P2.4 A RAIN EPISODE RELATED TO A MESOSCALE GRAVITY WAVE DURING MAP

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Gravity waves can influence precipitation by introducing periodic variations in its intensity. Eom (1975) wave conceptual model has been widely applied and successfully explained many observations of heavy precipitation bands in terms of wave-induced rising and sinking motions. In this model the waves are trapped (no tilt of phase lines with respect to height), and the greatest precipitation rate occurs between the maximum upward motion and the trailing wave ridge due to a time lag between the onset of vertical motions and cloud formation (Fig. 1).

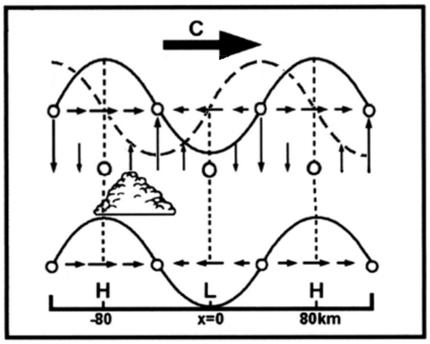

Figure 1: Wave conceptual model of Eom (1975) (from Koch and Saleeby 2001) compared with rain rate measured in the IOP8 episode (dashed line). Solid curves show pressure fluctuations at two different heights, little arrows the vertical velocity and the cloud the condensation maximum according to the model. The big arrow indicates the direction of propagation.

Uccellini and Koch (1987) proposed a model for the occurrence of mesoscale gravity waves which has been further refined by Koch and O'Handley (1997). It requires both a synoptic-scale setting for their generation by geostrophic adjustment and a maintenance mechanism by wave ducting.

During MAP experiment the University of Turin deployed in the western part of the Po valley a microbarometric network and a high precision pluviometer. During IOP8 of MAP (20-21 October 1999) the meteorological setting was favorable to the above mentioned mechanisms of generation and maintenance of gravity waves during conditions of moderate, stratiform rain. In particular, from 0600 h - 1200 h local time of 21 October, a simultaneous increase of gravity wave activity and rain rate was observed (Fig. 2).

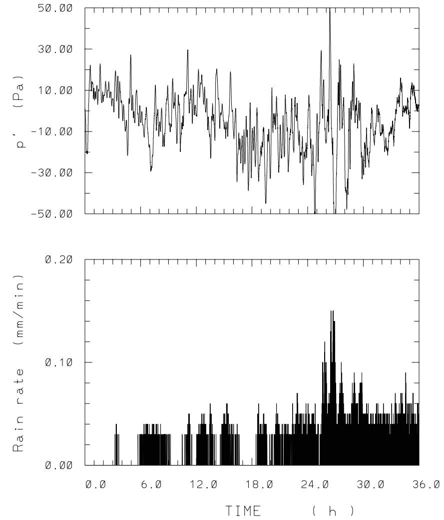

Figure 2: Time series (raw data)of pressure fluctuations and rain rate between 0600 h on 20 October and 1800 on 21 October 1999 (local time) at Trino Vercellese station.

In this 6 hours interval pressure and rain rate show the same periodical behaviour, with a period of about 66 minutes for the pressure and about 64 minutes for the rain (Fig. 3). The wave propagated with a phase speed of 25 ms^{-1}, implying a wavelength of about 100 km.

The cross-correlation between the two sets of raw data is significant at the level $\alpha = 0.01$ for about 4 cycles (Fig. 4). The time lag between the two signals is equal to 20 minutes, with the rain rate following the pressure. If the delay (5 minutes) introduced at these frequencies by the microbarometer (Richiardone 1993) is taken into account (Fig. 5), the time lag between pressure and rain rate becomes equal to 15 minutes, which is almost equal to one quarter of a period.

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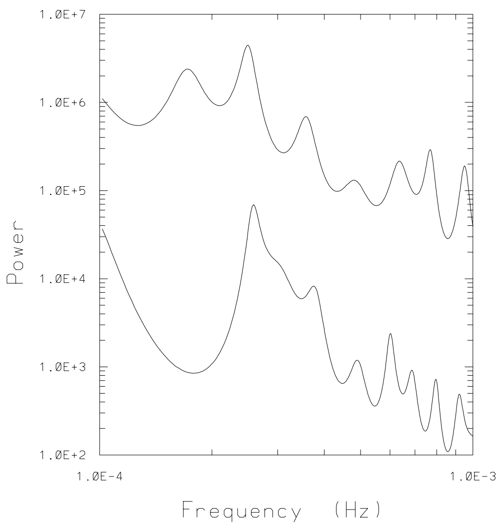

Figure 3: Pressure fluctuations (upper line) and smoothed rain rate (multiplied by 10^4, lower line) spectra from 0600 to 1200 (local time) on 21 October 1999 at Trino Vercellese.

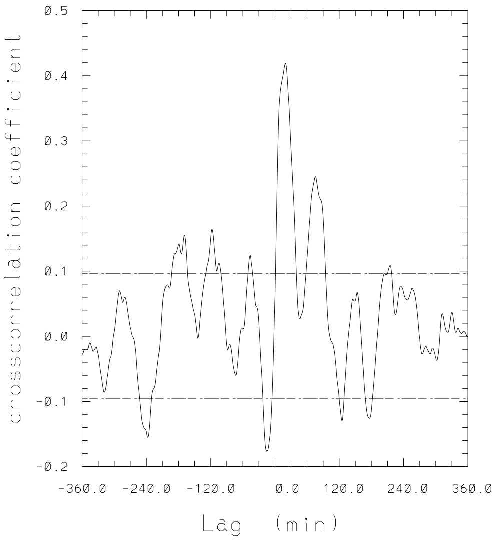

Figure 4: Pressure-rain rate crosscorrelation coefficient versus lag from 00 to 1200 (local time) on 21 October 1999 at Trino Vercellese. Dashed horizontal lines indicate the 99 % confidence interval for two uncorrelated variables.

In this episode the delay differs therefore from what one would expect from Eom (1975) model. The delay of one quarter of a period is the same that exists between the pressure and the downward component of the vertical velocity in a trapped wave (Fig. 1). In the present case the rain is therefore in phase with the downward velocity. This could be due to the fact that in this situation of moderate, stratiform rain the gravity wave modulates the rain more through its influence on the downward velocity of the droplets than on the process of condensation, which is more effective in convective conditions. In the Eom (1975) model the wave modulates the condensation, which is proportional, with a certain delay, to the upward velocity.

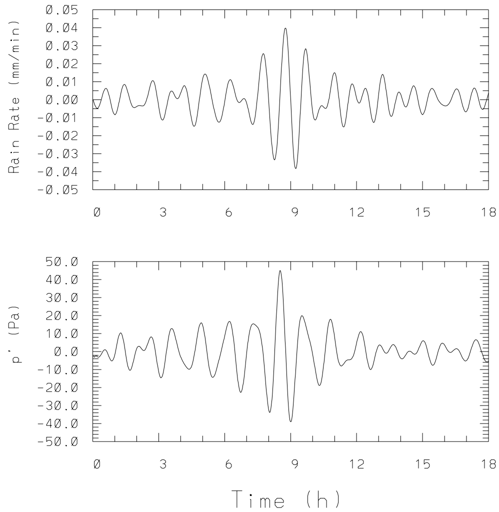

Figure 5: Temporal evolution of rain rate and pressure fluctuations filtered by a band pass filter (40-80 min) between 00 h and 1800 h (local time) on 21 October 1999. Amplitude and phase correction to microbarometer's output have been applied (pressure shifted forward 5 minutes and multiplied by 1.13).

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