity: LFM, Barotropic, and Anal/Progs.

f. Height Value/Change (500mb): Same as vorticity.

g. Stability: NWS Composite Chart, LFM Anal/Prog, FOUS KWBC, Lifted Index, and Mean RH/Vertical Velocity.

h. Thickness: SFC/1000-500mb Anal, 30hr Prog, LFM Anal/Progs, and FOUS KWBC.

i. Frontal Positions: SFC Anal, SFC/1000-500 Thickness Anal/Prog, Weather Depiction, Satellite, and SFC Weather Progs (12, 24, 36).

j. Misc TTY Bulletins: FAUS KWBC/KGWC (Area fcsts), FPUS KWBC (Public fcsts), and TBXX6 (Satellite discussion).

5.4. Overprinting Maps. Worksheets should be tailored to the terminal or area by overprinting small maps to depict positions of frontal systems, jet cores, etc. An excellent source for maps of the size needed is the Defense Mapping Agency Catalog of Maps, Charts, and Related Products, Part I - Aerospace Products, Vol II Weather Plotting Charts. The map chosen can then be traced on to the master for printing.

For more flexible worksheets such as those needed to produce or met watch forecasts for several different terminals or areas, "bulls-eyes" can be substitued for the maps to show relative positions of synoptic systems. Bulls-eyes with two range circles of 100nm and 200nm and four cardinal directions are generally satisfactory for most applications.

5.5. Record of Forecast and Amendments. Space should be provided on the worksheet to record the TAF and two amendments.

5.6. Forecast Reviews. Four or five lines should be allotted for recording a brief review of the forecast. This space should be adequate for forecasts that do not warrant an in-depth review. When in-depth reviews are needed, they can be recorded on plain paper and attached to the worksheet.

5.7. Supervisor Comments. Allot space for supervisor comments on strengths, problems, and whether or not an in-depth review should be done.

6. CONCLUSIONS.

6.1. Operational Use. Although the actual value of this new concept in worksheets has not been quantified in terms of improved forecasting skill, experiences gained thus far indicate that the potential benefits are significant. It has reached the stage where it can be used operationally. Undoubtedly, a number of refinements that can be made, but these can be accomplished by individual units through experience, especially in the area of integrating local techniques. This worksheet is a new routine that takes more of the forecaster's time; therefore, command and supervisory interest will probably be necessary to overcome natural resistance to change.

6.2 Overseas Applications. The concept also appears flexible enough to be used by forecasters worldwide. Since the type and amount of data sources will vary, some adjustments in application will be necessary; but they should not be extensive.

6.3. Workload. Supervisors will find that it takes approximately 20 - 25 minutes total time to complete the basic worksheet illustrated, provided there are no major inconsistencies to resolve. On the surface, this might seem to be a lot of time, but it's certainly not an unreasonable amount to devote to preparing an operational forecast when one considers that this is where most of the "heavy thinking" is done. Worksheet entries must be made as the data arrives - not just prior to forecast deadlines! Thus, the workload is normally spread over six-hour periods between forecasts. This is a key point in successfully using the worksheet; it promotes evaluation of developments as they occur, rather than trying to sort out what's happening at the last minute.

6.4. Formal Training. This concept should be taught in our technical schools so students can learn proper habits from the beginning.

6.5. Need for Improved Centralized Guidance. One of the most difficult problems encountered in this study was development of simple procedures to handle the incompatible and incomplete centralized guidance provided by AFGWC and NWS. Field forecasters should be free from the burden of filling data gaps, converting data to standard units, and extrapolating data to common reference levels before they can interpret and compare progs from different models or sources. The goal should be products which can be compared directly and which provide a continuous and complete picture for at least 30 hours in the future. This will allow field forecasters to devote more of their time toward evaluating differences between real-time developments and progs from different models or sources.

6.6. Future Automation. The concept described in this report deals with manual processing of the data; however, designers of the AWS Automated Weather Distribution System (AWDS) should consider including similar capabilities in future equipment being developed. Other systems in which this concept might be applied are the NWS Automation of Field Operations and Services (AFOS) system and the Naval Environmental Data System (NEDS).

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