WESTERN REGION TECHNICAL ATTACHMENT
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WIND PROFILER UPDATE

Introduction

Between late 1988 and early 1990, a 31-station wind Profiler network will be deployed in the central U.S. (Figure 1). The purposes of this demonstration network are to:

1. Assess the impact of a large wind Profiler network on meteorological forecasting.
2. Test Profiler hardware designed for commercial production.
3. Provide data for research programs and models.

Profiler Background

As more powerful and sensitive radars were developed in the 1960s, it was found that scattering from refractive turbulence was the source of many clear-air echoes. By the early 1970s, radars sensitive enough to detect backscattered energy from turbulent eddies moving with the mean wind began to provide component wind measurements at different levels. Since then many advances have been made by scientists in the Aeronomy and Wave Propagation Laboratories (WPL) of NOAA/ERL in Boulder, Colorado. They have demonstrated the feasibility of accurately measuring wind profiles from near the earth's surface up to the tropopause. Presently, the WPL operates a network of 4 profiler sites in northeastern Colorado. The Program for Regional Observing and Forecast Services (PROFS) has developed useful display algorithms for these data and have made this output available in real-time to the Denver WSFO.

Principles of Profiler Operation

Wind profilers are basically upward pointing Doppler radars which detect backscatter energy from irregularities in the moisture and temperature fields caused by turbulent eddies. By measuring the shift in the frequency of the backscattered signal, the component of wind toward or away from the radar can be determined. Most wind profiling systems have 3 upward pointing beams. Two are oriented 15 degrees off vertical and along azimuths 90 degrees apart to measure north and east wind components, and a third beam pointed vertically to measure the vertical wind component (Figure 2).

As shown in Figure 2, each of the 3 beams samples a different volume of space. Therefore, uniformity of the wind among the 3 sampled volumes must be assumed in the computations. In order to decrease the effect of fast moving gravity waves and other anomalous disturbances, it's best to time average several wind component measurements at each level. Profile displays at PROFS and WSFO Denver are generally a 1-hour average.

~~The capability of the profiler to accurately resolve heights of the sampled components~~ and to sample over a wide range of heights is dependent upon the profiler's frequency (wavelength). The WPL network in Colorado consists of profilers operating at 50MHz (6m), 405MHz (74cm), and 915MHz (33cm). The longer wavelength profilers are able to sample to greater heights but have poor height resolution. Another

disadvantage of the longer wavelength profilers is that they require considerably more land area. The 50MHz (6m) profiler antennae occupy a 50mx50m grid. As the wavelength is shortened, better accuracy and height resolution can be obtained, but vertical range is decreased. For example, the 915MHz (33cm) has a vertical limit of 10km. The 405MHz (74cm) profiler was developed in 1984 as a compromise and as a potential candidate for a large network of profilers.

In 1986, UNISYS (Sperry) won the contract to build the profilers for the central U.S. demonstrations. These 3-beam profilers will operate at 404.37MHz (74cm). The east/north sampling beams will be 16.3 degrees off vertical, and the profiler will have a vertical range of .5-16.25km. The profilers will be unmanned, designed for all-weather use, and located in remote locations across the central U.S. The tentative schedule calls for the first profiler to be installed in December 1988, with the network complete in April 1990.

Profiler Hub and Communications

The demonstration network will consist of 31 profilers in the field and communication links to a central collection point called the Hub (Figure 3). The Hub, located in Boulder, will be responsible for ingesting the data, quality control, and product generation/distribution. Every 6 minutes, data from 36 levels will be transmitted from each profiler to the Hub via land lines. Data from 10 six-minute periods are then averaged and subjected to quality control algorithms, resulting in an hourly product. Hourly data from profilers will also be sent via GOES to the Hub, serving as a backup in case land communications fail.

Based on research from the WPL profilers, the profiles of the upper level winds should be at least as accurate as rawinsonde profiles. Profiler accuracy has been estimated at $\pm$0.8m/s. Direct comparison of the two instruments is difficult because they operate differently. While profilers measure turbulent spectra within a fixed volume (near vertical) over a short period of time, the rawinsonde winds are derived from tracking a balloon for about an hour. If winds are strong, the balloon may be carried many kilometers downstream before run completion.

Meteorological Products

The profiler's capability for high temporal resolution (one hour or less) is an order of magnitude improvement over soundings available from rawinsonde sites (2/day). From these observations there is the potential to develop a number of meteorologically significant fields in near real-time. As an example, PROFS has developed the following display formats:

- Time-height course sections of winds for each site (Figure 4).
- Kinematic analysis of profiler winds, which displays vertical profiles of relative vorticity, divergence, and vertical velocity as calculated from a triangle of profilers (Figure 5).
- A 3-dimensional vertical stack of winds for each profiling site on a map of Colorado.

- A constant-level plot of wind at all sites for overlay on a satellite image.
- Time variation of vertical profiles of convergence, vorticity, and vertical velocity at a given level.

Summary

The profiler network will be able to provide uniquely new information in considerably greater quantity and in less time than is now possible. It represents a major step in the development of temporal and spatial data sets that will be necessary to provide accurate mesoscale forecasts in the future. Once the demonstration network is installed, there will be a 5-year evaluation period. If successful, the NWS will consider a national network of profilers for operational use.

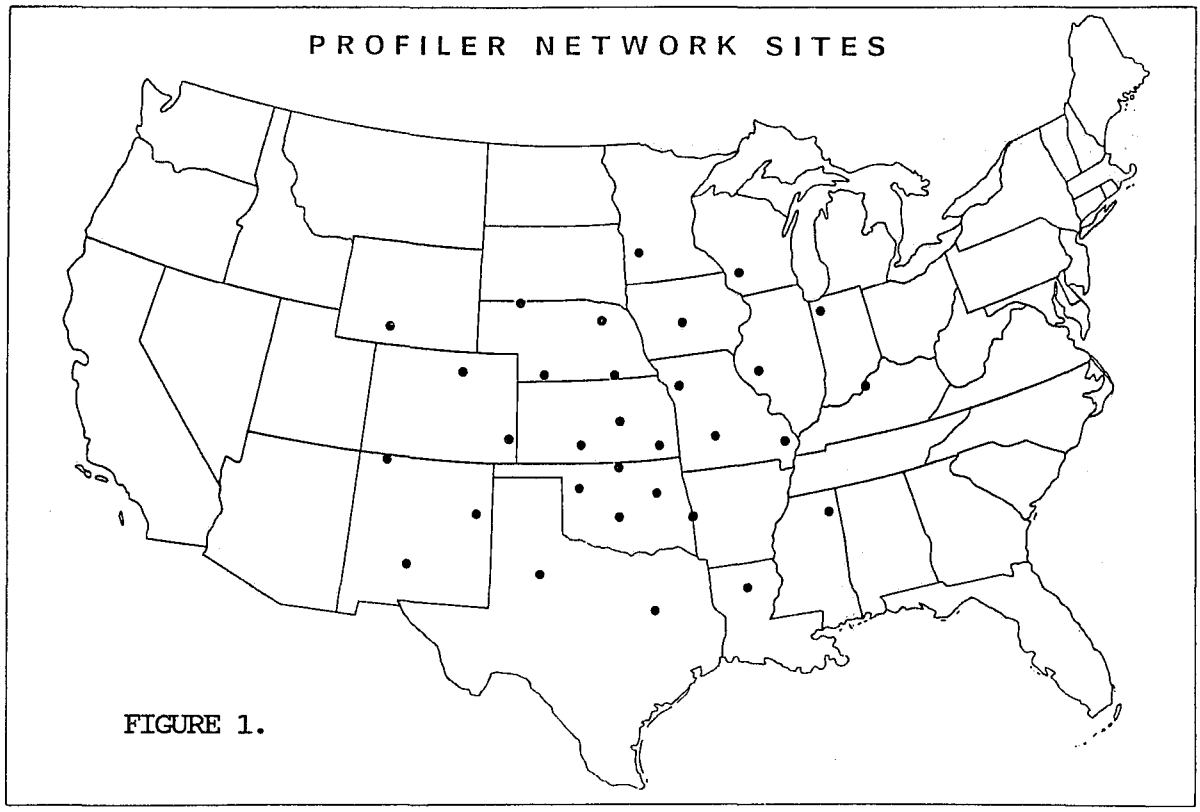


FIGURE 1.

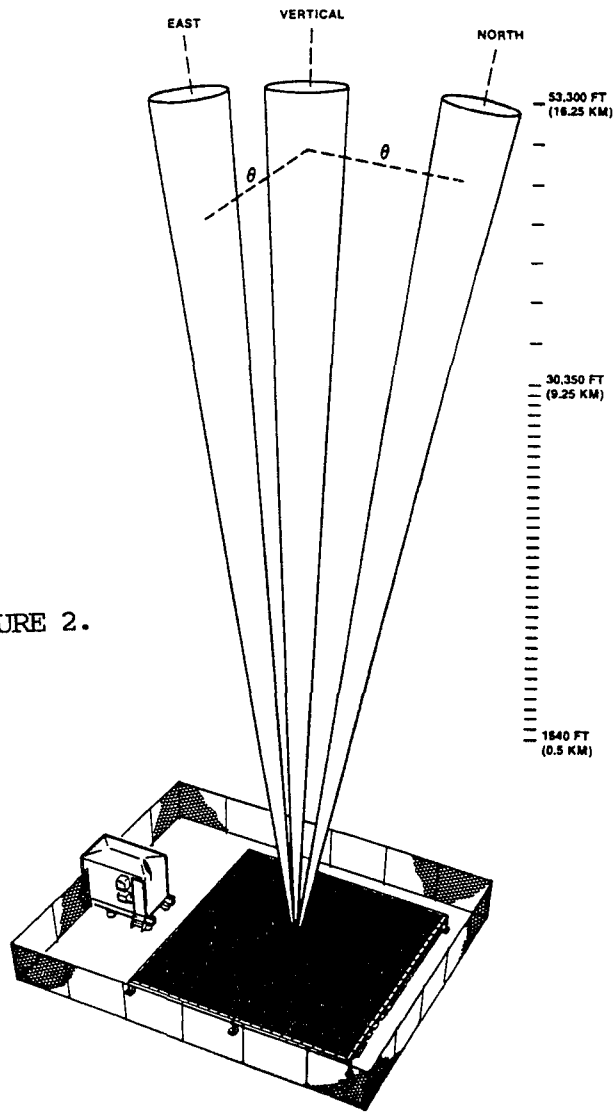


FIGURE 2.

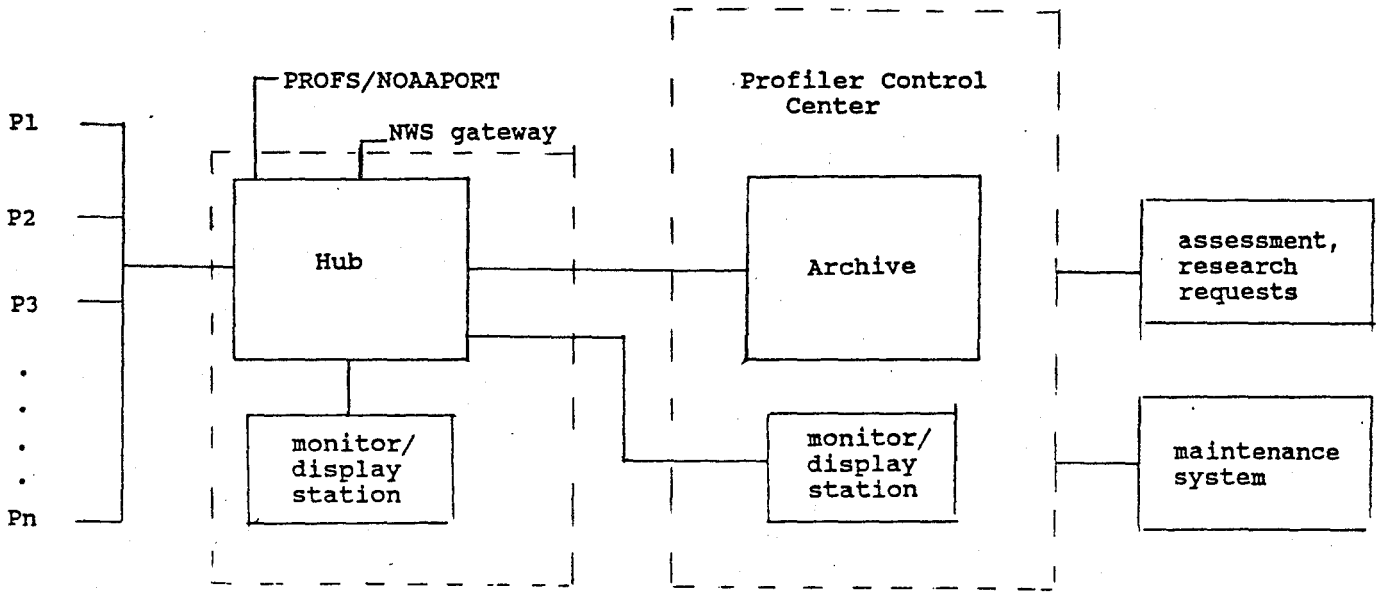


FIGURE 3.

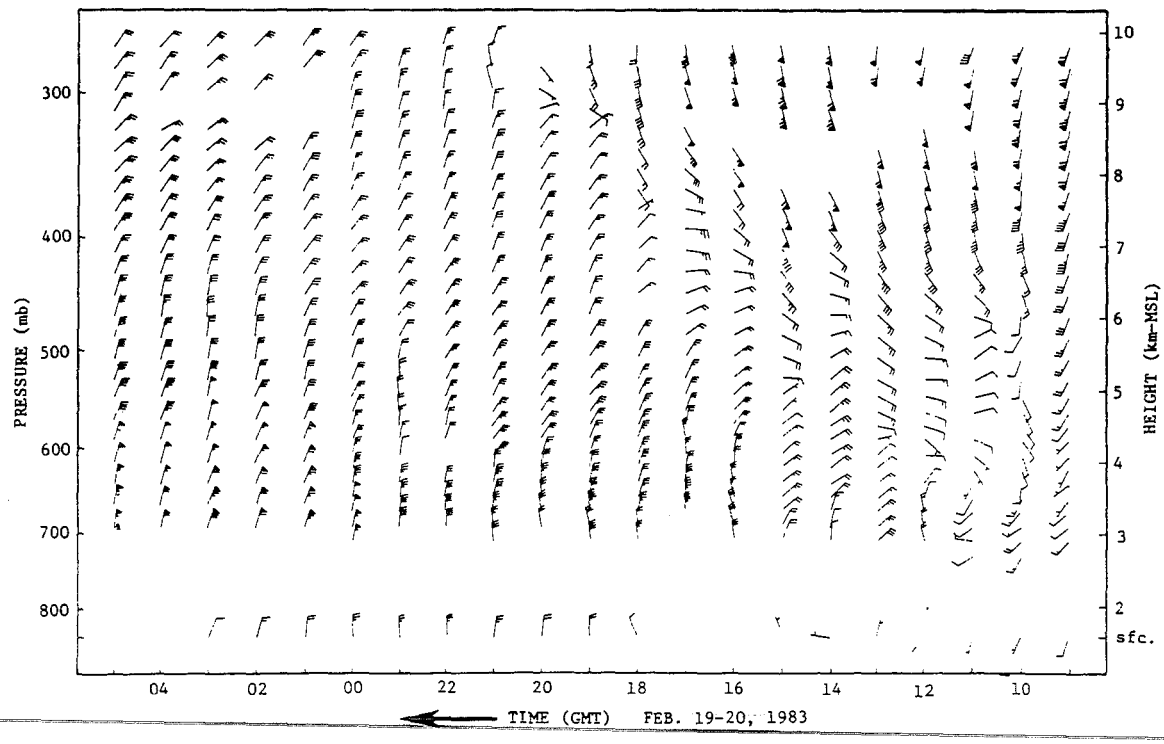
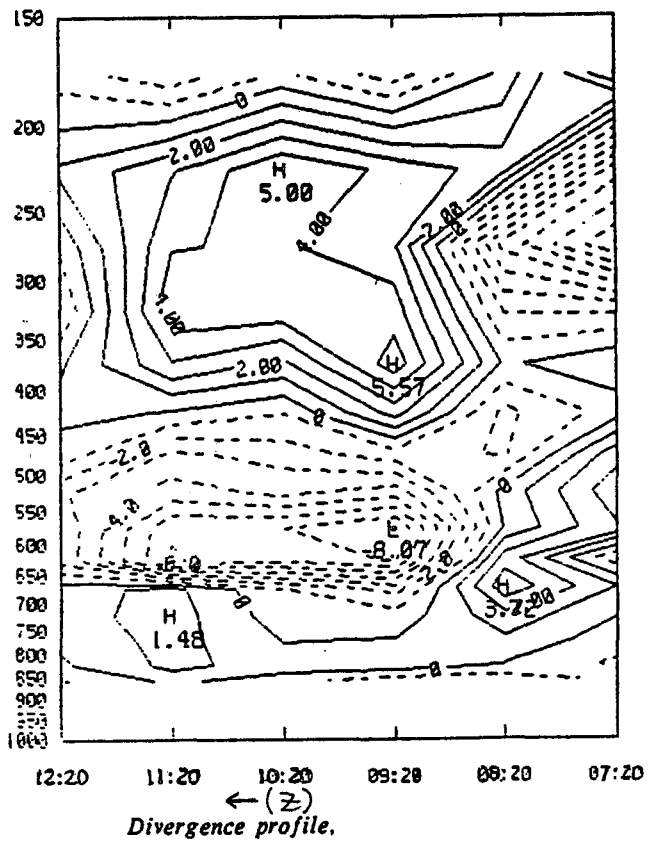
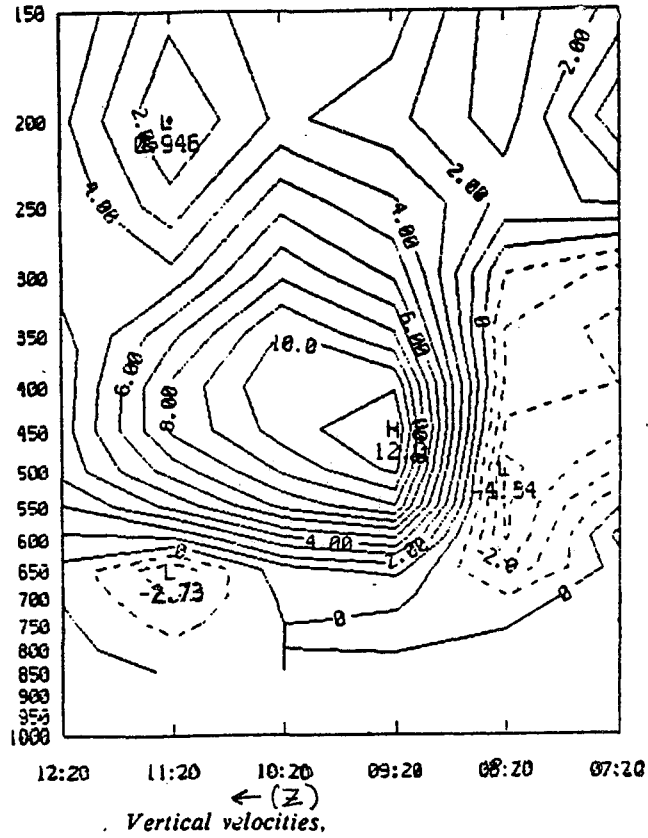


FIGURE 4. - This graphic represents a 24-hour history of 1-hour profile averages for one profiler site in northeastern Colorado. Note the passage of a low level disturbance between 10-12Z and its reflection in the upper levels at later times.



Divergence profile.

A



Vertical velocities.

B

FIGURE 5. - Both (A) and (B) were derived from the profiler network in northeastern Colorado on June 18, 1987. During the evening, a short wave moved through the state triggering nocturnal thunderstorms. Figure 5(A) shows a convergence maximum near 600mb at 0920 UTC. In 5(B) note the rapid shift from downward vertical motion (dashed) to strong upward motion during this same period.