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AN OPERATIONAL GUIDE TO THE WIND PROFILER NETWORK

Jeff S. Waldstreicher
Scientific Services Division
Eastern Region Headquarters
Bohemia, NY

1. INTRODUCTION

This document is intended to give the operational forecaster a overview of the demonstration wind profiler network. I will discuss what these profilers are and are not designed to do, explore some potential uses of the data, and describe the limitations. A series of four videotapes and manuals have been sent to all Eastern Region WSFO's and RFC's. These tapes and manuals provide an excellent source for training and reference. This paper will deal primarily with the profiler data which will soon be available to the field via AFOS, and the applications software written to process and display these data.

2. THE PROFILER NETWORK

Figure 1 shows the demonstration profiler network. All of the profilers will be owned by NOAA except the profilers in Maynard, MA and White Sands, NM, which are owned by the Department of Defense. While only one of the profilers (Maynard, MA) is located within the Eastern Region, the network does extend far enough east to be of use to some Eastern Region Offices.

For the NOAA profilers, 6-minute wind data will be sent from via GOES to the Profiler Control Center (HUB) in Boulder, CO. This information will be used to generate hourly average wind profiles for each site by using the consensus averaging method discussed in the *Principles of Wind Profiler Operation* (van de Kamp, 1988) and *Quality Control of Wind Profiler Data* (Brewster, 1989) videotapes and manuals. For the DOD profilers, hourly averaged data will be computed at the profiler site before being transmitted to the HUB. While these hourly averages will be computed slightly differently than those at the HUB, the differences are subtle and, most likely, operationally insignificant.

From the HUB, data will be transmitted to AFOS through the NWSTC gateway hourly under the AFOS pil NMCWPDERL. While all data will be available on all AFOS loops, file size limitations will require up to three separate transmissions per hour once most of the profilers come on-line. (For more information, consult AFOS Change Notice 518.) Since these files are not displayable on AFOS, it will not be possible to determine which profilers have been transmitted within a given version of NMCWPDERL. This presents a minor problem as to when to run the AFOS profiler decoder at the local office, especially for those sites that use a background scheduler (i.e., AEX or WATCHDOG). Until more is known, time scheduling the decoder to run toward the end of each hour may be the best procedure.

3. THE PROFILER DATA

A. Data Resolution

The Unisys doppler radar wind profilers that comprise the demonstration network operate at a frequency of 404 MHz. They operate in two modes; a low mode that extends from 500 m AGL to 9.25 km AGL, and a high mode that ranges between 7.5 km AGL and 16.25 km AGL. Due to hardware limitations, all wind profilers are not able to measure winds within a certain distance above the surface. For the 404 MHz profilers, this distance is approximately 500 m AGL. There may also be instances when the lowest one or two winds are contaminated by these hardware limitations.

In the low mode, winds are calculated every 250 m, and all of this information will be transmitted over AFOS. In the high mode, the data will be transmitted with a resolution of 1000 m. In the overlap region of the low and high modes (7.5 km to 9.25 km), only the low mode data will be transmitted.

B. Data Quality

The overall quality of data from the wind profilers is expected to be very good. The data will pass through rigorous quality control routines at the HUB; this is explained in detail in the QC manual. There are some factors the operational forecaster should keep in mind, however, when using profiler data.

First, no quality control system will ever be perfect. There will inevitably be bad data that make it through the QC checks, as well as good data which is flagged by the QC. It is also possible that after some questionable data pass the QC routines, the next set of good data might be flagged as bad. The profiler HUB will be transmitting all of the data which passes the consensus averaging routine. Data that fails this check will be transmitted as missing. Data that did not pass the other QC routines, however, will only be flagged. The AFOS applications program, which is menu driven, will allow the forecaster to determine if he wants to display the flagged data. (The AFOS program is discussed in Section 4.)

Second, it is important to remember that the radar measures winds using three beams; one pointing directly vertical, and the other two pointing 15° north and east, respectively, off vertical. Figure 2 shows this beam orientation. Note how the beam separation increases with height, reaching 2.5 km to 3.8 km at a height of 10 km. This beam orientation causes the profiler to "assume" uniform conditions exist throughout its scan. While this assumption is valid most of the time, convection can wreak havoc with the profiler. This is a problem for two reasons. First, since convection is often on a very small scale, it is very possible that only one or two of the radar beams will intersect the thunderstorm. This can result in conflicting and erratic radial velocity measurements. Other small scale features could cause similar problems such as each radar beam intersecting a different segment of a mountain wave or rotor cloud.

Additionally, when the radar beam intersects falling precipitation, the return from the falling raindrops overwhelms and signal return from any other atmospheric hydrometeor. The radar therefore measures the fall speed of the precipitation as the vertical velocity, rather than any true rising or sinking air. To calculate a horizontal wind, the vertical component of the measured radial velocity must be removed trigonometrically. If the vertical velocity measured from the vertical beam is representative of the vertical component of the radial velocity measured in the other two beams, then a valid horizontal wind can be calculated. In stratiform precipitation, the fall speeds are, for the most part, uniform over the area viewed by the radar. In convective precipitation, however, fall speeds are not uniform. In this case, each radar beam will measure a different vertical component of the radial velocity. This will cause the resulting calculated horizontal winds to be erratic or erroneous. This usually results in a number of winds failing the consensus averaging routine (and thus being reported as missing), and/or numerous winds being flagged by the QC routines. An example of a wind profile being affected by both convective and stratiform precipitation is shown in Figure 3.

A third factor to keep in mind is that the profiler requires a minimum threshold of atmospheric turbulence to measure radial velocities. In the absence of such turbulence, wind observations will often "drop-out" by failing the consensus averaging test, or will appear erratic in directionence, wind obs light speeds. This is most common during the warm season under stagnant airmasses.

Lastly, the videotapes and manuals discuss the problem of aircraft flying through the radar beams. This should not be a significant problem for two reasons. First, one of the siting criteria (at least for the NOAA profilers) was to place the profilers away from airports and heavily flown air corridors. Second and most important, should an aircraft fly through a radar beam, it would only contaminate one 6-minute wind observation. There would still be nine other presumably good observations to generate an hourly average, with the consensus averaging technique weeding out the one contaminated observation.

4. AFOS PROFILER APPLICATIONS PROGRAM

The profiler applications software package is being written by Gary Battel of General Sciences Corporation (GSC) under contract to the Techniques Development Laboratory (TDL). The program will consist of a decoder and three product generating routines, each of which is menu driven. The three routines are time-section plots, cross-sections, and plan views. The decoder and time-section segments are completed and will probably be distributed in February. The remainder of the program should be completed during 1990 and will be distributed as each segment becomes available. The program should be complete by Spring 1991, which is when the profiler network installation should also be fully implemented.

A. Time-Section Plots

Figure 4 shows the menu for the time-section segment of the program. The software allows you to store several completed versions of the menu, which can each be run using a single macro command. The first nine products listed can be run for up to ten stations at a time. The last three kinematically derived products calculate the values over a triangular area bounded by three selected profilers. Up to four triangles can be selected at one time. The contoured products (horizontal wind speed, wind speed and direction shears, u/v/w wind components, returned power, and the kinematic products can be overlaid on the plotted products (horizontal wind, thermal wind and perturbation wind). Figure 5 shows a horizontal wind plot for the Flagler, CO, site with the horizontal speed contours overlaid.

The menu allows you to specify at what height you wish to start plotting data and for what time period. All of the defaults are listed on the menu. The maximum time interval the program will allow is 16 hours.

Figures 6 and 7 show examples of the thermal wind and perturbation wind graphics respectively. Notice in Figure 6, the graphic indicates (with a "w" or a "c") whether warm or cold advection is occurring in the layer. The perturbation wind is defined as the hourly wind's vector departure from the average wind calculated over the specified time. The average wind is displayed on the extreme right. Figure 8 shows the derived vorticity within the triangle bounded by the Stapleton, Platteville, and Flagler profilers. Note, that you are looking at vorticity in both time and height (not horizontal space--at least not explicitly) on the same graphic. This will take some getting used to.

B. Cross-Sections and Plan Views

Figures 9a and 9b show preliminary versions of the cross-section and plan view menus. Since this software is not completed yet, it is not possible to show examples of what the output will look like. Figure 10, however, is an example of what the plan views (in this case, 500 mb derived divergence) will probably look like. You can see from the menus that there are a lot more useful and interesting products in the works for the profiler data.

C. AFOS Resources

A potential problem with the AFOS profiler applications package is that it can require a significant amount of AFOS resources, both time and disk/database storage space. Individual segments of the program do not take excessively long to execute separately (the decoder takes about 3-5 seconds per profiler). The execution time can add up quickly, however, especially if a large number of kinematic and contoured graphics are chosen. One option may be to make arrangements with your WSO's to run different graphics and transmit them to each other using the Western Region XMIT program. TDL is currently examining the possibility of utilizing a switch which would allow sites to automatically transmit the graphics on the SDC.

5. POTENTIAL APPLICATIONS OF PROFILER DATA

The profiler network should enable us to view the atmosphere in greater spatial and temporal detail than ever before. The potential of this new information is tremendous. While much research on the use of profiler data has already been done, primarily by the Environmental Research Laboratory (ERL) and Pennsylvania State University, the studies have utilized only a minimum of profilers over a limited geographical area. Here is a short list of potential applications of this data:

- o Augmentation of the Sounding Network
    - Enhanced spatial resolution
    - Hourly data instead of once every 12 hours

- Modifying Soundings and Severe Weather Indices
    - SWEAT Index
    - Bulk Richardson Number - Shear Term
    - Hourly Hodographs
- Evolution of Low Level Jets
- Detection of Ascending and Descending Jets
- Jet Streaks and Jet Structure
- Omega Equation and Other Vertical Motion Diagnostics
    - PIVA (Positive Isothermal Vorticity Advection)
        - Vertical Structure of Vorticity Advection
        - Thermal Advection from Thermal Winds
- Characteristic Signatures for Synoptic/Mesoscale Features
    - Troughs/Fronts
    - Ridges
    - Cutoff Lows
- Diagnosis of Air Masses
    - Depth of Air Masses
        - Cold Air Damming/Overrunning Warm Air
        - Sea/Lake Breeze Fronts
    - Frontal Passages/Airmass Boundaries
- Spatial and Temporal Diagnosis of Thermal Advection
- Mesoscale Features Above the Surface
- Model Diagnostics and Validation

This list is just the tip of the iceberg. The profilers will open a whole new world of meteorological information, especially when augmented by other atmospheric sensor data such as NEXRAD, GOES I-M, Acoustic and Radiometric Soundings, etc. The Eastern Region SSD is looking forward to working with field offices in evaluating and determining new applications for these exciting new tools.

6. REFERENCES

Augustine, J. A. and E. J. Zipser, 1987: The Use of Wind Profilers in a Mesoscale Experiment. *Bull. Amer. Meteor. Soc.*, **68**, p4-17.

Battel, G., 1989: Wind Profiler Applications Software Development Plan. TDL Office Note 89-3, 16pp.

Brewster, K, A., 1989: *Profiler Training Manual #2: Quality Control of Wind Profiler Data*, NOAA/ERL/FSL, 39pp.

van de Kamp, D. W., 1988: *Profiler Training Manual #1: Principles of Wind Profiler Operation*, NOAA/ERL, 49pp.

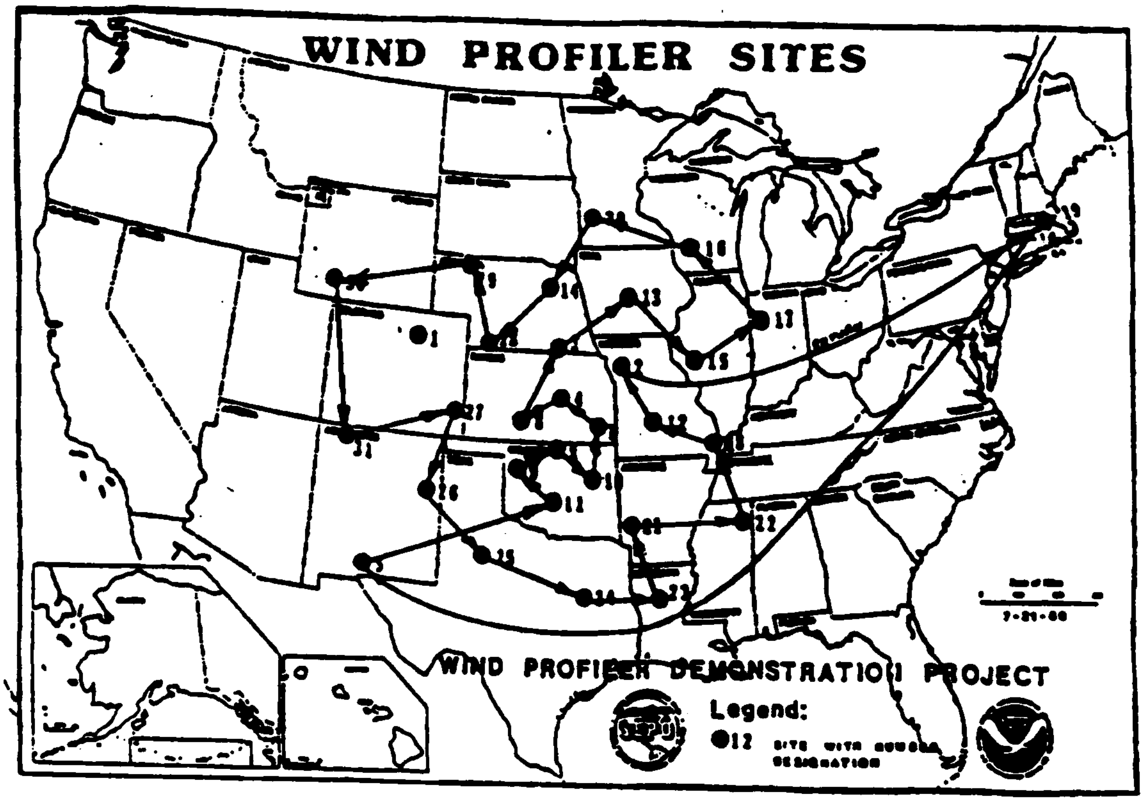


FIGURE 1: The Demonstration Wind Profiler Network

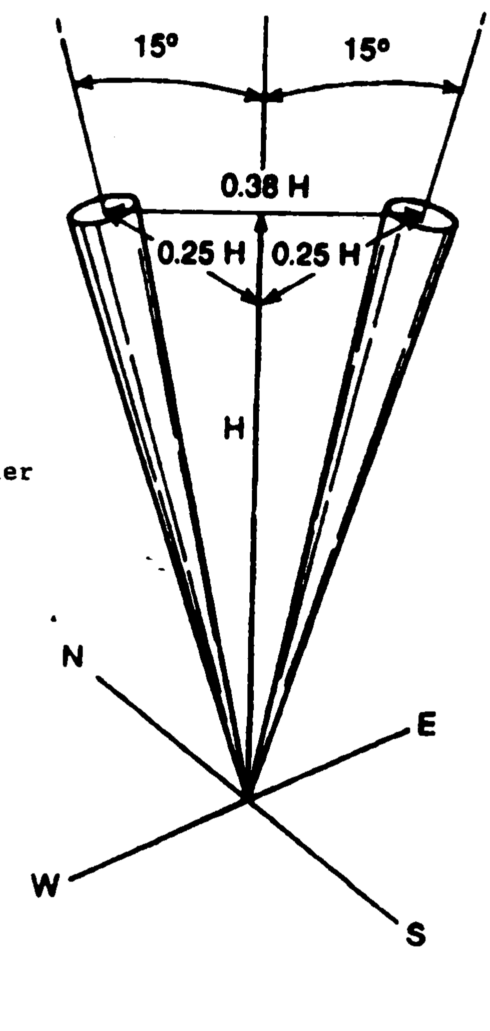


FIGURE 2: Diagram of Profiler Beam Separation

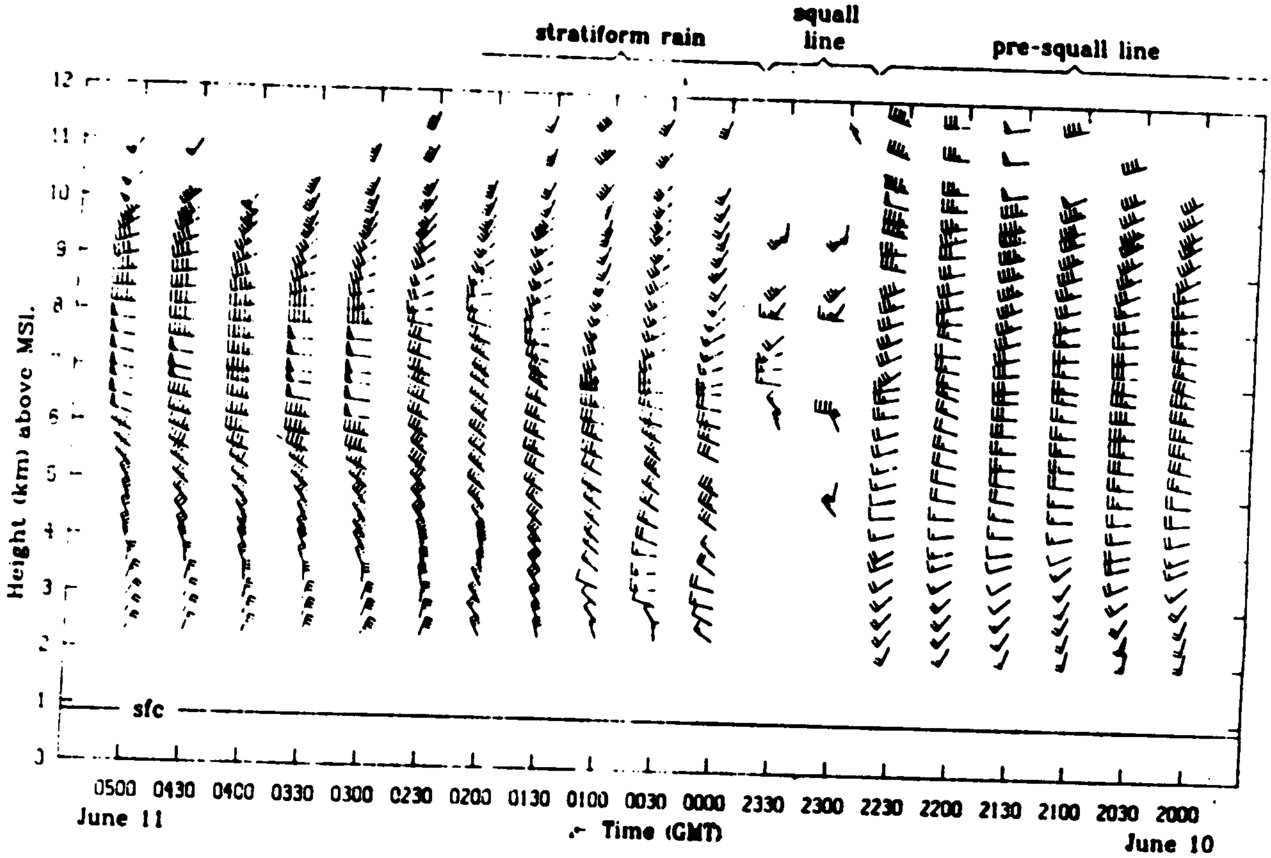
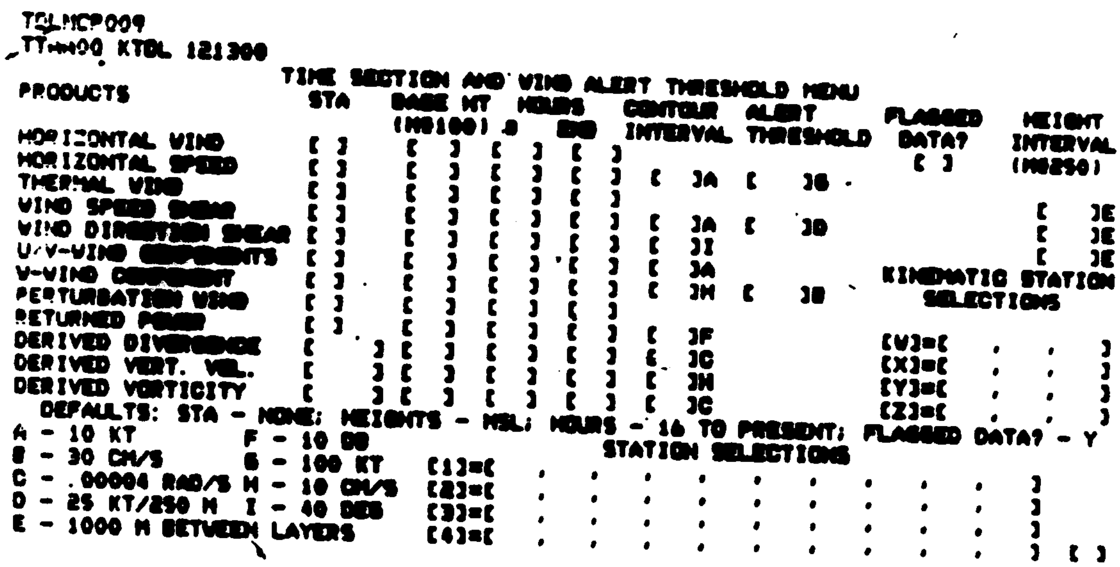


FIGURE 3: Precipitation Affected Wind Profile from the Oaklahoma Panhandle During the PRE-STORM Experiment in 1985. (From Augustine and Zipser, 1987)



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TSLMCP009
TTAA00 KTOL 121300
                    TIME SECTION AND WIND ALERT THRESHOLD MENU
PRODUCTS                 STA   BASE HT   HOURS    CONTOUR   ALERT      FLAGGED  HEIGHT
                               (MSL00) B   END    INTERVAL  THRESHOLD  DATA?    INTERVAL
HORIZONTAL WIND          [ ]   [   ] [   ] [   ]                       [ ]      (M0250)
HORIZONTAL SPEED         [ ]   [   ] [   ] [   ] [  ]A    [   ]G
THERMAL WIND             [ ]   [   ] [   ] [   ]
WIND SPEED SHEAR         [ ]   [   ] [   ] [   ]                                [   ]E
WIND DIRECTION SHEAR     [ ]   [   ] [   ] [   ] [  ]A    [   ]D                [   ]E
U/V-WIND COMPONENTS      [ ]   [   ] [   ] [   ] [  ]I                          [   ]E
V-WIND COMPONENT         [ ]   [   ] [   ] [   ] [  ]A                KINEMATIC STATION
PERTURBATION WIND        [ ]   [   ] [   ] [   ] [  ]H    [   ]B        SELECTIONS
RETURNED POWER           [ ]   [   ] [   ] [   ]
DERIVED DIVERGENCE       [   ] [   ] [   ] [   ] [  ]F              [W]=[   .   .   ]
DERIVED VERT. VEL.       [   ] [   ] [   ] [   ] [  ]C              [X]=[   .   .   ]
DERIVED VORTICITY        [   ] [   ] [   ] [   ] [  ]H              [Y]=[   .   .   ]
                                                 [  ]C              [Z]=[   .   .   ]
   DEFAULTS: STA - NONE; HEIGHTS - MSL; HOURS - 16 TO PRESENT; FLAGGED DATA? - Y
A - 10 KT            F - 10 DB                 STATION SELECTIONS
B - 30 CM/S          G - 100 KT     [1]=[  .  .  .  .  .  .  .  .  .  .  ]
C - .00004 RAD/S H - 10 CM/S        [2]=[  .  .  .  .  .  .  .  .  .  .  ]
D - 25 KT/250 M   I - 40 DEG        [3]=[  .  .  .  .  .  .  .  .  .  .  ]
E - 1000 M BETWEEN LAYERS           [4]=[  .  .  .  .  .  .  .  .  .  .  ]  [ ]
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FIGURE 4: Menu for the Time-Section Segment of the AFOS Wind Profiler Program.

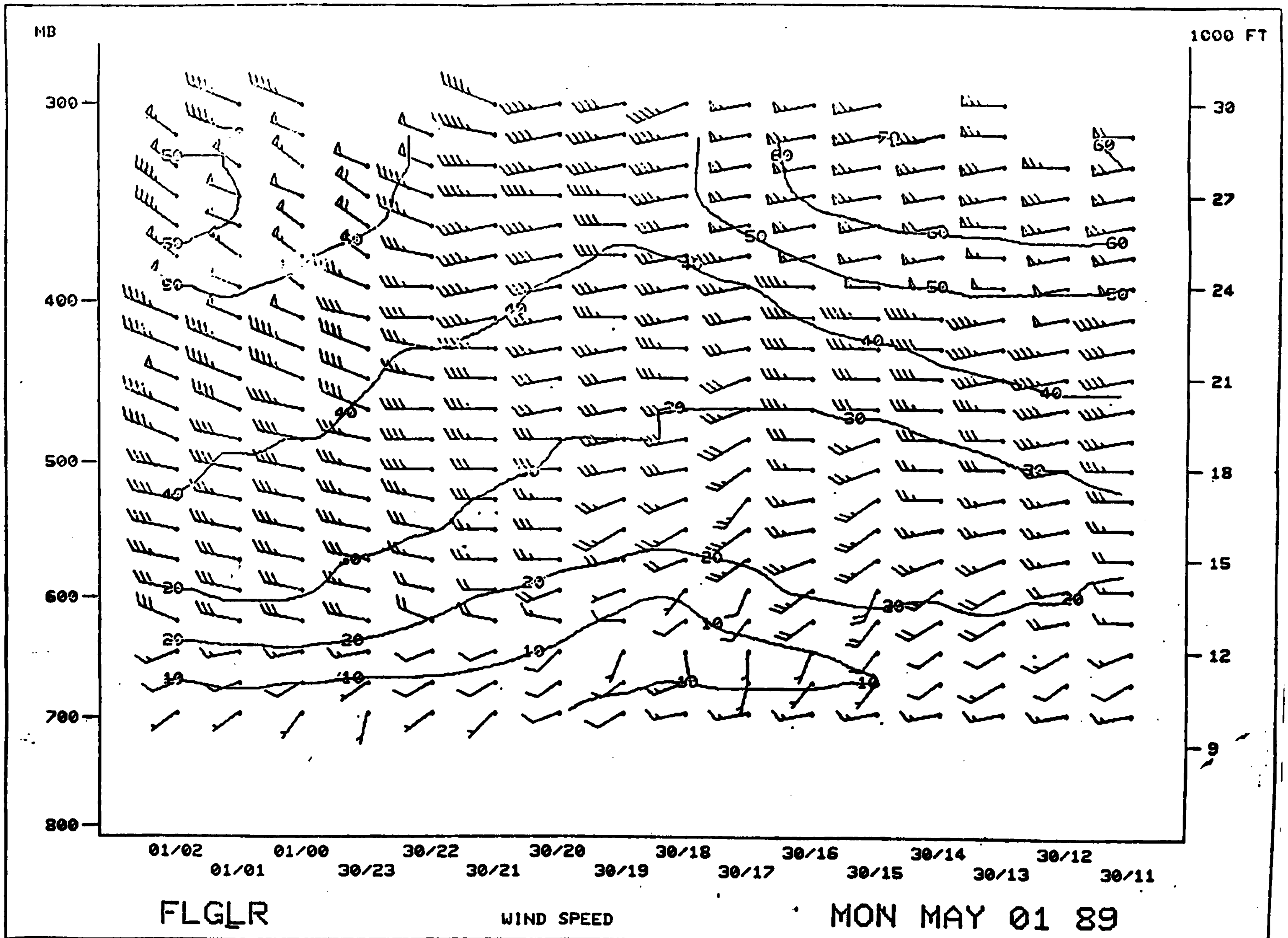

FIGURE 5: Horizontal Wind Plot and Wind Speed Contours for Flagler, CO from 11Z Sun April 30, 1989 to 02Z Mon. May 1, 1989.

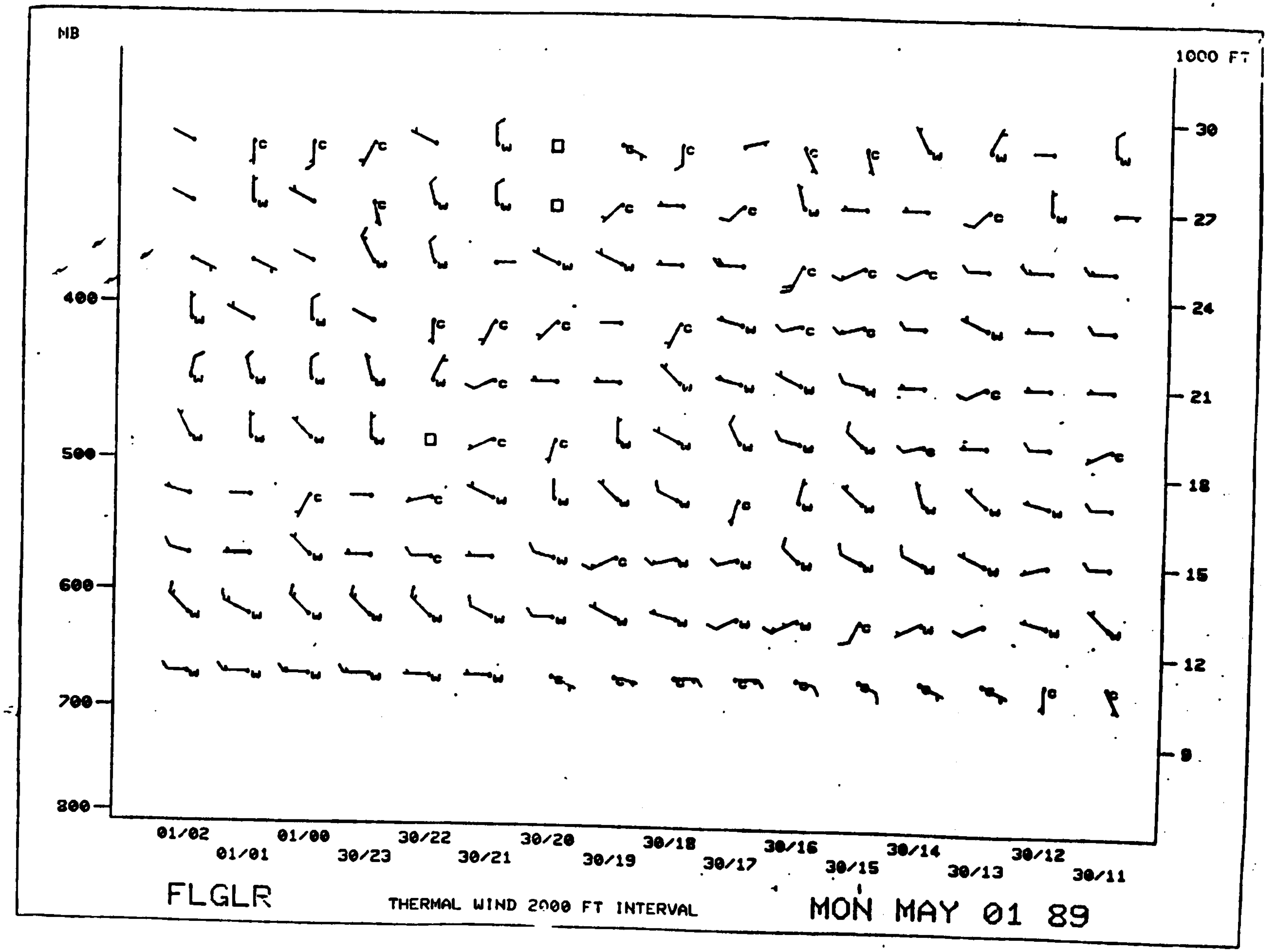

FIGURE 6: Same as Figure 5 but Thermal Wind Plot Using Layers 2000 Feet Thick.

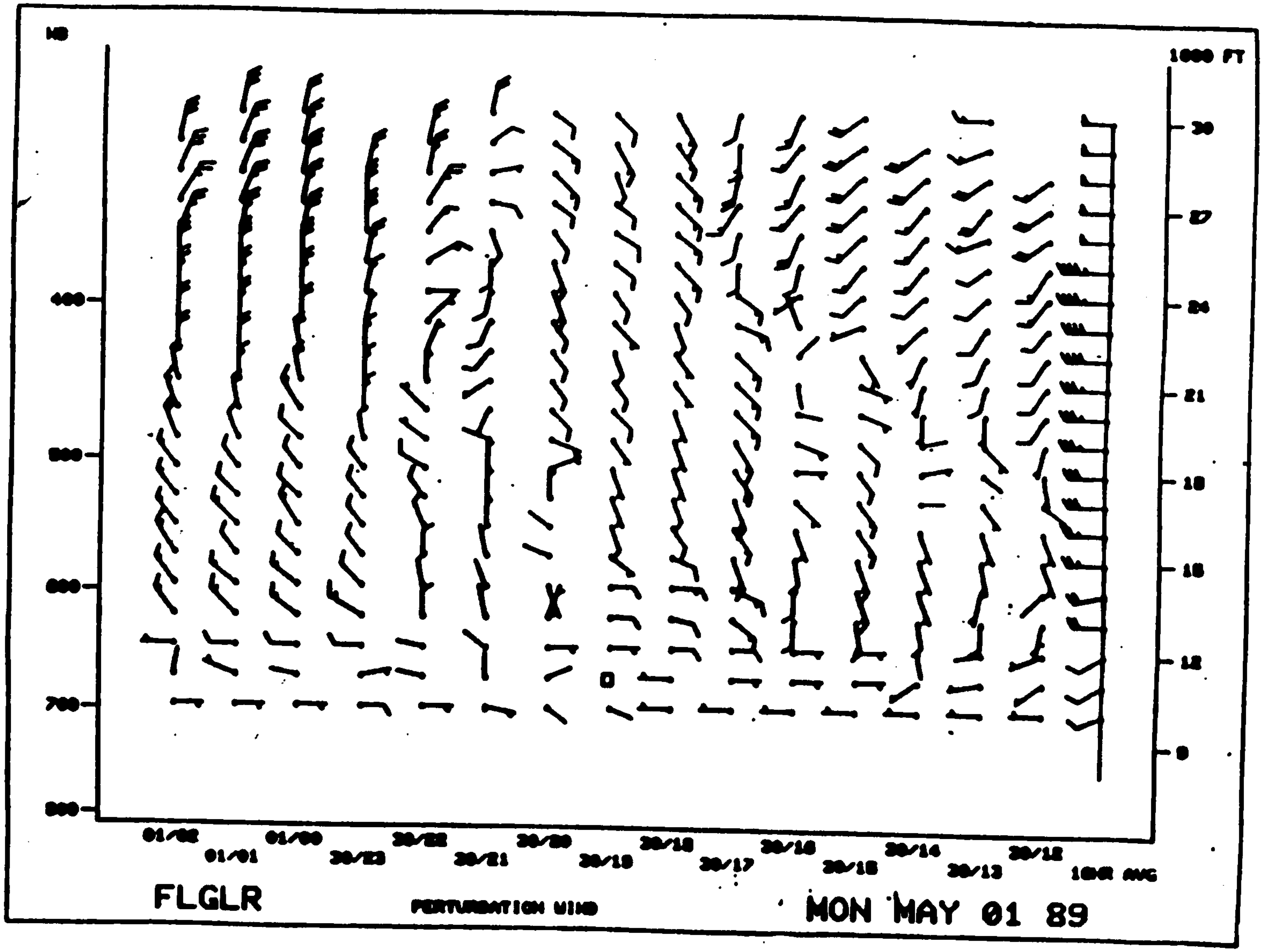

FIGURE 7: Same as Figure 5 but for Perturbation Wind.

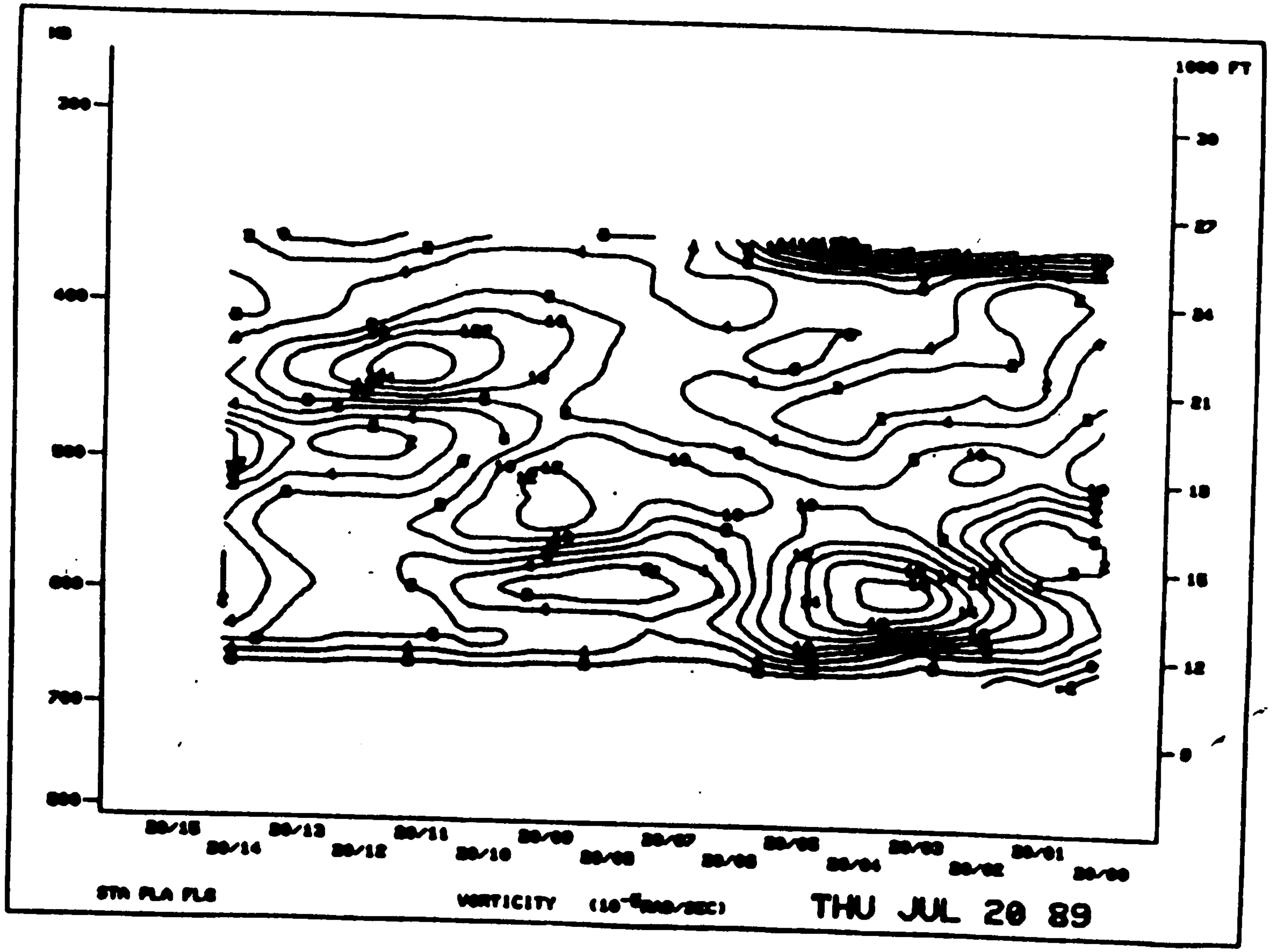

FIGURE 8: Derived Relative Vorticity over the Triangle Bounded by the Profilers located at Stapleton Airport (Denver), CO (STA), Platteville, CO (PLA) and Flagler, CO (FLG) between 00Z and 15Z Thu. July 20, 1989.

CROSS SECTION MENU

PRODUCTS	STATION GROUPS	LOWER HT (FT*1000)	HOUR	CONTOUR INTERVAL	FLAGGED DATA?	HEIGHT INTERVAL (M*10)
HORIZONTAL WIND	[ ]	[ ]	[ ]		[ ]	
ORTHOGONAL COMPONENTS	[ ]	[ ]	[ ]	[ ]A		
W-WIND COMPONENT	[ ]	[ ]	[ ]	[ ]B		
THERMAL WIND	[ ]	[ ]	[ ]			[ ]C
RETURNED POWER	[ ]	[ ]	[ ]	[ ]D		

DEFAULTS: STATIONS - NONE; HEIGHTS - ALL; HOUR - CURRENT; FLAGGED DATA? - Y

A - 10 KT
B - 2 CM/S
C - 1000 M BETWEEN LAYERS
D - 10 DB

STATION SELECTIONS

[W]=[, , , , , , ,]
[X]=[, , , , , , ,]
[Y]=[, , , , , , ,]
[Z]=[, , , , , , ,]

FIGURE 9a: Preliminary Version of the Cross-Section Menu for the AFOS Profiler Program (Battel, 1989).

PLAN VIEW MENU

PRODUCTS	PRESSURE LEVELS	HOUR	#HOURS DIFF	CONTOUR INTERVAL	FLAGGED DATA?	HEIGHT INTERVAL (M*10)
HORIZONTAL WIND	[ ]	[ ]			[ ]	
HORIZONTAL SPEED	[ ]	[ ]		[ ]A		
W-WIND COMPONENT	[ ]	[ ]		[ ]B		
STREAMLINES	[ ]	[ ]				
DERIVED VORTICITY	[ ]	[ ]		[ ]D		
DERIVED DIVERGENCE	[ ]	[ ]		[ ]D		
DERIVED VERT. VEL.	[ ]	[ ]		[ ]B		
THERMAL WIND	[ ]	[ ]				[ ]E
TIME DIFF OF U-WIND	[ ]	[ ]	[ ]	[ ]A		
TIME DIFF OF V-WIND	[ ]	[ ]	[ ]	[ ]A		
TIME DIFF OF W-WIND	[ ]	[ ]	[ ]	[ ]B		
TIME DIFF OF DIV.	[ ]	[ ]	[ ]	[ ]D		
TIME DIFF OF VORT.	[ ]	[ ]	[ ]	[ ]D		
RETURNED POWER	[ ]	[ ]	[ ]	[ ]C		

DEFAULTS: HEIGHTS - STD; HOUR - CURRENT; #HOURS DIFF - 3; FLAGGED DATA? - Y

A - 10 KT
B - 2 CM/S
C - 10 DB
D - .00002 RAD/S
E - 1000 M BETWEEN LAYERS

PRESSURE LEVEL SELECTIONS

[1]=[, , , , , ,]
[2]=[, , , , , ,]
[3]=[, , , , , ,]
[4]=[, , , , , ,]

FIGURE 9b: Preliminary Version of the Plan-View Menu for the AFOS Profiler Program (Battel, 1989).

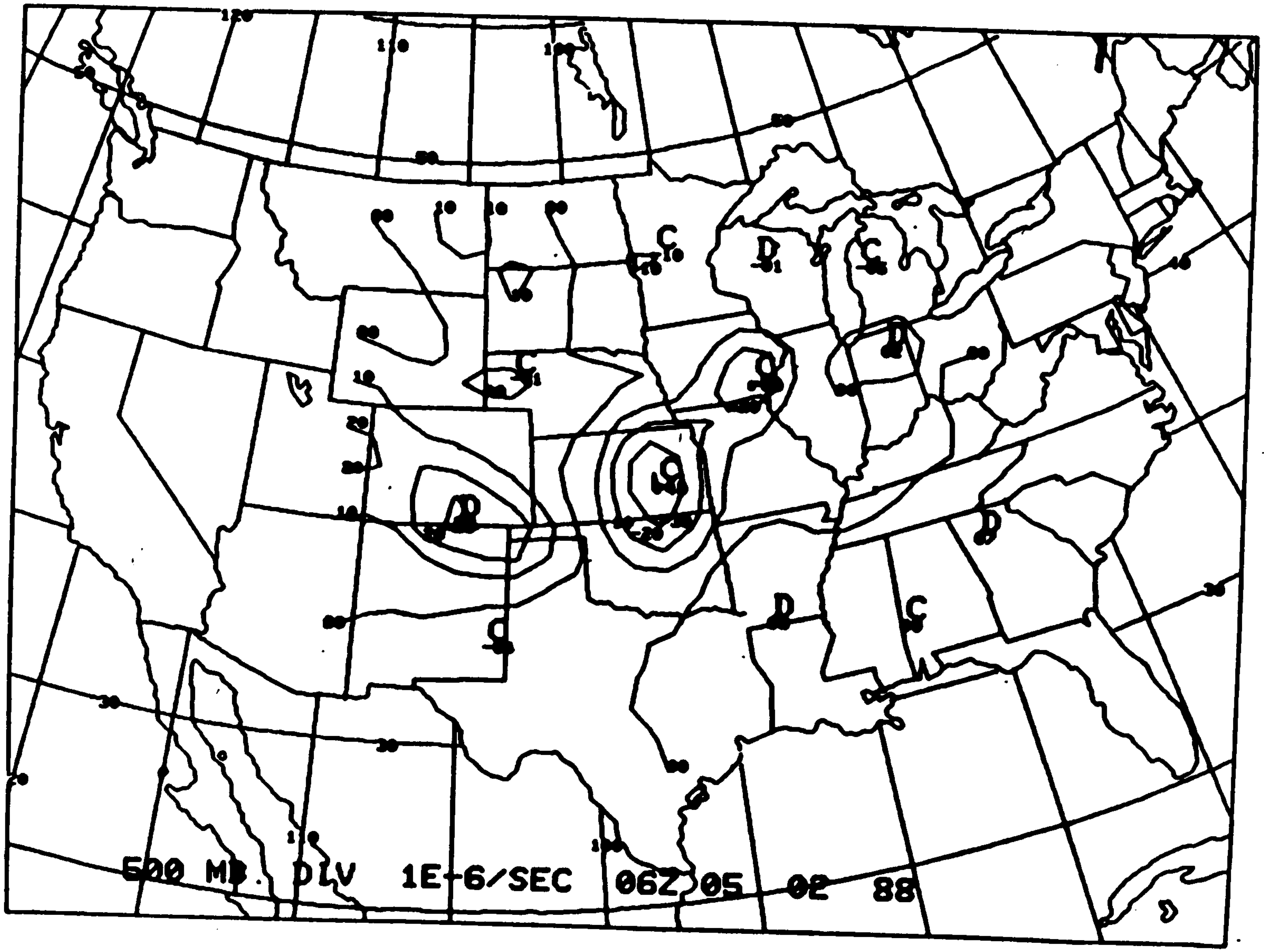

FIGURE 10: Example of a 500 mb Divergence Plan-View.