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3.2.5 THE PROUST RADAR: FIRST RESULTS

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Two campaigns took place in 1984 with the PROUST Radar operating in a bistatic mode, the transmitting antenna pointing at the vertical and the receiving one, 1° off the vertical axis. The antenna beam intersection covers an altitude range between 3 and 9 km. A complete description of the radar characteristics can be found in BERTIN et al. (1986). The first of these campaigns are analysed here.

1. LEE WAVES OBSERVATION DURING AN "AUTAN WIND" SITUATION.

The "Autan" wind is a strong southeasterly wind observed in the southwest of France, generated by a typical synoptic situation: high pressure over Scandinavia associated with low pressure over Spain. Radiosonde measurements yield a horizontal wind contribution of at most 0.2 m/s along the radar line-of-sight. The dashed line in Figure 1b gives the observed vertical wind profile, and the vertical line, the estimated horizontal wind contribution. The observed wind can be regarded as mainly due to the vertical component. Over the whole range of observed altitude, a downward wind is detected with an amplitude that decreases from 1.2 m/s (at 3 km) to 0.25 m/s (at 7.2 km). The horizontal bars give the error on the vertical wind, inferred from the Doppler shift estimation. This profile shape might be interpreted as due to the interaction between "Autan" wind and "Massif Central" topography. In order to test this assumption, the lee wave model of QUENEY (1948) is used (Figure 1a). This model gives a downward vertical wind above St Santin up to 7 km. For comparison, this theoretical wind profile is also plotted in Figure 1b. A good agreement is found between observation and theory, the systematic difference between the two profiles being probably due to the horizontal wind contribution.

2. OBSERVATION OF WAVE - TURBULENCE INTERACTION IN A STORMY WARM FRONT

On June 6th, 1984, a stormy warm front was crossing over St Santin. The echo power profiles associated with this front show an intense turbulence observed both on the refractive index (signal-to-noise ratio) and on the vertical wind fluctuations (spectral broadening). Figure 2 shows the spatio-temporal evolution of the radar echo intensity and Doppler shift in the altitude range 3-10 km. In each gate, the echo power (S/N ratio expressed in dB) is scaled according to a dashed code. The Doppler shift is scaled in m/s on the vertical axis, while the local time is scaled in hours on the horizontal axis. The contribution of the horizontal wind is, in this experiment, never greater than 0.1 m/s. The mean value of the Doppler shift gives evidence of a global upward wind of about 1 m/s during the front crossing. Associated with this global upward movement, a very active turbulence gives rise to the observed radar echoes.

2.1 Estimation of the energy dissipation rate. For the strongest echoes (occurring in gates n° 6 and 7), a spectral broadening of about 0.5 m/s is observed. It is noteworthy that the spectral broadening due to the deformations introduced by the antenna beam geometry (and detailed in SPIZZICHINO, 1975) is estimated to be never greater than 0.1 m/s. In these conditions, the observed spectral widths give an estimation of the rms value of the turbulent wind fluctuations w' along the vertical. The energy dissipation rate ε can be easily inferred from w' by using the following expression

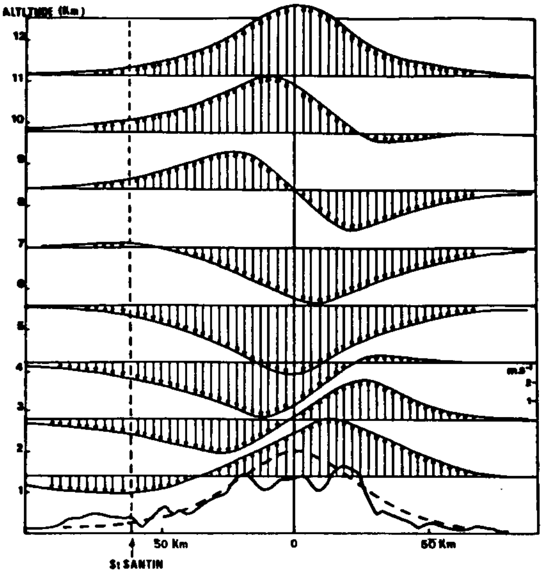

Figure 1a. Vertical velocity field and streamlines over the "Massif Central", modelised by a symetrical shape.

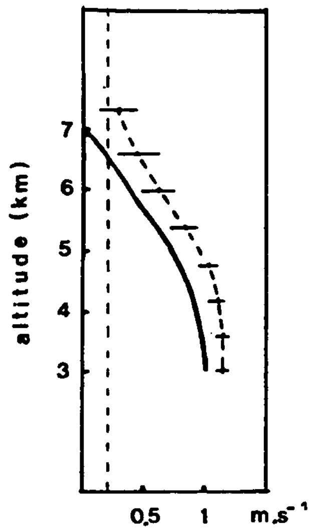

Figure 1b. Vertical wind profile (observed and theoretical).

proposed by WEINSTOCK (1981).

$$\varepsilon = 0.4 \overline{W'^2} \omega_B \qquad (1)$$

where ω_B is the Brunt-Vaisala frequency.

Figure 3 shows the Brunt-Vaisala period (BVP) profile, obtained from radiosonde data. Finally, relation (1) yields an energy dissipation rate value in the range

$$1.10^{-3} < \varepsilon < 2.10^{-3} \ m^2 s^{-3}$$

for the strongest echoes observed in gate n°7. This is a typical value for a very active turbulence (LILLY et al., 1974).

2.2 Waves and turbulence. Besides the global upward movement of the air along the front, oscillations are observed in the vertical wind intensity, period and amplitude of which vary versus altitude. In gates n°8 to 10, oscillations with a range period of 8-9 minutes are clearly observed, while a 3-minute period appears in gates n°6 and 7 just after the strong intensification of the turbulent activity mentioned above. Comparison between these periods and the BVP profile plotted in Figure 3 exhibits a striking agreement. This observation is consistent with theoretical studies on gravity waves generated by turbulence in stratified fluids. WEINSTOCK (1978, 1981) has shown that, in a stratified atmosphere, the time evolution of the vertical velocity spectrum implies the emission of gravity waves, generated by the vertical motion of the air particles, with a frequency ω_K given by:

$$\omega_K = \omega_B \frac{K_H}{K} \qquad (2)$$

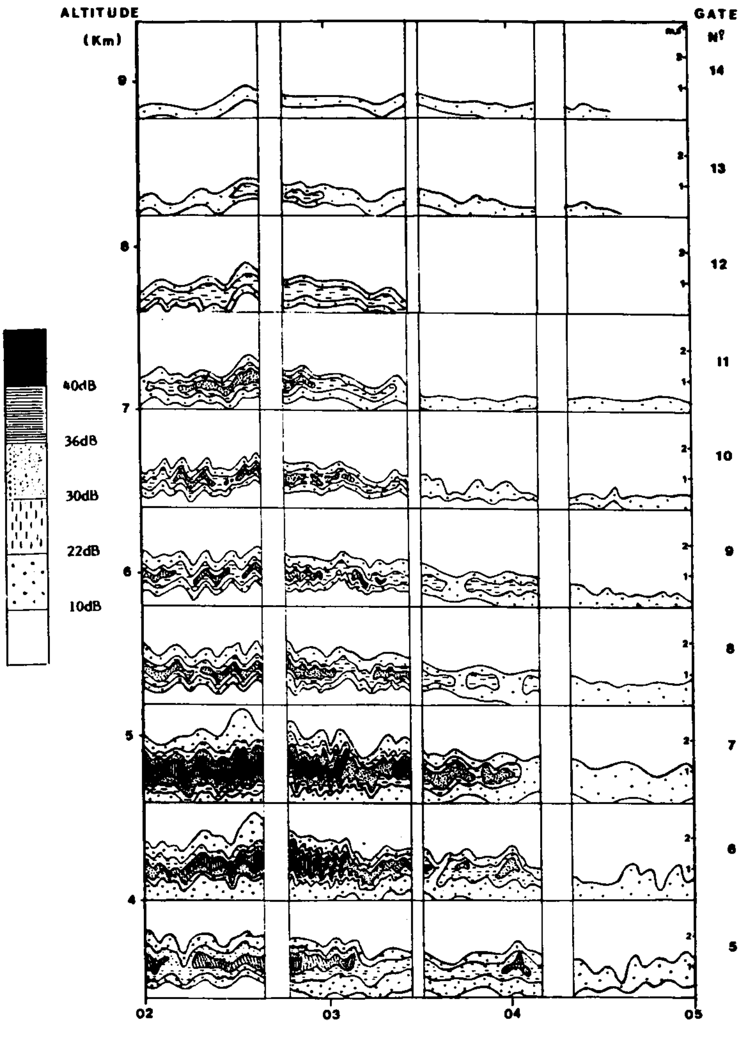

Figure 2. Spatio-temporal evolution of the radar echo power on June 6, 1984.

where K is the wave number and K_H its horizontal component. The good correlation between BV and observed frequency seems to indicate that the wave propagation is mainly horizontal. These propagation characteristics are also found by METAIS (1984) with a numerical model.

CONCLUSION

The first results analysed above show the capability of the PROUST Radar to measure the turbulent parameters and study the turbulence-wave interaction. In its present configuration (bistatic mode and 600 m vertical resolution), it has been necessary to make some assumptions that are known not to be truly fulfilled: homogeneous turbulence and constant vertical wind intensity over a 600-m thickness. It is clear that a more detailed study of the interaction

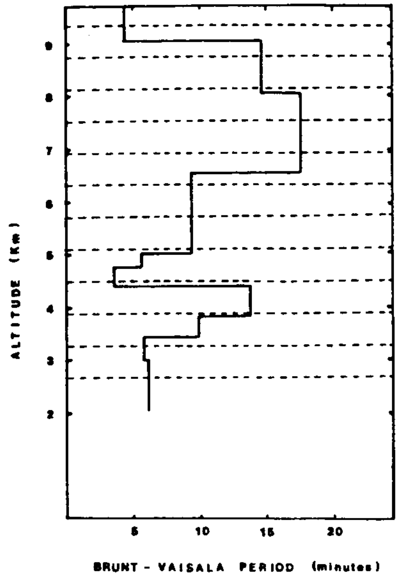

Figure 3.

between wave and turbulence will be possible with the next version of PROUST Radar (30-m altitude resolution and monostatic mode) that will soon be achieved.

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