2.3B SPECTRAL CHARACTERISTICS OF THE RETURN

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Doppler spectra of VHF radar returns typically indicate a Gaussian background shape with superimposed spikes as shown in Figure 1. Here an average of 10 Doppler spectra is shown which was calculated from a time series of 7 min of complex data. One accepts a proper Gaussian fit to the background distribution neglecting the strong amplitude spikes. If this background distribution is due to beam width broadening, either diffuse reflection or rather isotropic scattering is required. If beam width broadening is neglected (mean winds were only 2 m s^{-1} during this observation, which supports this assumption), the width of the distribution σ_S is given by turbulent velocity fluctuations $\sigma_W = \sigma_S/k$, where $k = \frac{4\pi}{\lambda}$. For each frequency bin the amplitudes A are Rayleigh distributed. The standard deviation around a mean amplitude $\bar{A}$ is $s_A = 0.8\ \bar{A}/\sqrt{N}$, where N is the number of averaged spectra. Any amplitudes that scatter around $\bar{A}$ by more than $2s_A = 0.5\ \bar{A}$ are not due to scattering from Gaussian-distributed irregularities (with a significance of 95%). Some amplitude spikes exceed the $2s_A$ limit, and we have to assume that these are due to Fresnel reflection. The discreteness of these spikes points to several distinct reflectors moving with radial velocity $w = \omega_o/k$, where ω_o is the frequency interval where the spikes are observed. It is assumed that the spikes result from reflection at different parts of a corrugated refractivity structure, which is consistent with the model of diffuse refelection. The scattered contribution C_s^2 is the integral over the power of the Gaussian background distribution, whereas the reflected contribution C_r^2 is the integral over the remaining spikes. From the spectrum shown in Figure 1 we estimate $C_r^2/C_s^2 \sim 0.3$, i.e. the reflected component is about 1/3 of the scattered component.

One may infer from the Doppler spectrum shown in Figure 1 that an interpretation of a "vertical" velocity has to be carefully examined. The spikes, caused by diffuse reflection from corrugated surfaces, may shift considerably the mean value of the spectrum. For a tilted surface of reflection the interpretation can become even worse if one does not measure the incidence angle to correct for off-vertical velocity components. It is assumed that the amplitude spikes due to diffuse reflection indicate a Gaussian frequency distribution such as for the amplitudes due to scattering. However, the mean spectral distribution of spikes must be calculated for a much longer time interval than is needed to determine a turbulence spectrum. This time interval to calculate the distribution of spikes may be much longer than the typical time scales of vertical velocity changes (e.g., due to gravity waves).

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The spectral width of the returned signals is a measure of the rms velocity fluctuations in the scattering region. It has been discussed by ROTTGER et al. (1979) that thicker structures have a larger spectral width, hence larger rms velocity fluctuations. On the average the rms velocity fluctuation σ_w found in blobs and sheets below 69 km is ±0.7 m s^{-1} (corresponding correlation time τ = 4 s), whereas the thicker layers exhibit the largest velocity fluctuations σ_w = ±1.7 m s^{-1} (τ = 1.6 s). This confirms the conjecture relating rms velocity fluctuations and structure thickness, which is based upon a turbulence interpretation. Since thin structures, viz. blobs and sheets, predominantly

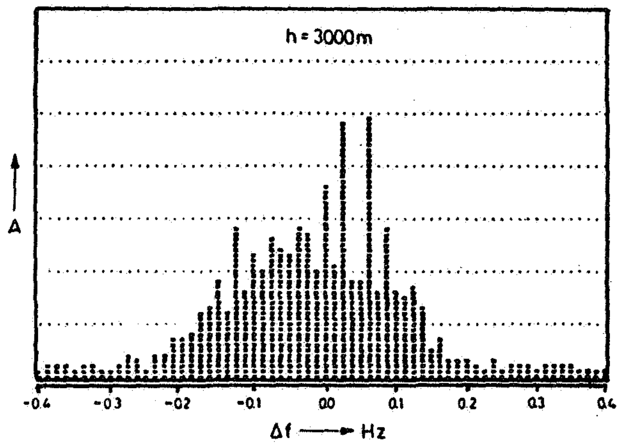

Figure 1. Doppler spectrum measured with vertically pointing antenna. Δf is the Doppler frequency, and A the amplitude in arbitrary units.

occur at lower heights and layers occur at larger heights, an increase in velocity fluctuation with height is in agreement with studies of turbulence by ZIMMERMAN and MURPHY (1977) and 2-3 MHz partial-reflection studies (VINCENT and BELROSE, 1978) that layer thickness (as opposed to the height of occurrence) gives a reasonable indication of the velocity fluctuation to be expected.

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