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WIND PROFILERS - THE FUTURE IS NOW

Samuel K. Beckman
National Severe Storms Forecast Center
Kansas City, Missouri

Introduction

There have been several recent papers in meteorological journals on the use of profiler data during severe storm and winter weather events. More informal notes or less rigorous study of single events can be found in NWS Regional Technical Attachments or in a NOAA/ERL publication from the Boulder Forecast Systems Laboratory called the FSL Forum. National Weather Service forecasters have been enticed by seeing experimental wind profiler data from the northeast Colorado network during the past few years and reading about the usefulness of the winds in diagnosing features to help solve forecast problems over that limited area. Now, with the implementation of the central U.S. network, observation of the hourly profile winds over another area, removed from the local effects of the Rockies, is a reality.

Beginning 11 January 1991 wind profiler data from six new profiler sites in the Central Plains began flowing into the AFOS. The data were released temporarily for testing purposes during the week of 14 January. This note demonstrates the value of this new data set by briefly describing a period of about 30 hours on 15-16 January when a synoptic scale weather feature moved from the Southern Plains to the Ohio and mid-Mississippi Valleys. Several subsynoptic scale features became apparent in the hourly profiler winds from the six sites circled in Figure 1 that were not obvious in the conventional 12 hour synoptic scale RAOB network.

Analysis of Data

A synoptic scale system over the south central U.S. was well defined by a classic comma shape in satellite imagery (Fig. 2a). At the 500 mb level, the initial 1200 UTC RGL (Fig. 3a) showed an open trough over Oklahoma and north Texas with a 20 unit vorticity center over northeast Texas. Although a low was initialized in central Oklahoma, there were no analyzed closed contours. Southeasterly RAOB winds at 1200 UTC 15 January over Arkansas and south Missouri suggested a possible closed circulation at 850 and 700 mb near the Arkansas/Oklahoma border (charts are not shown). The hypothesis of a possible closed circulation was supported by the cyclonic appearing cloud pattern over this area in the visible satellite imagery (Fig. 2c).

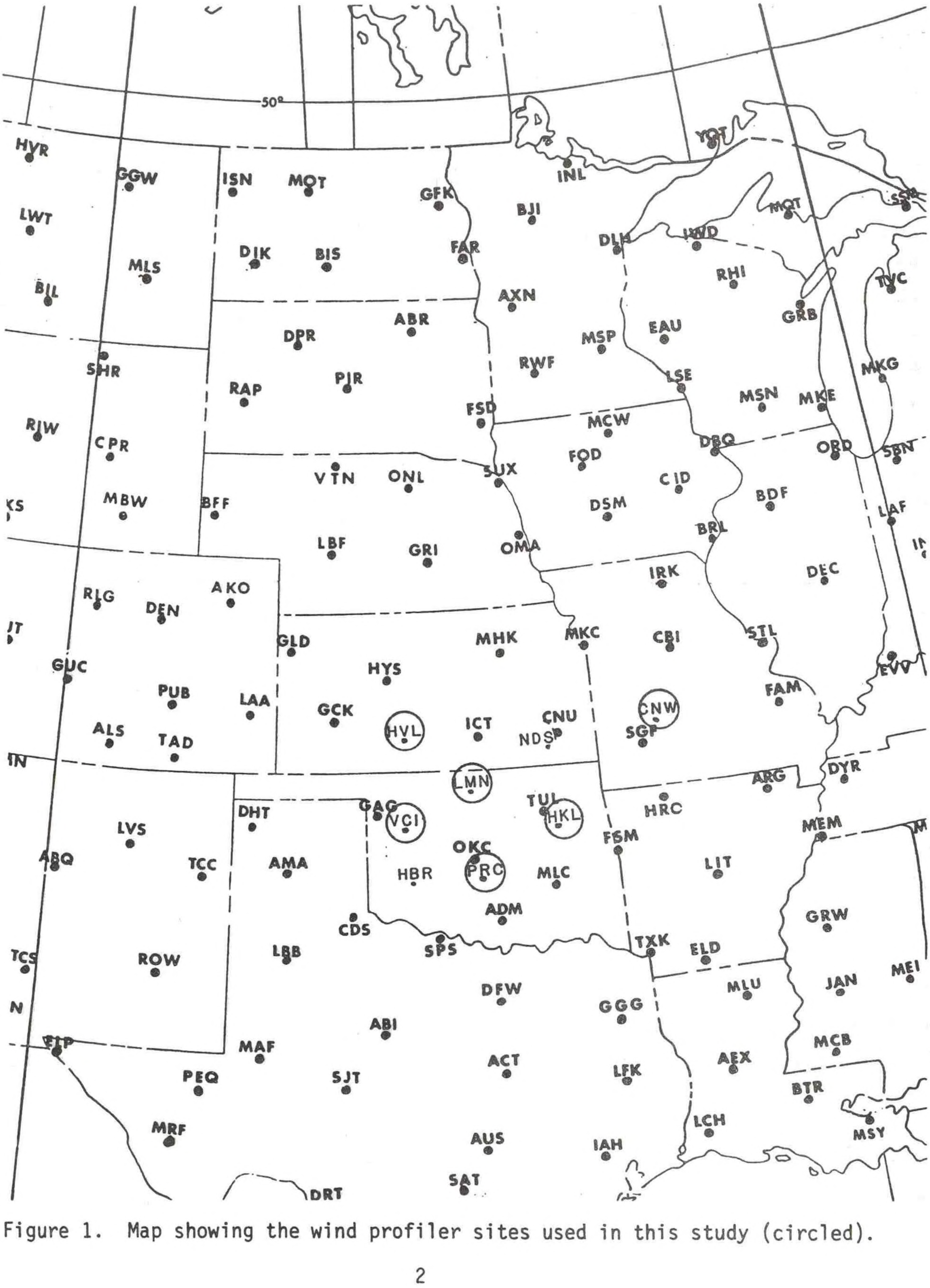


Figure 1. Map showing the wind profiler sites used in this study (circled).

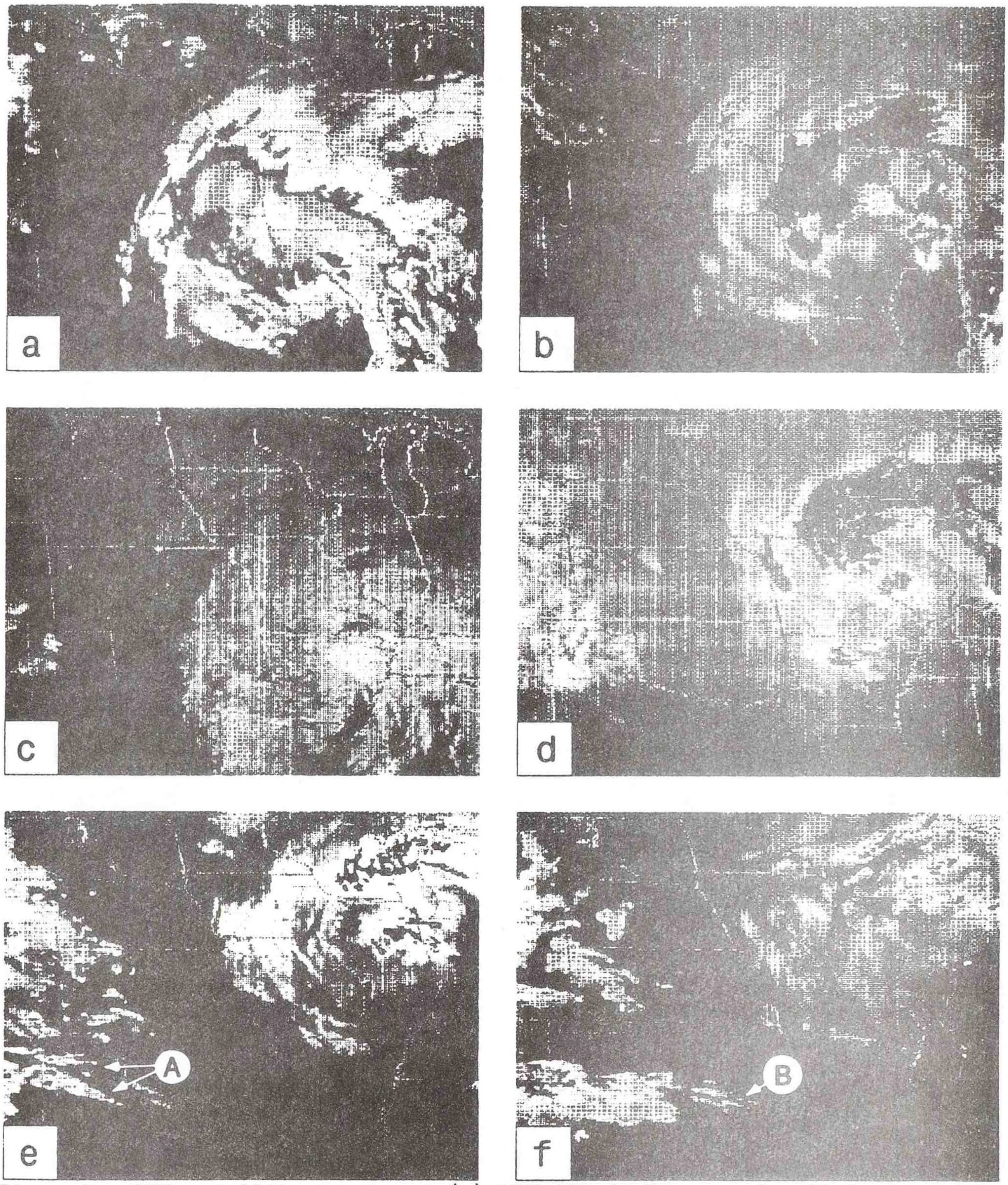


Figure 2. GOES satellite imagery at (a) 1231 UTC IR CC curve for 15 January 1991, (b) 1801 UTC IR MB curve for 15 January 1991, (c) 1831 UTC visible for 15 January 1991, (d) 0000 UTC IR MB curve for 16 January 1991, (e) 0631 UTC IR CC curve for 16 January 1991, and (f) 1231 UTC IR CC curve for 16 January 1991.

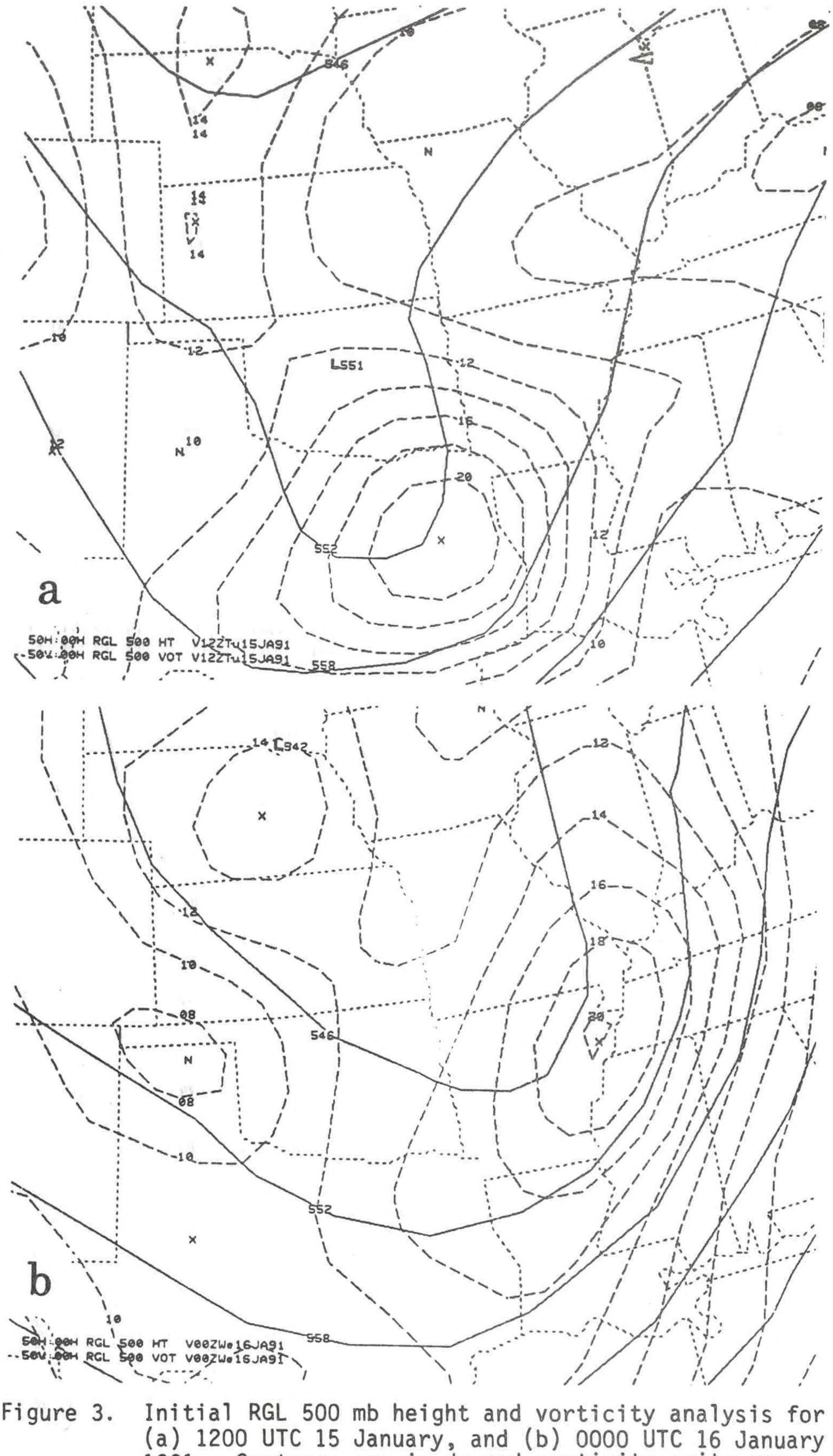


Figure 3. Initial RGL 500 mb height and vorticity analysis for (a) 1200 UTC 15 January, and (b) 0000 UTC 16 January 1991. Contours are in dm and vorticity units are X10 s^{-1}.

A surface low located over north Louisiana at 1200 UTC 15 January (Fig. 4) moved northeastward across the Missouri Bootheel around 0000 UTC enroute to north central Indiana by 1200 UTC 16 January. The surface low was rather innocuous with the central pressure varying only 1 mb during this 24 hour period. The cloud pattern in the initial satellite imagery looked impressive and suggested a mature system with a closed circulation through a large depth of the low and middle atmosphere. The cloud pattern started to become disjointed during the day (Figs. 2b-d) and continued to disorganize during the next 12 hours (Figs. 2e and f) suggesting the system was weakening. At 0000 UTC 16 January, the initial RGL indicated about a 100 m height fall over Missouri in the past 12 hours and no closed contours. The vorticity center maintained the same intensity as it moved into northeast Arkansas. An east wind at 850 and 700 mb over north central Illinois supported a closed circulation at those lower levels.

The hourly profiler winds between 1300 UTC 15 January and 1900 UTC 16 January 1991 indicated several subsynoptic scale features moved through the network. These features were either not readily apparent or difficult to resolve in the RAOB data. The following is a brief description of five such features:

1. The low-level circulation suggested in the RAOB data over west Arkansas was confirmed by the east winds in the Haskell (HKL) and Conway (CNW) profilers (Figs. 5a and b). The closed circulation was best defined around 850 mb, extended upward to near the 700 mb level and passed by to the south and east of these farthest east profilers in the network. Southeast winds to 30 kt at CNW occurred just prior to the passage (around 1800 UTC 15 January) of an inverted trough between the surface and 800 mb. This concentrated inflow of low level moisture appeared to relate to the occurrence of heavier precipitation over southwest Missouri and southeast Kansas. Observations at Springfield, Missouri, and Chanute, Kansas, indicated about .25 inch of rain fell between 1500 and 1800 UTC on 15 January.

2. A well defined sharp trough was evident between 500-650 mb passing HKL around 1500 UTC 15 January. The trough tilted back to the west at higher levels (through 400 mb) and passed the next site to the east (CNW) around 2100 UTC. The trough was evident between 400 and 650 mb with a tilt downward to the surface, indicating a link to the low level inverted trough. This trough related to the west or back edge of enhanced clouds in the IR satellite imagery (Figs. 2b and d) and back edge of precipitation in the radar summary charts (Fig. 6a). The precipitation developed ahead of this trough during the afternoon northeastward across east Missouri into southeast Iowa and north Illinois.

Figure 4. Six hour positions and track of the surface low between 1200 UTC 15 January and 1200 UTC 16 January 1991. Central pressure is in mb with the leading two digits omitted.

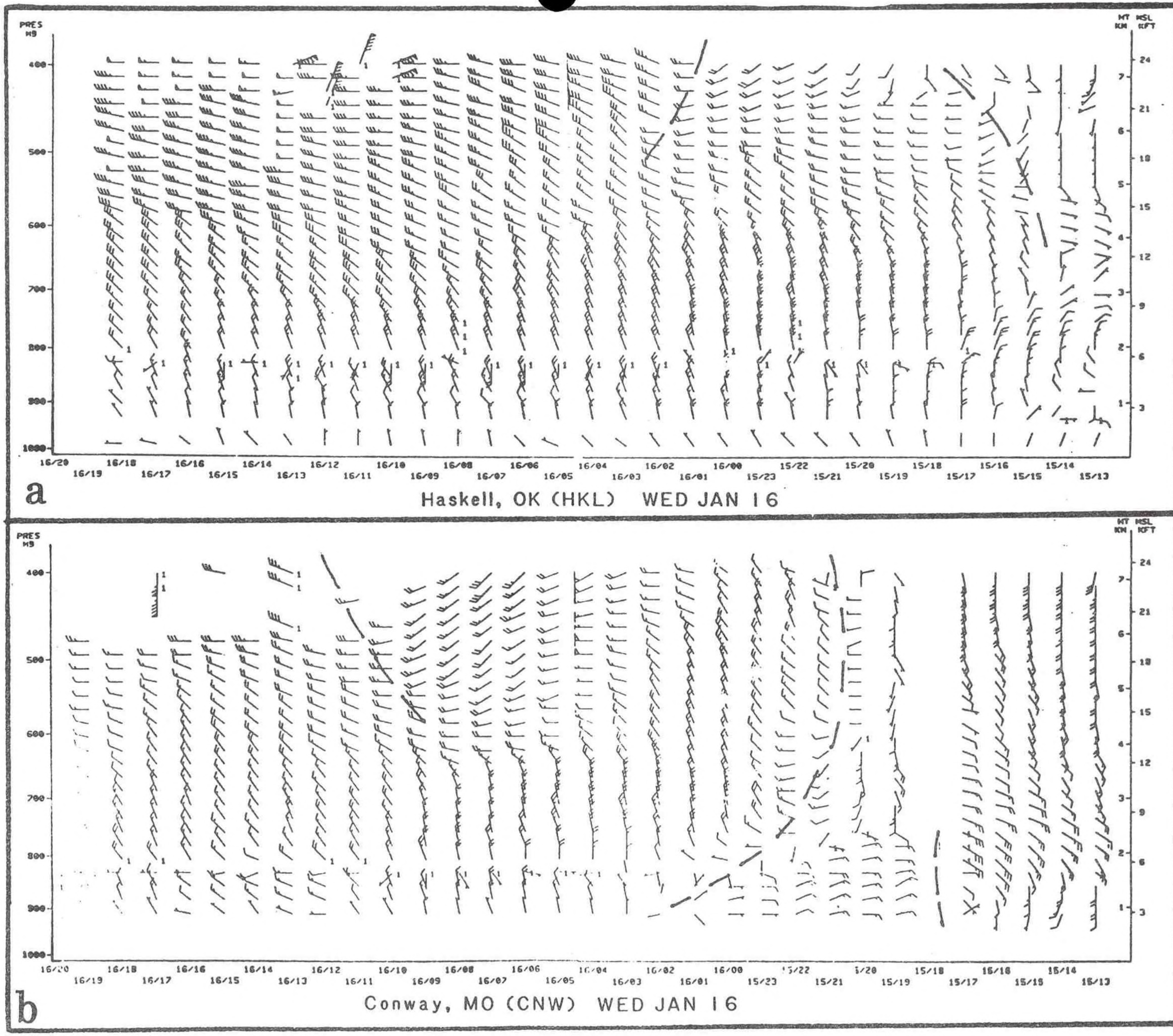
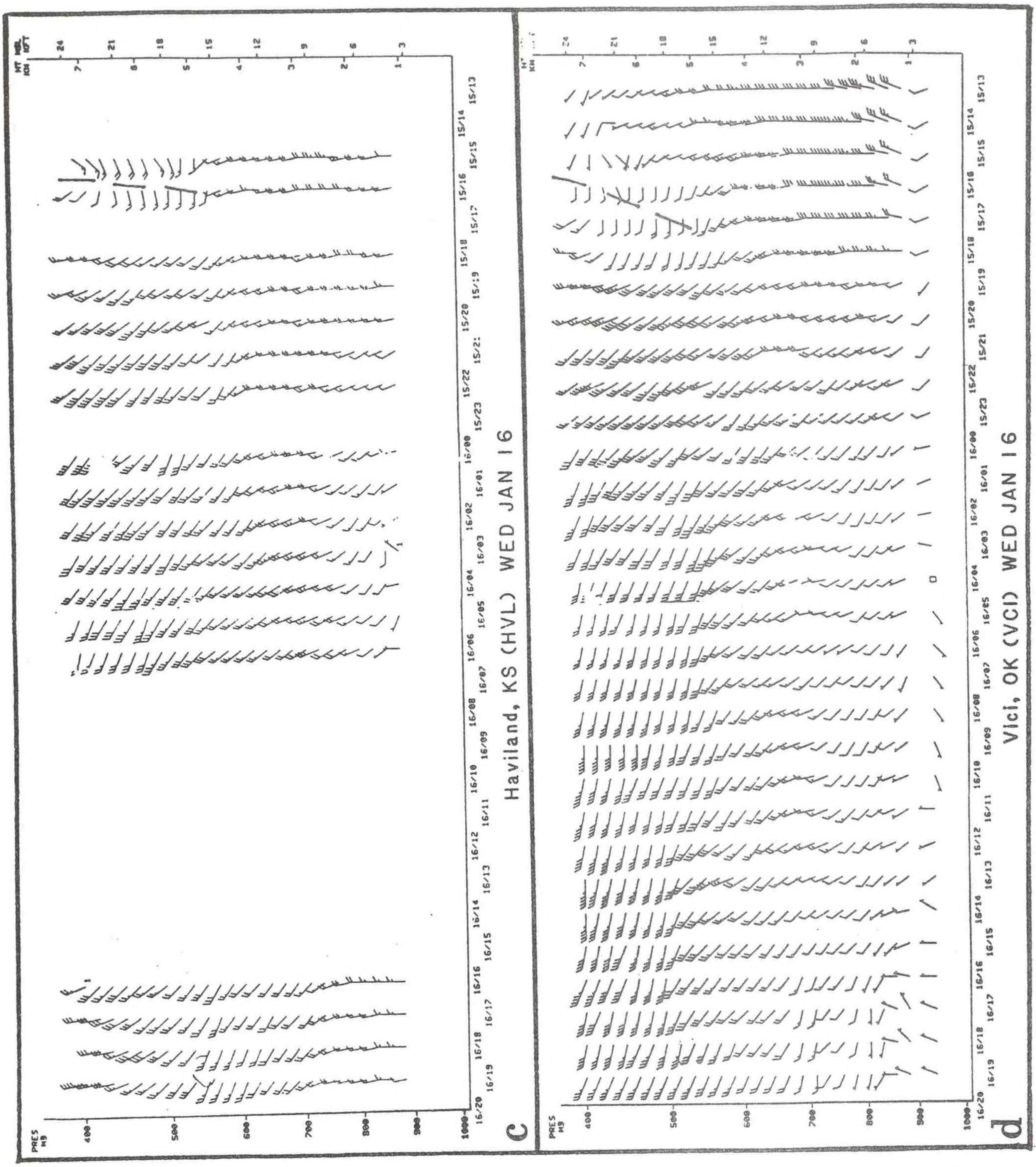
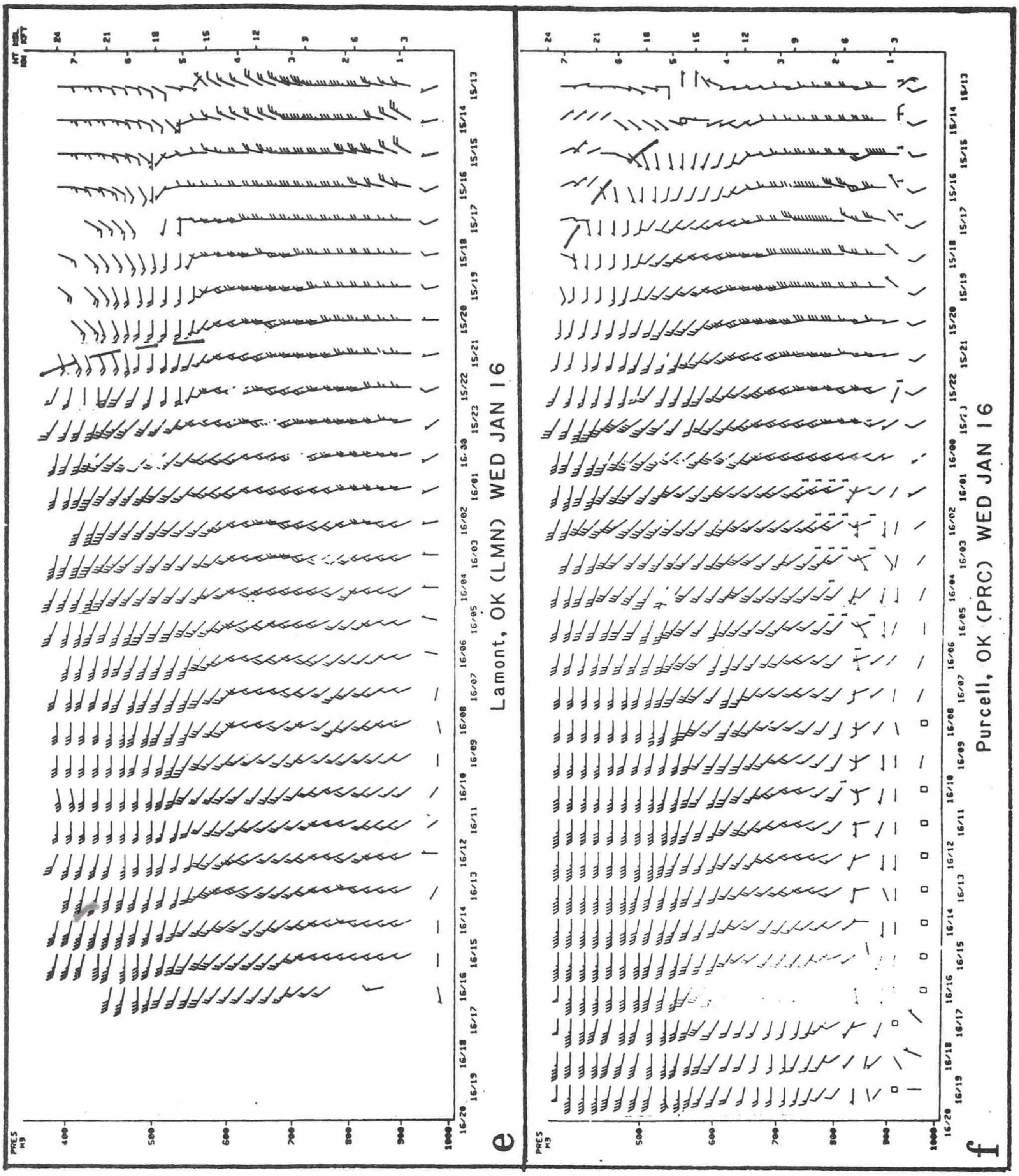


Figure 5. Time-height cross sections of 1 hour averaged winds for the following wind profilers between 1300 UTC 15 January and 1900 UTC 16 January: (a) Haskell, Oklahoma (HKL); (b) Conway, Missouri (CNW); (c) Haviland, Kansas (HVL); (d) Vici, Oklahoma (VCI); (e) Lamont, Oklahoma (LMN); and (f) Purcell, Oklahoma (PRC). Each long barb is 10 kt, a short barb 5 kt, and a pennant 50 kt. The 1s flag a failed QC check.


Haviland, KS (HVL) WED JAN 16
c
Vici, OK (VCI) WED JAN 16
d


Lamont, OK (LMN) WED JAN 16
e
Purcell, OK (PRC) WED JAN 16
f

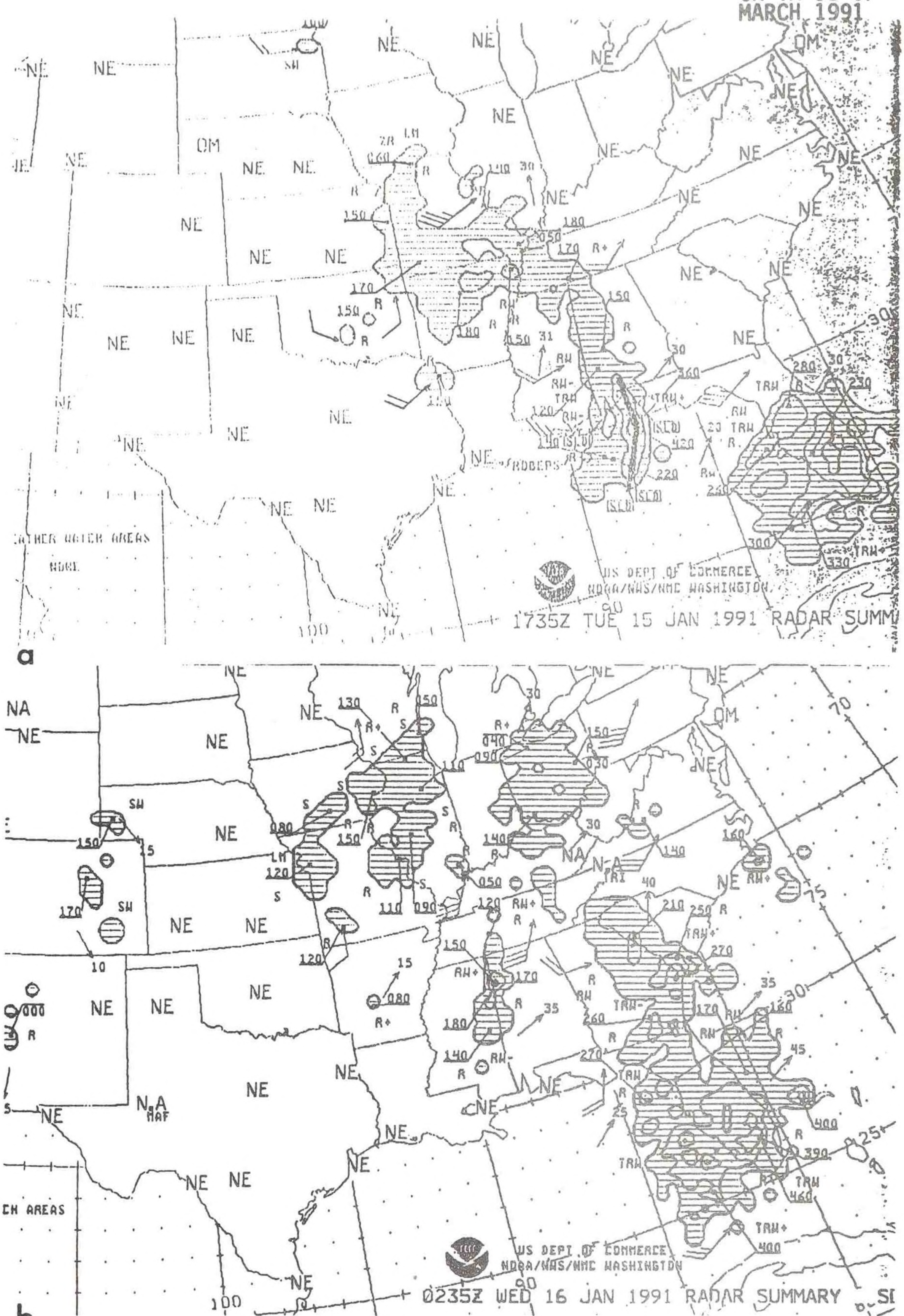


Figure 6. Radar summary charts for (a) 1735 UTC 15 January 1991, and (b) 0235 UTC 16 January 1991.

3. The radar summary chart during the evening showed low topped (12,000 ft) precipitation remaining over west Missouri and extreme east Kansas (Fig. 6b). A high level feature was evident at 400/500 mb passing over Vici (VCI) and Haviland (HVL) around 1600 UTC 15 January (Figs. 5c and d). This feature was defined by the winds backing briefly with time to the west and southwest before trough passage then veering sharply to the northwest. This trough was also evident around the 400/500 mb level as it moved east over Purcell (PRC) between 1500-1900 UTC (Fig. 5f), Lamont (LMN) about 2100 UTC (Fig. 5e), Haskell about 0000 UTC and Conway (CNW) about 1100 UTC 16 January (Figs. 5a and b). The time series also indicates that the trough had a negative tilt since, at a given level, it passed the farthest south site (PRC) before the most northern one (LMN) (see Figs. 5e and f). The trough also extended upward to the west. In summary, the trough maintained good continuity as it moved eastward across all sites in the profiler network. It related to the far back edge of high clouds in satellite imagery and possibly provided just enough lift to maintain a secondary band of persistent light precipitation over west Missouri.

4. The IR satellite imagery showed high clouds spreading rapidly eastward across the south Texas Panhandle into south Oklahoma between 0600 and 1200 UTC 16 January (A and B depicts the leading edge in Figs. 2e and f). This related to an increase in Haskell (HKL) (Fig. 5a) and Purcell (PRC) (Fig. 5f) profiler winds to around 50 kt at 400-500 mb. The winds were not available at Lamont (LMN) after 1600 UTC 16 January. The jet core was likely near the north edge of high clouds across the central Texas Panhandle into central Oklahoma, passing just north of Purcell (PRC) and very close to Haskell (HKL).

Summary

This note briefly described several subsynoptic scale features which were evident in the hourly profiler winds. A concentrated low level inflow of moisture occurred for a short time immediately ahead of the upper trough and probably accounted for the heaviest 3 hour rainfall totals. The initial trough extended through a deep layer of the mid/lower atmosphere and related to multiple cloud layers with cold cloud tops. A secondary trough trailing the first was evident in a shallow layer around the 400/500 mb level. This feature helped to explain the lingering light precipitation and slow clearing of higher clouds. High clouds streaming across the Texas Panhandle into Oklahoma related to a zone of 45-55 kt winds above 500 mb.

The system in this case was not very well developed and it appeared to weaken as evidence by the disorganized cloud pattern in satellite imagery and little change in the surface low's central pressure. Nevertheless, subtle small scale features could be identified, related to the ongoing weather and tracked progressively through the small profiler network of six test sites.

Recently the Haviland (HVL), Kansas, and the Haskell (HKL), Lamont (LMN), and Vici (VCI), Oklahoma profilers routinely began sending data via AFOS. The other sites used in this study should soon become available. The wind profiler demonstration network is a completely automated system with the data passing from the sites to the central Hub in Boulder, Colorado, and onto the NWS data distribution circuits, without any input or examination by people. A number of phenomena can cause the profiler to produce spurious wind measurements. Automatic quality control (QC) algorithms have been installed at the profiler network Hub to screen the data for errors. The QC checks are described in the Wind Profiler Training Manual Number 2, Quality Control of Wind Profiler Data. The small 1s around 800 mb level at Haskell (HKL) (Fig. 5a) flag the winds for failing the QC check. Some of these winds appear to be horizontally and vertically consistent (0800 UTC 750-800 mb) while other winds are obviously in error (0900-1100 UTC 400 mb). The final determination of "good" and "bad" winds resides with the user of the data.

This new data set offers the forecaster another tool for diagnosing subtle changes in the atmosphere so he or she can better refine the forecast. It's a good time to review those profiler training tapes and manuals. The future is now.