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TRAINING GUIDE

FOR

SEVERE WEATHER FORECASTERS

BY

MSgt Charlie A. Crisp

November 1979

UNITED STATES AIR FORCE
AIR WEATHER SERVICE (MAC)
AIR FORCE GLOBAL WEATHER CENTRAL
OFFUTT AFB NE 68113

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Presented here is a formal and detailed training guide designed for a forecaster's initial exposure to the Air Force Global Weather Central's (AFGWC) severe weather function. This TN details the analysis procedures for all charts and prognostic tools available to the severe weather function. Significant severe weather parameters are analyzed at the surface, 850 mb, 700 mb, and 500 mb levels. Additionally, the 850/500 mb thickness and maximum wind charts are examined. Also discussed are the severe weather parameters chart and the 12-hour surface pressure change chart. A detailed, step-by-step evaluation of a synoptic (over)

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situation is presented along with appropriate forecasts and verification data. Finally, the automated prognoses available at AFGWC are discussed in relation to severe weather forecasting.

Prior to using this guide, forecasters should become familiar with AWSTR 200 (Rev), "Notes on Analysis and Severe Storm Forecasting of the Air Force Global Weather Central". AWSTR 200(Rev) is referred to briefly when relating analyzed parameters to those synoptic patterns producing severe thunderstorms and tornadoes. This TN will familiarize field users with the techniques used to produce the Military Weather Advisory (MWA).

PREFACE

This note is a formal, detailed, step-by-step guide to the practical aspects of severe weather forecasting. It is designed to supplement formal instruction and to summarize material presented. This note is not intended to serve as a self-instruction workbook. Rather, this work, AWSTR 200(Rev) and a competent forecaster should accompany the beginner through the wilderness of severe weather forecasting.

This note will consider required analysis and prognostic techniques, synoptic weather patterns, and numerical models required to produce high-quality forecasts of severe weather activity. Analyses are discussed parameter by parameter and level by level. Most of the figures are reproduced in multi-colored ink to facilitate parameter identification. An attempt has been made throughout this note to convey the philosophy and "flavor" as well as the mechanics of the art called severe weather forecasting.

Prior to launching into the details of this note, I feel obligated to express my deepfelt thanks to Mr Robert C. Miller, former Chief Scientist of the Air Force Global Weather Central's Environmental Applications Branch. His patience and training, plus the four and one half years of experience which I gained, helped build the reservoir of knowledge from which the techniques detailed in this guide were drawn.

I wish to extend thanks to Major William Irvine, and Captain James Hoke for their assistance in editing this paper. Captains Richard W. Anthony and John R. Bemis rendered invaluable encouragement, and assisted with technical matters. My appreciation is hereby tendered. The superb typing skills and infinite patience of Mrs Mary Zimmerman and SSgt Kathleen Tittle are greatly appreciated. Last, but by no means least, the author thanks his wife Margaret for her encouragement and patience throughout the development of this note.

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15 November 1979

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1 INTRODUCTION

The need for this technical memo became apparent when it was discovered that no publication exists outlining a detailed step-by-step description of analysis procedures for severe weather forecasting. As with any type of forecast, the severe weather forecast is only as good as the analyses used in making that forecast. If the parameters (to be discussed in detail later) are not accurately located through analysis, any prognosis of their location will also be in error. Because an accurate and detailed analysis is imperative, this guide is directed primarily toward analysis techniques used for finding the parameters of interest in severe weather forecasting. Significant severe weather parameters are analyzed at the surface, 850 mb, 700 mb, and 500 mb levels. Additionally, 850/500 mb thickness and maximum wind analyses provide insight into severe weather forecasting problems. Also discussed are the severe weather parameters and the 12-hour surface pressure change charts. Prior to using this guide, the forecaster should read AWSTR 200(Rev), Notes on Analysis and Severe Storm Forecasting Procedures of the Air Force Global Weather Central. The analysis techniques described in this technical report are, for the most part, the same techniques introduced by Col Robert C. Miller, USAF (Retired) and currently in use at the Air Force Global Weather Central (AFGWC).

Following the discussion of analysis techniques is an outline of the five severe weather synoptic patterns examined in AWSTR 200(Rev). This outline is included so the forecaster can compare the composite analysis with these synoptic patterns to determine where the greatest potential for severe weather, the threat area, is located. These same five synoptic patterns are used to determine the threat area on the composite prognosis. A description of the prognosis technique that worked very well for the example forecast is used to show the importance of parameter intensities and the actual thought processes that go into the severe weather forecast.

Finally, a description of techniques used to evaluate and adjust various AFGWC and National Weather Service (NWS) atmospheric prognostic models is included. Techniques to locate major severe weather parameters for use on a composite prognosis are examined in detail.

2 ANALYSIS TECHNIQUES

The approach used throughout this section will be to discuss individual parameters at a given level, to combine resulting analyses into a complete analysis at each level, and finally to transfer significant level features from the completed level analysis to an "overlay" upper-air composite analysis. The resulting composite analysis, which may appear confusing initially, allows an examination of the interaction of various parameters from several levels and an evaluation of their overall effect. Parameters are indicated by a consistent set of symbols and color coding on all charts, which have been reduced to 50 percent of their original size for convenience. An indication of key parameter intensity can be found at the end of Subsections 2.1 through 2.9 and can be used as a guide for evaluating severe activity potential.

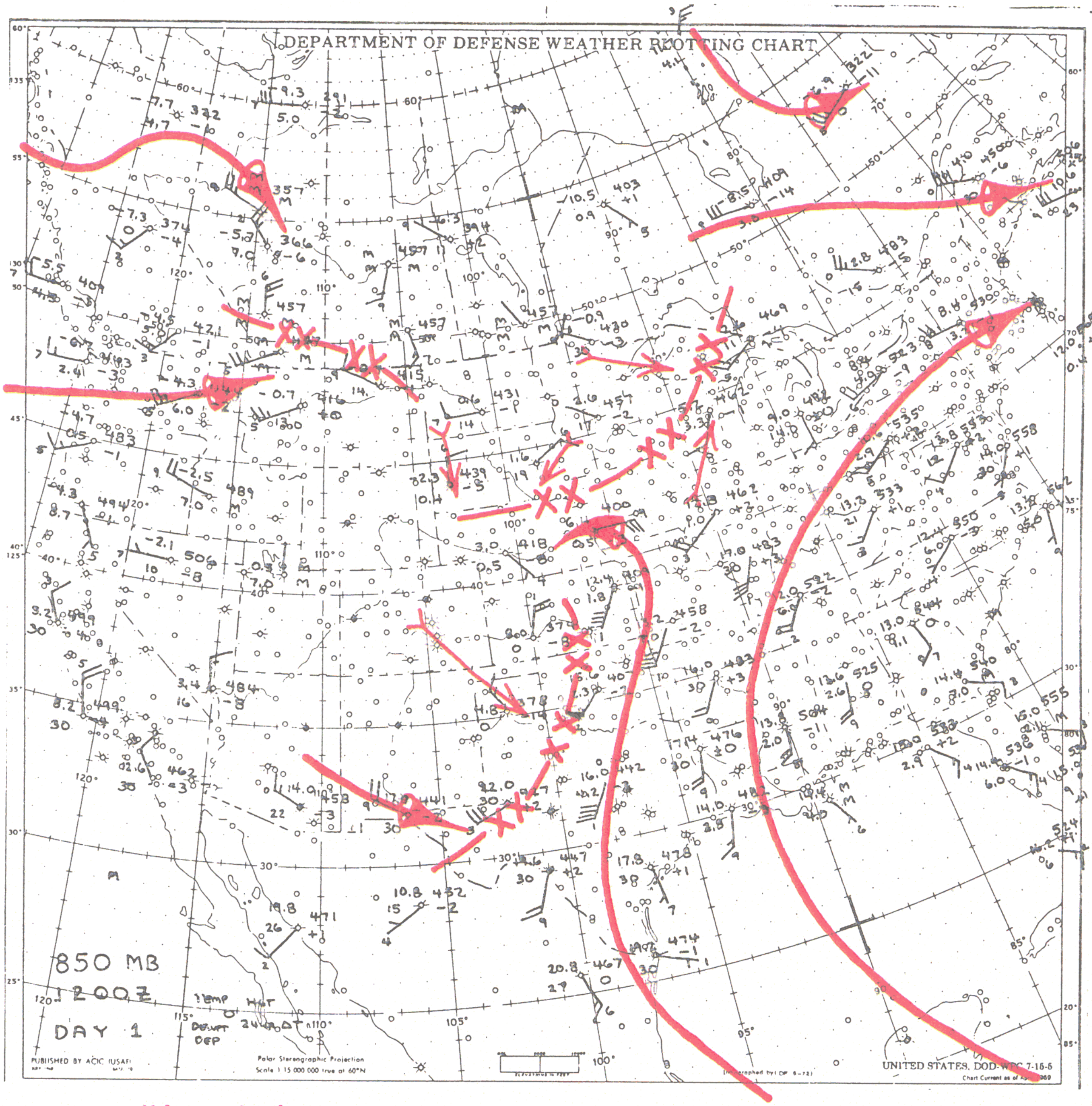
Before analyzing each chart, forecasters should be aware of certain appropriate and inappropriate analysis procedures for any chart used in this highly specialized type of forecasting. The severe weather forecaster is most concerned with unconventional map features. All values attached to the analyzed parameters must be considered relative to the immediate environment. Analysis of any particular level incorporates the use of all available information, such as the previous analysis, additional data from radar and satellite sources and from levels above and below the level of interest. A great deal of care must be taken not to ignore, change, or smooth data that may at first appear to be in error. Meticulous attention to minor changes and transitory features in the atmosphere is imperative. A highly systematic analysis routine is required to ensure the necessary attention to small details.

2.1 850 mb analysis. This very important chart enables the forecaster to estimate atmospheric stability and helps in forecasting changes in static stability. Each step in this analysis is essentially a separate analysis, but all analyses are done operationally on the same chart. These steps are shown here on separate illustrations to simplify the explanation of the complete level analysis. This entire process will be repeated for the 700 mb and 500 mb levels. Details in Figures 1 through 3 are combined into a completed analysis shown in Figure 4. The parameters listed at the bottom of Figure 4 have been transferred to the composite upper-air analysis shown in Figure 17.

2.1.1 Streamlines and convergence zones are the first parameters of interest (reference Figure 1).

2.1.1.1 Significant streamlines.

Maximum wind bands (jets) are important features since they may be associated with significant maximum moisture and thermal advection. Maximum wind band information is part of the vertical directional windshear term in the Severe Weather Threat (SWEAT) formula, which will be discussed later in its relationship to AFGWC's atmospheric prognostic models. This maximum wind band will be referred to as the low-level jet (LLJ). There is no minimum speed criterion for the LLJ.



Convergence Zones (Red)

Maximum Wind Band (Jet) (Red)

Significant Streamlines (Red)

Figure 1. 850 mb Streamline Analysis.

Significant streamlines are also analyzed to assist in locating areas of moisture and thermal advection and especially in identifying convergence zones.

2.1.1.2 Convergence zones.

Convergence zones must be carefully analyzed to avoid always showing troughs in the streamline analysis. When a storm moves out of the Rocky Mountains the flow at 850 mb will come from the Gulf of Mexico, a primary moisture source. Strong westerly flow and southerly flow (from the Gulf of Mexico) converge. Weaker convergence zones are also important and, in some cases, are the only indication of a weak front.

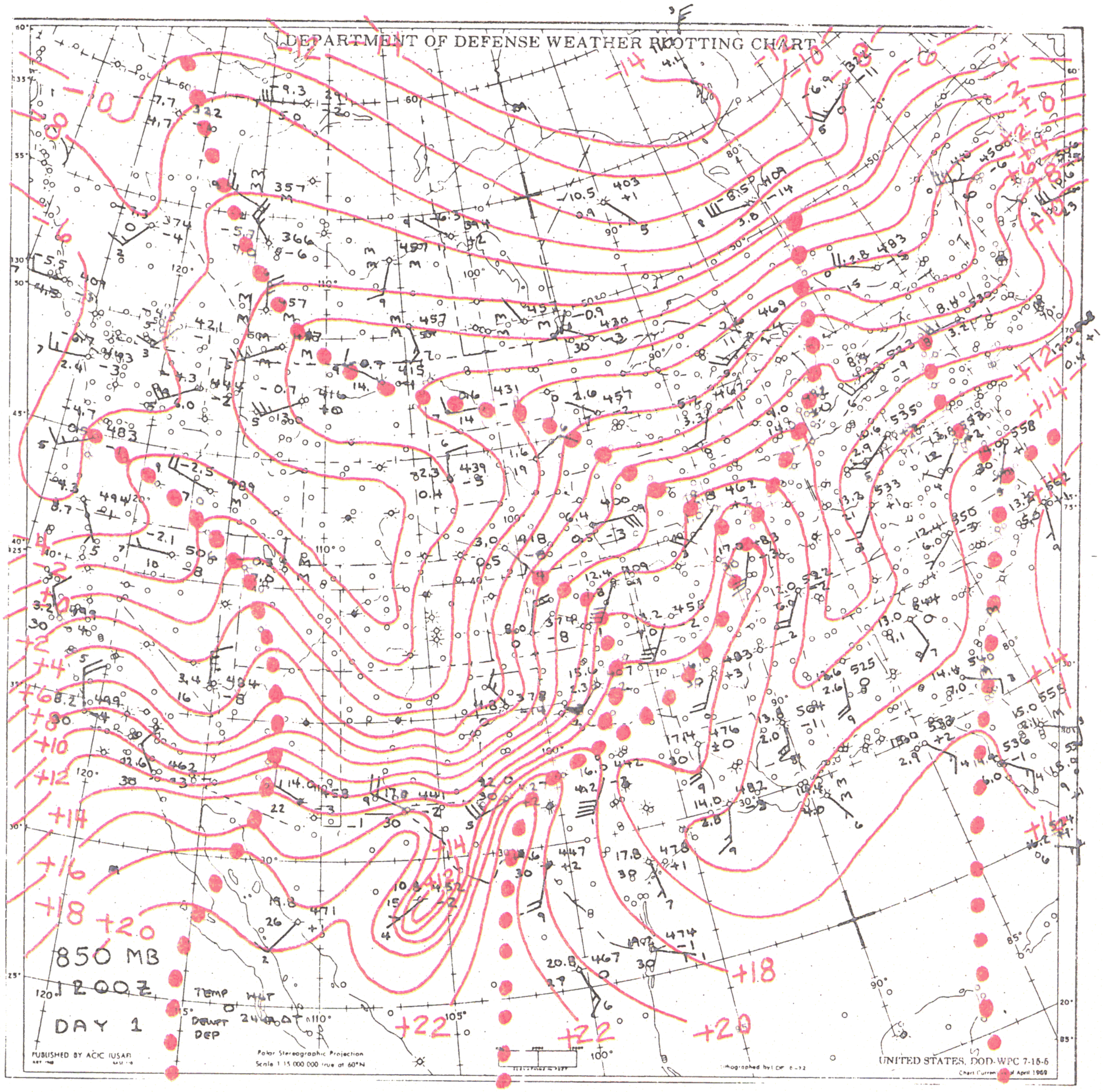
Accurate analysis of the convergence zones will assist in locating the most important thermal ridge and the main axis of maximum moisture advection near a potential severe weather threat area.

At this level in certain parts of the country, a minor trough or weak convergence zone is sometimes the first indication that moisture advection from a source region is occurring. If significant moisture is already present, the convergence zone may indicate a deepening of the moist layer.

2.1.2 A detailed analysis of the thermal field will correctly locate the thermal ridge (reference Figure 2). Analyze the isotherms every 2° C. Select an even numbered temperature that forms a continuous line across the entire chart as your first isotherm.

2.1.2.1 While analyzing the isotherms, remember to look for the thermal ridge and not just draw isotherms. To accentuate the thermal ridge, isotherms should parallel the streamlines wherever the data permit. Do not be reluctant to erase and adjust the pattern. A good analyst modifies his analysis continuously from start to finish.

2.1.2.2 The thermal ridge of prime interest will lie just ahead of the strongest convergence zone. Also note that in most cases, cold advection will be behind the convergence zone with warm advection ahead of it. An exception to this occurs in the southern plains when a strong southwesterly wind drives the dry line eastward ahead of the front and consequently ahead of the cold advection. Frequently a strong thermal ridge can be found on the lee side of the Rocky Mountains, as a result of katabatic (downslope) flow. At times, the same type of thermal ridge will occur on the lee side of the Appalachian Mountains.



Isotherms (Red)

Thermal Ridge (Red)

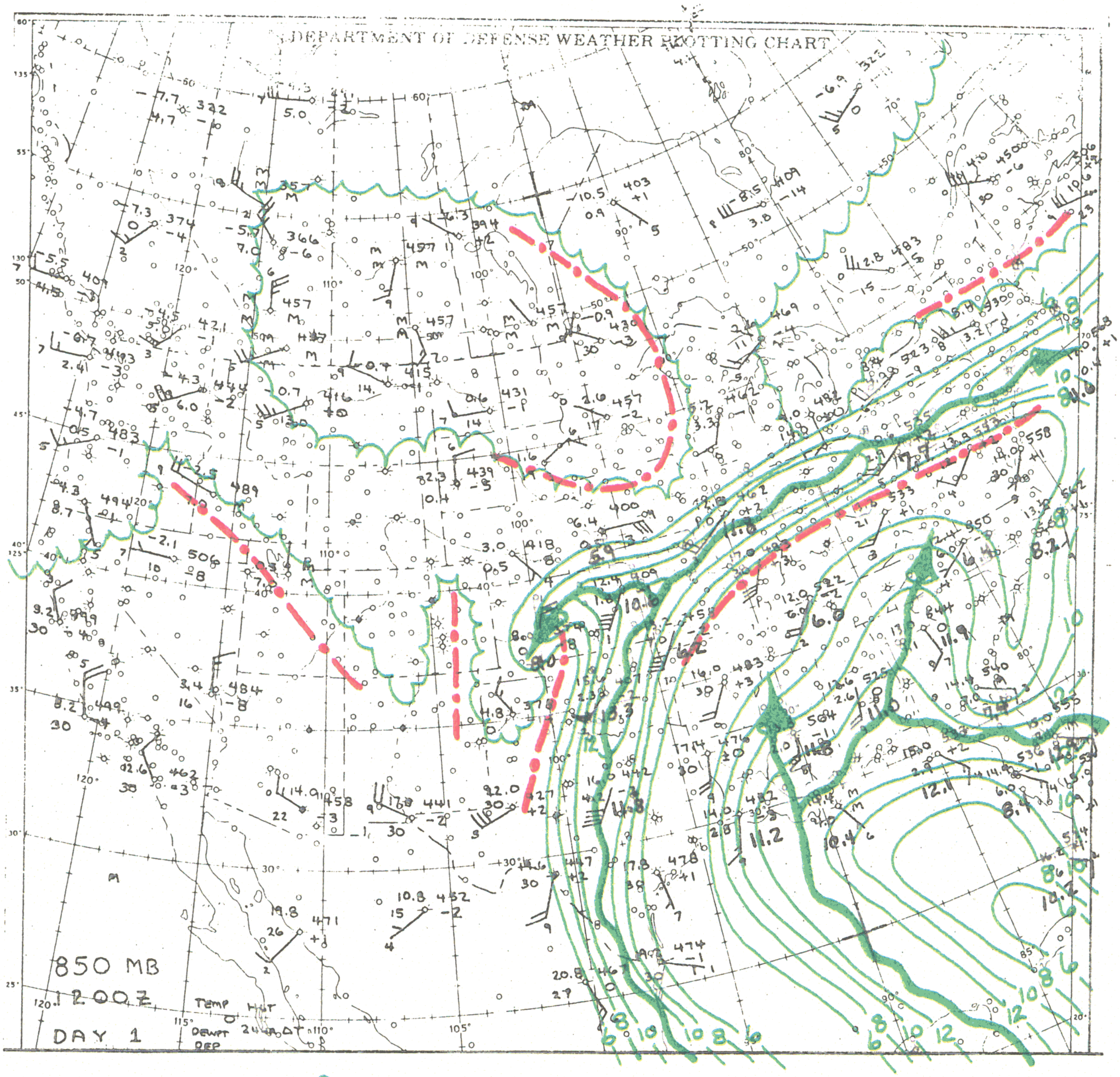
Figure 2. 850 mb Thermal Analysis.

2.1.3 A portion of the chart will require a detailed analysis of the significant moisture field. In preparation for this analysis, ensure that actual dewpoints are indicated in the area suspected of having the most moisture (reference Figure 3).

2.1.3.1 Isodrosotherms (isopleths of dewpoints) are analyzed starting with a dewpoint of 6° C and in increasing values of 2° C. When drawing these isodrosotherms, remember to analyze them for the axis of maximum moisture advection and areas of maximum moisture. The isodrosotherms should parallel the streamlines wherever the data permit. This accentuates the moisture axis. Do not just draw isolines, analyze them. Create the most representative field. There are times when subsidence will produce a moist, mixed layer lying just below the 850 mb level. As the day progresses, boundary layer turbulence caused by low-level winds will often result in a deeper mixed layer. Twelve hours later, on the next analysis, considerable moisture may now be available at the 850 mb level.

2.1.3.2 Additional regions of significant moisture are associated with areas having temperature-dewpoint spreads of 6° C or less.

2.1.3.3 Dry lines are indicated where the streamline flow is from dry air into an area of significant moisture. The severe weather forecaster is primarily interested in determining regions where a maximum wind band is flowing across a dry line from dry to moist air.



Axis of Maximum Moisture Advection (Green)

Area of Significant Moisture (Green)

Axis of Maximum Moisture (Green)

Dry Line (Red)

Isodrosotherms (Green)

Figure 3. 850 mb Moisture Analysis.

2.1.4 This description of the 850 mb chart analysis has been partitioned into three distinct and separate analyses. All of these analyses are actually done operationally on the same chart as shown in Figure 4. All the parameters listed in Figures 1 to 3 are displayed in conspicuous symbols as shown in Figure 4.

2.1.5 Summarizing these key parameters at the 850 mb level in terms of intensity:

2.1.5.1 For the low-level jet,

Values of 20 knots or less indicates weak activity,

values 25 through 34 knots indicate moderate, and

35 knots or more indicate strong activity.

2.1.5.2 Low-level moisture (dewpoint depression values),

Values of 8^{o} C or less indicate weak activity,

values of 9 through 12^{o} C indicate moderate, and

values greater than 12^{o} C indicate strong activity.

2.1.5.3 Relationship of the thermal ridge (maximum temperature) to the axis of maximum moisture,

Ridge east of maximum moisture indicates weak activity,

ridge coincident with maximum moisture indicates moderate, and

ridge west of maximum moisture indicates strong activity.

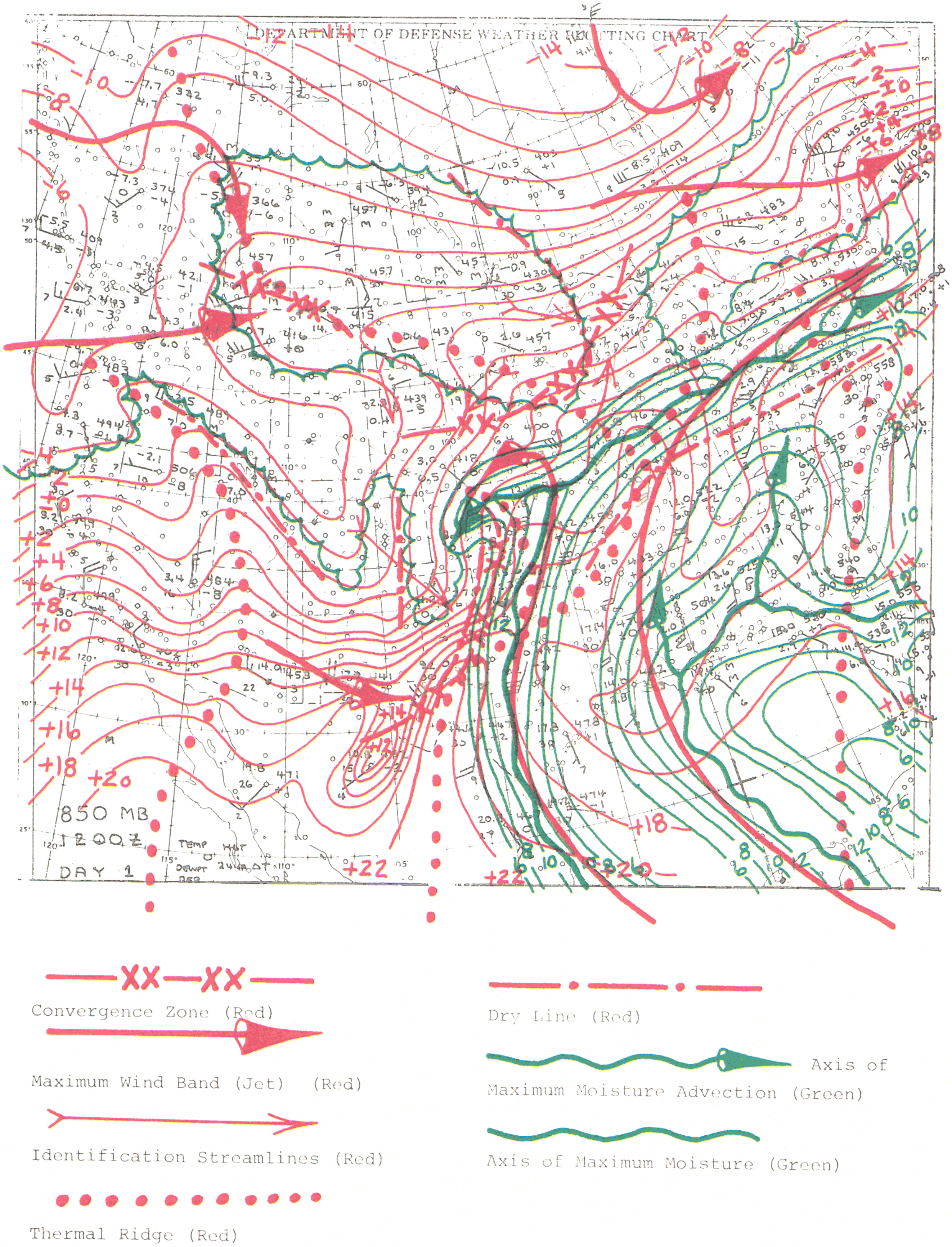


Figure 4. Completed 850 mb Analysis.

2.2 700 mb analysis. Details in Figures 5 through 7 are combined into a completed analysis shown in Figure 8. Parameters listed at the bottom of Figure 8 have been transferred to the composite upper-air analysis, Figure 17.

2.2.1 Streamlines and difluent zones are the primary parameters analyzed in this step. Secondary parameters include temperature falls (12 or 24 hour) and the temperature no-change line (12 or 24 hour). (Reference Figure 5.)

2.2.1.1 Maximum wind bands (jets) are important features because they produce dry intrusions. These wind bands are also useful in depicting areas of most rapid cold or warm-air advection.

2.2.1.2 Significant streamlines, which are not necessarily maximum wind bands, are drawn to help identify areas of difluence.

2.2.1.3 The significant temperature falls (over 12 hours from late fall through early spring and 24 hours from late spring through early fall) should be analyzed to indicate areas of cold advection.

2.2.1.4 The temperature no-change line (over 12 hours from late fall through early spring and 24 hours from late spring through early fall) will assist in forecasting the approximate position for squall-line development.

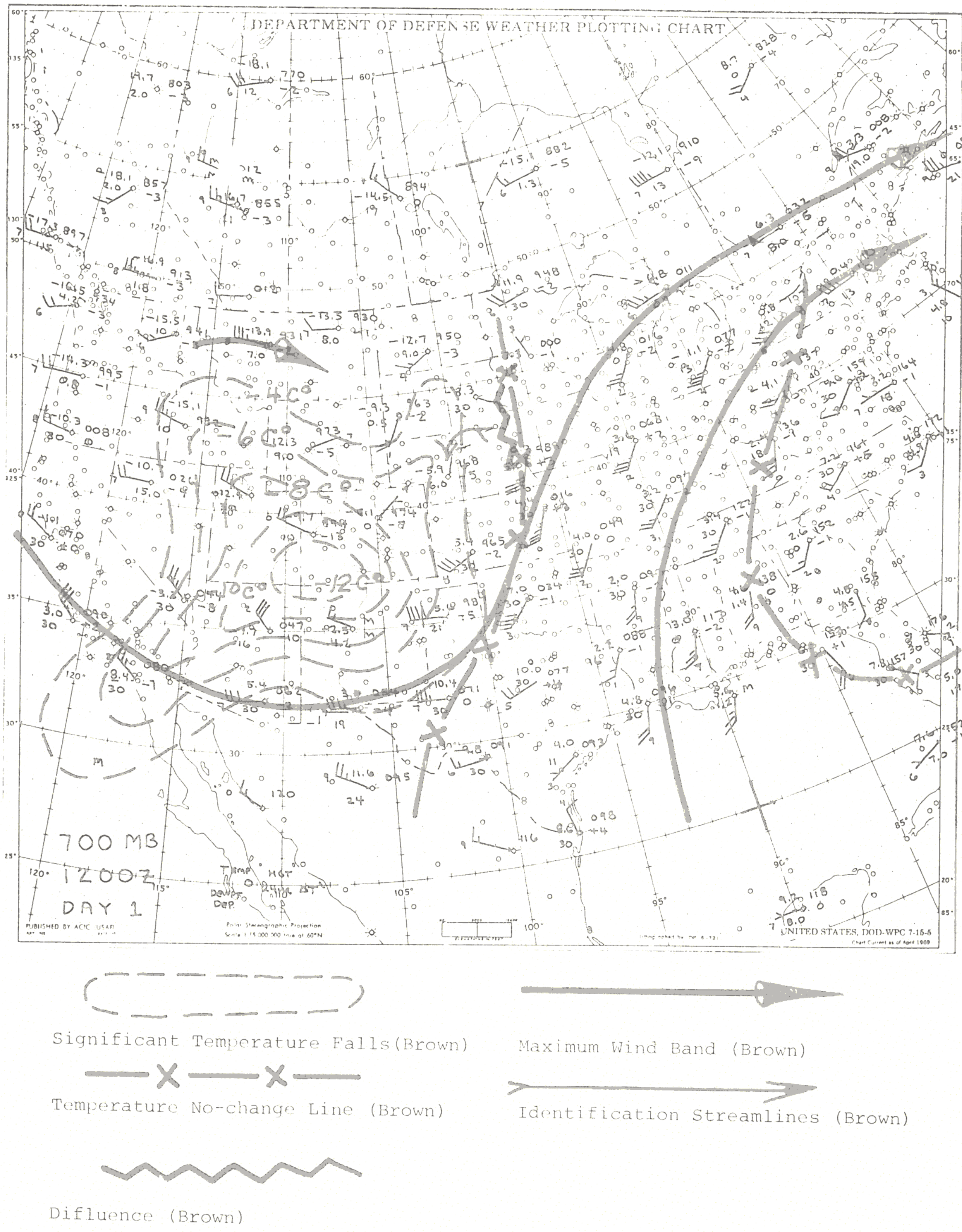
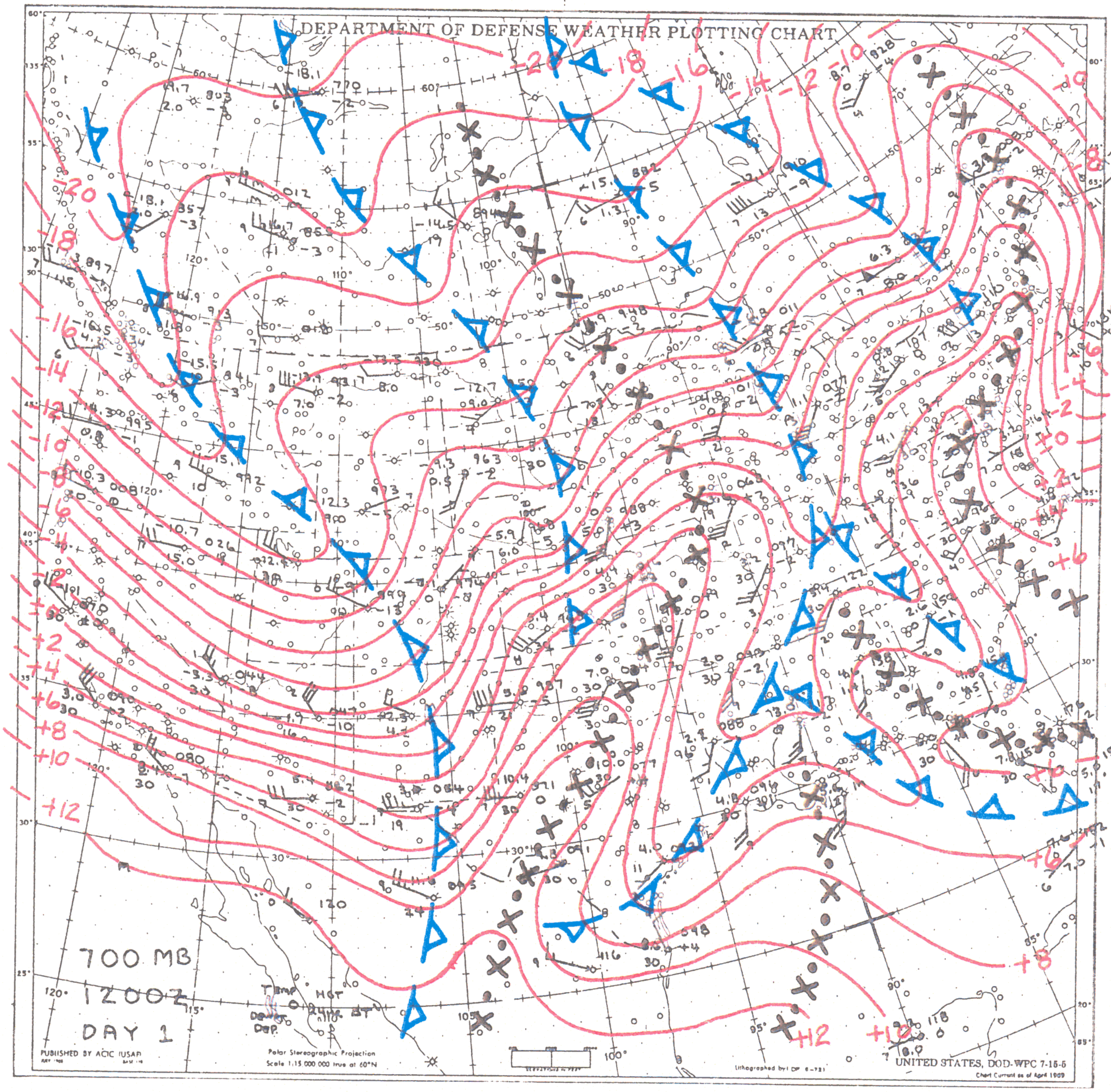


Figure 5. 700 mb Streamline and Temperature Fall Analyses.

2.2.2 Thermal troughs and ridges are located using the thermal analysis. Analyze isotherms every 2^{o} C. Select an even-numbered temperature that forms a continuous line across the whole chart for the first isotherm. (Reference Figure 6.)

2.2.2.1 While analyzing the isotherms, remember to look for thermal troughs and ridges. Where possible, the isotherms should parallel the streamlines, so that the thermal troughs and ridges will be accentuated. The thermal ridge becomes important in late spring through early fall; at temperatures of 12^{o} C or greater (except in mountainous regions), convective activity is subdued or capped.

2.2.2.2 Use the current or previous 500 mb chart to assist in vertical stacking of the cold troughs. The previous 700 mb chart should be used to ensure temporal continuity. These troughs help to locate the most probable areas of vertical motion.



Isotherms (Red)

Thermal Troughs (Blue)

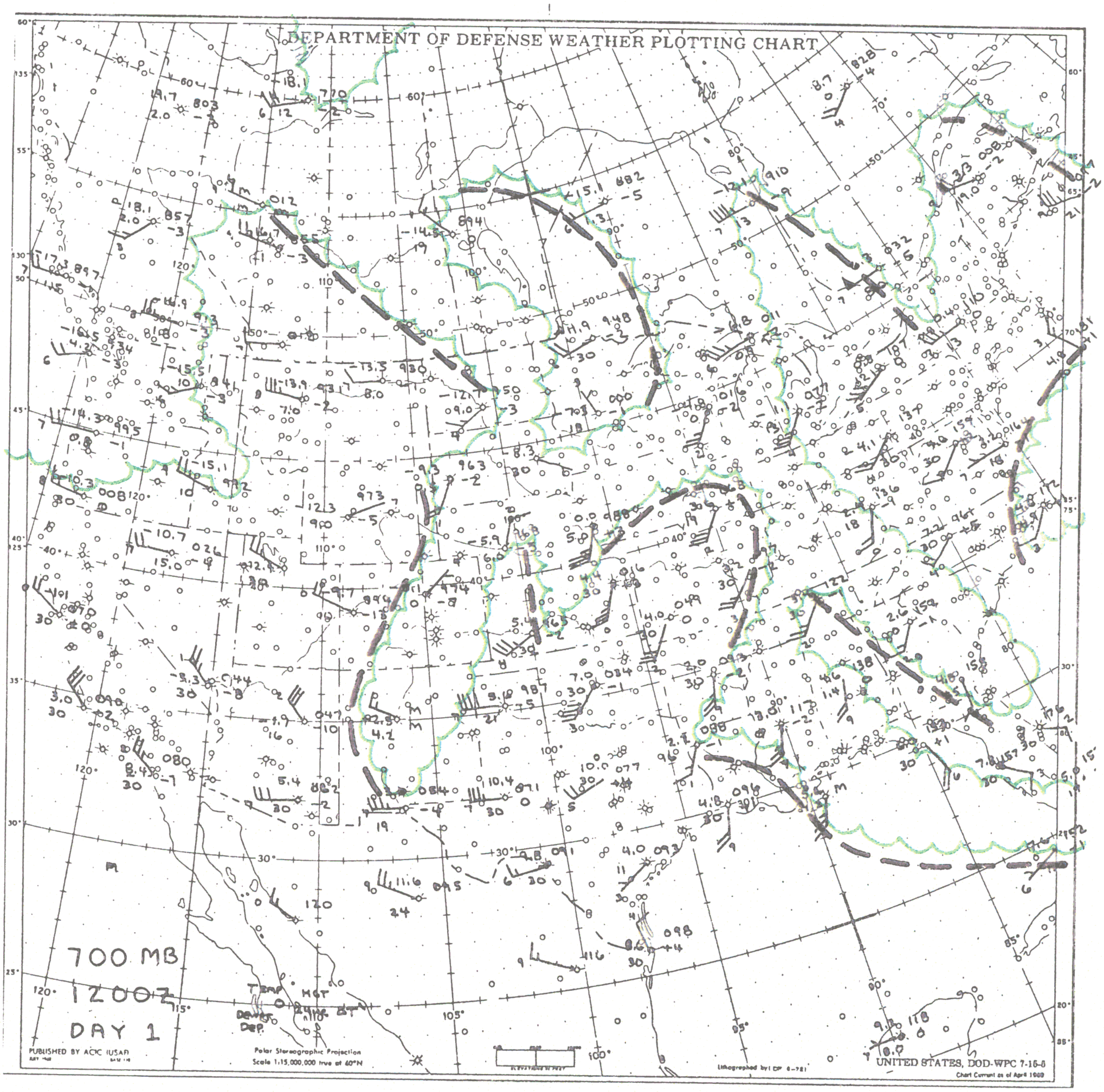
Thermal Ridge (Brown)

Figure 6. 700 mb Thermal Analysis.

2.2.3 The significant moisture field at 700 mb is defined by a temperature-dewpoint spread of 6^{o} C or less (reference Figure 7).

2.2.3.1 Areas of moisture detached from a primary moisture source and not solely explained by advection are most likely the result of upward motion associated with positive vorticity advection (PVA). These areas indicate that a minor short wave trough is a short distance upstream.

2.2.3.2 Dry lines are depicted when the streamline flow, especially a maximum wind band, crosses from dry to significantly moist air.



Significant Moisture (Green)

Dry Line (Brown)

Figure 7. 700 mb Moisture Analysis.

2.2.4 All three analyses discussed are completed on the same chart. All the parameters and symbols listed in Figures 5 through 7 are displayed in conspicuous symbols as shown in Figure 8.

2.2.5 Summarizing these key parameters at the 700 mb level in terms of intensity:

2.2.5.1 Intrusion of the dry line and:

Wind field weak or not available indicates weak activity,

wind from dry to moist at an acute angle of 10 to 40 degrees and speed 15 to 25 knots is moderate, and

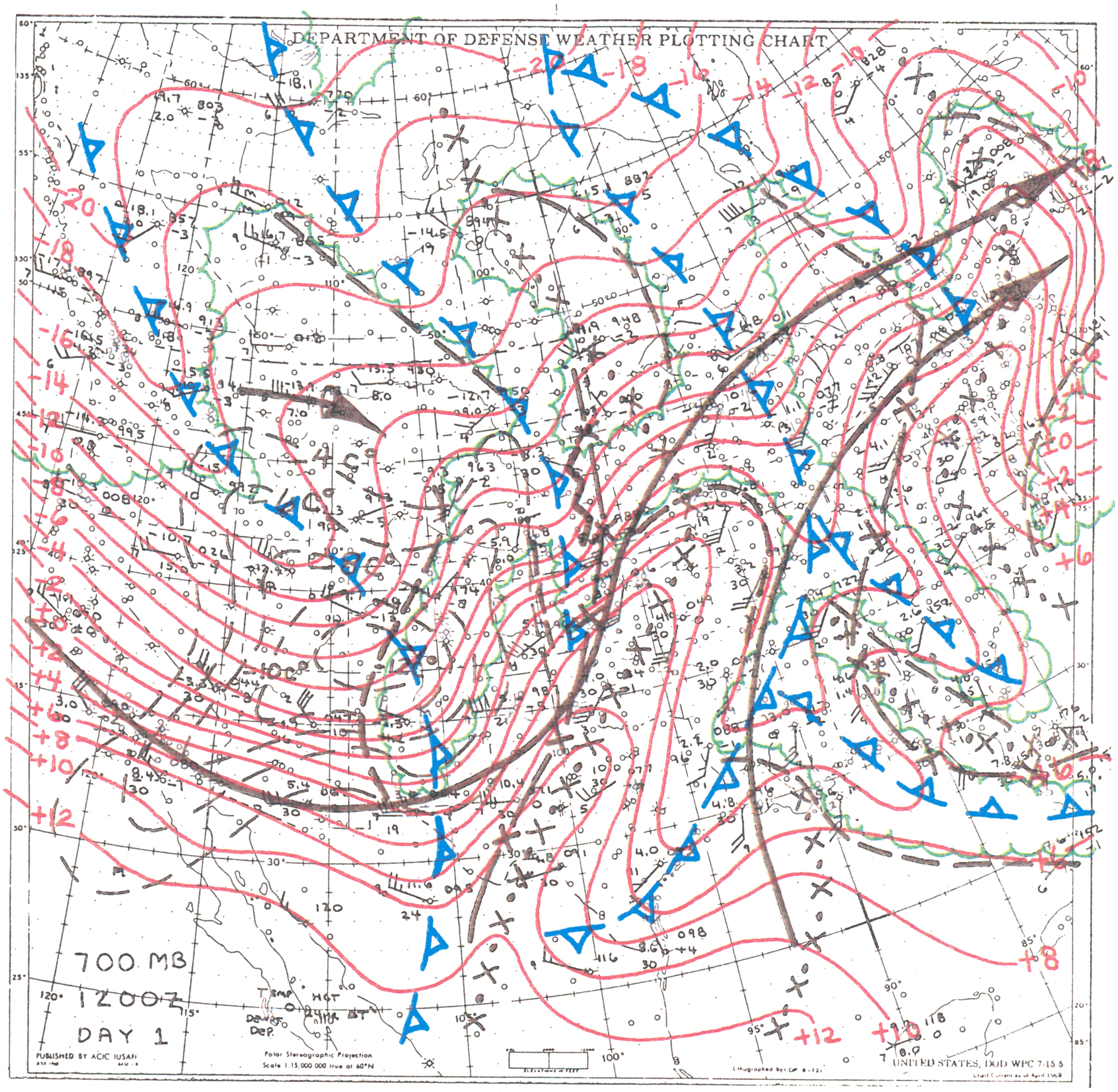
wind intruding at an angle of 40 to 90 degrees with wind speed of 25 knots or greater is strong.

2.2.5.2 Relationship of wind to temperature no-change line (or significant change line),

Wind crossing line at acute angle less than 20 degrees is weak,

wind crossing line at 20 through 39 degrees is moderate, and

wind crossing line at 40 through 90 degrees is strong.



Dry Line (Brown)

Maximum Wind Band (Jet) (Brown)

Temperature No-Change Line (Brown)

Identification Streamlines (Brown)

Difluence (Brown)

Thermal Ridge (Brown)

Figure 8. Completed 700 mb Analysis.

2.3 500 mb analysis. The details shown in Figures 9 through 11 are all included in the completed analysis shown in Figure 12. The parameters listed at the bottom of Figure 12 will be transferred to the composite upper-air analysis shown in Figure 17.

2.3.1 Streamlines, difluence, horizontal speed shear, and height falls are the first parameters analyzed (reference figure 9).

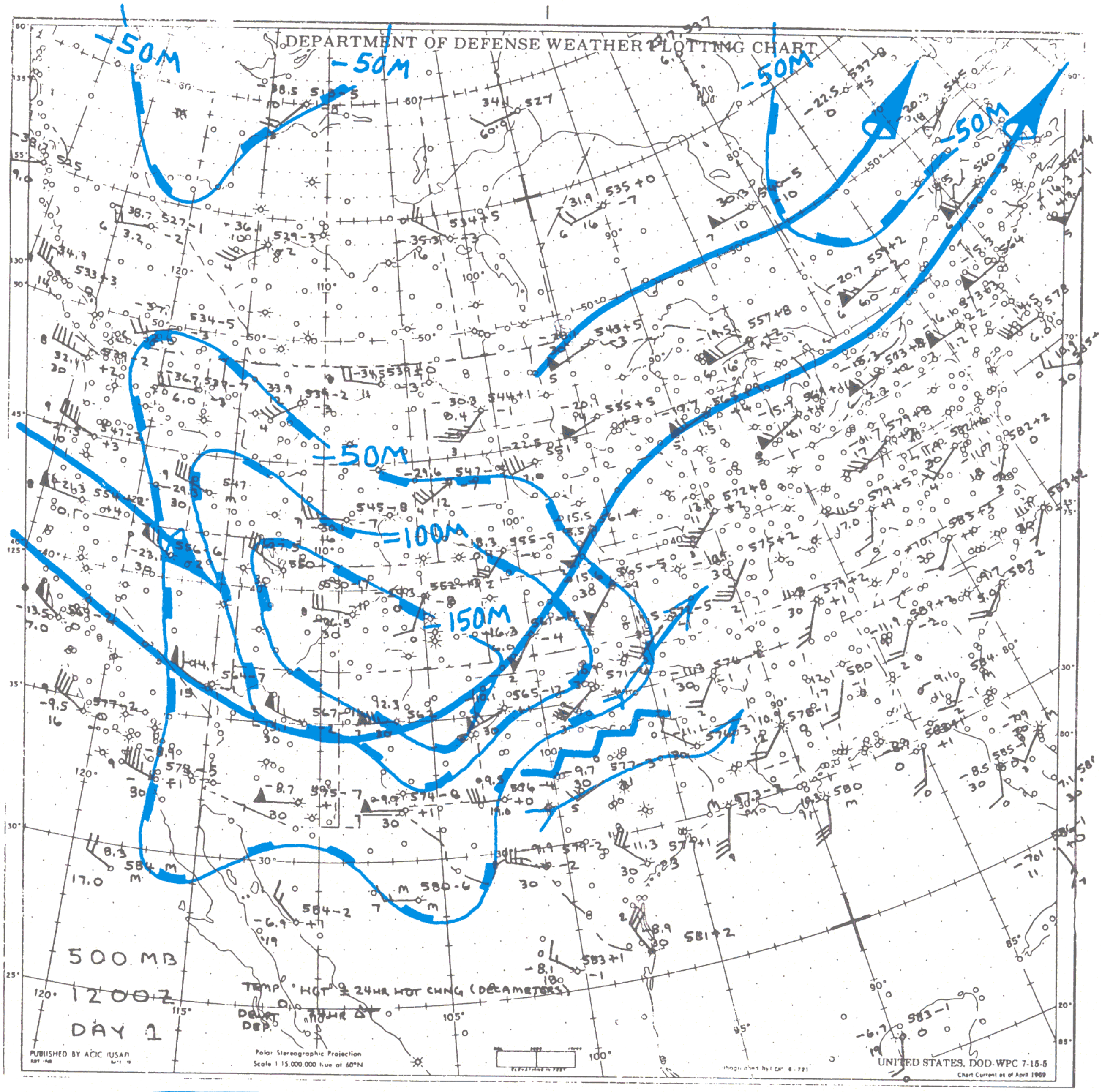
2.3.1.1 Significant streamlines.

Maximum wind bands are the most significant streamlines. Their location and forecast position help to outline the severe weather areas (reference AWSTR 200(Rev), Chapter 3). The direction of flow is one factor considered in calculating the vertical (directional) wind-shear term in the SWEAT formula. Speed is also one of the terms in the SWEAT formula.

Any split in the flow has to be considered as possible branching of the maximum wind band (jet). Evaluate this carefully as the difluence parameter should lie between the two branches in the maximum wind band (jet). There are times when difluence is present and no branching is evident. In this case there may be a weaker flow pattern spreading away from the main jet.

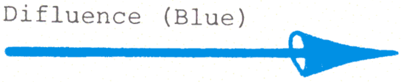
A rapid decrease in the speed of flow to the right of the jet, but moving in the same direction, will depict a horizontal speed shear zone. As in the previous paragraph, the weaker flow branching away from the jet may be considered a horizontal speed shear zone if the decrease in speed with distance is significant.

2.3.1.2 Height falls at this level furnish a clue to the location and movement of long and short wave troughs. Height fall areas also approximate the area of maximum positive vorticity. Because of the seasonal variation in the frequency of migratory waves, 12-hour height falls should be used from late Fall through early Spring (higher frequency) and 24-hour height falls should be used from late Spring through early Fall (lower frequency).

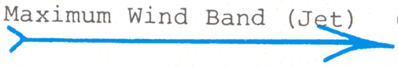


12/24 Height Falls (Blue)

Difluence (Blue)



Maximum Wind Band (Jet) (Blue)



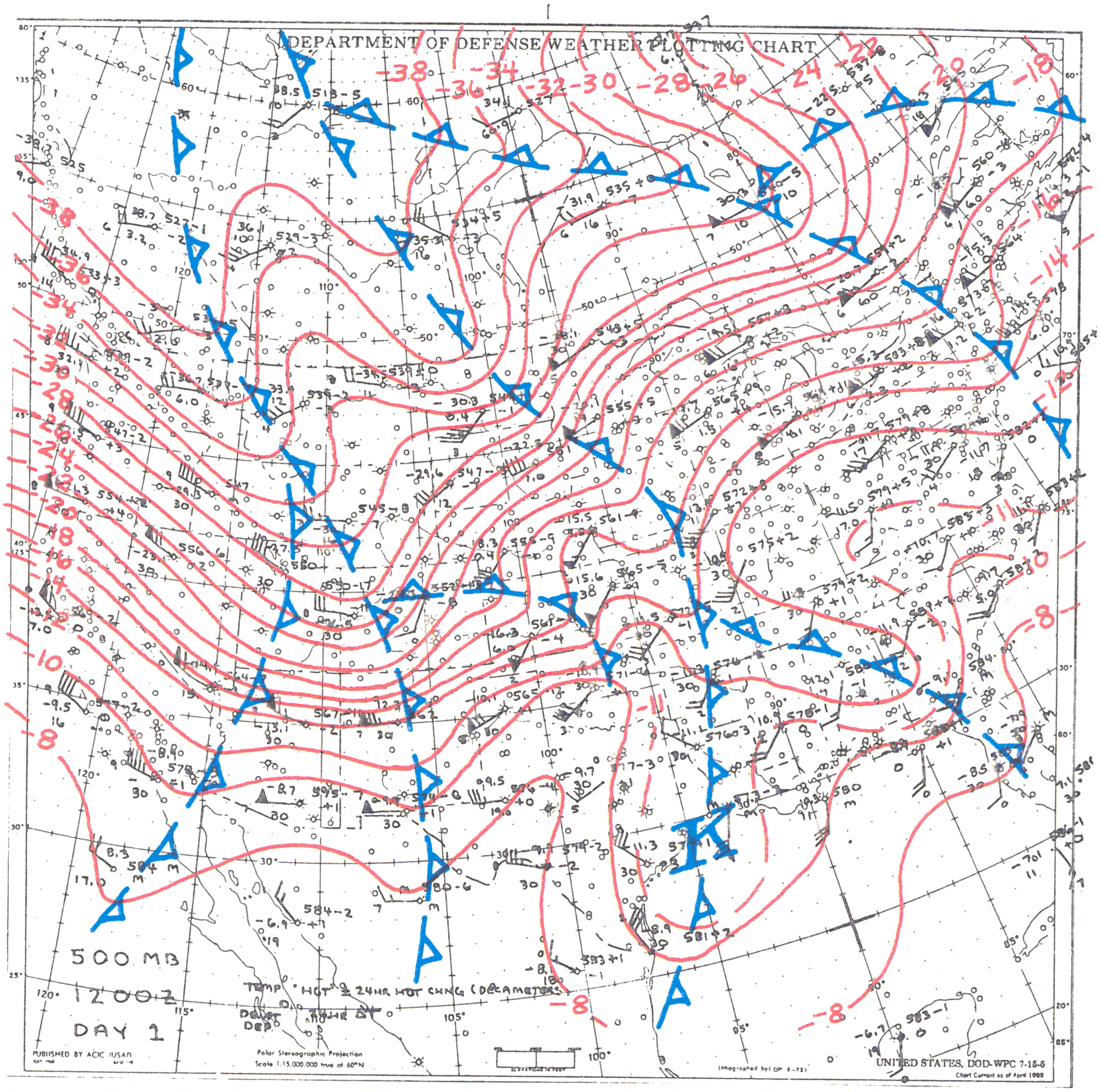
Identification Streamlines (Blue)

Figure 9. 500 mb Streamline and Height Fall Analyses.

2.3.2 A detailed analysis of the thermal field will accurately locate thermal troughs, an important parameter (reference Figure 10). Draw the isotherms every 2^{o} C. Select as the first isotherm an even-numbered temperature that forms a continuous line across the whole chart. The height fall field can assist in the analysis of the thermal field. Note that the trough-like protrusions in the height fall field (Figure 9) appear as cold thermal troughs in Figure 10.

2.3.2.1 While analyzing the isotherms, remember to look for cold pools and thermal troughs and not just draw isotherms. The isotherms should parallel the streamlines wherever possible. Such analysis will enhance the short waves, but take care not to overdo it or the result will be thermal troughs that always coincide with streamline troughs. This tendency to draw thermal troughs coincident with streamline troughs should be avoided (unless observations indicate otherwise) for it will not depict warm or cold advection into or out of a streamline trough.

2.3.2.2 The thermal ridge is not used as a major parameter at this level. It must be considered, however, because most convective activity is subdued or capped near its axis and/or its eastern half, especially when the thermal ridge coincides with the streamline ridge.



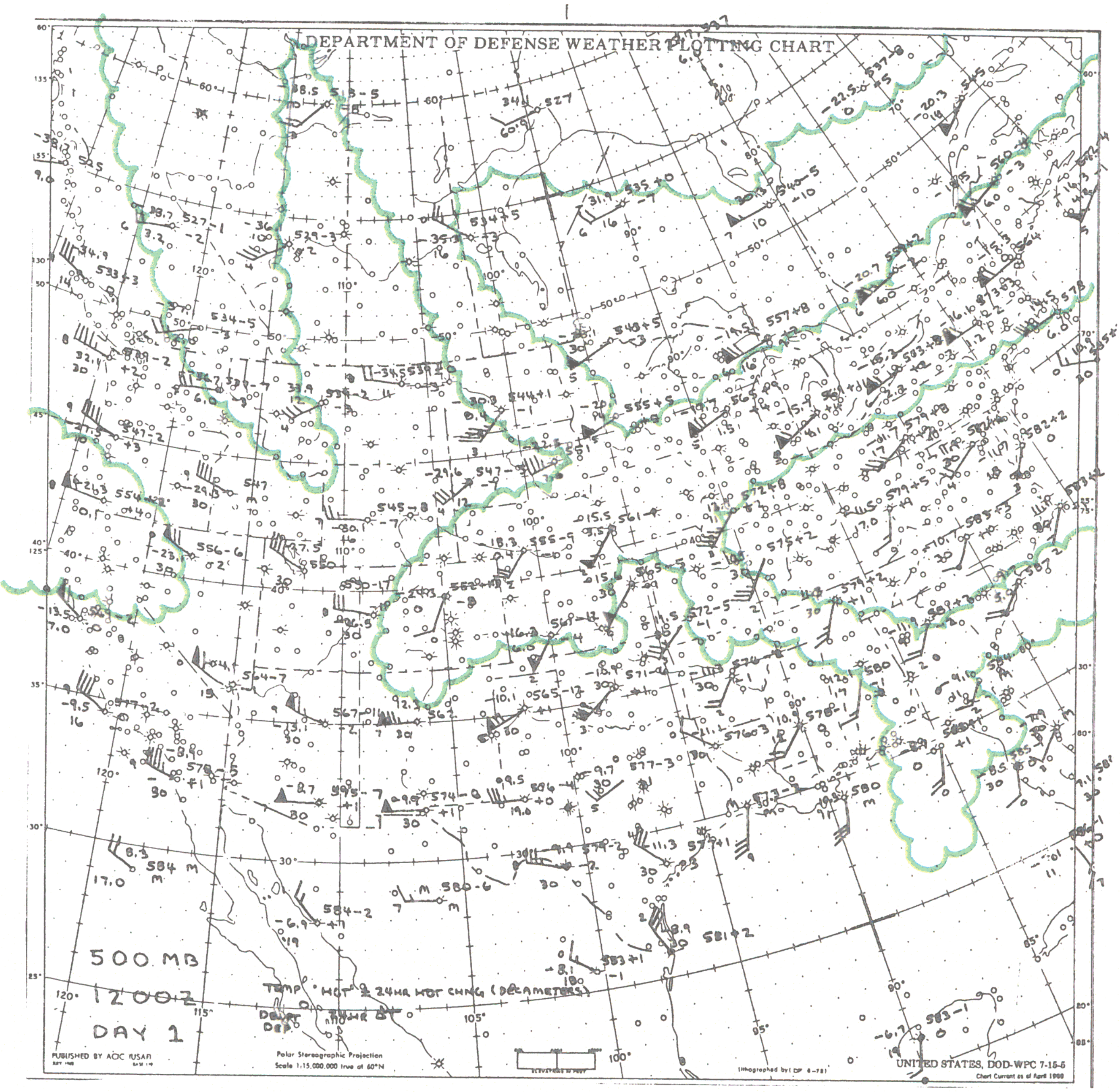
Isotherms (Red)

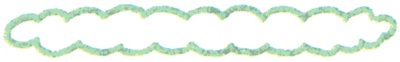
Thermal Troughs (Blue)

Cold Pools (Blue)

Figure 10. 500 mb Thermal Analysis.

2.3.3 The significant moisture field at 500 mb is defined by those areas where the temperature-dewpoint spread is 6° C or less and/or where the dewpoint is -17° C or greater (reference Figure 11). Detached areas of moisture, not solely explained by advection from a primary moisture source, most often result from vertical motion. These areas if associated with PVA will indicate that a minor short wave is a short distance upstream.





Significant Moisture (Green)

Figure 11. 500 mb Moisture Analysis.

2.3.4 All three analyses discussed are completed on the same chart. The parameters and symbols listed in Figures 9 through 11 are displayed in conspicuous symbols in Figure 12.

2.3.5 Summarizing the key parameters at the 500 mb level in terms of intensity:

2.3.5.1 Vorticity advection,

Neutral or negative vorticity advection is weak,

positive vorticity advection with the wind crossing vorticity isopleths at angles less than 30 degrees is moderate, and

positive vorticity advection with the wind flow crossing vorticity isopleths at angles greater than 29 degrees is strong.

2.3.5.2 Mid-level jet strength,

Less than 35 knots is weak,

35 through 49 knots is moderate, and

jets that are 50 knots or greater are strong.

2.3.5.3 Mid-level shear zone (over 90 nm),

Less than 15 knots is weak,

15 through 29 knots is moderate, and

30 knots or greater is strong.

2.3.5.4 Height falls during the previous 12 or 24 hour period (use 12 hour falls from late Fall through early Spring and 24 hour falls from late Spring through early Fall),

Less than 30 meters is weak,

30 through 60 meters is moderate, and

greater than 60 meters is strong.

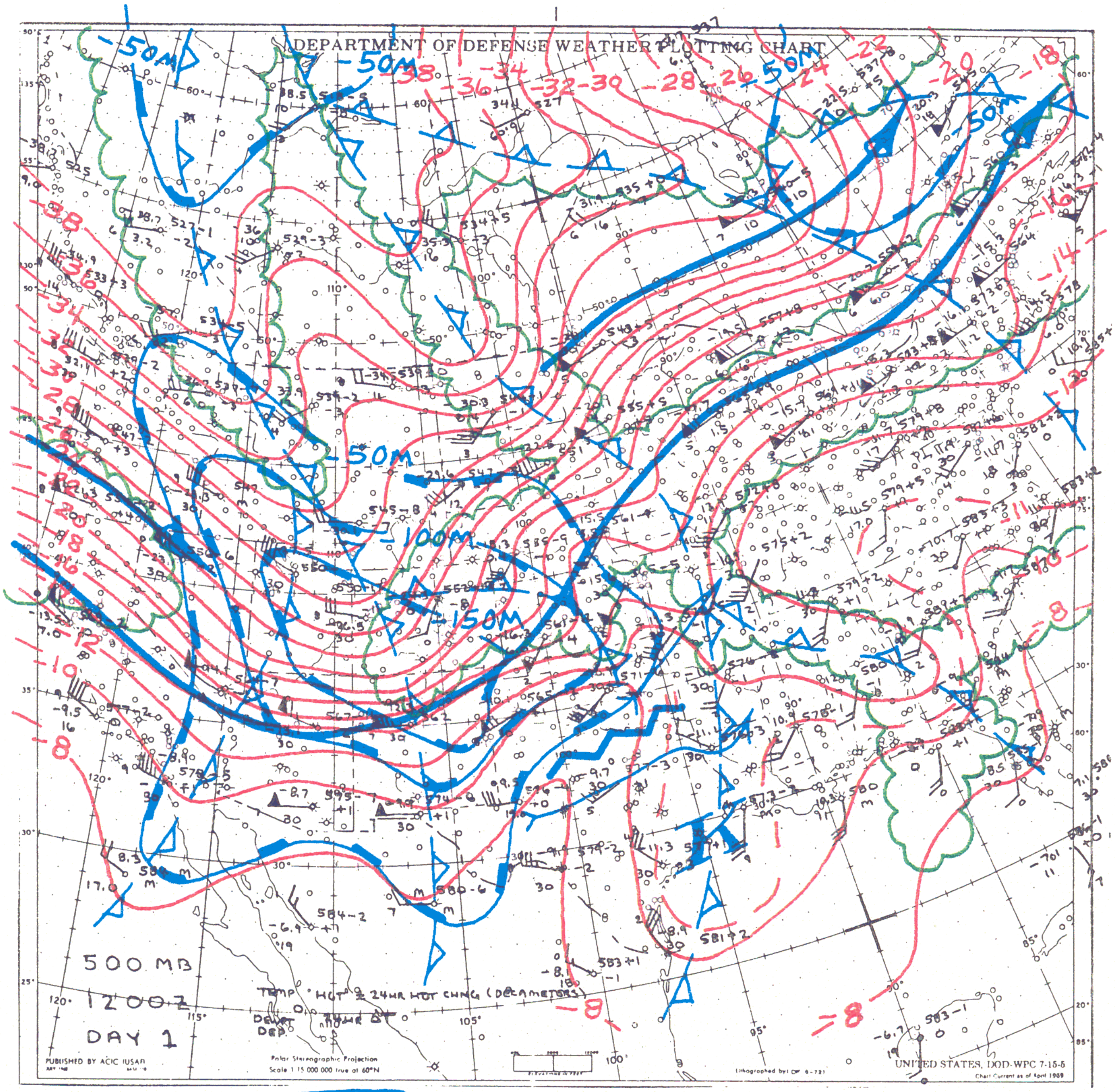
2.3.5.5 The important isotherm value for severe weather by month are:

December, January, and February...-16^{o} C,

March, April, October, and November...-14^{o} C,

May and June...-12^{o} C, and

July, August, and September...-10^{o} C.



12/24-hour Height Falls (Blue)

Thermal Troughs (Blue)

Difluence (Blue)

Cold Pools (Blue)

Maximum Wind Band (Jet) (Blue)

Identification Streamlines (Blue)

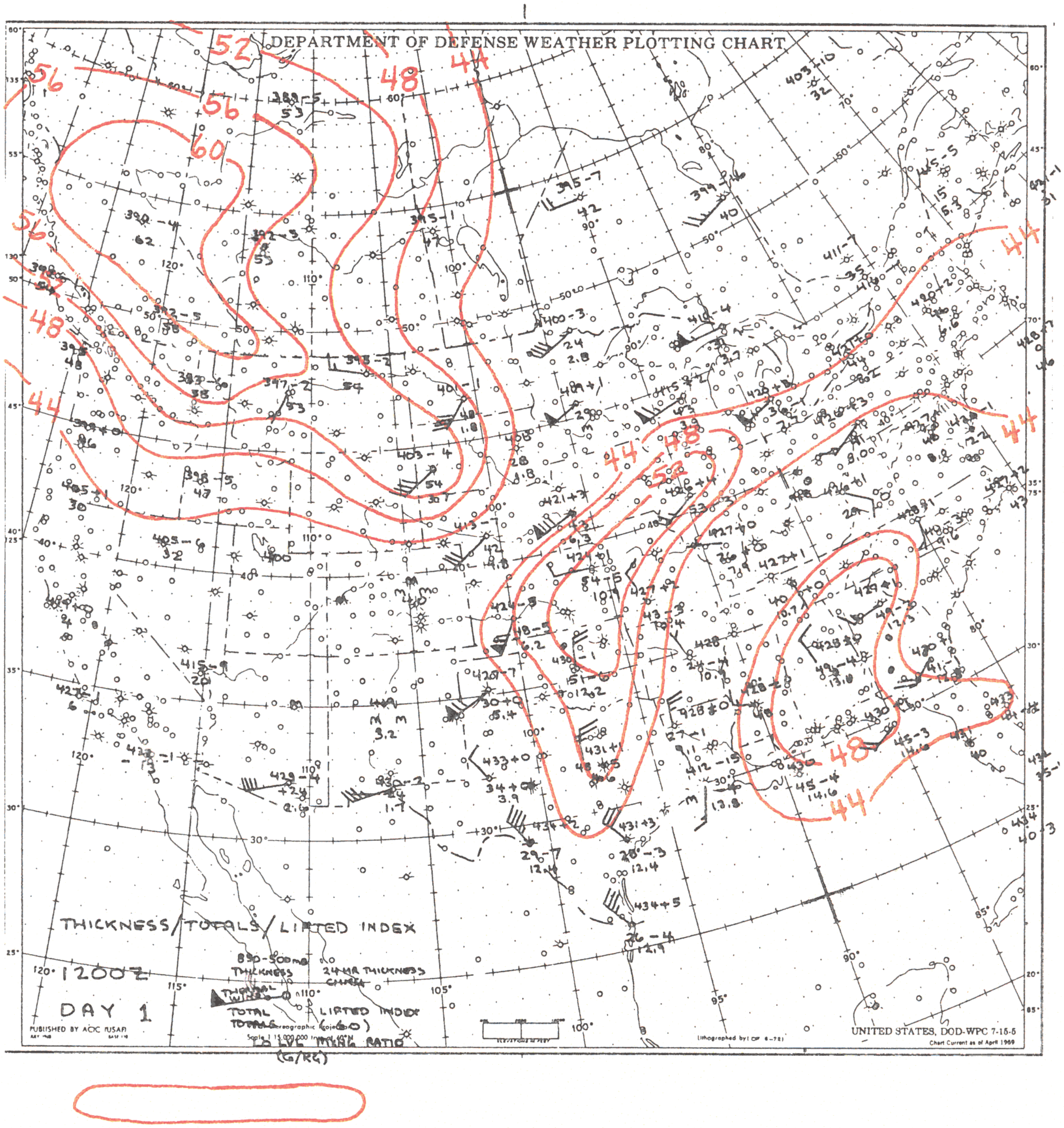
Figure 12. Completed 500 mb Analysis.

2.4 850/500 mb thickness analysis. The thickness chart can be used by the severe weather forecaster to delineate the approximate area of potentially severe activity by locating the most probable area for squall-line development (reference Chapter 4 of AWSTR 200(Rev)). Details shown in Figures 13 and 14 are all included in the completed analysis, as shown in Figure 15. The parameters listed at the bottom of Figure 15 will be transferred to the composite upper-air analysis (Figure 17).

2.4.1 Vertical totals, cross totals, and a combination of the two (total totals) can be used to provide an approximate delineation of the most unstable areas. Reference Chapter 8 of AWSTR 200(Rev) for the definition of vertical totals, cross totals, and total totals. Figure 13 indicates only total totals.

2.4.1.1 Total totals are routinely analyzed on this chart. Areas with total totals equal to or greater than 44 are analyzed at intervals of 2 or 4.

2.4.1.2 At certain times of the year, vertical totals or cross totals are more important than total totals in some parts of the country.



Total Totals (Orange)

Figure 13. 850/500 mb Total Totals Analysis.

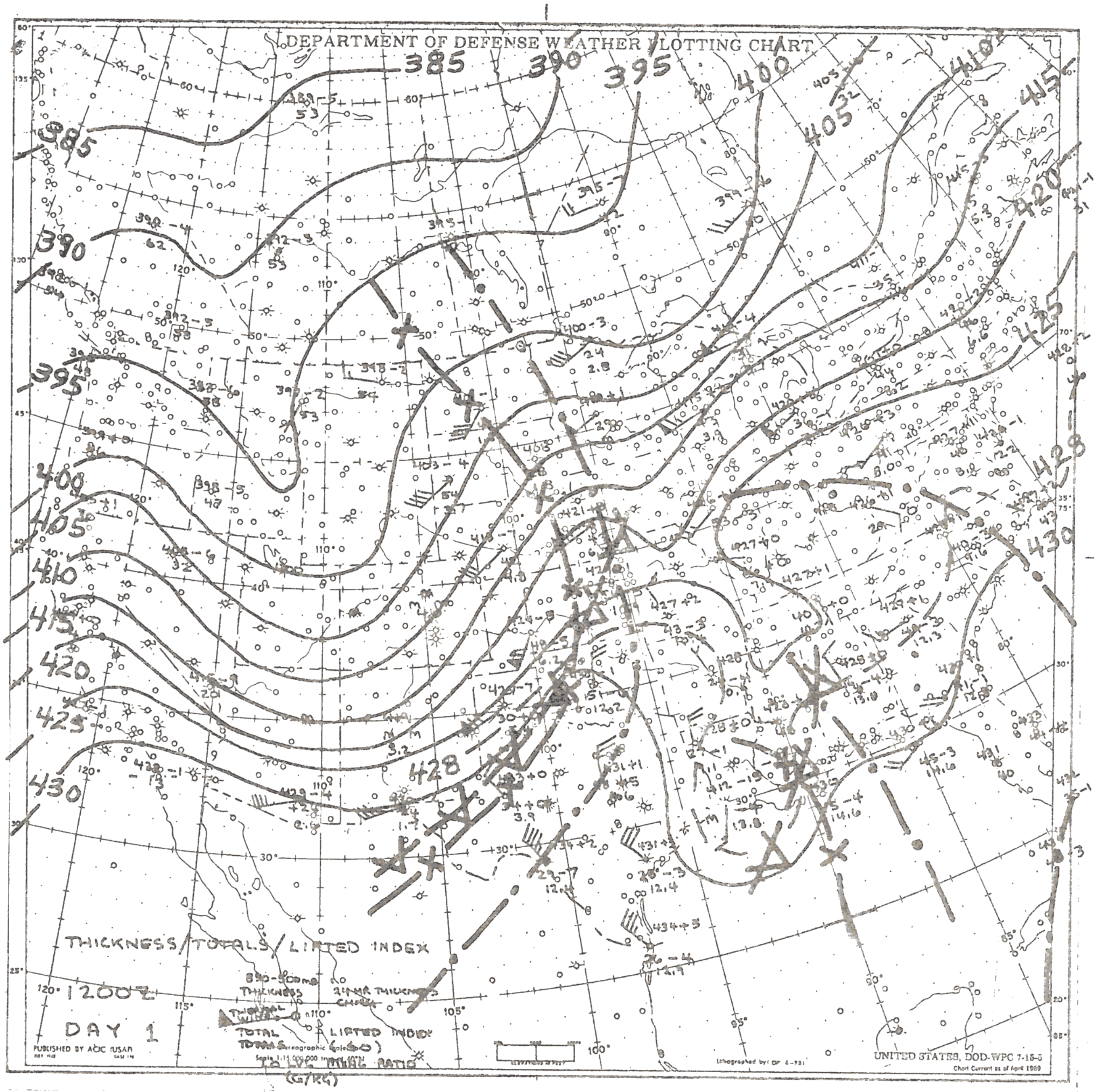
2.4.2 Isopleths of 850/1000 mb thickness are drawn at 20 - 50 meter intervals starting with an even value. Twenty meter intervals are used from late spring through early fall and 50 meter intervals from late fall through early spring. Variations of these values may be used to provide a finer analysis. The thickness ridges, no-change lines, and areas of maximum anticyclonic wind are the parameters that will be analyzed (reference Figure 14).

2.4.2.1 When analyzing the isolines of thickness, remember to look for the thickness ridge and not just draw isolines. Note that squall lines tend to develop 100 nm upstream from the thickness ridge.

2.4.2.2 The thickness no-change line is found using 12-hour changes from late fall through early spring and 24-hour changes from late spring through early fall.

The no-change line should reflect the location where significant thickness falls begin. If there is a broad band of 10 to 20 meter falls with an area of 40 to 60 meter falls behind it, then the no-change line should be at the leading edge of the larger falls. The no-change line delineates the leading edge of the significant cold-air advection.

2.4.2.3 The wind field used on this chart is the 850/500 mb thermal wind. The parameter of interest here is the axis of maximum anticyclonic curvature in the thermal wind streamlines or, as stated in AWSTR 200(Rev), the area of maximum anticyclonic wind shear.



Thickness Ridge (Black)

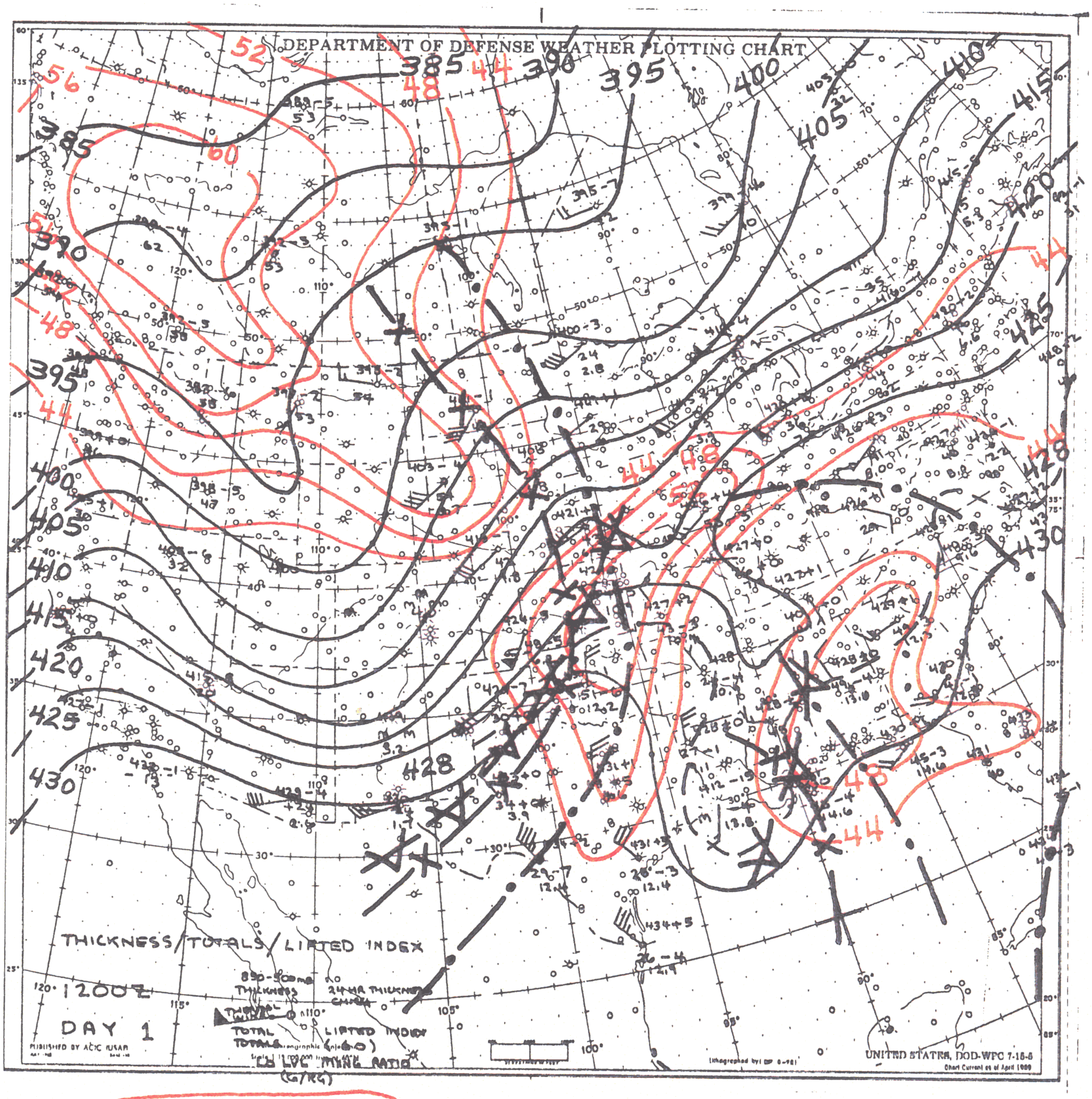
Thickness No-Change Line (Black)

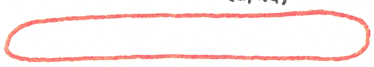
Zone of Maximum Anticyclonic Wind (Thermal Wind) Shear (Black)

Isolines of Thickness (Black)

Figure 14. 850/500 mb Height Analysis.

2.4.3 All the analyses discussed are accomplished on the same chart. The parameters and symbols listed in Figures 13 and 14 are displayed in Figure 15.





Total Totals (Orange)

Thickness Ridge (Black)

Thickness No-Change Line (Black)

Zone of Maximum Anticyclonic Wind (Thermal Wind) Shear (Black)

Figure 15. Completed 850/500 mb Thickness Analysis.

2.5 Severe Weather Parameter Work Chart. This chart is designed for quick reference to parameters that can be derived from a skew-T analysis. Below is a list of some of these key parameters and, where applicable, reference material describing derivation and use. Some of these parameters may be considered when developing a severe weather parameter worksheet. Figure 26 shows one possible combination of parameters.

2.5.1 The 12-hour temperature change values at 850 mb assist in locating areas of low-level warm advection.

2.5.2 The 12-hour temperature change values at 700 mb assist in locating areas of cold advection.

2.5.3 The 12-hour temperature change values at 500 mb assist in locating areas of cold advection.

2.5.4 The 12-hour height change values at 500 mb assist in determining the trough movement as well as delineating areas of strong cold advection.

2.5.5 Hail size...AWSTR 200(Rev), Chapter 9. Thunderstorms which produce hail .75 inches in diameter or larger are classified as severe.

2.5.6 Maximum surface gust...AWSTR 200(Rev), chapter 10. Thunderstorms which produce gusts of 50 knots or greater are classified as severe.

2.5.7 Average mixing ratio (g/kg) in the lower 100 mb above ground level...AWSM 105-124, Chapter 4. When using this mean mixing ratio as a forecast parameter, the following intensity guidance applies:

8 g/Kg or less is weak,

9 through 12 g/Kg is moderate, and

13 g/Kg or greater is strong.

2.5.8 Height of the wet bulb zero...AWSTR 200(Rev), Chapter 7. Wet-bulb zero height (above ground level) as a severe weather parameter will indicate the following intensities:

Below 5,000 feet and above 11,000 feet is weak,

5,000 to 7,000 feet and 9,000 to 11,000 feet is moderate, and

7,000 to 9,000 feet is strong.

2.5.9 Critical (convective) temperature...AWSM 105-124, Chapter 4. This is the temperature necessary to generate thermals that reach the convective condensation level (CCL). Clouds will begin to form at this level. When the critical temperature is less than the expected maximum surface temperature, convective cloudiness can be expected. The larger the diference between the expected maximum temperature and the critical temperature the more likely that severe thunderstorms will occur.

2.5.10 Cumulonimbus tops...AWSM 105-124, Chapter 4, Para 4.23; positive and negative areas (cumulonimbus top is the top of the positive area plus 1/3 of the thickness of the positive area).

2.5.11 Tropopause height...AWSM 105-124, Chapter 6. Compare radar reported tops to these heights. Thunderstorm tops which come within 5,000 feet of (or penetrate) the tropopause are considered potential severe weather producers.

2.5.12 Lifted index...AWSM 105-124, Chapter 5. When used as a severe weather forecast parameter, consider the following intensity indicators:

Minus 3 or greater is weak,

Minus 3 through minus 5 is moderate, and

Minus 6 or less is strong.

2.5.13 Vertical totals...AWSTR 200(Rev), Chapter 8.

2.5.14 Cross totals...AWSTR 200(Rev), Chapter 8.

2.5.15 Total totals...AWSTR 200(Rev), Chapter 8. When used as a severe weather forecast parameter, the following intensity indicators apply:

Values less than 50 are weak,

Values of 50 through 55 indicate moderate, and

Values greater than 55 are strong.

2.5.16 K Index...NWS Forecasters' Handbook No. 1, July 1976, pages 5-12.

2.6 Maximum Wind Analysis. This automated chart, (see Figure 16) produced by the AFGWC computer system, has plotted maximum winds from individual RAOBs with the height of the wind indicated. When the AFGWC product is not available, the NWS tropopause wind chart, 300 mb chart, or 200 mb chart may be used instead. The maximum wind chart is substituted whenever the 500 mb wind field is too weak to identify properly the maximum wind band (primarily in summer). When substituting a higher wind field for the one at 500 mb, remember that the 500 mb maximum wind band is a reflection of the true jet stream at higher levels. Mental adjustments must be made for vertical stacking. Significant features will be transferred to the composite chart as shown in Figure 17 when the 500 mb wind field is too weak to show a pronounced maximum wind band.

2.6.1 Isotachs (isolines of wind speed) are drawn at an appropriate interval considering the overall wind field. Isotachs are drawn to locate the axis of maximum wind and to isolate the maximum wind cores.

2.6.2 Significant streamlines, other than the maximum wind axis, are drawn to assist in identifying difluent zones.

2.6.3 Difluent zones are indicated where the flow of the axis of maximum wind branches significantly.

2.6.4 Horizontal speed shear zones are indicated when there is a significant decrease in speed per distance from the axis, or from the edge of the maximum wind band. The symbol is like the one used on the 500 mb chart but the color code is purple.

2.6.5 Maximum wind analysis key parameters and their intensities:

2.6.5.1 Upper-level jet,

Wind speeds less than 55 knots indicate weak activity,

values 55 through 85 knots indicate moderate, and

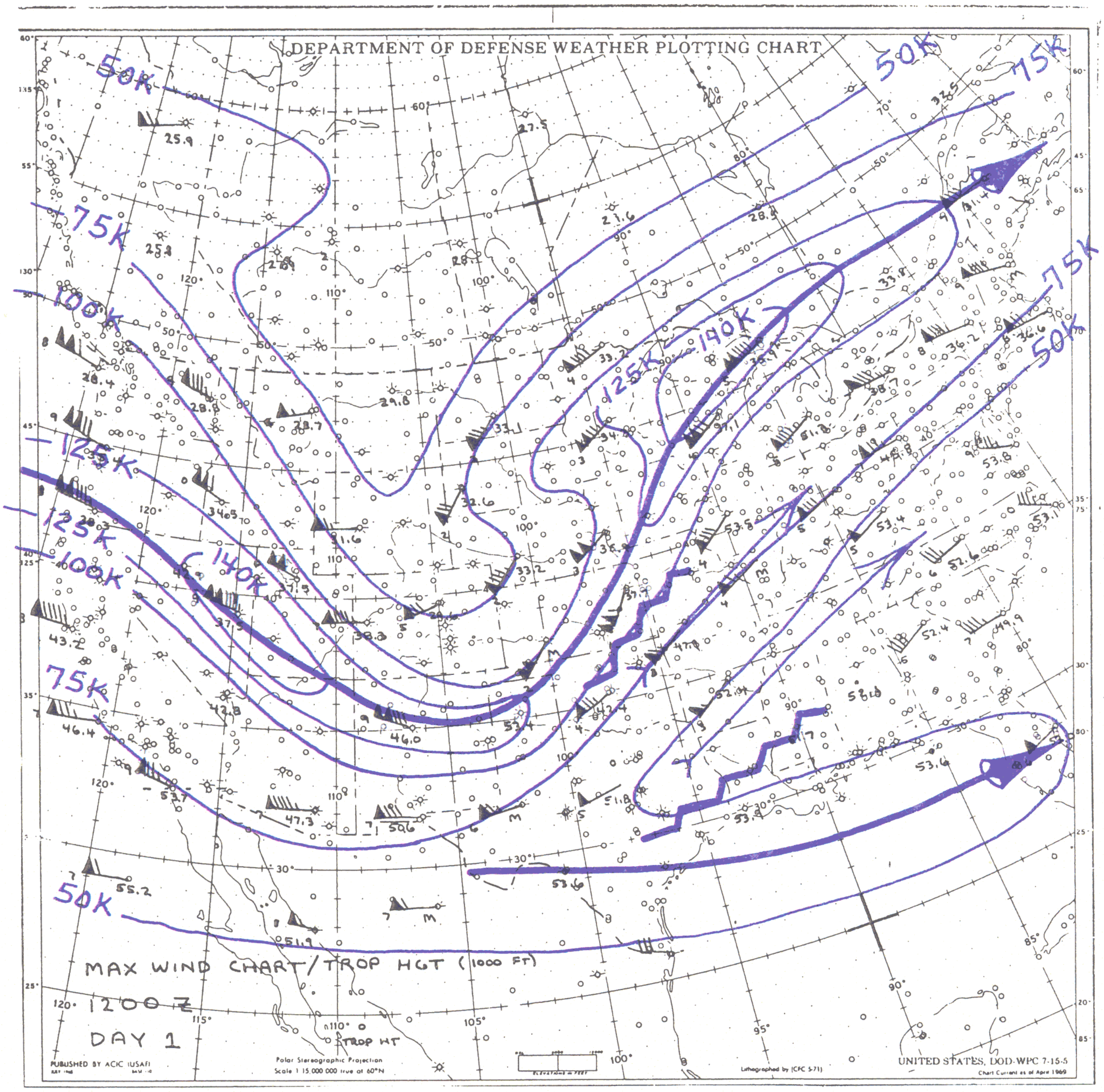
values greater than 85 knots indicate strong activity.

2.6.5.2 Upper-level shear (over a 90 nm horizontal distance)

Values less than 15 knots are weak,

values between 15 and 29 knots are moderate, and

sear values greater than 30 knots are strong.



Isotachs (Purple)

Streamlines (Purple) Identification (On Composite)

Difluence (Purple) (On Composite)

Maximum Wind Core (Purple) (On Composite)

Maximum Wind Band (Jet) (Purple) (On Composite)

Figure 16. Maximum Wind Analysis.

2.7 Upper-air composite. All the significant parameters discussed and indicated in Figures 4, 8, 12 and 15 are placed on the same chart (reference Figure 17). The primary purpose of this composite chart is for comparison of the predominant patterns with known severe weather patterns. Surface fronts, squall lines, and lows from the continuity chart for the upper-air data-base time (00/12Z ± 3 hours) should also be indicated on this composite chart for use in short-range forecasting by extrapolation.

2.8 12-hour pressure change analysis (surface). On the surface 12-hour pressure change chart, pressure falls are used more extensively than the pressure rises.

2.8.1 Both pressure rises and falls should be analyzed. The axis connecting the maximum rise center to the maximum fall center will assist in making a short-range extrapolation prognosis of the movement of a significant low pressure center.

2.8.2 In most productive severe weather situations, a concentrated area of pressure falls appears to be more significant than a widespread area. A pressure fall area indicates many changes in the parameters discussed, especially those at lower levels (850 mb).

2.8.2.1 Movement and shape of an area of falls provide clues to probable areas of maximum low-level convergence and changes in the low-level wind field. If the pressure falls extend, in an elongated shape, south of the warm front and east of the cold front a low-level jet is most likely transfering warm, moist air northward in this region.

2.8.2.2 Location of falls will indicate the direction a surface low is moving.

2.8.2.3 Used in conjunction with other clues, the falls also may indicate temperature and moisture advection.

2.8.3 Use the following values of 12-hour surface pressure falls as intensity indicators:

Less than 1 mb is weak,

values from 1 to 5 mb indicate moderate activity, and

values greater than 5 mb indicate strong activity.

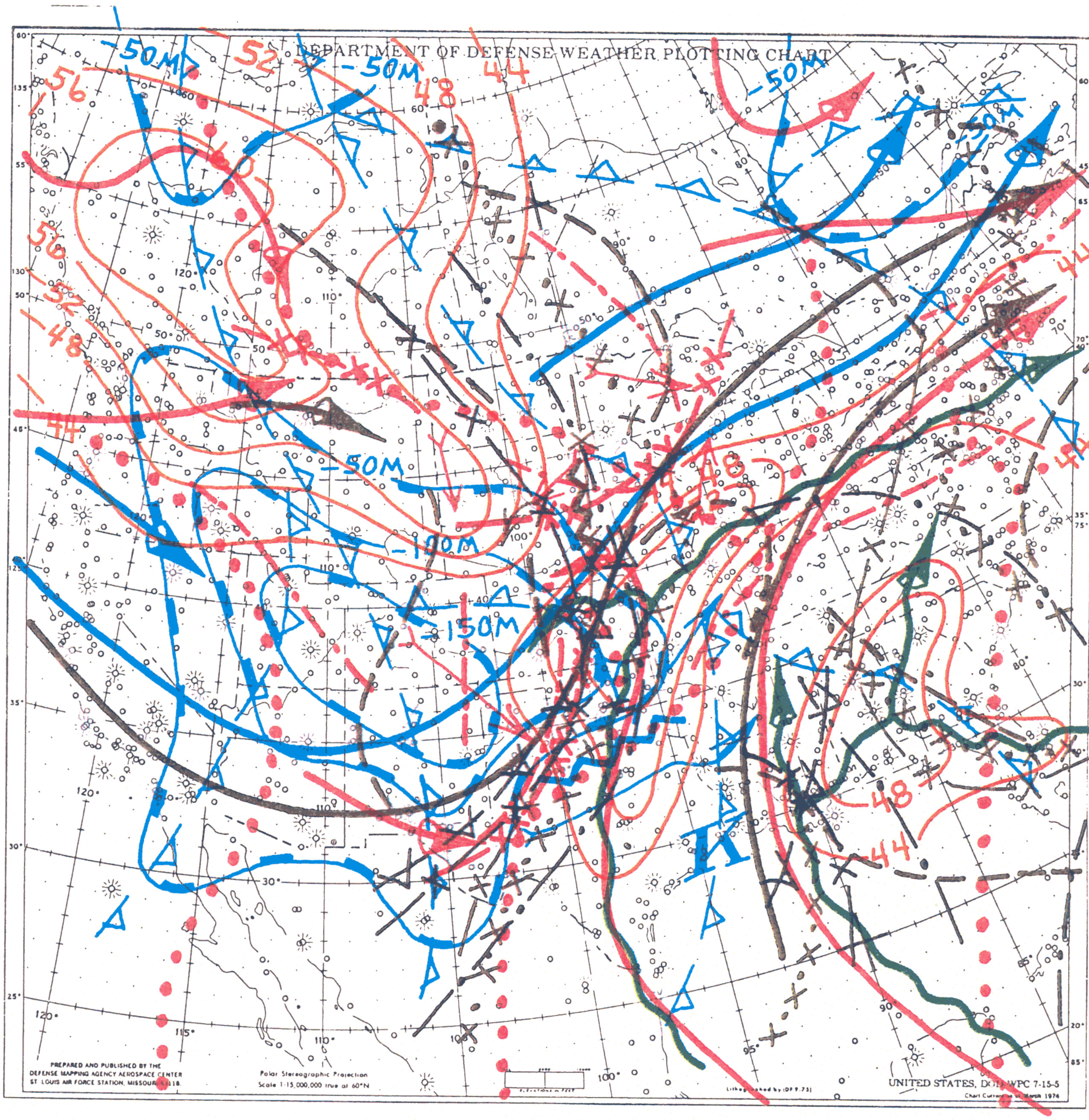


Figure 17. Upper-air Composite Analysis.

2.9 Surface Analysis. This chart, probably the most significant tool routinely available, is received more frequently and has the densest reporting station network of any available. The color-coded symbols shown in Figures 18 through 21 are used in the completed analysis shown in Figure 22. (Optional symbols and their color codes may be transferred to the composite analysis).

In this memo, fronts will not be defined rigidly. Emphasis instead will be on discontinuity lines. The following is a list of discontinuities of interest to the severe weather forecaster.

Temperature	Surge lines
Dry lines	Convergence zones
Dewpoint	Squall lines
Pressure change	Fronts
Pressure troughs	

The analysis techniques outlined in the following subsections will assist in locating these discontinuities.

2.9.1 Step one (reference Figure 18). Analyze the surface pressure field. Isobars are drawn every 2 millibars, starting with an even value. When analyzing pressure, do not just draw isolines, but look for pressure troughs, highs, and lows. The fronts and some other discontinuity lines should be drawn coincident with the pressure troughs. The pressure trough is a discontinuity and is the first indicator that some other discontinuity may be near. There are many types of discontinuities that are of interest to the severe weather forecaster. The strength of a discontinuity depends on the isopleth gradient ahead of or behind the line of most evident change. Some discontinuity lines can not be found on the surface chart displayed in Figure 18; on any particular day some are present and some are not.

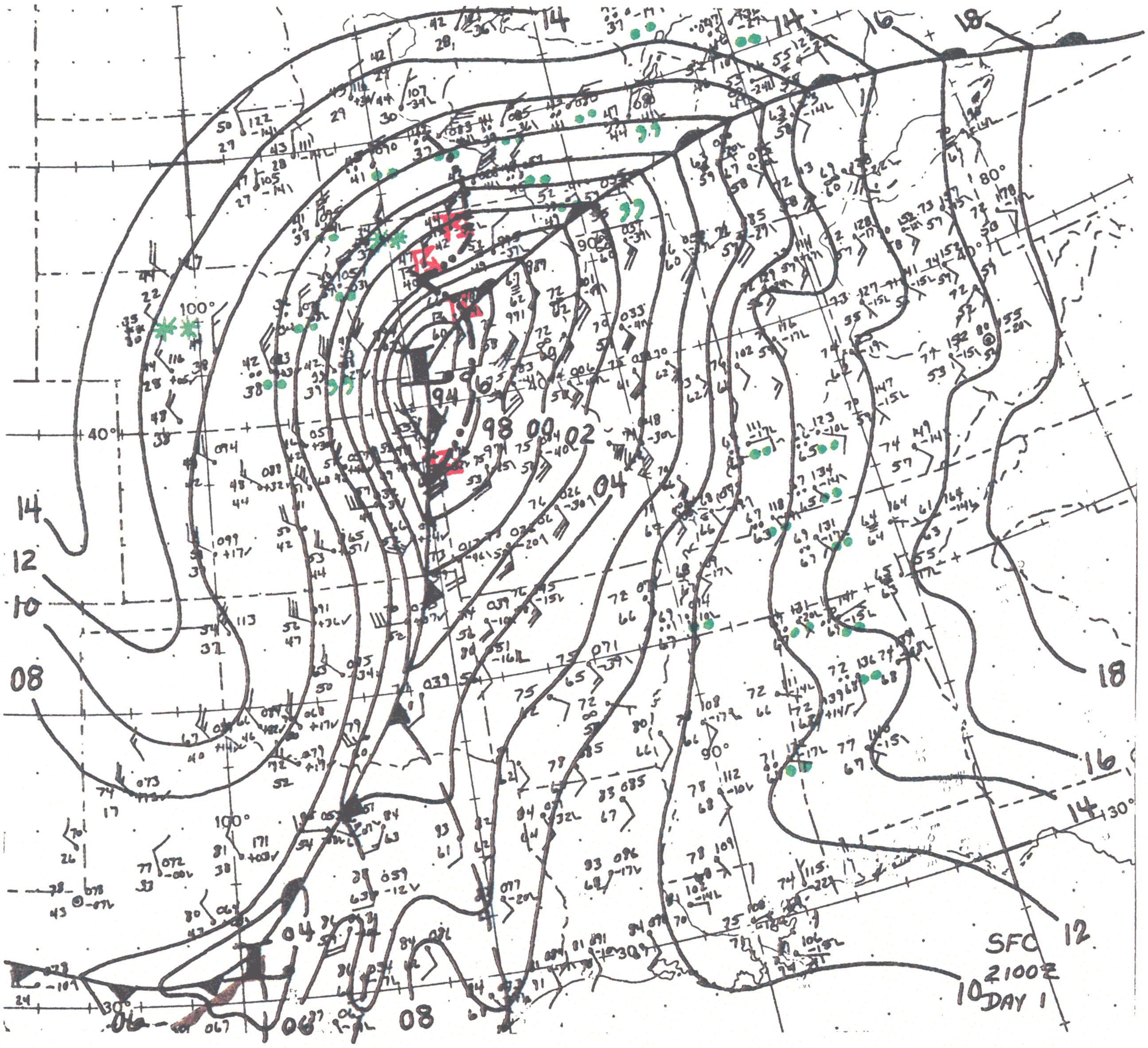
2.9.1.1 Temperature - A rapid change from cold to warm or warm to cold.

2.9.1.2 Dry line - A rapid change from moist to dry air or dry to moist air.

2.9.1.3 Dewpoint - Significant change from moist (dewpoint of 55° F or greater) to more moist or the reverse.

2.9.1.4 Three-hour pressure rises and falls - The pressure no-change line defines this discontinuity.

2.9.1.5 Pressure trough - Evaluate the pressure values along a line drawn normal to the axis of the pressure trough. The pressure decreases upon approaching the axis and then increases upon leaving it. The pressure trough axis defines the discontinuity.



Isobars (Black)

Dry Line (Brown)

Cold Front (Black)

Squall Line (Black)

Warm Front (Black)

Low and High Pressure Centers (Black)

Pressure Trough (Black)

Figure 18. Isobaric Surface Analysis.

2.9.1.6 Surge line (wind) - The surge line indicates wind speed convergence, that is, an area of strong winds moving into an area of weaker winds. The leading edge of the stronger wind area is considered the discontinuity line. Such a discontinuity is commonly found along the lee slopes of mountain ranges and often accompanies an upper-air trough and cold advection aloft.

2.9.1.7 Convergence zone (vectorial) - The merging of winds with different directions is a convergence zone. An example is wind flow from the WSW-WNW merging with winds from the SSE-SSW. The angle at which they meet and the speed determines the strength of the convergence.

2.9.1.8 Squall line - A squall line is a first-order pressure discontinuity with thunderstorms along it. The squall line is a combination of two or more of the discontinuity lines already discussed. Strength of the squall line is determined by the number of coincident discontinuity lines. For a detailed description of squall line development, see Chapter 4 of AWSTR 200(Rev).

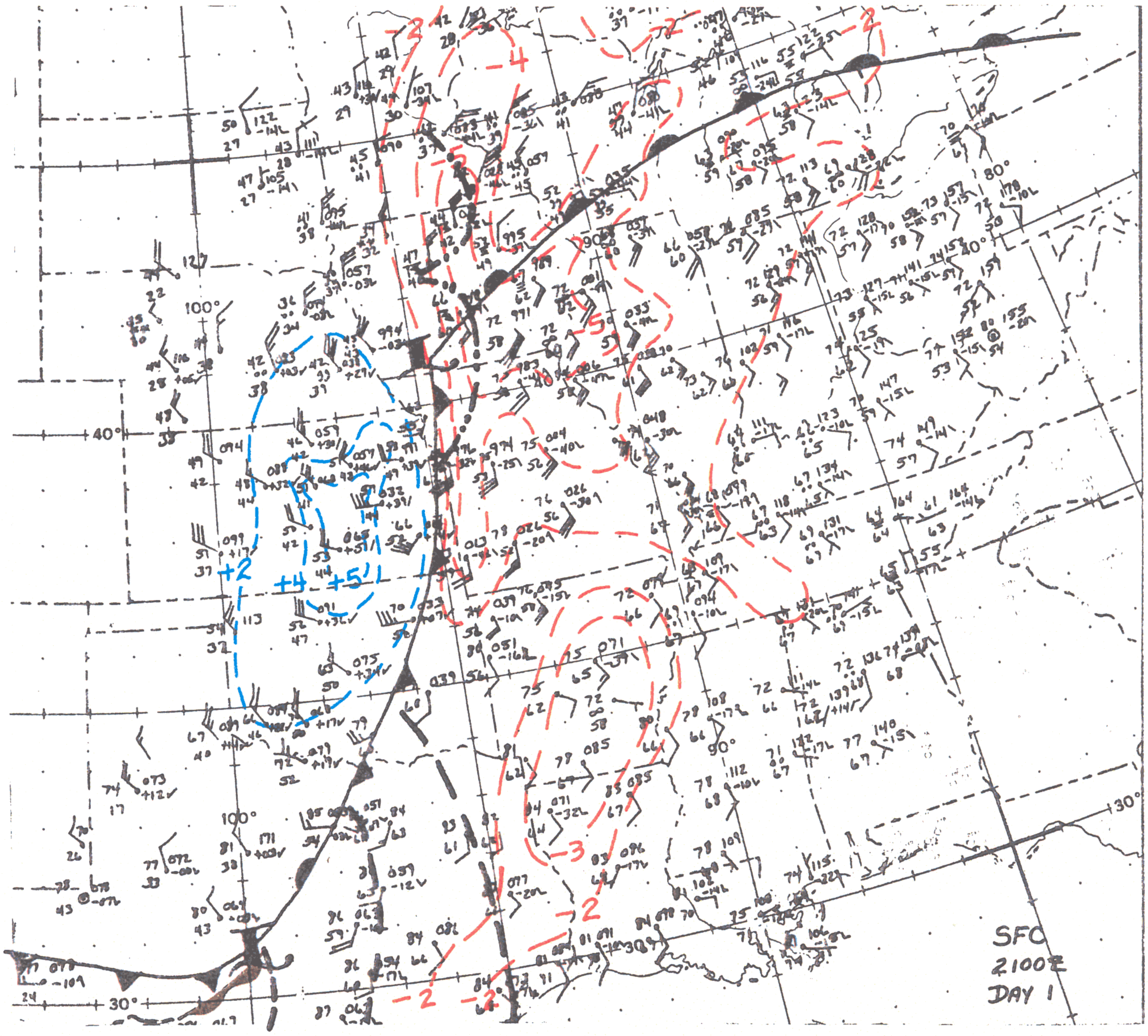
2.9.1.9 Front - This is also a special case of a discontinuity line. A front is a combination of two or more discontinuities (in order of importance): temperature, dewpoint, pressure trough, convergence zone, dry line, surge line, pressure change, squall line. An old squall line (that is, one in which the thunderstorms have dissipated) is often confused with a front.

2.9.2 Step 2. The standard weather symbols (in their designated colors) should be plotted where the weather is occurring. The weather will assist in properly locating some of the discontinuity lines.

2.9.3 Step 3 (reference Figure 19). The 3-hour rises and falls should be analyzed for significant values. The symbols and color codes are shown in Figure 19.

2.9.2.1 A combination of falls and rises will assist in determining the direction of movement of lows, highs, and discontinuity lines.

2.9.2.2 Falls will assist in locating areas of moist and/or warm advection.

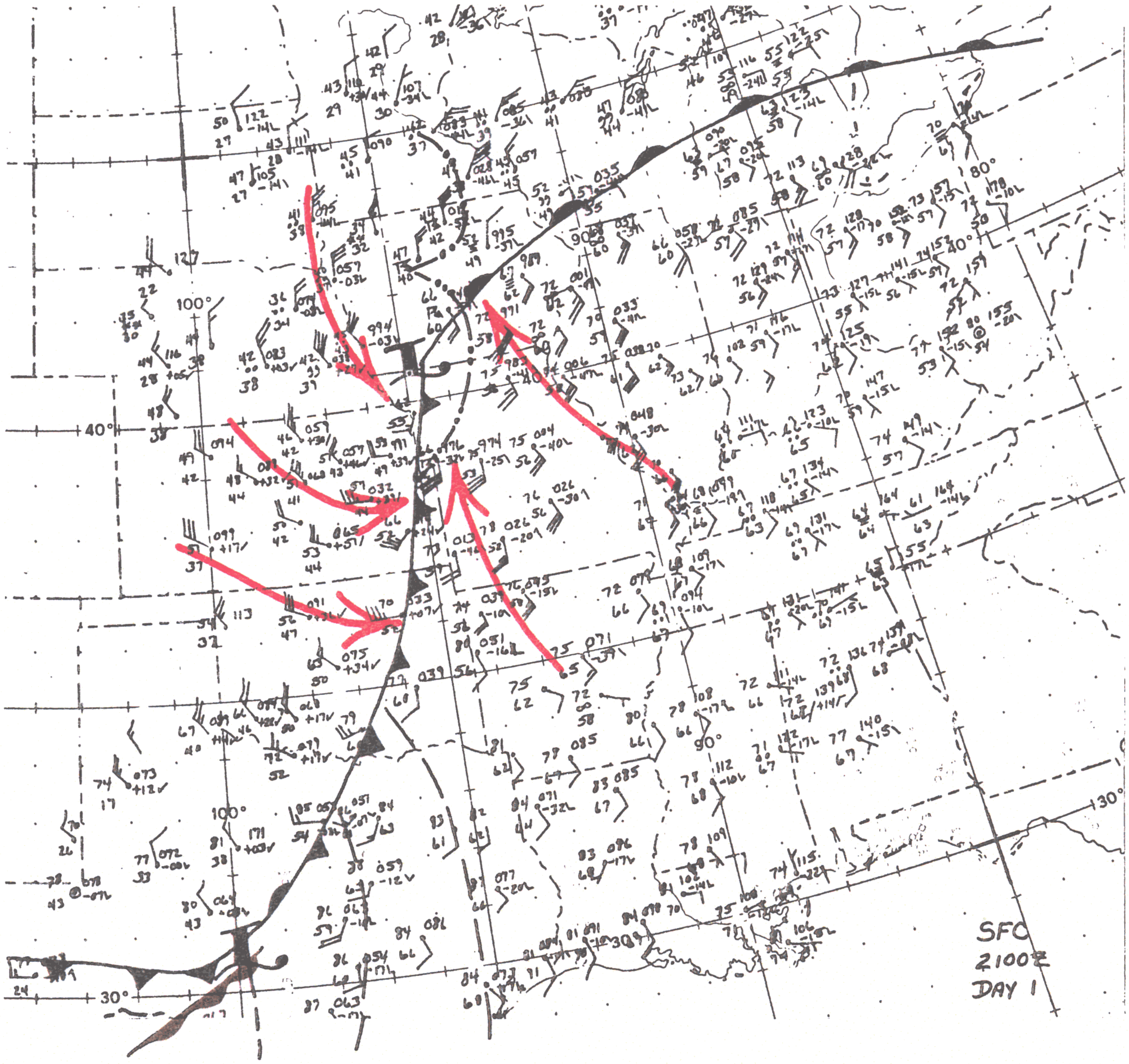


Significant 3-hour Pressure Falls (Orange)

Significant 3-hour Pressure Rises (Blue)

Figure 19. Isallobaric Surface Analysis.

2.9.4 Step 4 (reference Figure 20). Significant streamlines should be drawn to highlight the maximum convergence area and, in many cases, assist in locating the maximum wind band at lower levels. The symbols and color code are indicated in Figure 20.



Significant Streamlines (Red)

Figure 20. Surface Streamline Analysis.

2.9.5 Step 5 (reference Figure 21). The thermal and moisture analyses will help track the low-level thermal ridge, the axis of maximum moisture advection, and the axis of maximum moisture. Symbols and their color codes are shown in Figure 21.

2.9.4.1 Locating the thermal ridge is accomplished by picking an isotherm that will accurately depict the warmest air. When drawing these isotherms, remember to analyze for the thermal ridge.

2.9.4.1 In locating the axis of maximum moisture advection, start with the 55° F isodrosotherm (isopleth of dewpoint) and draw isodrosotherms at an interval that will adequately define the moist air. When analyzing the isodrosotherms, remember to look for the axis of maximum moisture advection.

2.9.6 All the different analyses accomplished in Figures 18 through 21 are done on the same chart. Figure 22 shows what the complete surface should look like.

2.9.7 Summarizing key parameter values and their intensities:

2.9.7.1 Dewpoint,

Values of 55° F or less indicate weak activity,

values between 56 and 64° F indicate moderate, and

values greater than 64° F indicate strong activity.

2.9.7.2 Lowest pressure in potential threat area,

Greater than 1010 mb indicates weak activity,

pressure between 1010 and 1005 mb indicates moderate, and

pressure less than 1005 mb indicates strong activity.

2.10 Summary. There are other charts which can assist in severe weather forecasting, but the ones described in this section will give a good foundation from which to work. The upper-air charts are available every 12 hours and should be analyzed as soon as possible. The surface chart, available every hour, should be analyzed at least once every three hours. When severe weather is occurring or expected to occur in the near future, surface charts should be analyzed every hour. When analysis proficiency is attained, interactions of primary parameters can be associated with the severe weather synoptic patterns.