# P5.25 NUMERICAL SIMULATIONS OF HEAVY RAINFALL DURING THE MESOSCALE ALPINE PROGRAM (MAP)

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## 1. Introduction

To assess the characteristics of heavy precipitation over the Lago Maggiore region of northern Italy, we selected two IOP's from the MAP Field Study of Fall 1999. The IOP-2B (19 September) and IOP-8 (19-21 October) events were selected for intensive study because they represent two precipitation events that exhibit similar low-level flow patterns, yet differ in the amount of observed precipitation (Houze et al., 2000).

The precipitation in IOP-2B developed in association with a cold frontal passage across the southern Alps as a trough moved from western Europe into northern Italy. Heavy rainfall developed on the western side of Lago Maggiore as moist inflow from the south and southwest over the Mediterranean Sea impinged on the steeply sloping terrain of the southern Alps. This southerly low level flow has been seen in other Alpine events (see Sénési et al., 1996; Massacand et al., 1998; Buzzi et al., 1998; Buzzi and Foschini, 2000; Fehlmann and Quadri, 2000; Tripoli et al., 2000)

Precipitation in IOP-8, in contrast to the convective environment of IOP-2B, developed in a more stable environment ahead of a front as 850 hPa southeasterly flow overran a surface cool layer.

In order to understand these events better, numerical simulations using the PSU/NCAR MM5 model were performed. Each IOP event was simulated using a triple nested grid of 45, 15, and 5 km resolution.

## 2. Results

Following are results of the simulations for IOP-2B and IOP-8.

### 2.1 IOP-2B

Numerical simulations for IOP-2B captured the low pressure system off the west coast of Ireland (Fig. 1) and a deep upper level trough over the eastern Atlantic (Fig. 2). A broad 300 hPa jet was located over Spain with diffluence over the Alps. Throughout the simulation, the precipitation was located with the confluent southwest, south inflow toward the western Alps (Fig. 3). The southern area of the rainfall was closely aligned with the inflow while the northern area of the rainfall near the concave region of the Alps was associated with the easterly flow perpendicular to the mountains.

A contributing factor to the instability associated with IOP-2B was the northward transport of a tongue of high $\theta_e$ 850 hPa air from northern Africa over the Lago Maggiore region between 0000 UTC 20 September and 1200 UTC 20 September 1999 (Fig. 4). The southern area of the rainfall was just west of this high $\theta_e$ flow. Also during this time, the Lago Maggiore region was under 300 hPa diffluence, which was collocated with low-level confluence and orographic lifting, leading to ascent and rainfall.

### 2.2 IOP-8

In contrast to IOP-2B, the dominant moist flow for IOP-8 was from the southeast off the Adriatic Sea. At the time of the simulation initialization, 1200 UTC 19 October 1999, a low pressure system was west of the Alps over the Bay of Biscay. Twenty-four hours later (1200 UTC 20 October), a closed low was over the Bay of Biscay (Fig. 5). Initially at upper levels, a broad zonal 300 hPa jet extended from Spain into Russia with a trough west of France over the Atlantic. By 0000 UTC 21 October, a jet streak had formed along the Mediterranean coast of France with diffluence over the Lago Maggiore region (Fig. 6a). Twelve hours later, the right entrance region was just northwest of Lago Maggiore, possibly providing lifting via ageostrophic circulations or upper level divergence(Fig. 6b).

Rainfall totals were not heavy until 36 hours into the simulation (0000 UTC 21 October). As with IOP-2B, the rainfall then propagated eastward (Fig. 7a). Examination of the 5 km output shows the low-level easterly flow turning to southeast flow over the Adriatic and flowing into northeast Italy. A confluence zone can also be seen in northeast Italy as northeast, easterly, and later southeasterly winds came together inland from the Adriatic (Fig. 7b).

As previously noted, the rainfall for IOP-8 developed as southeasterly flow overran a surface cool layer. A model cross section (Fig. 8) shows the surface cool layer over the same period as the rainfall (36-48 hours) (See Fig. 7a for cross section location). The isentropes show the location of the surface cool air with

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the flow coming off the Adriatic and rising over the terrain.

### 2.3 Rainfall Totals

The 48 and 60 hour accumulated precipitation (mm) for IOP-2B and IOP-8 respectively are shown in Figure 9. The model results were consistent with observations in that the accumulated rainfall for IOP-2B was larger than for IOP-8. For IOP-2B, the observed totals over Lago Maggiore ranged from 100-300 mm (Houze et al., 2000). Model accumulated precipitation ranged from 80-260 mm over Lago Maggiore. For IOP-8, observed totals over Lago Maggiore ranged from 20-50 mm (Houze et al., 2000) with model accumulations of 50-100 mm. It appears that the model did adequately in simulating the rainfall amounts.

## 3. Summary

Simulations using the MM5 model showed the evolution of rainfall over the Lago Maggiore region of northern Italy for two MAP events, IOP-2B and IOP-8. IOP-2B was marked by a south/southwest low-level flow impinging against the mountains. Also, low level flow of high $\theta_e$ air into the Lago Maggiore region from North Africa added to the instability of the atmosphere leading to rainfall production. The results for IOP-8 showed the southeasterly flow off the Adriatic flowing into the Alps with the 850 hPa flow overrunning a surface cool layer and rising over the terrain.


## Acknowledgements

This research is supported by NSF Grant ATM-0096876. Part of the computations performed at North Carolina Supercomputer Center


## 4. References


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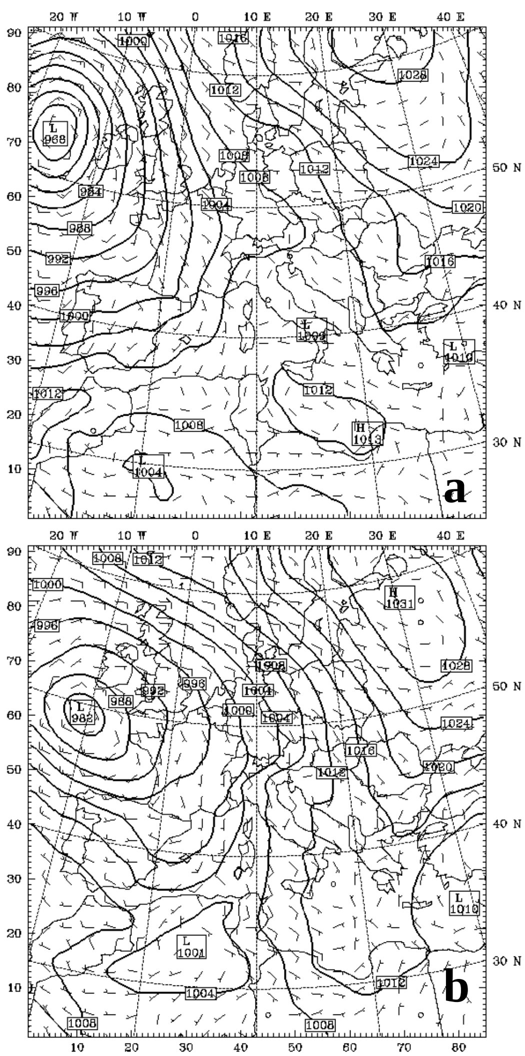


Figure 1. 45 km resolution sea level pressure (every 4 hPa) and winds (1 full barb equals 10 $ms^{-1}$) for a) 0000 UTC 19 September and b) 0000 UTC 20 September 1999.

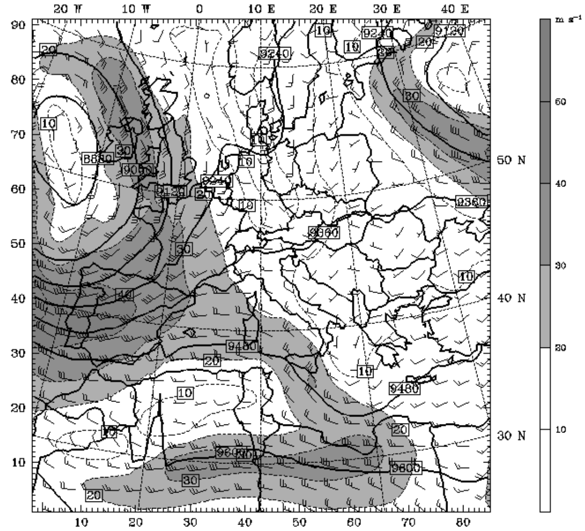


Figure 2. 45 km grid 300 hPa heights (every 120 m), isotachs (every 20 $ms^{-1}$), and winds (1 full barb equals $10ms^{-1}$) for 0000 UTC 19 September 1999.

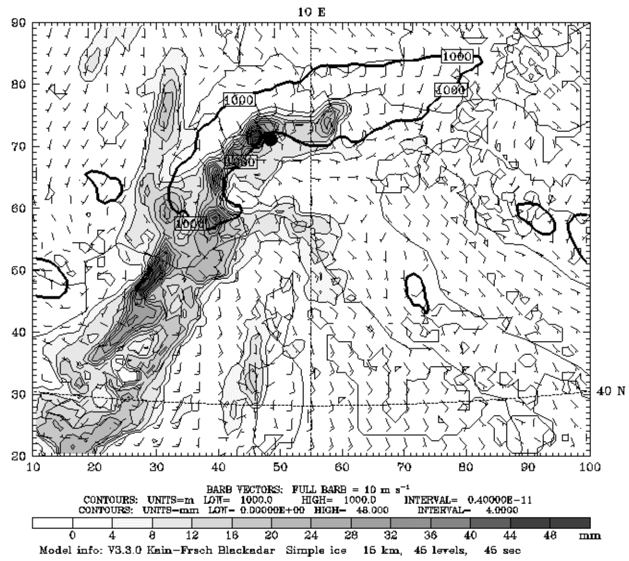


Figure 3. 15 km grid 6 hour accumulated rainfall (mm) and winds (1 full barb equals 10ms-1) for 0300 UTC 20 September 1999. Bold line is 1000 m terrain elevation contour. Dot represents approximate location of Lago Maggiore.

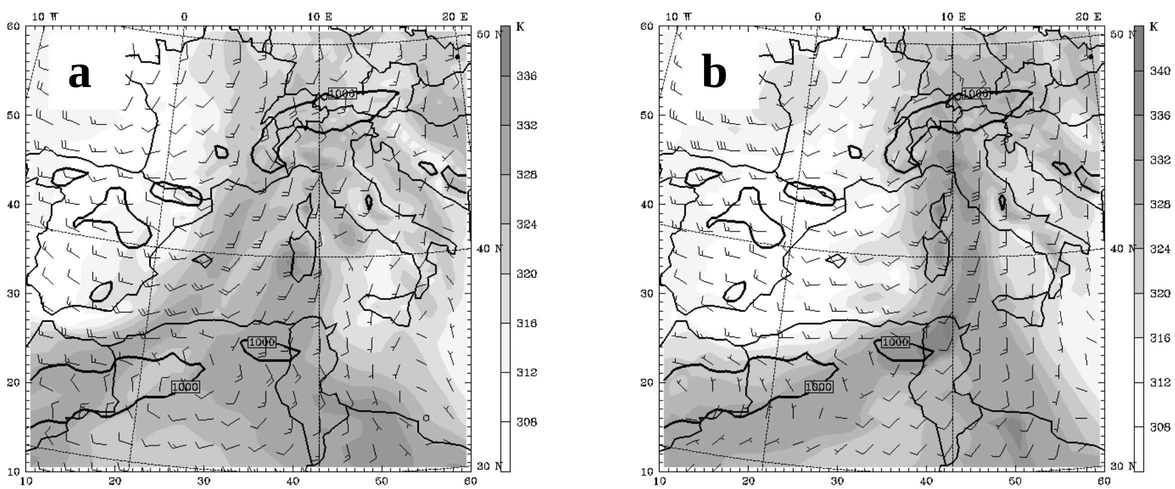


Figure 4. 45 km grid 850 hPa $\theta_e$ and wind vectors (convention as in Figure 3) for a) 0000 UTC 20 September and b) 1200 UTC 20 September 1999. Bold line is 1000 m terrain elevation contour.

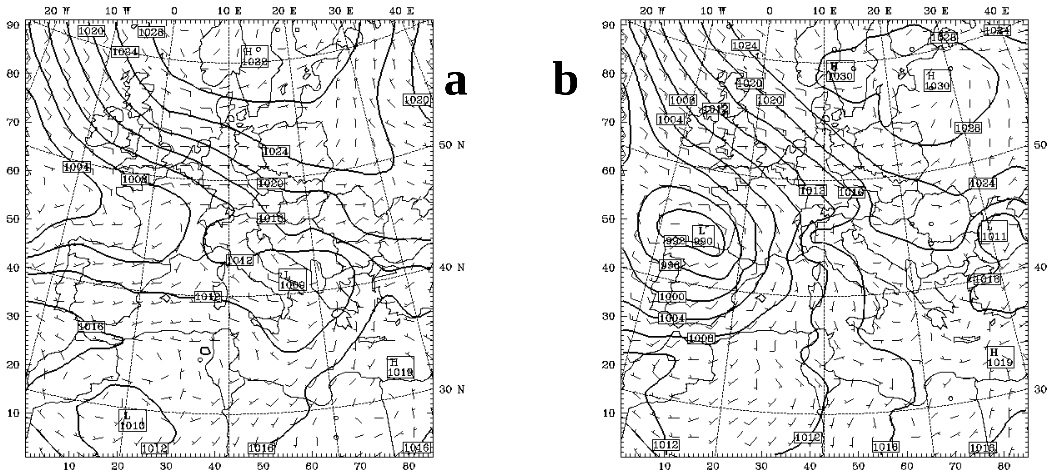


Figure 5.  As for Figure 1 except for a) 1200 UTC 19 October and b) 1200 UTC 20 October 1999.

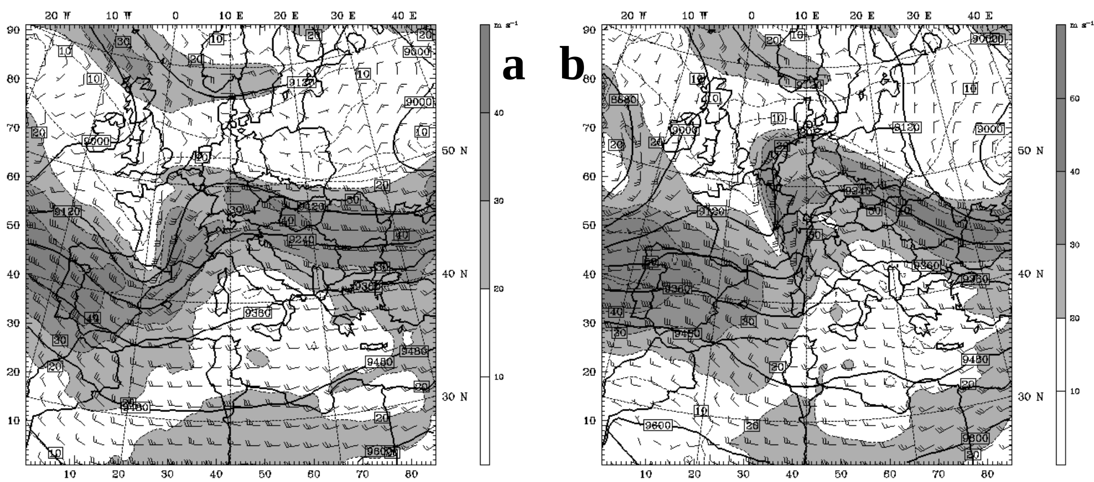


Figure 6.  As for Figure 2 except for a) 0000 UTC 21 October and b) 1200 UTC 21 October  1999.

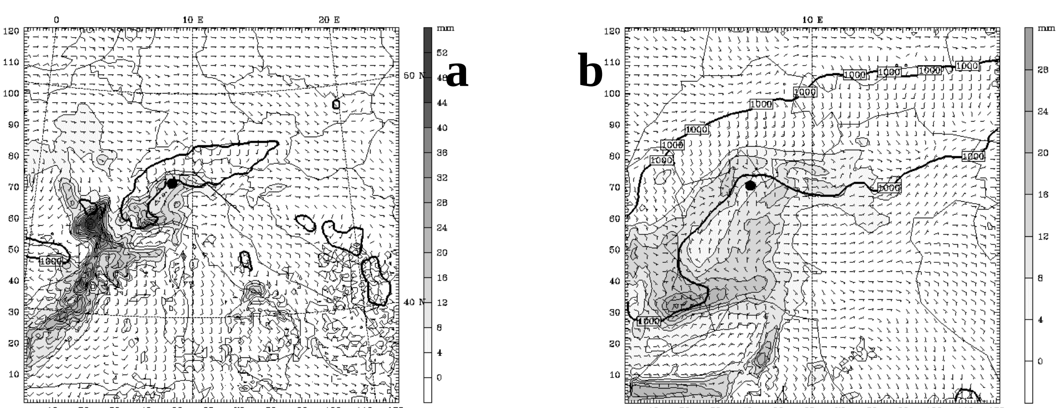


Figure 7.  6 hour accumulated rainfall (mm) for 0000 UTC 21 October for a) 15 km grid and b) 5 km grid.  Bold line is 1000 m terrain elevation contour. Straight line running northwest to southeast shows the location of the cross section in Figure 8. Dot represents Lago Maggiore.

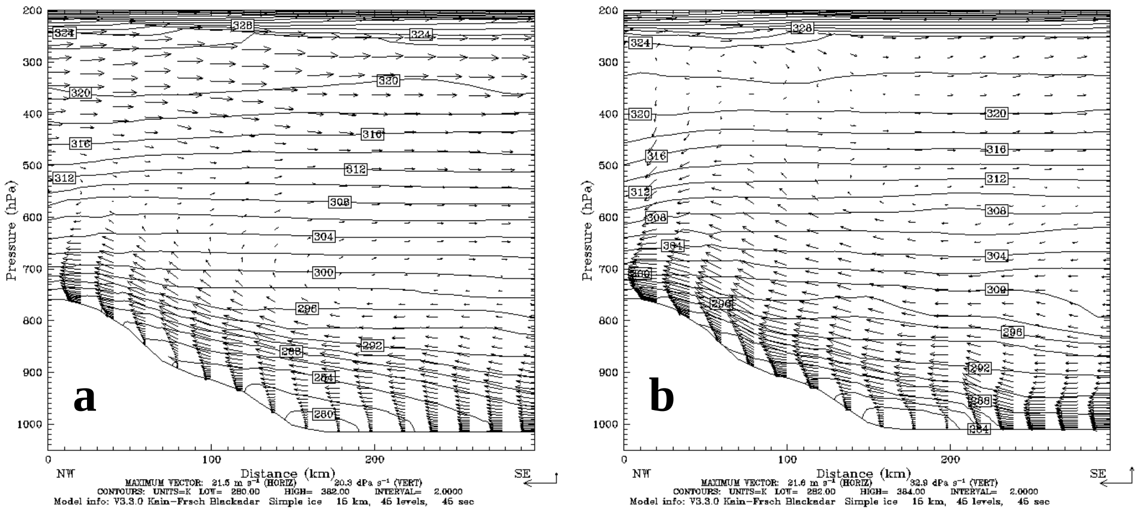


Figure 8.  15 km grid cross section of Potential temperature (every 2 K) and ageostrophic circulation vectors for a) 0000 UTC 21 October and b) 0600 UTC 21 October.  Location of cross section is shown in Figure 7.  Northeast is into page.

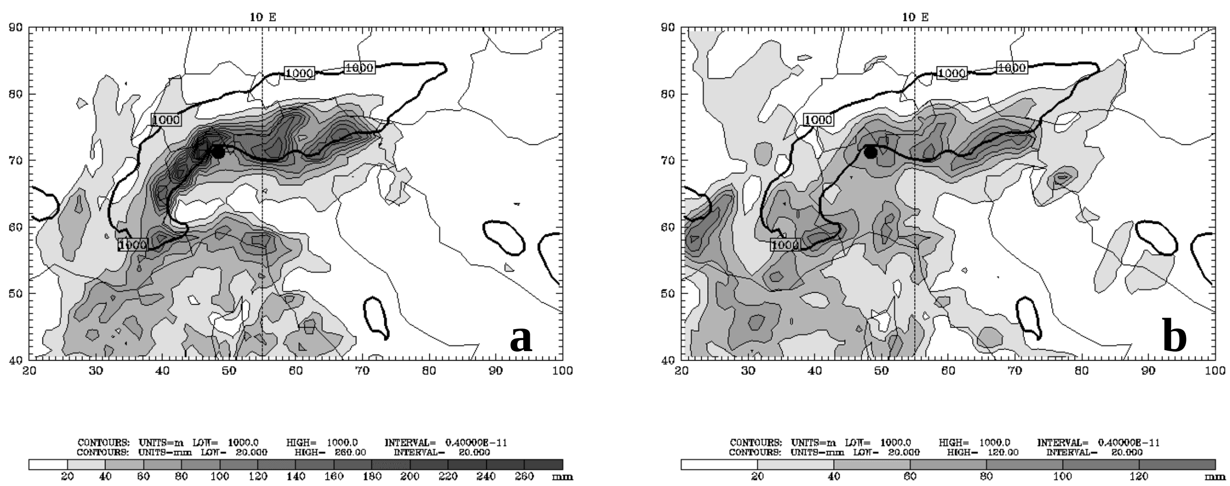


Figure 9.  a) 48 hour accumulated rainfall (mm) for IOP-2B for the period 0000 UTC 19 September to 0000 UTC 21 September and b) 60 hour accumulated rainfall (mm) for IOP-8 for the period 1200 UTC 19 October to 0000 UTC 22 October 1999.  Bold line is 1000 m terrain elevation contour and the dot represents Lago Maggiore.