1.2.4 COMPARISON OF VERTICAL VELOCITIES ANALYZED BY A NUMERICAL MODEL AND MEASURED BY A VHF WIND PROFILER

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1. INTRODUCTION

The use of wind profilers for measuring vertical velocities in the troposphere and lower stratosphere is potentially of great interest for verification of forecasts, diagnosis of mesoscale circulations, and studies of wave motions. The studies of profiler vertical velocities to date (ECKLUND et al., 1981; LARSEN and ROTTGER, 1982; NASTROM et al., 1985; DENNIS et al., 1986) have shown that the observed patterns of ascent and subsidence are reasonable when compared to the synoptic conditions. However, difficulties arise when a direct verification of the profiler vertical winds is sought. Since no other technique can measure the vertical velocities over the same height range and with the same claimed accuracy as the profilers, direct comparisons are impossible. The only alternative is to compare the measurements to analyzed vertical velocity fields.

In this paper, we will compare vertical velocity measurements made with the SOUSY VHF radar over a period of 11 days at the beginning of November 1981 to the analyzed vertical velocities produced by the European Centre for Medium-range Weather Forecasting (ECMWF) model for grid points near the radar site.

2. PREVIOUS STUDIES

A number of studies have compared the overall characteristics of the measured vertical velocity fields to the synoptic conditions (e.g., ECKLUND et al., 1981, 1982; LARSEN and ROTTGER, 1982; NASTROM et al., 1985; DENNIS et al., 1986) and have found the expected trends. Thus, upward velocities were generally on the warm side of the front and downward velocities on the cold side. Also, the variability in the vertical velocities was found to increase in connection with flow over nearby mountains, as opposed to prevailing winds coming from the direction of flatter terrain.

Only one study that we are aware of has compared the measured vertical velocities to the analyzed vertical velocity fields (NASTROM et al., 1985). NASTROM et al. (1985) used measurements made with the VHF radar located at Platteville, Colorado, and a temporary installation of three VHF radars located in the Rhone Delta in connection with ALPEX. Radiosonde data were the basic input to the analysis scheme which used the quasi-geostrophic omega equation, the kinematic method, and the adiabatic method to calculate the vertical velocity expected at the radar sites. The conclusion of the study was that the measured velocities were generally many times larger, and sometimes an order of magnitude larger, than the calculated values, although there was general agreement between the measured and calculated directions. Perhaps the

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difference in the magnitudes is not surprising because the radar measurements are most likely associated with a smaller spatial scale than the vertical velocity analysis. However, we will show that better agreement is possible when a more sophisticated analysis scheme is used.

3. DESCRIPTION OF THE DATA SET

The radar data consists of vertical velocity measurements made with the SOUSY VHF radar located in the Harz Mountains near Bad Lauterberg, West Germany. Data used in the comparison cover the period from November 1-11, 1981, and have a height resolution of 300 m above 3 km. The radar was operated for 12 min beginning on the hour. A vertical wind profile was produced every minute while the radar was operating, and 12 values were averaged to produce an hourly wind profile. Only a few hours of data were missing during the 11-day period.

The ECMWF data consists of analyzed vertical velocities at the 6 grid points nearest the radar site. The model analysis uses the 12-hour model integration as the initial guess and updates the analyzed field once every 6 hours based on the standard meteorological observations, including radiosonde data, pilot reports, satellite cloud motions, etc. (DELL'OSSO, 1984). The analysis scheme is a normal mode initialization procedure which includes the divergent motions associated with those gravity wave modes allowed by the dynamics of the model. Vertical velocity data were available at all the standard levels up to 70 mb.

4. MODEL AND RADAR COMPARISON

The synoptic situation during the 11-day period of the comparison has been described in much greater detail by DENNIS et al. (1986) in this volume. However, Figure 1 shows the radar reflectivities for the period with the location of the frontal zones indicated by dashed lines. The location of the fronts was determined by analyzing a combination of the surface and upper air maps, the potential temperature cross sections, and the radar reflectivities.

Figure 2 shows the comparison of the radar vertical velocities and the analyzed vertical velocities at nine standard levels from 700 to 70 mb. The radar data are the barbed wire and the model analysis is indicated by the solid line. The "hourly" radar data were averaged over a period from three hours before to three hours after the model analysis time in order to decrease the smaller time scale variations in the radar data.

The comparison shows that the amplitude of the radar and model velocities are close in magnitude. The analysis used here produced vertical velocities 3 or 4 times larger than the velocities produced in the analysis used by NASTROM et al. (1985). The overall trends in both sets of velocities are the same, but there are short periods when the variability is larger and there are more significant discrepancies. A comparison between Figures 1 and 2 shows that periods when the disagreement is most pronounced are associated with times of frontal passages. Finally, the variance of the vertical velocities can be seen by inspection to decrease in both the radar and model data above the tropopause.

5. CONCLUSION

Our comparison of analyzed model vertical velocities and vertical velocities measured with a VHF wind profiler have shown good agreement in both the overall magnitude and general direction. The most prominent discrepancies occur at times of frontal passages. An earlier study by NASTROM et al. (1985) which used a cruder analysis scheme did not find such good agreement with

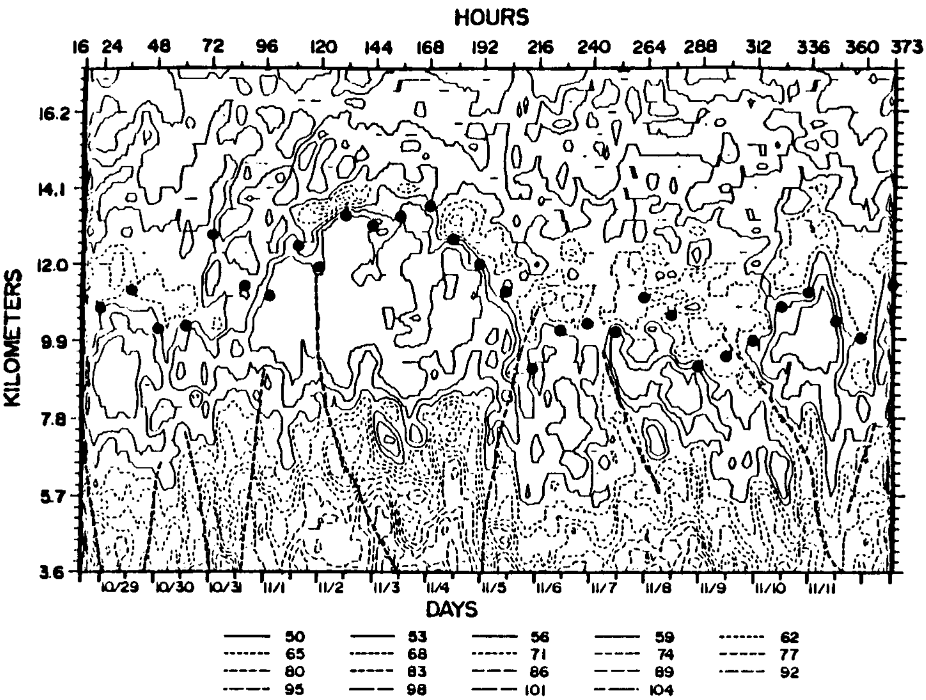

Figure 1.

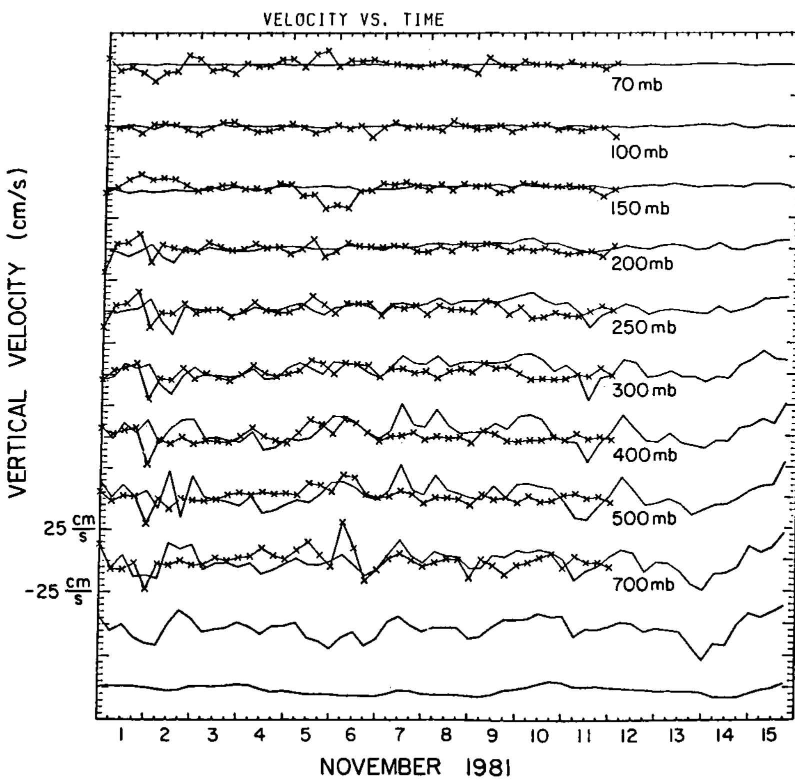

Figure 2.

respect to the amplitudes. The implication is that the more sophisticated normal mode analysis used by ECMWF preserves more of the divergence in the analyzed fields and this leads to an improved estimate of the vertical velocities.

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