CRH SSD
AUGUST 1993

CENTRAL REGION TECHNICAL ATTACHMENT 93-22

TRACKING A WINTER STORM VIA WIND PROFILERS

Miles G. Schumacher
National Weather Service Forecast Office
Des Moines, Iowa

1. Introduction

A major storm system moved from the southwest U.S. into the upper Midwest during the period April 20-22, 1992. The upper low was not completely stacked until it reached northern Iowa on the morning of the 22nd. Data from the Wind Profiler Demonstration Network (WPDN) were used by the forecasters at WSFO Des Moines to track the storm system and assist in the forecasting of heavy snow. Specifically, the perturbation wind product generated from the profiler applications software was most helpful.

2. Synoptic Situation

The weather situation was a difficult one for the forecasters. A variety of weather was associated with this storm, and the contrast in air masses was quite striking. A stationary front extended across Iowa from near Lamoni to Mason City on the morning of the 20th. The surface map and 500 mb map for 1200 UTC on April 20 are shown in Figure 1. East of this front, the weather was typical of the Spring season--temperatures in the 60s and lower 70s and dew point temperatures around 60°F. To the west, cold air had settled in with temperatures in the upper 20s and 30s. The lower left corner of Figure 1 shows a full latitude trough at 500 mb, with a nearly closed low on the North Dakota-South Dakota border south of Bismarck at 1200 UTC 20 April 1992. Figure 2 shows that the low had intensified by the next morning, with three closed contours surrounding the closed low. The low had moved southeast into northwest Iowa by 1200 UTC 21 April 1992. The temperature contrast, combined with a dynamic weather system, created a wide variety of weather conditions across Iowa. A flood watch was in effect for much of the state for the potential of heavy rainfall on the evening of the 20th. At the same time, a Winter Storm Warning was in effect for the west, where up to 14 inches of snow fell. In southeast Iowa, a tornado watch was issued on the afternoon of the 20th. That watch verified because of one confirmed tornado in Jefferson County.

3. Discussion

As the storm developed, there were large differences among the NMC models with regard to the track and speed of the surface and upper-air systems. These differences were apparent beginning with the 0000 UTC run of the 19th, and on subsequent runs. Although it was too soon to use the WPDN as a check of model placement, forecasters waited with anticipation for the system to move into the WPDN. During the next three runs, or 36 hours, the models became less divergent with one another. Agreement among the three models was good beginning with the analysis and forecast made at 1200 UTC on the 20th. However, by the afternoon of the 20th the observed vorticity and wind fields did not agree with the model forecast. This was observed by the forecasters on duty. Discussions by the satellite meteorologists at SELS also referred to wind profiler data when updating discussions concerning the movement of the upper level features.

During the afternoon of the 20th, the storm system began to accelerate to the north and intensify rapidly. The movements were evident in the WPDN through the use of the plan view plots of standard levels (i.e. 850 mb, 700 mb etc.). One method to determine the location of the vorticity center was the use of the TSKIN program available to the forecasters. The TSKIN program is a part of the AFOS Wind Profiler Applications software (Battel, et al. 1993). It performs the kinematic analysis of a selected triangulation. The absolute vorticity map (Figure 3) indicated that a 28×10^{-5} sec^{-1} absolute vorticity center near 500 mb passed over the Fairbury, NE-Lathrup, MO-Slater, IA (FBY-LTH-SLA) triangulation area around 0000 UTC. That feature was positioned well ahead of and much stronger than the forecasts made by the numerical models. The TSKIN program enabled forecasters to obtain knowledge of where the 500 mb vorticity center was located. This information helped in the placement of the heavy snow band (Weber 1979).

The derived vertical velocity field from the WPDN (not shown) indicated an upward vertical velocity in advance of the vorticity center of 35 cm sec^{-1} to the north and east of the center. The derived vertical velocity field was instrumental in evaluating the strength and validity of the absolute vorticity field. Forecasters then turned their attention toward locating the upper low. The question asked was: "Is the vorticity depicted from the TSKIN program near the actual center of the upper low or a vorticity lobe?" To answer that question, horizontal wind and perturbation wind products were used.

The upper low passed over the profiler site at FBY between 2100 UTC and 2200 UTC on the 20th. Figure 4 is the true wind plot for the FBY site for the period 1100 UTC on the 20th through 0200 UTC on the 21st. From this figure, we can see the upper low center was near 460 mb as it passed over the station. Figure 5 is the perturbation wind plot for the same time period. The far right plot is the 24-hour average wind over the station. Subsequent plots are the perturbation winds. The perturbation wind is simply the vector difference between the 24-hour average wind vector and the current wind vector. This graphic accentuates change in the wind field to the forecasters. Examination of Figure 5, shows that the perturbation wind center passed over the Fairbury station at about 2000 UTC on the 20th.

In the example presented, the passage of the upper low in the true wind field and the "passage" in the perturbation wind field had a separation of about two hours. Why was there a difference between the passage times and levels of the low? The reason for this occurrence is because the perturbation wind is not a true wind, rather a vector difference. The perturbation wind field showed an apparent passage of the upper-level system earlier than the horizontal wind field because of the change in wind velocities. From basic meteorology, the wind flow around the upper low will usually become lighter as it approaches a site. For this reason, as the southerly component decreased in strength from the 24-hour average, the perturbation vector became northerly. Thus, the perturbation wind indicated the passage before it actually occurred. In this example, the perturbation wind was a lead indicator of the passage of the upper-level system.

This occurrence will not always be true. The author has seen cases where these two fields nearly coincide. Cases have been observed where there is a larger difference between passage times. The forward speed and structure of the system itself will dictate the time differential between the two passages. There are times when the perturbation winds will indicate a closed center when a true closed center does not exist. This can be caused by ageostrophic changes in the flow field. That information can also be useful in the determination and location of a weak vorticity center or lobe in the sub-synoptic scale. Many times when a vorticity center passes over a station, the winds will present a closed image in the perturbation wind field. That is not to say the perturbation field is in error, but that it will enhance subtle changes in the horizontal wind field that are not readily discernable. Because the perturbation wind serves to accent any changes that take place in the wind flow, it should be frequently examined by the operational forecaster.

The storm system was tilted in the typical fashion of middle latitude cold core lows. Since the system was tilted to the west with height, the forecasters could reasonably expect the passage to occur at a lower level at Slater. Figure 6 is the true wind plot from the Slater site for the same periods as shown in Figures 4 and 5. From these figures, only a slight veering of the winds over time is apparent, with the low clearly to the west. The perturbation winds shown in Figure 7 indicate a "passage" of the low at 800 mb between 0100 UTC and 0200 UTC on the 21st. From that information, the forecasters anticipated that the track of the 850 mb low would be very close to central Iowa. This information was important in the preparation of the forecast, and was used for the placement of the heavy snow band with the storm (Weber 1979; Air Weather Service 1979). Maps for later time periods indicated that the 850 mb low did indeed pass to the west of the Slater station. There was never a passage indicated on true wind plots. The fact that the perturbation winds indicated a "passage" suggested that the lower level low would pass very near the profiler site, if not indeed over it.

4. Conclusions

In this example, forecasters were able to recognize quickly the passage of a vorticity maximum in the FBY-LTH-SLA triangulation generated by the TSKIN program. Forecasters were able to observe the potential value of the perturbation wind plot. In tracking, keep in mind that the perturbation winds are not the true wind, but rather a vector difference from the 24-hour average wind. Using wind profiler information, one can make some reasonable decisions about what is actually occurring in the atmosphere. Gone are the days when one must wait for the next set of radiosonde observations to arrive in the forecast office or depend solely on the numerical guidance to make a forecast.

5. Acknowledgements

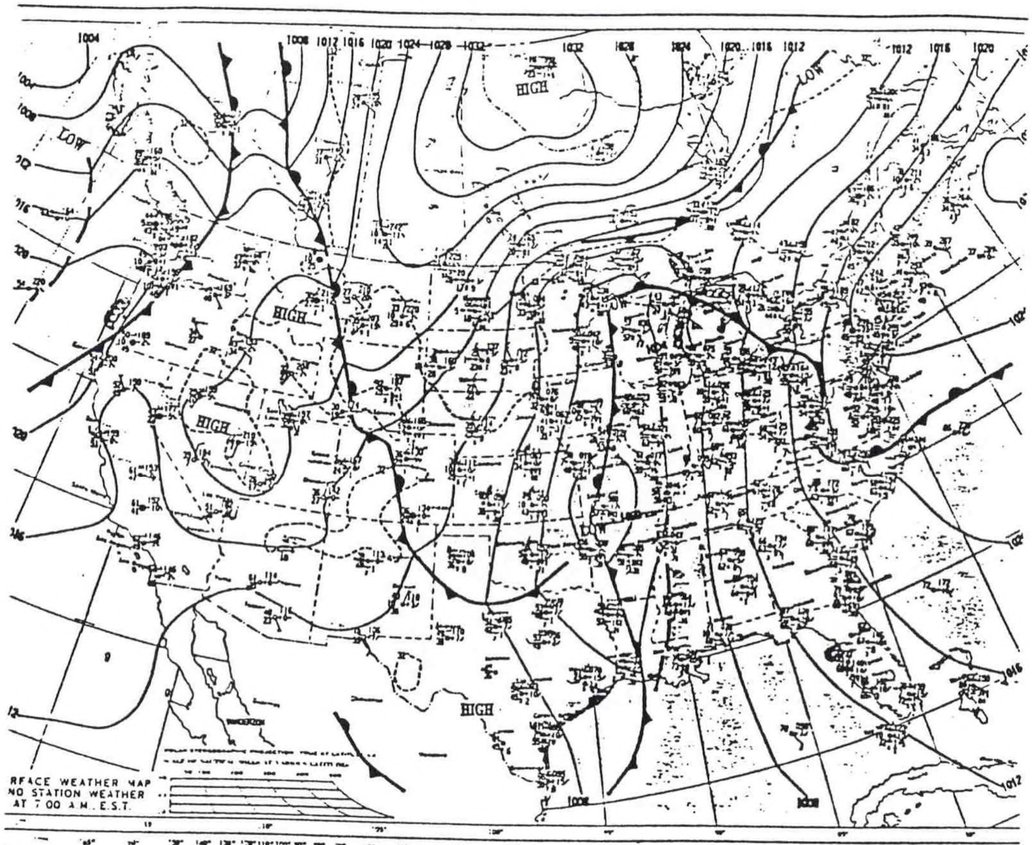
Special thanks goes to Lee Anderson (Deputy Meteorologist in Charge, National Weather Service Forecast Office in Des Moines, Iowa) for his review of this paper. Thanks also goes to Preston Leftwich (Techniques Improvement Meteorologist) and Rick Ewald (Profiler Assessment Meteorologist) for their review and support of this paper.

6. References

Air Weather Service, 1979: Meteorological Techniques. Air Weather Service Pamphlet 105-56, Headquarters Air Weather Service, Scott AFB, IL.

Battel, Leaphart, Moeller 1993: AFOS Profiler Software System, NOAA Techniques Development Laboratory Computer Program NWS TDL CP 93-01.

Weber, E. M., 1979: Major Midwest Snowstorms. USAF 3WW Technical Note 79-2, Offutt AFB, NE, 95 pp.



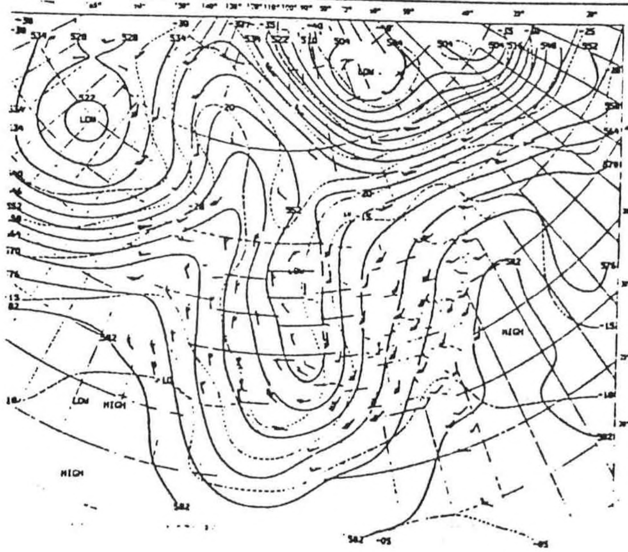
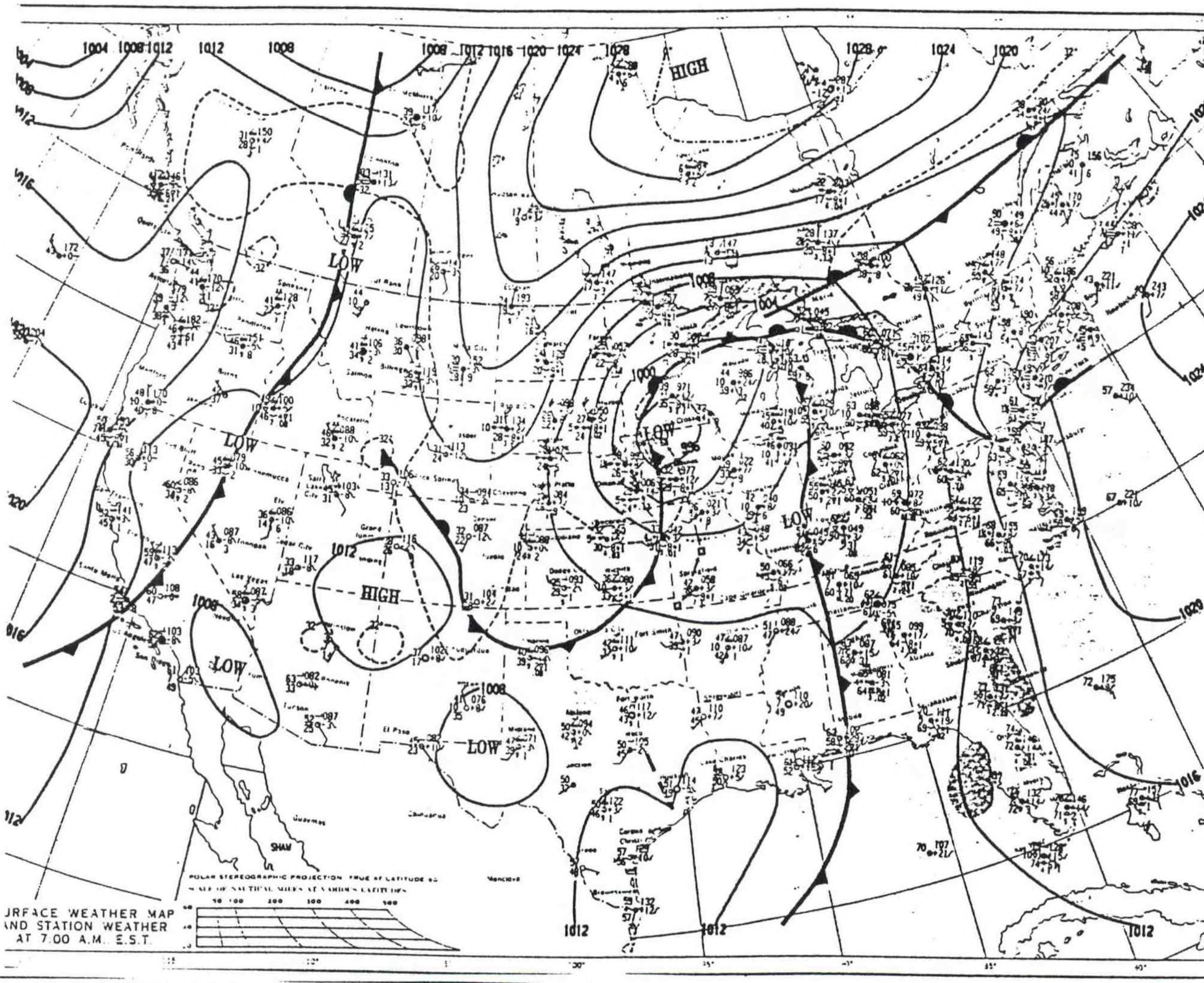


Figure 1. Top is the observed surface plot from 1200 UTC 20 April 1992. Below is the observed 500 mb contours from 1200 UTC 20 April 1992.



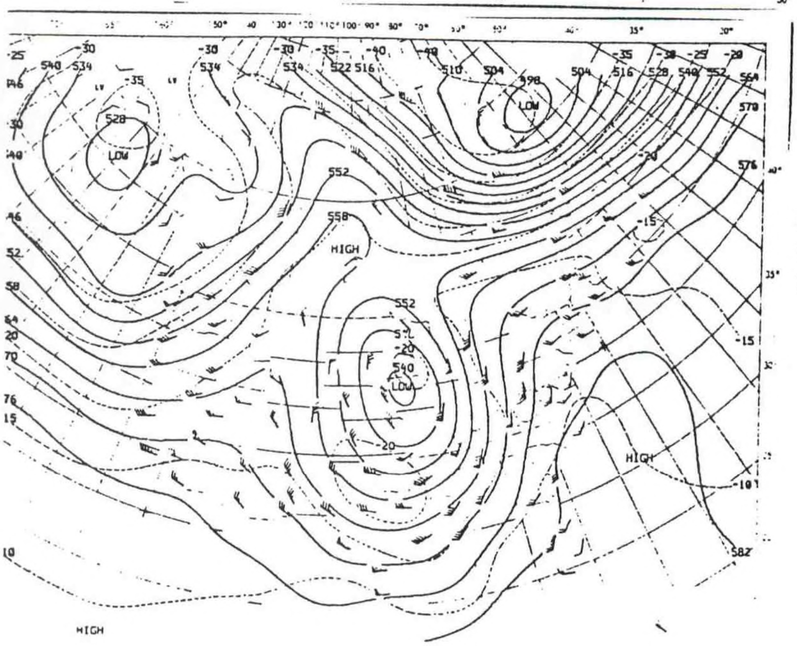


Figure 2. Same as in Figure 1 except maps are from 1200 UTC 21 April 1992.

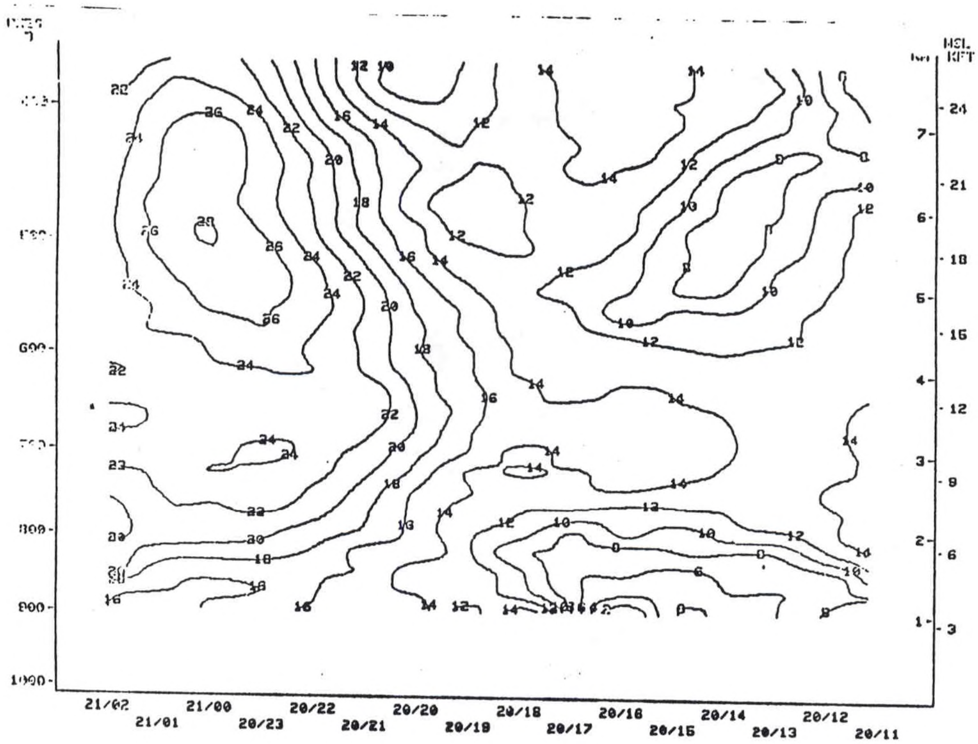


Figure 3. Absolute vorticty plot ($10^{-5}sec^{-1}$) from the SPDN for the period 1100 UTC 20 April - 0200 UTC 21 April 1992. Time on the ordinate increases from right to left, height on the abscissa from bottom to top increases from surface to 8 km. Triangulation is the FBY-LTH-SLA triangular area.

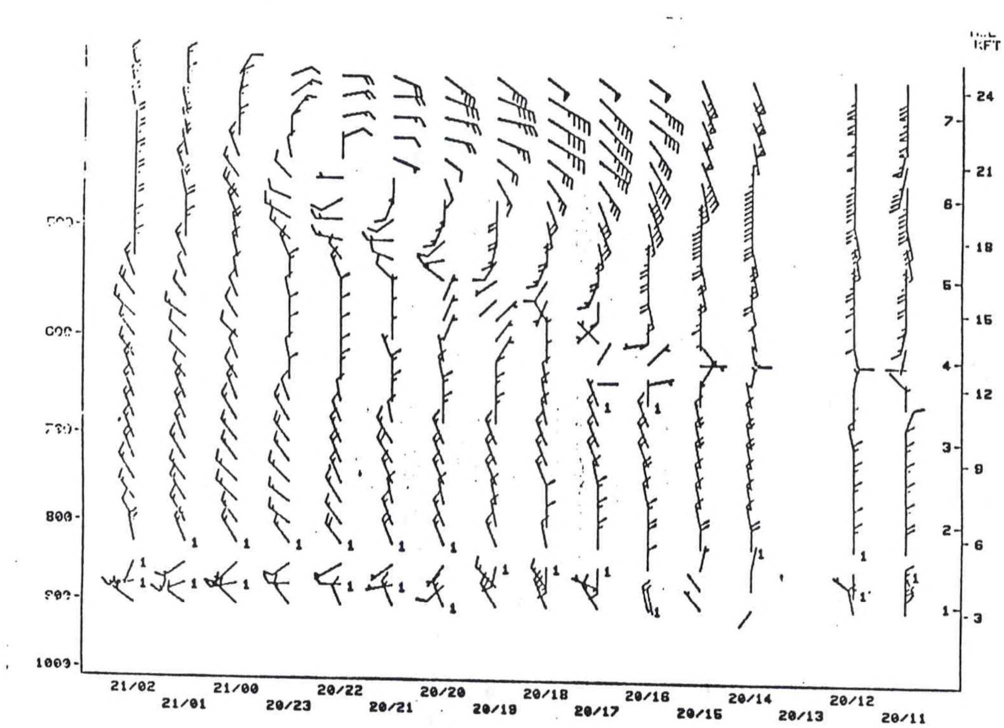


Figure 4. True wind plot for the FBY profiler. Wind speed is in knots with each half barb representing 5 kts. Ordinate and abscissa is the same as in Figure 3.

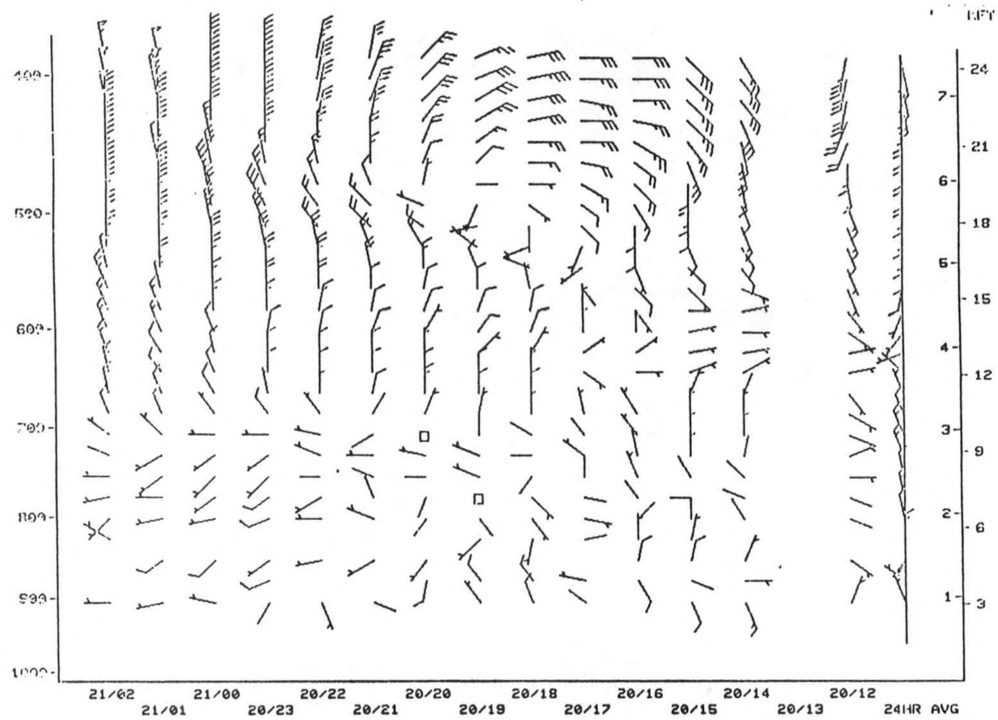


Figure 5. Perturbation wind field for the FBY profiler (kts). Time period is from 1200 UTC 20 April - 0200 UTC 21 April 1992. The 24-hour average wind is plotted on the far left, the remainder of the plots are the perturbation wind departure from the 24-hour average. Ordinate and abscissa are the same as the Figures 3 and 4.

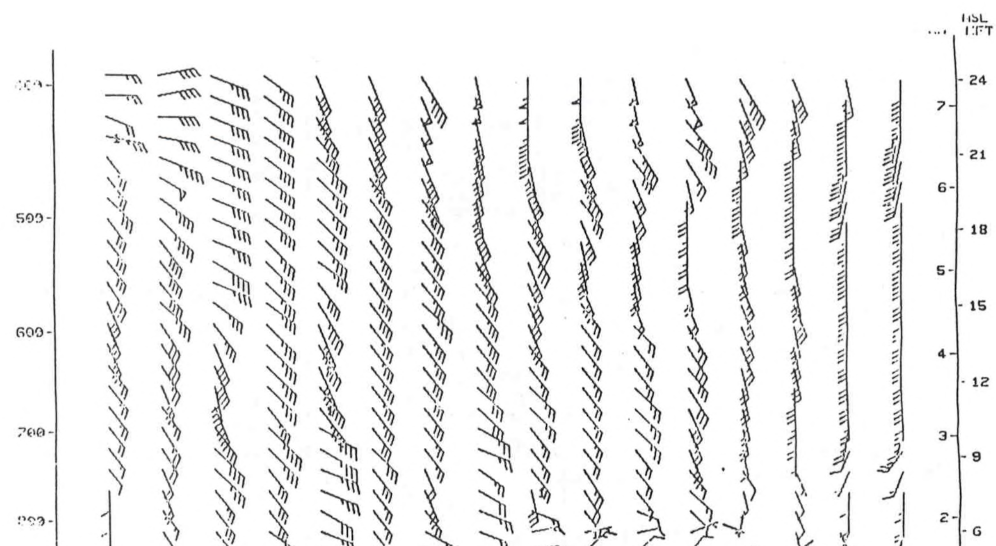


Figure 6. Same as Figure 4 except for the SLA profiler.

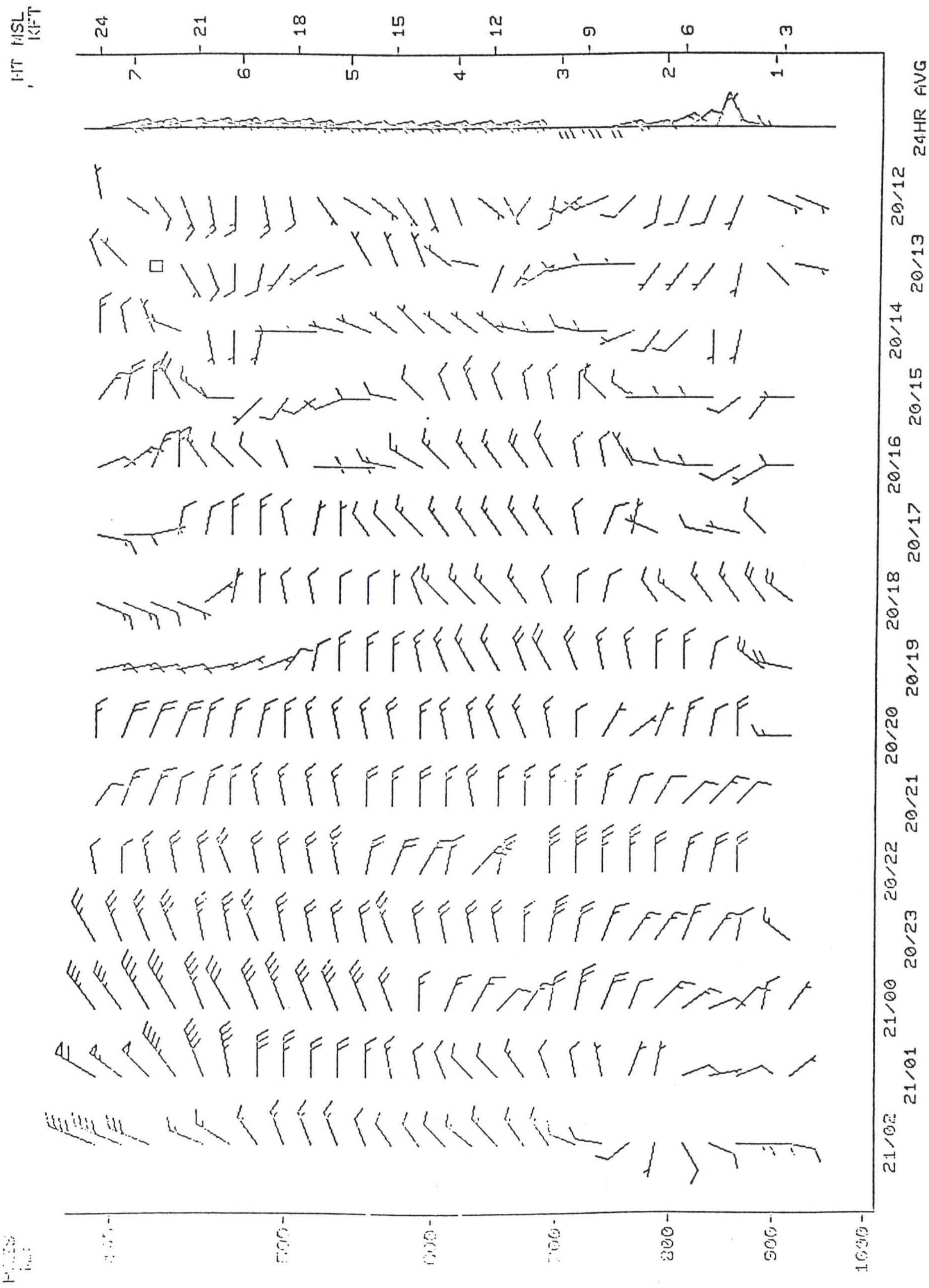


Figure 7. Same as Figure 5 except for the SLA profiler.