Mesoscale diagnostics of prefrontal and frontal precipitation in the Southeast Alps during MAP IOP 5

T. Vrhovec, J. Rakovec, and G. Gregorič

With 9 Figures

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Summary

In terms of heavy precipitation, the MAP IOP 5 was a two-phase event. During the first phase – on 3 October 1999 – there was strong precipitation in the Lago Maggiore MAP target area, while the prefrontal precipitation was mainly limited to the mountain ranges of the MAP mission area in the Julian and the Karnic Alps involving a series of thunderstorms developing continuously for about 15 hours and contributing most to precipitation levels. During the second phase – on 4 October – the main precipitation was limited to the Julian and the Karnic Alps where a frontal passage was noted by a squall line moving from Veneto region towards the east, accompanied by a strong SW upper-level jet. At the same time, a strong low-level cold flow invaded the region to the north of Adriatic Sea from the east as a significant amount of cold air moving ageostrophically around the eastern edge of the Alps was arriving in the area. To study MAP IOP 5 in detail, we describe the development for mesoscale features of the event’s radar images, time-height cross-sections and estimates of Convective Available Potential Energy (CAPE) based on radio-sounding data, and how surface-measured precipitation offers some smaller scale information. Surface potential temperature and winds are also studied. Very large precipitation accumulation gradients are diagnosed (150 mm per day/25 km in S–N direction) and time distributions of hourly precipitation shows completely diverse regimes in the Friuli plain and in the Alps with peak intensities in the Julian Alps. The mesometeorological mechanisms for high precipitation rate in the SE Alps are diagnosed and some characteristics of the squall line are discussed.

1. Introduction

The climatological precipitation maximum of the whole Alps is located on the SE flank of this mountain massif in the Julian and the Karnic Alps (Frei and Schaer, 1998) – in the mountainous part of Friuli-Venezia Giulia (FVG) and Veneto (VE) of NE Italy and in the Posočje region of W Slovenia (WSI). Accordingly, this area was chosen as a secondary target area – a so-called “mission area” of the Mesoscale Alpine Program (MAP) (see Bougeault et al, 2001). This international cooperative effort involving several research institutions, universities and meteorological services consisted of several sub-projects where P1 – heavy precipitation – was the most extensive. The primary and most instrumented target area for P1 was the Lago Maggiore area (LMTA) in Ticino (Switzerland) and Piedmont (Italy).

The most intensive event of the MAP Special Observing Period (SOP, 1 September–15 November 1999) in the SE Alps mission area was the Intense Observing Period 5 (IOP 5) lasting from 2 to 5 October 1999. In this meteorological event, several different phenomena interesting for the MAP developed. On 3 October, there was heavy precipitation in the LMTA and moderate precipitation in the whole Alps, intensifying in the SE
Alps and continuing on 4 October mainly in the mission area of the Julian and the Karnic Alps with potential vorticity (PV) streamers to the north of the Alps. Here we analyze the precipitation in the SE Alps mission area where intense precipitation periods were observed for two consecutive days.

The event in the SE Alps was observed with ground-based weather radar (Fossalon, FVG Italy), two upper-air soundings (Udine, FVG and Ljubljana, Slovenia), operational surface networks (in FVG, WSI, N Croatia and S Austria), and with an additional network of 25 automatic pluviographs deployed (in WSI) during the MAP SOP (Fig. 1). Further, aircraft mission flights of Electra and P-3 recorded radar data on 4 October morning when the most prominent feature was a narrow convective line and also some dropsondes were launched in later part of the event above the Adriatic Sea west from Istria. Due to good aircraft coverage in most of the reports on MAP IOP 5 the greatest emphasis is given to this squall line (e.g., UCAR/NCAR 2000; Yu et al, 2001; Pradier et al, 2002) which, in spite of its intensity as seen by radar images, contributed only a small part to the precipitation level that accumulated mainly during the pre-frontal precipitation (Rakovec et al, 2001; Vrhovec et al, 2001).

Intense precipitation is common in the SE Alps and its duration in the area normally lasts from several hours to several days. The annual maximum of precipitation is in late autumn. The climatic maximum of annual precipitation centered in the Julian Alps in WSI and FVG partly extends to the Karnic Alps in southern Carinthia in Austria. Several stations in the area have long term means above 3000 mm/year but in a spatialization involving 25 km × 25 km resolution (Frei and Schaer, 1998) the calculated values are up to 6.4 mm/day (2336 mm/year). In a finer (1-km) resolution analysis of climatological data (1961–1990) for the region (Kastelec, 2001) shows that the 30-year mean annual precipitation exceeded 3000 mm/year in an area about 400 km². The meso-α-scale features and synoptic situations associated with the intense precipitation events in autumn have been extensively studied both in the past and more recently (e.g., Buzzi et al, 1998; Cacciamani et al, 2000; Stein et al, 2000; Vrhovec et al, 2001; Žagar et al, 2002). As a Mediterranean cyclone forms on the western edge of the Alps, and following the passage of the warm front, the south-west flow can persist for several days over the SE Alps, bringing warm and moist air to the Alpine slopes and ridges. The mountain ridges are running almost perpendicular to the warm SW flow, and are only 20 to 60 km away from the Adriatic Sea. The SE Alps are a steep barrier rising from 100 m up to 2000 m over a horizontal distance of just 10 to 20 km. Hence, direct lifting to the level of free convection (LFC) (e.g., Banta, 1990) is enabled by the steep slope and great relative height difference of the terrain itself, even for cases with relatively high LFC – up to 2000 m.

2. Weather situation during the MAP IOP 5

2.1 Synoptic situation

The MAP IOP 5 was a three-day event from 2 October 00 UTC to 5 October 00 UTC. It was characterized by a deep and wide trough descending from the Atlantic and spreading across Western and Central Europe (Fig. 2).