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ASSIMILATION OF RADIOSONDE-BASED VERTICAL WIND PATTERNS TO IMPROVE WIND PROFILER RETRIEVALS

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1. INTRODUCTION

Accurate, real-time upper level wind measurements can provide essential input into operational mesoscale models for their initialization and verification. In aviation and spacecraft flight planning, accurate upper level winds are important to the safety of pilot and passengers aboard. Although there are a number of ground based wind profilers available (wind tracer lidar, Doppler radar, and acoustical sounders), measuring upper level winds can be problematic and is highly dependent on favorable atmospheric conditions. Current methods to obtain wind velocity profiles include satellite-based data, thermal wind approximations, cloud tracking (Nieman et al, 1997), and moisture field tracking (Velden et al, 1997). Each of these methods can provide useful information for some synoptic scale applications but each one has certain limitations.

Early research conducted early 1990's (Measure & Yee, 1992) demonstrated the value of using historical radiosonde data sets to infer real-time measurements of temperature profiles. The success of these earlier studies prompted wind vector retrieval studies using satellite radiances (Cogan, etal, 1998). Those experiments had yielded mixed results because of varied spatial volumetric sampling. Current studies involve the assimilation of historical radiosonde data with real-time wind profiler measurements. The premise is that under severe weather conditions it can be very difficult to obtain complete vertical wind profiles. For specific locations, local terrain characteristics may produce predictable vertical wind patterns that can be captured by assimilation of radiosonde and wind profiler measurements.

In this paper, we describe a methodology to improve wind profiler retrievals by assimilating radiosonde-based vertical wind patterns. The concept is to retrieve reliable and continuous upper level wind information from incomplete or limited range wind profiler measurements. In particular, the objectives are (a) to extend the vertical measurement range of wind profilers, (b) to provide complete, continuous vertical wind profiles from fragmented wind measurements, and (c) to improve the accuracy of present day wind profiler systems. A typical wind profiler scenario in which radiosonde-based wind patterns for a specific geographical location will be outlined.

2. ATMOSPHERIC WIND PROFILERS

Typical wind profilers with various characteristics are shown in figure 1. The three major systems are based on Doppler Lidar, radar, and acoustics. One of the salient features of wind profilers, in general, is that they can provide continuous measurements without the extra expenditure of resources that a radiosonde would require. Satellite measurements can collect wind information at higher atmospheric levels but the accuracy is not sufficiently adequate for operational processing.

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Wind Profiler	Description	Maximum Range	Range Resolution
CTI Doppler LIDAR	- Eye safe infrared laser source - 2.0µm wavelength - 2 mJ pulse energy - 500Hz Pulse Rate Freq - VAD scans - Attenuation by clouds	<10 km	60 meters
924 MHz Wind Radar	- Phased array radar - Consensus processing - 10-30 minutes integration time - typical range 3-4km	<7 km	100 meters
SODAR	- Acoustical source - 300 vertical layers - 2.85-4.75 Hz freq - 5 min integration period	<2 km	5-100 meters

Figure1. Summary of various characteristics of several different types of wind profilers.

3. PROCEDURAL OUTLINE

An overview of the assimilation procedure is shown in figure 2. The procedure would involve the collection of coincident wind profiler data and rawinsonde data. These data would be filtered via algorithms that screen the data for missing fields and defective data records. If data is missing in any of the training set's data fields, that individual test case, ie wind profile, will be rejected for the purpose of training or testing. After extracting the wind direction and wind speed for selected height levels of interest, the wind parameters will be converted to U components (East-West) and corresponding V components (North-South) of the wind.

To identify specific vertical wind patterns for a geographical location, synoptic-scale and mesoscale-scale information must be collected, assembled, and matched with the corresponding wind profiler and rawinsonde data sets. The wind profiler measurements can be taken continuously but the rawinsonde wind data can take over an hour to complete its profile. Thus exact matching is not possible but if the vertical wind pattern is predictable and persistent as in certain atmospheric conditions such as sea breezes over land and downslope winds from mountains, there should be reasonable correlation

4. PLANNING AN EXPERIMENTAL STUDY

The first step to developing meaningful algorithms to improve wind profiler retrievals is to obtain an adequate data set of coincident measurements from an operational radiosonde site and a continuously operated wind profiler. Since there was only a small data set of coincident wind radar profiles and rawinsonde wind profiles, one can select a specific site with known characteristic vertical wind patterns. These wind patterns may be seasonally dependent or diurnally dependent.

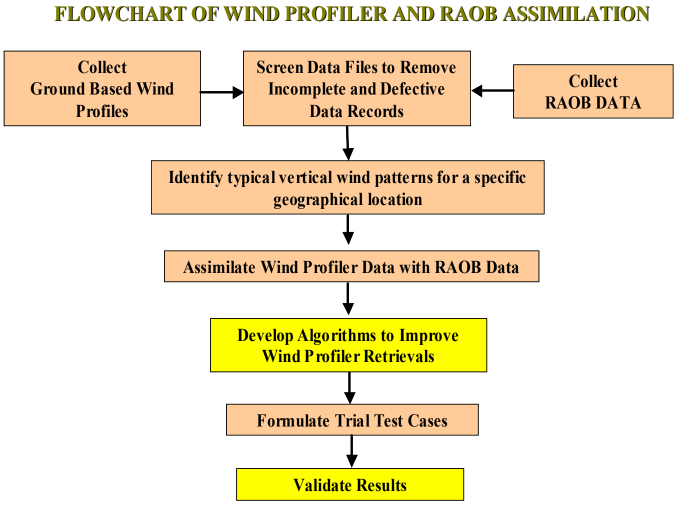

Figure 2. Flowchart of the assimilation procedure to retrieve upper level winds

5. FEASIBILITY

To show the feasibility of the methodology, a study of vertical winds between two different atmospheric levels was investigated. For this analysis, winds at 400mb were compared to the corresponding 700mb winds at El Paso, Texas. Archived rawinsonde soundings from the National Climatic Data Center for (1957-1994) was used to conduct this analysis. El Paso is approximately 60 miles from the White Sands Missile Range, NM (latitude 31.84N, longitude 1.06.40W). Data for both the 0000 UTC and the 1200 UTC cases were included in the assembled data sets.

Figure 3 is a scatter diagram showing the results of a neural network derived U component winds at 400mb versus the corresponding rawinsonde U component wind at the same height level. Figure 4 is a scatter diagram showing similar comparisons for the V component of the winds at 400mb level. The RMS error for the U component of the wind in the testing set was 9.1 m/s and the RMS error for the V component of the wind was 8.3 m/s. Comparing the ground-based derived winds at 400mb with previous derived winds from satellite radiances at the same height level, the RMS errors are comparable for the U component but there appears to be better correlation for the ground-based derived V component winds over the satellite derived V components.

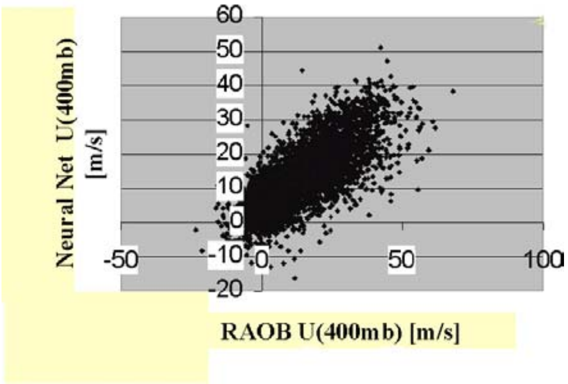

Figure 3. Scatter plot of the neural net retrieved U component of the winds at the 400mb height versus the radiosonde measured U component of the winds at 400mb.

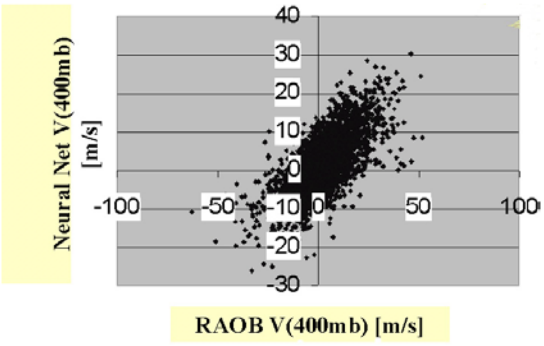

Figure 4. Scatter plot of the neural net retrieved V component of the winds at the 400mb height versus the radiosonde measured V component of the winds at 400mb.

6. CONCLUSION

Accurate real-time upper level wind measurements provide essential input into operational forecast weather models for their initialization and verification. Although there are a number of ground-based wind profilers available (wind tracer lidar, doppler radar, and acoustical sounders), measuring upper level winds and obtaining a complete continuous vertical wind profile can be problematic and is dependent on favorable atmospheric conditions. In this paper, we described a methodology to improve wind profiler retrievals by assimilating radiosonde-based vertical wind patterns. The concept is to retrieve reliable and continuous upper level wind information from incomplete or limited range wind profiler measurements. In particular, the objectives are (a) to extend the vertical measurement range of wind profilers, (b) to provide complete, continuous vertical wind profiles from fragmented wind measurements, and (c) to improve the accuracy of present day wind profiler systems.

To demonstrate the feasibility of this procedure, a large training and testing set was extracted from the NCDC archived radiosonde data of North America (1957-1994) for a single location (El Paso, Texas, 32.0N latitude, 106.6W longitude). The 700mb level winds were used as input into the neural network to derive the 400mb level winds in the preliminary simulation runs.

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