4.1.3 METHODS FOR VERIFYING THE ACCURACY OF WIND PROFILES

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Most of the verification tests of the accuracy of winds measured by UHF or VHF radars have been made by comparing the radar data with radiosonde-measured winds. The results usually "show general agreement" and differences are attributed to the "lack of temporal and spatial simultaneity." There have not been extensive or routine comparisons of radar-measured winds with radiosondes or other wind measurements. One of the reasons that routine radiosonde/radar comparisons have not been made is that the agreement that is obtained depends on the particular wind field that is being observed. This is also true for comparisons with other wind measurements such as those obtained by lasers because the instruments are measuring the winds in fundamentally different ways. For example, the Doppler radar and Doppler lidar do not measure the mean radial velocity of the atmosphere in the resolution volume, but rather measure the reflectivity-weighted average of the radial velocity. This is ignored when the measured radial velocities are converted to horizontal winds. The reflectivity weighting depends on the distribution of refractive turbulence for the clear-air radar and depends on the distribution of aerosols for the lidar. Also, the resolution volumes are usually very different. Another problem in making comparisons is the lack of a standard or truth. Winds measured by radiosonde are often regarded as the true wind; however, in tests where two radiosonde packages were flown from the same balloon, the vector winds measured by the two trackers had rms differences of 3.1 m/s (HOEHNE, 1980). Winds measured by radar or lidar will have much better precision. Therefore, comparisons of radar-measured winds have been made with several types of measurements not only to verify radar data but also to seek a satisfactory comparison method.

Three of the comparisons that have been made with Colorado Profiler radars are summarized below:

Radar/Radiosonde

The 915-MHz radar wind profiler at Denver's Stapleton Airport is located adjacent to the radiosonde launch site of the National Weather Service. Hourly averaged winds measured by the radar can be compared with the twice-daily radiosonde winds. Figure 1 illustrates a comparison that "shows general agreement." Note that in this case the 915-MHz radar did not have enough sensitivity to measure the winds in the core of the jet and that above the jet the radiosonde track was lost. If random cases are examined, poor agreement can also result. However, if the time-height cross section of radar-measured winds shows spatial and temporal changes such as illustrated in Figure 2, poor agreement should be expected since the instruments would be observing very different wind fields. Data from radar and radiosondes are available for two years, and these comparisons are continuing.

Radar/Lidar/Radiosonde

In March 1984, a series of comparisons were made with an infrared lidar (10.6 micrometer wavelength), the 915-MHz radar, and radiosondes. The lidar can measure winds with fixed telescope pointing, the same as the radar, or it can do 360-degree VAD (velocity-azimuth-display) scans. Figure 3 illustrates radar/lidar comparisons. Note that the data are plotted as radial velocities at 75-degree elevation angle. Radar and lidar data are from 10-minute

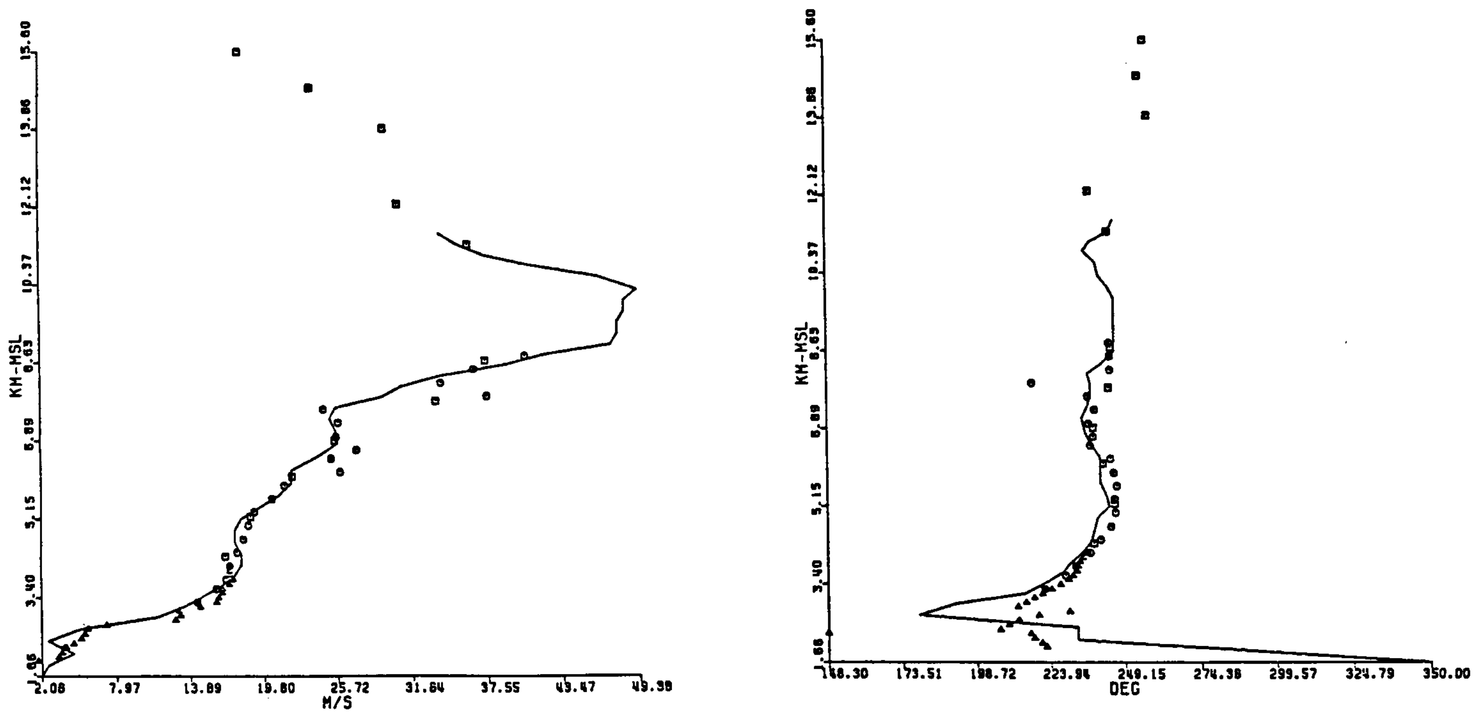

Figure 1. Comparison of radiosonde-measured wind speed (left) and direction (right) with 915-MHz profiler for 12 Z on April 1, 1984. Radiosonde data rate shown in solid lines, 9-μs pulse width profiler data are squares, 3-μs data are circles, and 1-μs data are triangles. Data obtained at the National Weather Service Forecast Office, Denver, Colorado.

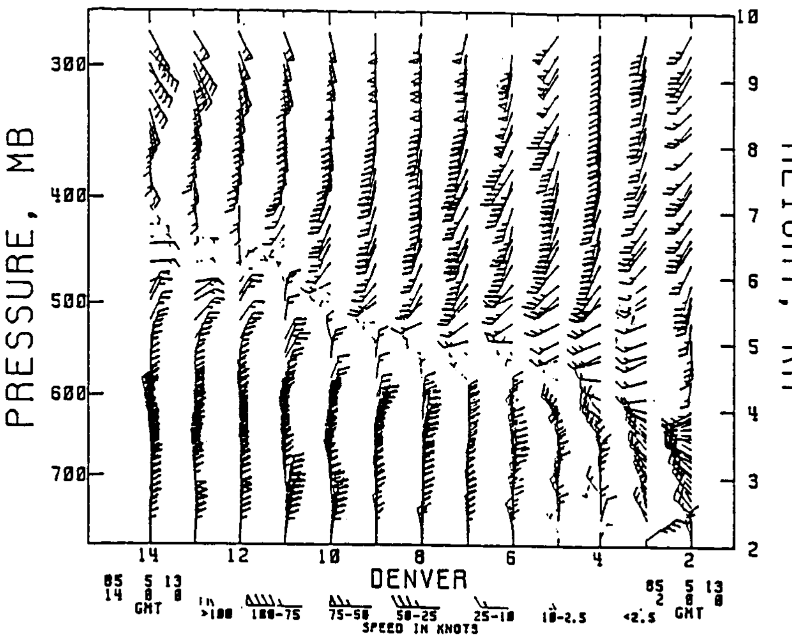

Figure 2. Example of wind profile obtained with 914-MHz radar during frontal passage.

averages. The results of these comparisons (LAWRENCE et al., 1985) show rms differences of about 3 m/s for horizontal wind comparisons for both lidar/radiosonde and lidar/radar. The radar and lidar data sometimes show changes in horizontal wind component speed of several meters per second between 10-min averaging periods.

Radar/Radar

A brief radar/radar comparison of wind measurements was made at Platteville (STRAUCH et al., 1983) using the 50-MHz radar and a 3-cm wavelength meteorological Doppler radar during precipitation. This comparison showed "good agreement." Since January 1985, there have been two profilers colocated at Platteville; a 50-MHz and a 405-MHz system. Both operate in the same modes and measure hourly-averaged winds. In one comparison, shown in Figure 4, the rms difference of horizontal wind components measured at 6.8 km MSL was about 1 m/s for a 5-day period. In general, the comparisons "show good agreement", but the data from the 405-MHz radar are much noisier than from all other profilers. This is believed to be caused by antenna sidelobes, and more of these comparisons will be made after the antenna performance is improved.

There are other comparisons that could be made to attempt to quantify the accuracy of radar wind profiles. Some of these are:

Radar/Aircraft

Routine comparisons of radar-measured winds and winds measured by commercial wide-body jet aircraft equipped with the Aircraft Communications and Reporting System (ACARS) could be made. These aircraft have inertial navigation systems and can derive wind data along the flight track when the

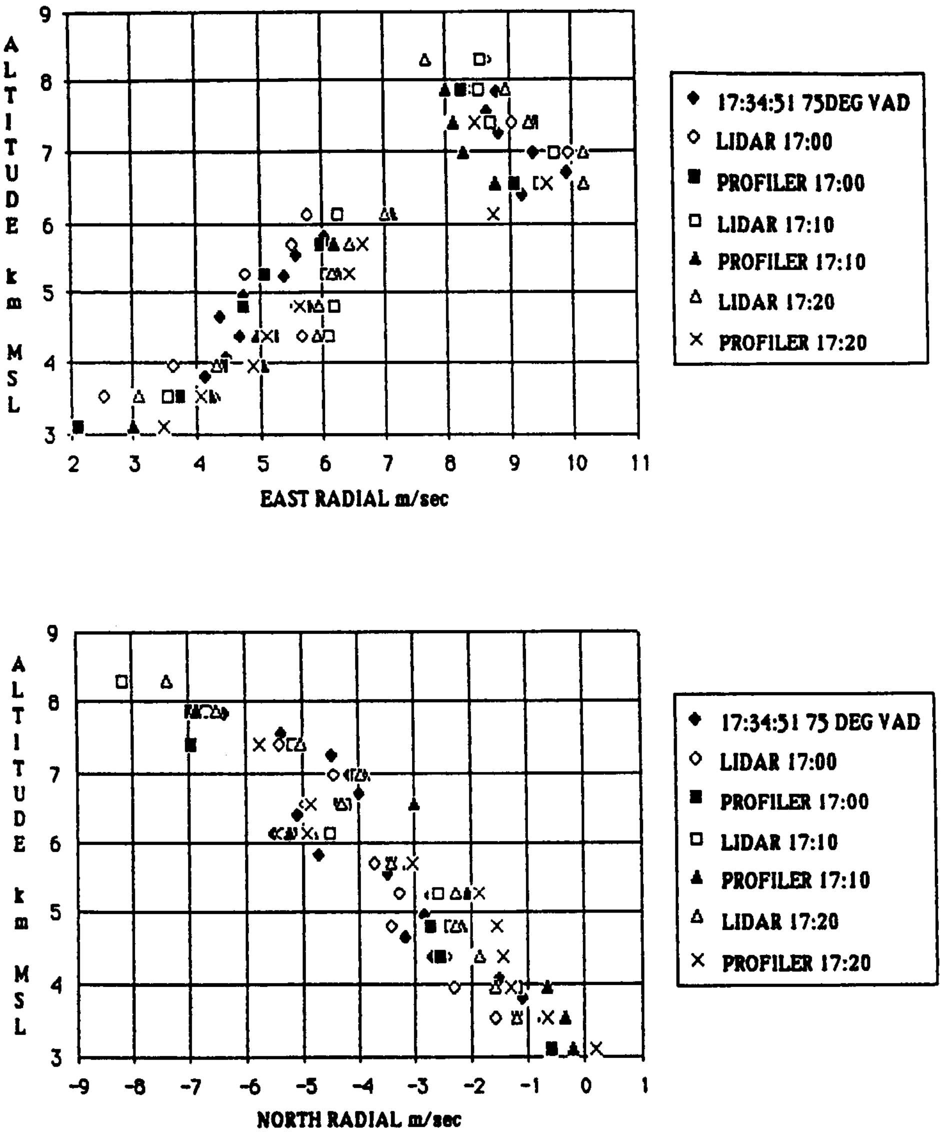

Figure 3. Lidar and 915-MHz profiler radial velocity profiles for 1700-1730 MST on April 12, 1984. Upper: east, 75° elevation radial; Lower: north, 75° elevation radial. Also plotted are lidar VAD data (75° elevation).

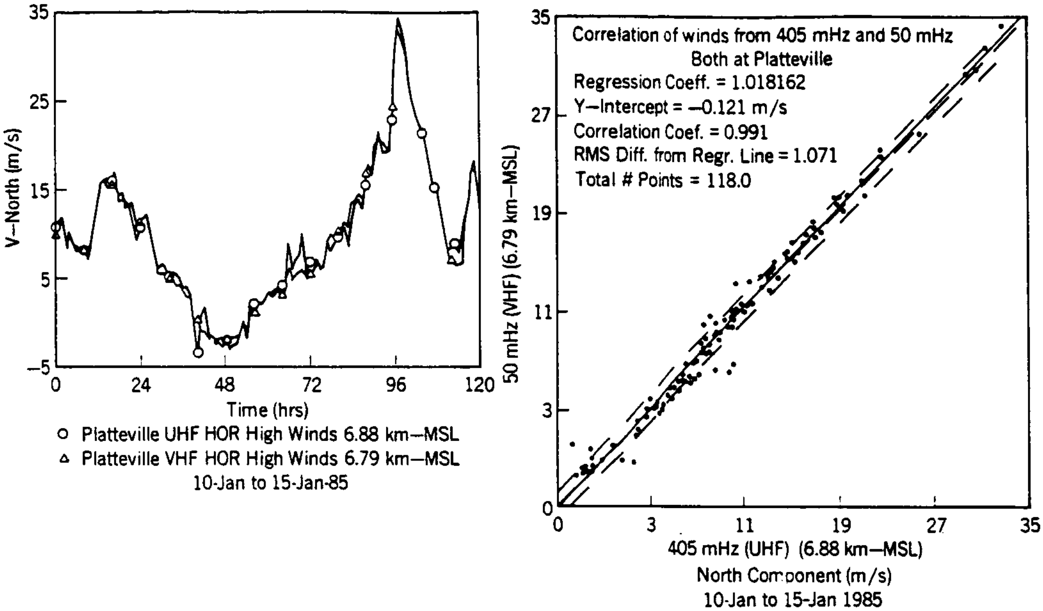

Figure 4. Comparison of north wind component measured with colocated 405-MHz and 50-MHz profilers. Left: 5-day time series of measured values. Right: Scatter plot of measured values.

track is a straight line at constant altitude. These data have not been used for profiler comparisons; they are a potential source of data at altitudes where wind speed is usually high. The aircraft-measured winds may be accurate enough to calibrate the profiler or check the pointing angles of fixed-beam profiles. Research aircraft could also be used for comparison but systematic comparisons would be too costly.

Radar/Meteorological Inference

Wind data from a network of radar wind profilers can be used to calculate divergence and vorticity; a case study was performed by ZAMORA and SHAPIRO (1984), and these calculations were "in agreement" with divergence and vorticity calculated from the radiosonde network. A comparison of winds or quantities derived from wind data obtained by a network with radiosonde data may yield a better accuracy determination than comparisons of individual profiles because the differences in temporal and spatial averaging will be less important when averaging over large areas. Data from a radar network could also be tested for accuracy by initializing models with current radar-measured winds and comparing model predictions with later data. This type of comparison should be tried in simple terrain (such as Eastern Colorado, where two 50-MHz profilers are collecting data routinely) and in simple flow regimes.

Radar/Scanning Radar

A fully scannable clear-air radar measuring wind profiles with VAD analysis at various elevation angles may be the best standard available for radar wind data. It would be especially valuable for calibrating fixed beam systems that use temporal integration rather than spatial integration to obtain representativeness and whose actual pointing angles are difficult to measure.

The antenna pointing angles of a scanning system can be checked using the sun as a source. The scanning system would operate at UHF to keep antenna size manageable and so there would be no pointing uncertainty due to aspect sensitivity. The effects of vertical motion and divergence on radar-measured winds could be assessed. Plans are being made to convert a relatively low-power 405-MHz radar to a scanning system that should be able to measure winds in the clear air to 7-10 km. It is hoped that such a radar would provide data that would be accepted as "true" wind data because it would have temporal resolution of about 5 min and height resolutions of less than 100 m as well as continuous scanning. In addition to calibration of other profilers, such a system would be a mesoscale wind profiler with many potential applications as a stand-alone (as opposed to part of a network) wind profiler.

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