P.9 MEASUREMENT OF VERTICAL VELOCITY USING CLEAR-AIR DOPPLER RADARS

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We have constructed a new clear-air Doppler radar, called the Flatland radar, in very flat terrain near Champaign-Urbana, Illinois. The radar wavelength is 6.02 m. The radar has been measuring vertical velocity every 153 s with a range resolution of 750 m almost continuously since March 2, 1987. We find that the variance of vertical velocity at Flatland is usually quite small, comparable to the variance at radars located near rough terrain during periods of small background wind. The absence of orographic effects over very flat terrain suggests that clear-air Doppler radars can be used to study vertical velocities due to other processes, including synoptic scale motions and propagating gravity waves. For example, near rough terrain the shape of frequency spectra changes drastically as the background wind increases. But at Flatland the shape at periods shorter than a few hours changes only slowly, consistent with the changes predicted by Doppler shifting of gravity wave spectra. Thus it appears that the short-period fluctuations of vertical velocity at Flatland are almost entirely due to the propagating gravity waves.

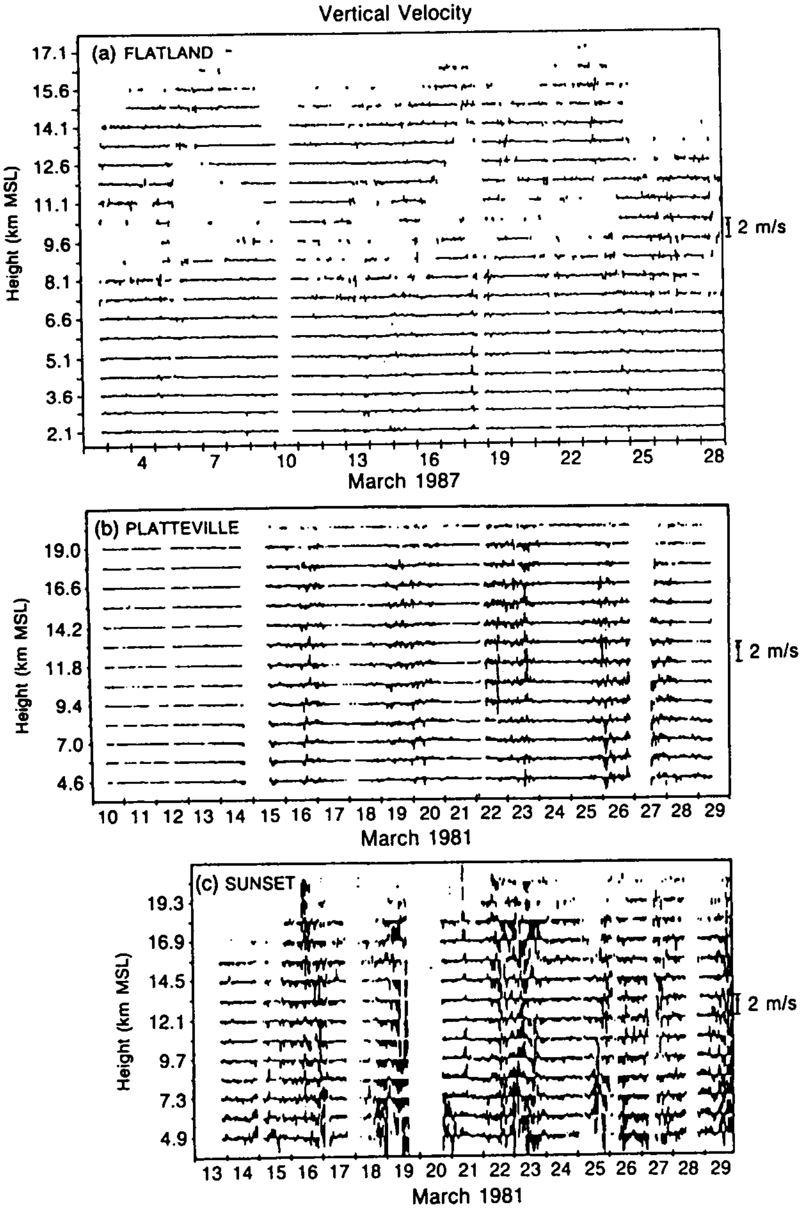

Figure 1. Time series of 15-minute averages of w. Panel (a) is from the Flatland radar, in very flat terrain, panel (b) is from the Platteville radar, in moderately flat terrain but 80 km east of the 4000 m crest of the Front Range of the Rocky Mountains, and panel (c) is from the sunset radar, in rough terrain 16 km east of the crest. It can be seen that the variance of w increases with increasing roughness of the terrain.

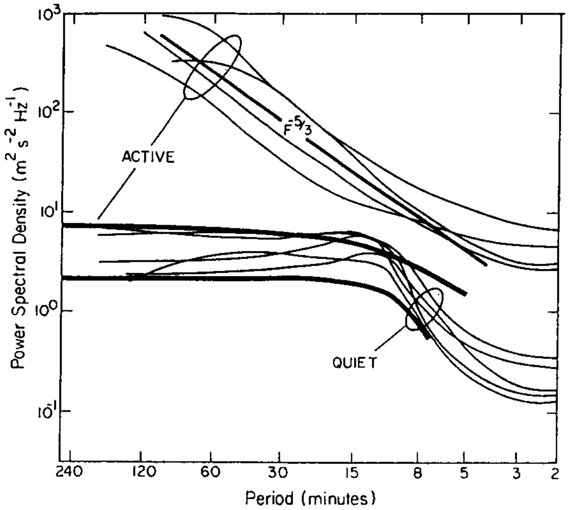

Figure 2. Frequency spectra of w in the troposphere. The lower two thick curves are from the Flatland radar at 5.3 km and the thin curves are from southern France [Ecklund et al., 1985] between 3.85 and 6.10 km. The thick reference line labeled $F^{-5/3}$ has a spectral slope of 5/3. The spectra labeled QUIET were obtained when the wind was ≦ 5 m/s and those labeled ACTIVE, when the wind was ≧ 20 m/s. At Flatland the ACTIVE spectrum is similar to the QUIET spectrum, but with a slightly flatter shape and greater amplitude. In southern France, the ACTIVE spectra are much steeper than the QUIET spectra with much larger spectral amplitudes. The difference between Flatland and southern France is presumably due to the absence of mountains near Flatland.

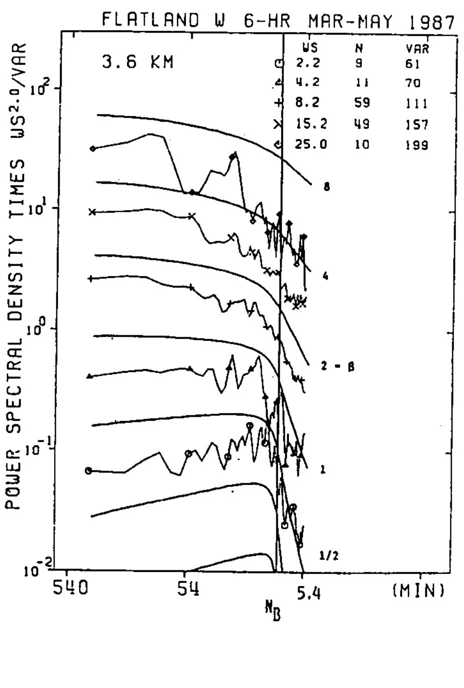

Figure 3. Comparison between observed spectra stratified by wind speed and Doppler-shifted model spectra. The mean Flatland spectra at 3.6 km are stratified into bins according to the mean wind speed WS at the middle of the 6-hour time series. WS, the number of spectra N entering the mean, and the variance VAR for each bin are given in the upper right-hand corner.

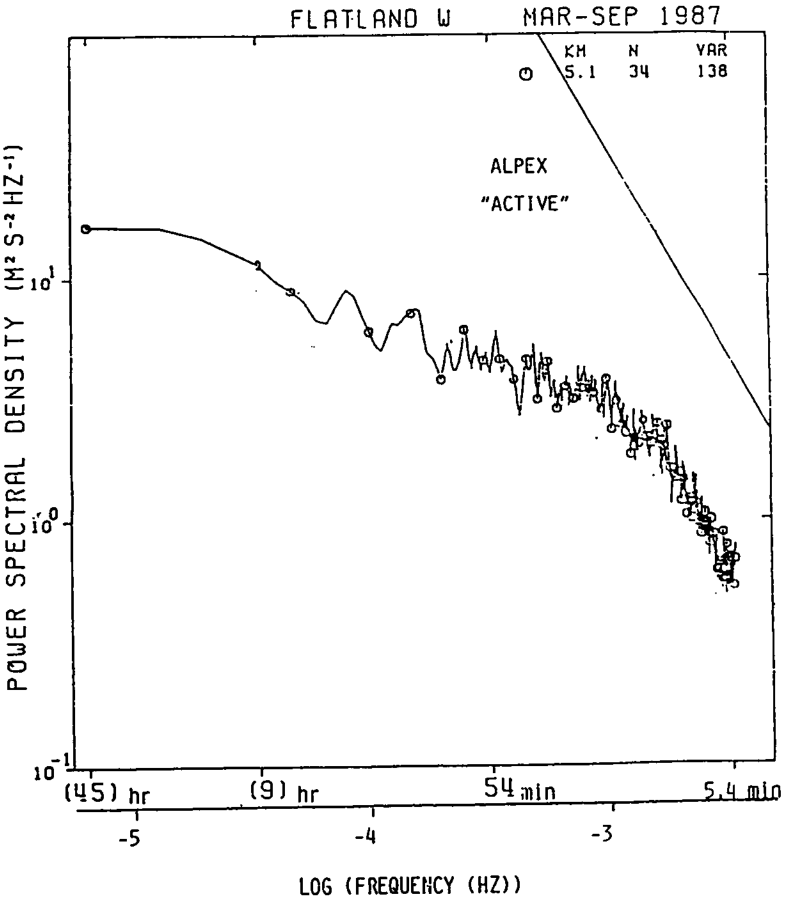

Figure 4. Mean frequency spectrum of w from 45 h time series.

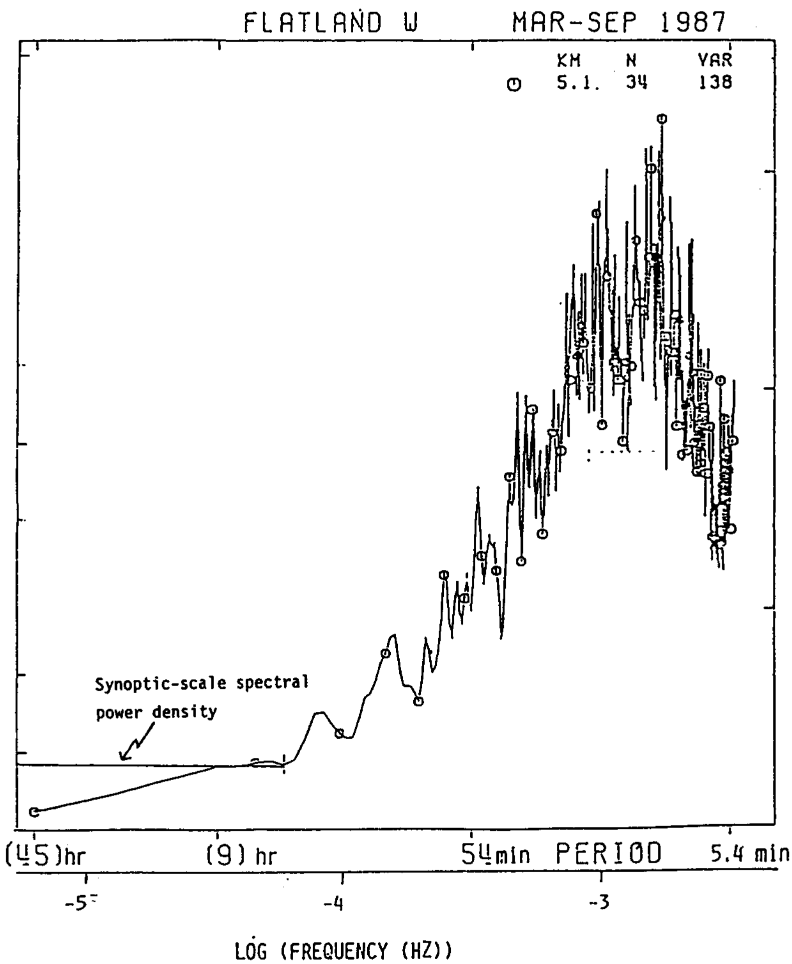

Figure 5. The same spectrum in area-preserving form, so that the contribution to the variance is proportional to the area under the spectrum. The horizontal line in the lower left-hand corner is the estimated spectral density due to synoptic-scale vertical motions, with a variance equal to 12.5 $(cm/s)^2$, distributed uniformly from 7 days to 5 hours. The fact that the observed spectral density is ≦ this level suggests that synoptic-scale vertical velocities can be measured by clear-air Doppler radars located in very flat terrain.

CONCLUSIONS

The conclusions of this study are:

1. The fluctuations of vertical velocity with periods ≦ 6 h are dominated by gravity waves.

2. The observed variance with periods ≧ 6 h is comparable with the estimated variance of vertical velocity due to synoptic-scale motions.

3. These results suggest that clear-air Doppler radars located in very flat terrain can be used to study vertical velocity due to gravity waves and synoptic-scale motions.