J8.4 OROGENIC SQUALL LINE OBSERVED WITH DOPPLER POLARIMETRIC RADARS DURING THE MAP EXPERIMENT

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1. INTRODUCTION

The Mesoscale Alpine Programme (MAP) is an international programme devoted to the study of mesoscale atmospheric and hydrological processes over complex terrain (Bougeault et al., 2001). The present study is related to the scientific project P1 (orographic precipitation mechanisms) of MAP devoted to the understanding of the basic mechanisms leading to the production or the enhancement of precipitation by the orography. The main scientific questions relevant to the P1 project are: i) how do special configurations of topography, such as curved mountains, valleys,…, concentrate precipitation into severe downpours and produce flash floods? ii) how does the flow over complex terrain modify the growth mechanisms of precipitation particles (vapour diffusion, riming, coalescence and aggregation) iii) how are the pre-existing mesoscale events (fronts, rainbands, convective systems) modified by the orography through uplift, mountain waves, blocking and channeling, and how do these modifications localize heavy and persistent precipitation?

During the Special Observing Period (SOP), in Autumn 1999, meteorological events were documented during 17 Intensive Observation Periods (IOP). The present study gathers results obtained during the IOP 2a (17-18 september 1999). This IOP exhibits 75% of the CG activity collected during the whole SOP in a 250×250 km² area around the LMTA . Results concerning the electric activity are presented in a companion paper (Sety et al, 2002).

This study mainly relies upon measurements from three Doppler radars installed in the Lago Maggiore Target Area which corresponds to the maximum climatological rainfall rate in the Alpine region. These radars are : the French C-band Doppler Ronsard radar, the operational Swiss C-band Doppler Monte-Lema radar and the American S-band Doppler / Polarimetric S_Pol and covered an area of about 140×140 km².

2. DATA PROCESSING

The combination of the three radar data provided the three-dimensional wind and reflectivity fields of the precipitating systems using the MANDOP analysis adapted to complex terrain (Tabary and Scialom 2001). One of the three radar (S-Pol) made polarimetric measurements. The microphysical structure of the convective system during its successive stages was retrieved using the particle-identification algorithm described in Vivekanandan et al (1999). Radar data were processed at a 30 minutes interval in order to provide a detailed description of the system when it reached the three-radar area. We briefly summarize in the next section the main results of the study.

3. RESULTS

a) Large scale conditions

As deduced from the ECMWF forecast for 18 september 1999 0000 UTC (not shown), a large scale cyclonic structure was located off the coasts of Ireland and was moving eastwards to Europe. The passage of the corresponding cold front over the Alps occurred two days later (19-20 september 1999) constituting the most intense heavy rain event of the MAP SOP (IOP2B). Ahead of this cold front, a very weak small-scale undulation was linked to the life cycle of the IOP2A convective system. At its mature stage, the cloud anvil of the system was forming a 200 km x 100 km cluster along the North-South axis, as it appears on the infrared satellite image (not shown) at 18000 UTC 17 september 1999.

b) Mesoscale and small scale results

Three stages of evolution of the studied convective system may be defined.

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In the first one, the initiation stage, convection is concentrated on the windward slopes, in the northwestern part of the Lago Maggiore region and precipitation is generated by isolated short-lived cells with little or moderate vertical extent and intensity. These cells are clearly associated with the small scale structure of the orography, but channeling effects by the Toce/Ticino valleys are also apparent (Fig. 1a). Figure 1a which displays the system at 1605 UTC also shows another line of convection, more regular and clearly associated to a horizontal wind convergence (convergence higher than 2 10^{-4} s^{-1} is displayed by white diamonds). This line is associated with the passage of a mesoscale trough. This initiation phase phase ends up at 18 00UTC where the system begins to intensify (Fig. 1b). This figure shows two separate lines of convergence, the first one to the south which organizes from the orographic cells, the second to the rear which corresponds to the mesoscale through. Fig. 1c (at 1905 UTC) shows that both lines have merged forming a southwest – northeast convective line. Fig. 1c gives an idea of the (second) mature stage of the system.

Another overview of the mature stage of system is displayed Fig. 2 at 1000 m (Figs.2a ,c and e) and at 3000 m (Figs. 2b, d and f) from 1935 to 2035 UTC. The system is 2-dimensional, aligned along a southwest-northeast axis corresponding to the mean undisturbed flow at mid and upper levels. The low-level flow turns from upslope and up-valley at 1935 UTC to downslope and down-valley at 2035 UTC. The blocking phenomenon is clearly apparent at 2005 UTC and gives rise to a return cold outflow at 2005 UTC and particularly at 2035 UTC. At 3000 m, the southwest-northeast convergence line slowly progresses at 3-4 ms^{-1}, the maximum convergence being strongly correlated with the 30 dBZ reflectivity contour (bold lines). After 2100 UTC the system appears to be 3D (it is the third phase of evolution not described here). The parallel evolution of the kinematic structure and of the microphysical description of the phasing is displayed on Fig. 3–4 on which several vertical cross sections along the AB line (Fig. 2) from 1805 UTC to 2035 UTC. The vertical velocity is seen to increase progressively as far as the phasing between the two lines occurs (up to 5 m s^{-1} at 2005 UTC). Light rain and ice crystals are preponderant at 1805 and 1835 UTC. Then rain is reinforced below the 0°C isothermal, and graupel/hail and hail appear progressively (maximum at 2005 UTC).

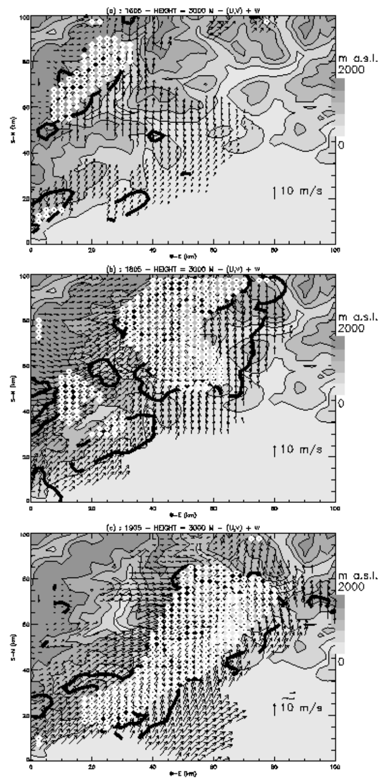


Fig.1 Horizontal flow at 1605, 1805 and 1905 UTC at 3000m. Diamonds are convergence higher than 2 10^{-4} s^{-1}. 30 dBZ boundary is in bold black.

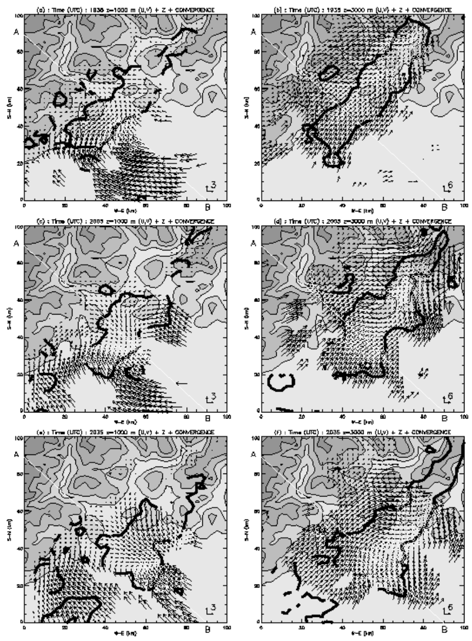
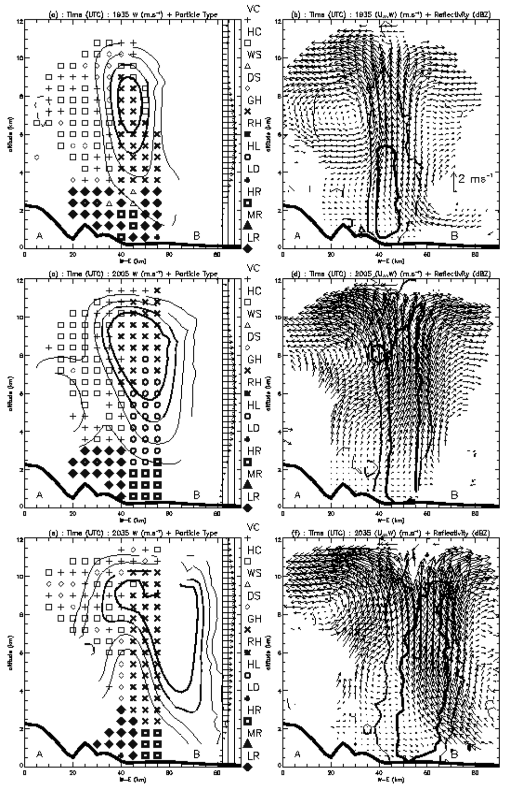


Fig. 2 Horizontal flow at 1605, 1805 and 1905 UTC at 1000 m (left) and 3000m (right). Diamonds are convergence higher than 3 10^{-4} s^{-1}. 30 dBZ boundary is in bold black.



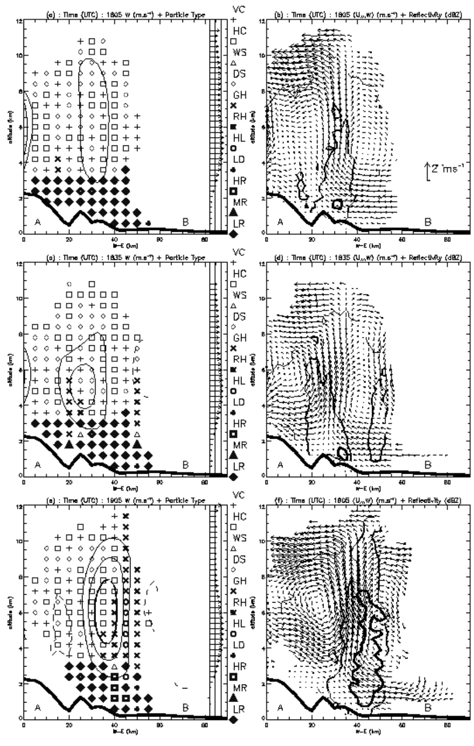


Fig. 3 (low left) and 4 (up right) Time evolution of microphysical and dynamical structures along the AB vertical section at 1805, 1835, 1905, 1935, 2005, 2035 UTC.

References

Bougeault, P., P. Binder, A. Buzzi, R. Dirks, R. Houze, J. Kuettner, R.B. Smith, R. Steinacker, H. Volkert and all the MAP scientists, 2001: The MAP Special Observing Period., *Bull. Amer. Meteor. Soc*., **82**, 433-462.

Seity Y., S. Soula S., P. Tabary and G. Scialom, 2002: Cloud-to-ground lighning flash production during IOP2A of MAP: Correlation with dynamics and microphysics, this conference.

Tabary, P., and G. Scialom, 2001: MANDOP analysis over complex terrain in the context of the MAP Experiment., *J. Atmos. Oceanic Technol*., **18**, 1293-1314.

Vivekanandan, J., D.S. Zrnic, S.M. Ellis, R. Oye, A.V. Rhyzhkov, and J. Straka, 1999: Cloud Microphysics retrieval using S-Band dual-polarization radar measurements, *Bull. Amer. Meteor. Soc*., **80**, 381-388.