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1.4.1 THE INFLUENCE OF VELOCITY VARIABILITY ON THE DETERMINATION OF WIND PROFILES

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High sensitivity radars allow the determination of velocity estimates at time resolutions down to one minute or better. Because of the variability introduced to the mean wind due to turbulence and waves, the high resolution profiles may not be too useful for forecasting applications, although they yield the most realistic estimate of the instantaneous wind profile. Figure 1 shows profiles of wind speed and direction, vertical velocity and echo power, which were deduced in real-time on 23 August 1981 with the spaced antenna drift mode of the SOUSY-VHF-Radar (ROTTGER, 1984). Whereas these profiles were measured within 1 minute, the operating routine allowed the selection of variable (longer) measuring periods, and one has to search for the optimum duration of the data averaging period.

Figure 2 shows a high time resolution wind vector diagram which gives an idea of the temporal variability (from ROTTGER, 1981a). The data were obtained with the spaced antenna technique, which allows a good estimate of the horizontal wind without having to correct for the vertical velocity component. The wind vectors of Figure 2 specifically indicate a quasi-periodic variation in direction. This is assumed to be due to gravity waves since also the vertical velocity (Figure 2b) shows periodical variations with the same period.

In addition to the variability due to waves we have to regard the variability due to turbulence as well as the variability introduced to the analysis due to statistical variations of echo power and correlation time. We have applied very stringent selection criteria, allowing only 5% of the latter "instrumental" or "analysis" effects diluting the data when deducing the distributions of wind speed and direction (Figure 3). These results indicate that the meteorological variability (due to waves and turbulence) can still be up to several 10% of the centre value, even at these fairly low wind velocities. Less stringent criteria allow a display of the total profile but introduce larger "analysis" variability (see Figures 4 and 5 of ROTTGER and CZECHOWSKY, 1980).

The selection or quality criteria (for the spaced antenna method: the relative difference between time lags around the spaced antenna triangle, the amplitude of the cross correlation maximum and the signal-to-noise ratio) can be used to weight the significance of velocity estimates when deducing a mean profile. In all our analyses only median values were used instead of mean values, since this procedure disregards large singular deviations which may occur due to analysis or meteorological effects (e.g., at 9:22 UT above 21 km in Figure 2). We also use half the difference between the upper and lower quartile instead of the variance. If the selection criteria did discard all data in one range gate, a spline function was used to interpolate these data. This procedure yielded mean wind velocities, which are shown in the profiles of Figure 4 and the time series of Figure 5. The consistency of these spaced-antenna VHF radar results with the radiosonde data allows us to be convinced that the method, which is only briefly outlined in this note, is quite suitable for wind profiling applications.

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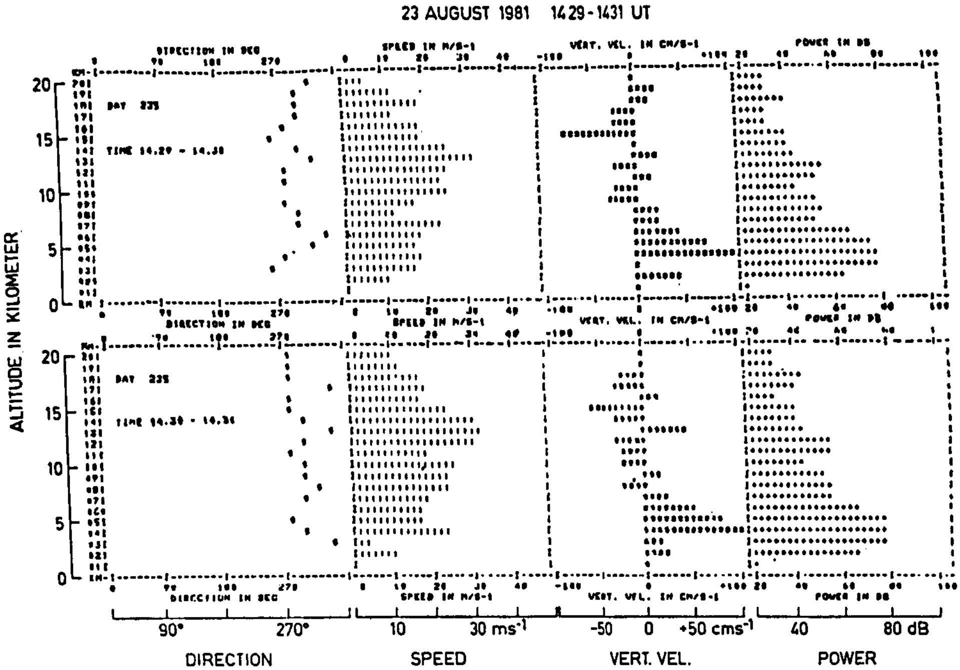

Figure 1. First real-time velocity and power (reflectivity) profiles recorded at intervals of 1 minute with the spaced antenna drift mode of the SOUSY-VHF-Radar: instantaneous wind direction and speed, and vertical velocity. The power profile allows an immediate determination of the tropopause height (here 10 km), defined by an intermediate power increase larger than 10 dB (ROTTGER, 1984).

The averaging time period T_v, to obtain a mean velocity profile, should be determined by the characteristic time scale τ_v of the velocity fluctuations. The time scale τ_v can be deduced form the time lag τ at which the autocovariance function of the velocity time series has fallen to a specified (absolute) value. In order to reduce the statistical variations due to turbulence, waves and analysis uncertainties, the averaging time T_v must be larger than the characteristic time τ_v. The latter can be deduced in real-time allowing to select also the velocity averaging period T_v in real time. Since a short time τ_v can be due to highly turbulent fluctuations, their large rms variations have to be smoothed out by averaging over a sufficiently large number of samples. Typical averaging time periods are between 5 and 30 minutes (Figure 5).

On the other hand, we also have to use as good a height resolution as possible, because serious velocity errors can occur when applying too coarse a height resolution. As was shown by SATO and FUKAO (1982), the wind velocity is considerably biased (of the order of 10 ms^{-1} for resolution of 3 km) when the wind shear is large and the echo power profile has strong gradients within the resolution volume. An appropriate height resolution appears to be 150-300 m.

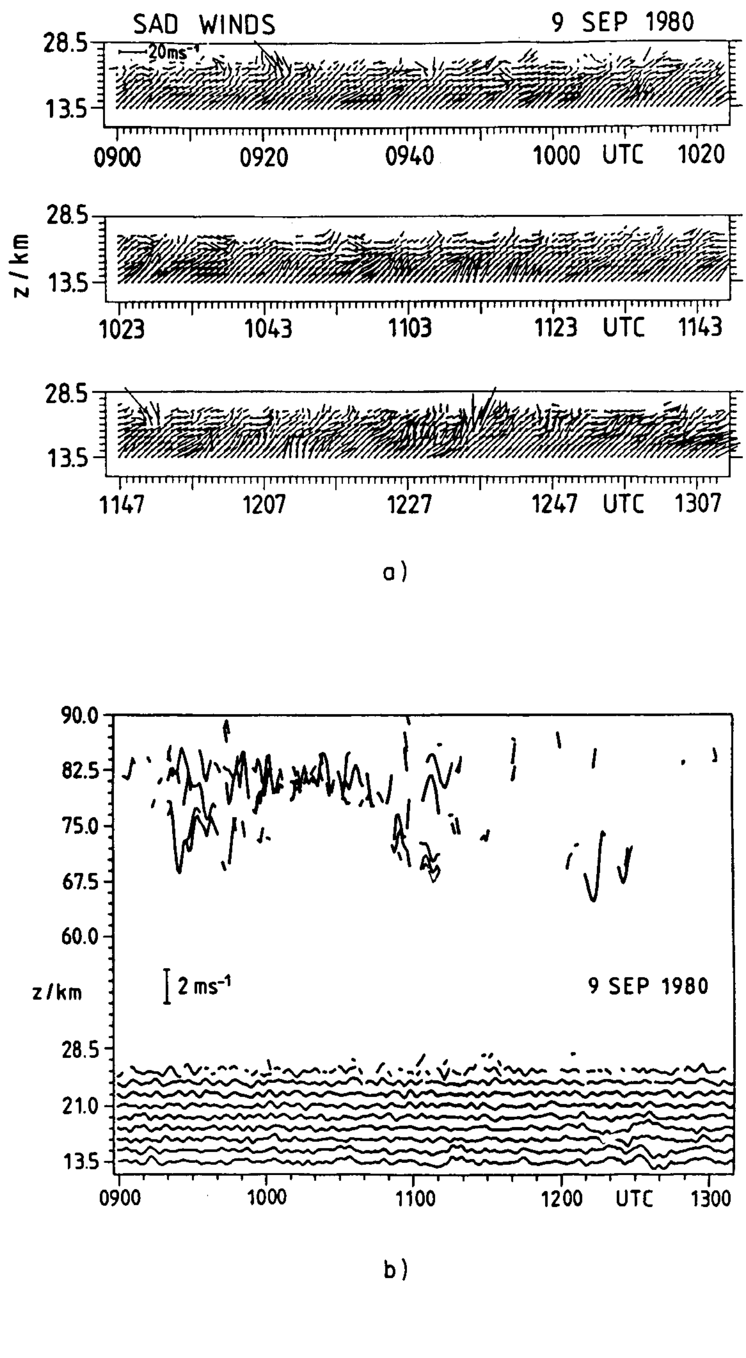

Figure 2. Vector field of horizontal velocity component (a) and corresponding time series of vertical velocity (ROTTGER, 1981a).

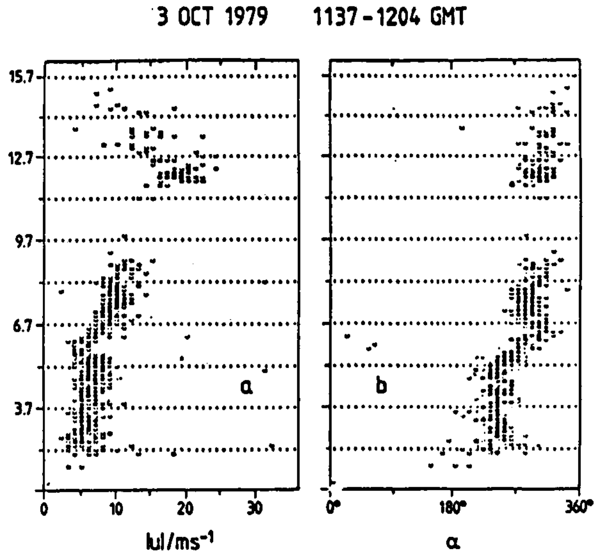

Figure 3. Meteorological variability of wind speed |u| and direction α, measured with the spaced antenna method (ROTTGER and CZECHOWSKY, 1980).

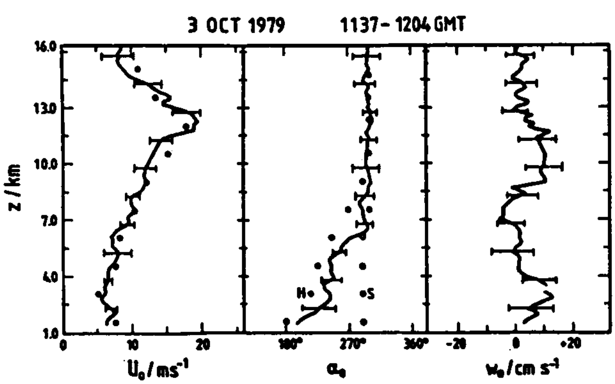

Figure 4. Mean profiles of wind speed U_o, direction and vertical velocity W_o. Circles are radiosonde data, north and south of the radar location (ROTTGER, 1981b).

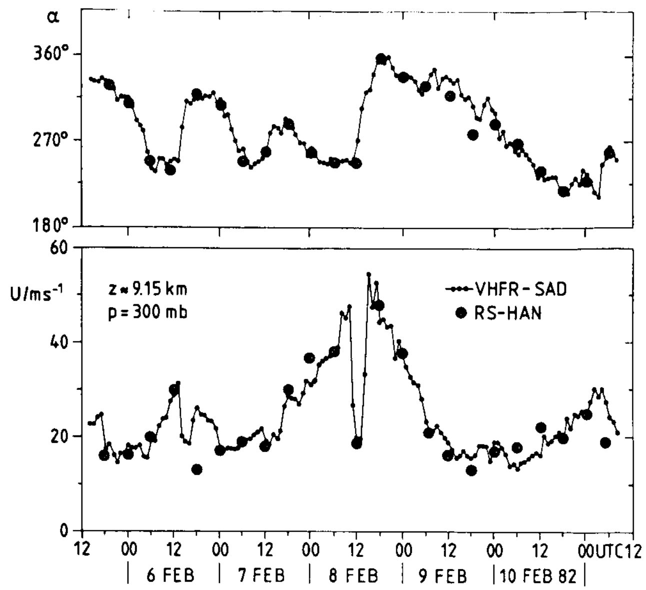

Figure 5. Wind speed U and direction α measured during 12 minutes every hour with the spaced antenna method and radiosonde data (ROTTGER, 1983).

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