Internationales Symposion
INTERPRAEVENT 1996 – GARMISCH-PARTENKIRCHEN
Tagungspublikation, Band 1, Seite 55 – 63

The Mesoscale Alpine Programme (MAP): An international research initiative in Alpine meteorology

Das Mesoskalige Alpine Programm (MAP): Eine internationale Forschungsinitiative der alpinen Meteorologie

H. Volkert, P. Binder, R. Benoit, P. Bougeault, A. Buzzi,
G. Mayr, C. Schär, and R. Steinacker

Abstract: The primary scientific objectives of MAP are introduced and their relevance for the improved prediction of flash flood episodes in the Alpine region is highlighted. Efforts to combine the quite inhomogeneous databases across institutional and national borders are outlined. Examples are presented to indicate the present status of operational and research type predictions of precipitation over two to three days ahead.

Zusammenfassung: Die grundlegenden wissenschaftlichen Zielsetzungen von MAP werden vorgestellt und ihre Bedeutung für verbesserte Vorhersagen von plötzlichen Überschwemmungen im Alpenraum wird dargelegt. Bemühungen werden beleuchtet, die ziemlich inhomogene Datenbasis über institutionelle und nationale Grenzen hinweg zu vereinheitlichen. Beispiele werden angeführt, um den gegenwärtigen Stand von operationeller und forschungsorientierter Niederschlagsvorhersage über zwei bis drei Tage zu verdeutlichen.

1. Introduction

Mountains, and in particular Alpine-type orography, instigate or influence a rich range of mesoscale[1]) phenomena. These phenomena and their associated processes are intricate in character, interact with larger and smaller scale flow, and are responsible for much of the day-to-day mountain weather and for many of the extreme weather events.

[1]) Mesoscale flow systems are those that possess space scales of 2 to 2000 km and time scales between 2 hours and 2 days.

Moreover their composite effect contributes significantly to determining the climatic features of mountainous regions.

These facets of orography-related mesoscale phenomena combine to make their adequate observation, basic understanding, and successful prediction both difficult and desirable enterprises. The challenge has been highlighted by various developments in the last decade: pertinent field studies helped establish the importance of orographic effects and pinpointed gaps in our information and knowledge base; new high resolution numerical models revealed various deficiencies (e.g. the representation of mesoscale moist processes and orographic effects), the lack of suitable observational data for the inter-related purposes of diagnostic analyses and the initialization and validation of forecasts; and the emergence of novel observing systems (e.g. profilers, light-weight dropsondes, airborne Doppler radar and lidar) can contribute substantially to remedying the shortcomings.

The Mesoscale Alpine Programme (MAP) is a measured response of the international atmospheric science community to the foregoing challenges and developments. It is conceived as a coordinated and integrated programme of basic research that has direct practical applications in the realm of numerical weather prediction. The programme's coupled overall aims is to further our basic understanding and forecasting capabilities of the physical and dynamical processes that

- govern precipitation over major complex topography, and
- determine three-dimensional circulation patterns in the vicinity of large mountain ranges,

and the strategy is to focus on key orography-related mesoscale effects that are exemplified in the Alpine region.

2. The MAP Design Proposal

As a first planning document the MAP Design Proposal was released early in 1995 from the MAP Programme Office in Zürich (MAP 1995). It had evolved from discussions at an internatioanl workshop with more than 70 participants from 42 institutions in 13 countries, among them representatives from 12 national meteorological services, WMO and ECMWF.

According to the overall aims mentioned above the following scientific objectives were formulated and discussed:

1) to improve the understanding of orographically influenced precipitation events, including deep convection, frontal precipitation and flash flooding episodes; and to improve the numerical prediction of moist processes over and in the vicinity of complex topography;

2) to improve the understanding and forecasting of the life cycle of Foehn-related phenomena, including their three-dimensional structure and associated boundary layer processes; and
to improve the understanding of three-dimensional gravity wave breaking and associated wave drag in order to improve gravity wave drag parametrizations in numerical weather prediction and climate models;

3) to provide data sets for the validation and improvement of high-resolution numerical weather prediction models in mountainous terrain.

In addition, a supporting objective was defined as:

4) to establish a climatology of mesoscale systems in the Alpine region, including the collection and exchange of non-GTS data.

Objectives 1) and 4) appear to be of direct relevance to the Interpraevent conference community as they address the problem of how to diagnose severe precipitation events in the Alpine region with exisisting observational networks and how to predict them one or two days in advance.

More information in this respect is given in the remainder of this extented abstract as well as in a video presentation and a poster display at the conference.

3. The MAP Data Centre

As outlined in section 4 of MAP (1995) a decentralized MAP Data Centre (MDC) is being set up under the supervision of the Atmospheric Science group of ETH in Zürich. Its primary task is to collect and make available relevant atmospheric data for the Alpine region, be it from operational or from special purpose sources. The establishment of a transnational precipitation data base is among the pilot activities of the MDC.

MDC works in close cooperation with the MAP Working Group on Observation Networks (WGON). The latter seeks contacts with agencies that maintain observing stations in the Alpine region and advocates the input of relevant data into the MDC. All stations, which are currently (Jan. 1996) known to WGON, are displayed in Figure 1.

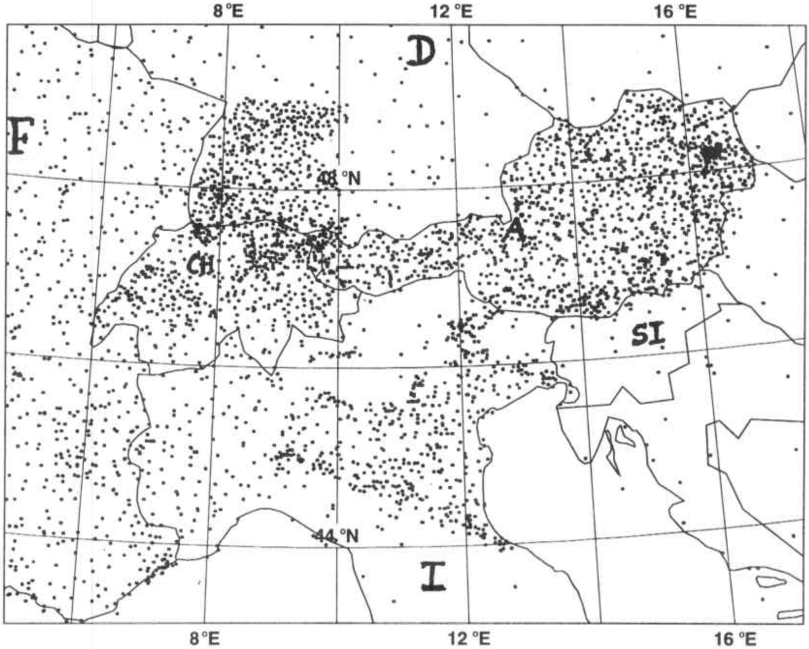

Fig. 1: Station distribution of various meteorological surface networks in the different Alpine countries (A: Austria; CH: Switzerland; D: Germany, F: France; I: Italy; SI: Slovenia). The backbone consists of the synoptic stations operated by the national weather services; these are augmented by automated networks and those operated by other agencies. See text for more details.

The considerable regional variation in station density is striking; it may be alleviated when other regional agencies have also been integrated. The synoptic stations, which are run by the different national weather services, serve as the basic net. They are augmented by automated networks as ANETZ/ENETZ in Switzerland, TAWES in Austria, and networks of regional Italian meteorological services as those in Emilia Romagna or Veneto. Also included are stations operated by the Austrian Umweltbundesamt, the Tiroler Lawinenwarndienst and providers in Baden-Württemberg.

We note that the Alpine region possesses the highest observing station density of all major mountain ranges on the globe. But as these stations are distributed over more than half a dozen countries and many more institutions, a concerted effort is necessary to make their data usable in a coherent fashion.

4. Examples of high resolution forecasts

In general, weather prediction by numerical models has made considerable advances during the last decade. Deutscher Wetterdienst and the Swiss Meteorological Institute, for example, started to apply a mesoscale model with 15 km horizontal gridsize in July 1993 for operational use. Initial and boundary values for each 48-h-forecast are provided by the Europa-Modell and the Global Model, which in turn cover larger domains at lower resolutions (SCHRODIN, 1995). The determination of the predictive skill of such high resolution models over terrain as complex as the Alps constitutes a considerable task of current research, in particular for precipitation forecasts.

An example of the close interrelation of orographically modified flow and moisture fields is given in Figure 2. In a height of about 3km an elongated band of saturated air extended roughly parallel to the eastern border of France marking a distinct, fast moving cold front on its approach towards the Alps. A well developed foehn-type flow crossed the Alps ahead of the front with maximum wind speed close to the lee slope of the Alps (see bottom frame of Fig. 2). Saturated air was predicted for the windward side over Northern Italy, in sharp contrast to the dry regions to the north of the mountains. The steep descent of the potential temperature lines indicates the subsidence in that area. All in all, the forecast was consistent with the textbook depiction of foehn flow ahead of an approaching front, but it also revealed the high spatial and temporal variability of flow and moisture fields, the interaction of which is of decisive importance for precipitation forecasts.

Preliminary investigations concerning the performance of the operational Swiss model regarding episodes of severe precipitation in the Alpine region is available for the Piedmont flood of November 1994 (BINDER and ROSSA, 1995; see also BUZZI et al., 1995 and LIONETTI, 1996). A comparison of model results, surface observations and radar sensed precipitaton patterns led to the conclusion that this flood event resulted from a complex evolution on the synoptic as well as on the mesoscale. The Swiss model appeared to have given valuable forecasts, but quantitative verification results are not yet available.

The present operational model resolution of about 15 km is not sufficient, if the scale of major Alpine valleys or massifs is to be resolved (cf. VOLKERT 1990). Therefore developments are underway at several meteorological services to introduce non-hydrostatic models with a grid resolution of one or two kilometres for routine usage. A sample result of the first research-type hindcast in this category is presented in Figure 3. It dealt with the flash flood that devasted the Swiss town of Brig on 23 September

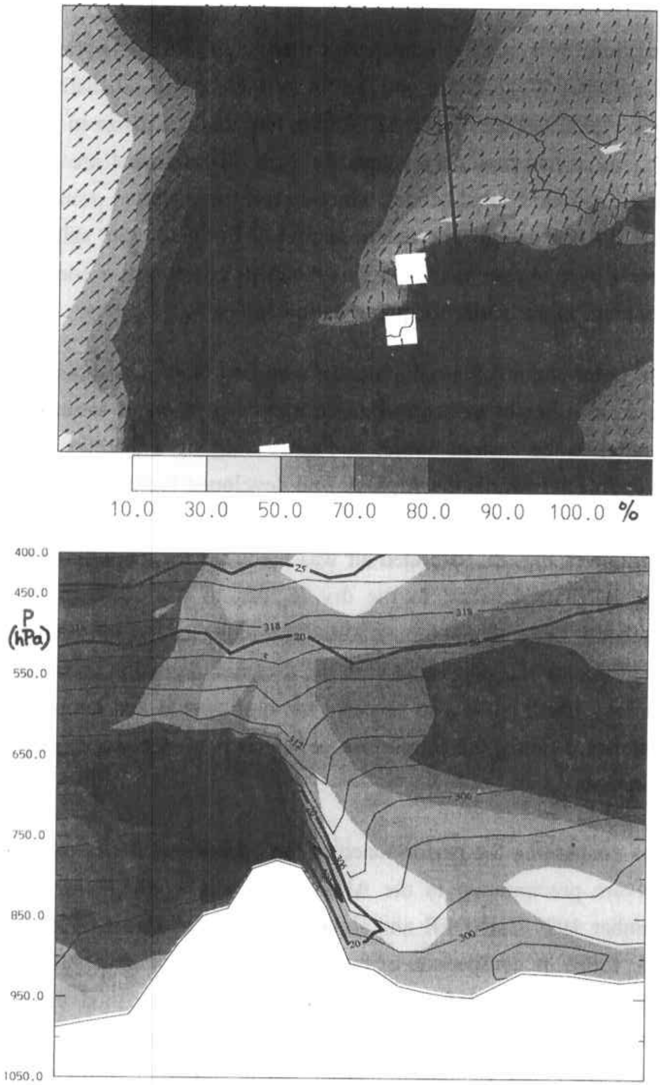

Fig. 2:
Operational 12 h forecast with the Swiss Model for 7 Sep. 1995.
Top: relative humidity (%; grey shades) and horizontal wind vectors (max. 17.7 m/s) at the 700 hPa pressure level (about 3 km high).
Bottom: Cross-section along the black line across Switzerland with rel. humidity (shaded), potential temperature (thin lines; increment: 2 K), along-section flow exceeding 20 m/s (increment: 5 m/s), and model orography (white).

1993 and was obtained with the MC2 modeling system, which is under development in Canada (BENOIT and DESGAGNÉ, 1995).

The hindcast was initialized with analyses from ECMWF and realized on three nested grids with 50, 10 and 2 km mesh size. The overall situation for 23 September 1993, 15 UT on the medium grid is given in the bottom frames of Fig. 3. The south-western Alps experience large precipitation totals (over 15 h) with maxima near Monte Rosa

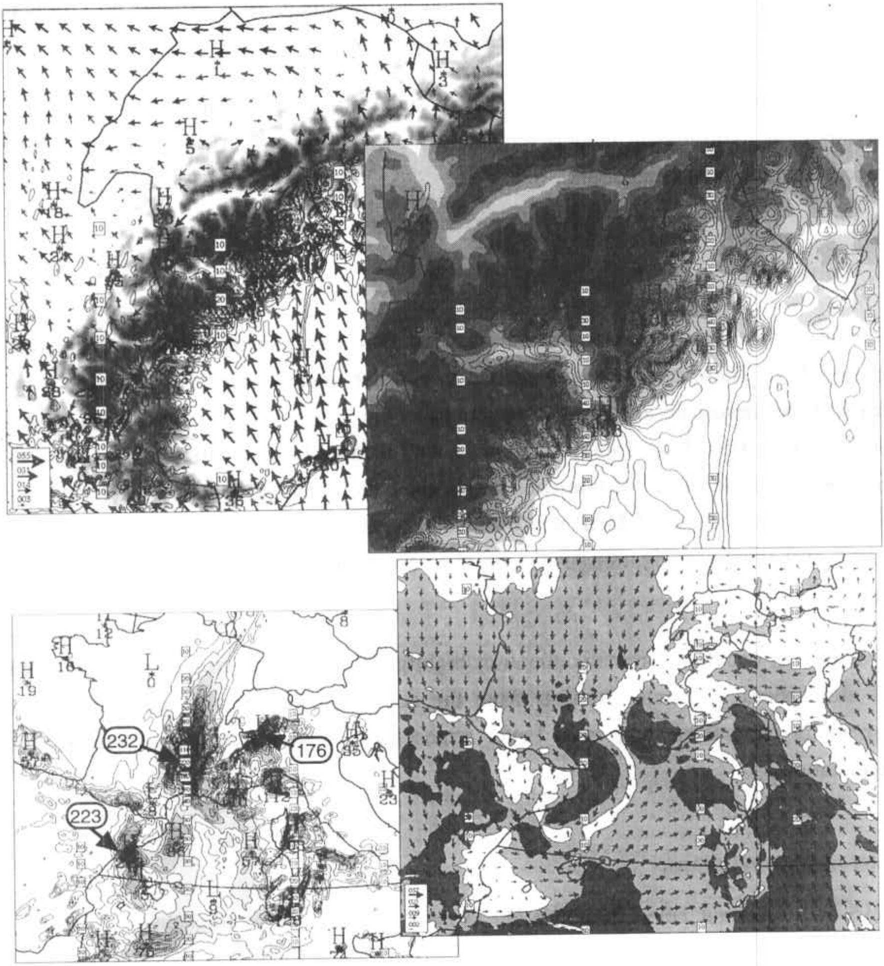

Fig. 3: Research-type hindcast with the Canadian MC2 model for 23 Sep. 1993.
Top: finest grid run (Δx = 2km) after 4 h; left frame: western part of Alpine orography (shades), accumulated precipitation (mm; thin contours) and wind vectors in 900 hPa (knots); right frame: zoom into the Swiss-Italian Alps with detailed precipitation field (note the 131 mm / 4 h maximum near the Toce river valley).
Bottom: medium grid run (Δx = 10 km); left frame: 24-h precipitation sum; right frame: surface winds for 15 UTC (knots; shading increment for speed: 10 kt).

(176 mm) and in the southern Rhône valley (232 mm). In the central part of the fine grid a highly structured precipitation field developed above the southern flank of the Alps with a maximum of 131 mm / 4 h close to the Swiss border and the catchment

area of river Saltina, which carried the flood northwards to Brig. Almost no rain was simulated to the north of the main crest consistent with the observations.

The determination of the predictive skill of such models for actual alarm procedures or input for hydrological models remains to be established, but the potential of such recent development is apparent.

5. Outlook

Recent advances in forecasting severe precipitation events in the Alpine region were exemplified. These efforts are embedded in a wider international research effort concerning the mesoscale atmospheric structures in the vicinity of major mountain ranges such as the Alps. It is anticipated that a well-balanced combination of analyses of routinely collected data, of numerical experimentation, and of focussed measurements during the field phase of MAP will eventually advance our knowledge in the complex topic of heavy precipitation over complex orography and improve our predicitve capabilities.

The team of coauthors from six countries highlights the widespread interest in this area of atmospheric research. Contacts from the conference community are encouraged, especially from those who need better atmospheric input for their own research or applications.

List of abbreviations:

GTS	Global Telecommunication System (to exchange weather data)
ECMWF	European Centre for Medium-range Weather Forecasts, Reading
ETH	Eidgenössische Technische Hochschule (Swiss Federal Institute of Technology)
IOP	Intensive observation period
LAM	Limited area model
MDC	MAP Data Centre
NWP	Numerical weather prediction
PYREX	Pyrénées Experiment, Oct. and Nov. 1990
WGNO	Working Group on Observational Networks (within MAP)
WMO	World Meteorological Organiztion

References:

Binder, P. and A. Rossa, 1995: The Piedmont flood: operational prediction by the Swiss Model. MAP-newsletter No. 2, 12-16; available from MAP-Programme Office c/o SMA, CH-8044 Zürich.

Benoit, R. and M. Desgagné, 1995: Application of the non-hydrostatic MC2 LAM to the Brig 1993 flash flood event and The PYREX IOP-3 foehn case. MAP-newsletter No. 3, 24-26; available from MAP-Programme Office c/o SMA, CH-8044 Zürich.

Buzzi, A., N. Tartaglione, C. Cacciamani, T. Paccagnella, P. Patruno, 1995: Preliminary meteorological analysis of the Piedmont flood of November 1994. MAP-newsletter No. 2, 2-6; available from MAP-Programme Office c/o SMA, CH-8044 Zürich.

Lionetti, M., 1996: The Italian floods of 4-6 November 1994. Weather **51**, 18-27.

MAP, 1995: Mesoscale Alpine Programme – design proposal. P. Binder und C. Schär (eds.), available from MAP-Programme Office c/o SMA, CH-8044 Zürich, 63 pp.

Schrodin, R., (ed.), 1995: Quarterly report of the operational NWP-models of the Deutscher Wetterdienst. No. 3, April 1995, DWD, Forschungsabteilung, Offenbach, 61 pp.

Volkert, H., 1990: An Alpine orography resolving major valleys and massifs. Meteorol. Atmos. Phys. **43**, 231-234.

Authors' addresses:

Dr. Hans Volkert, DLR–Oberpfaffenhofen, Institut für Physik der Atmosphäre, D-82230 Weßling; *email:* Hans.Volkert @ dlr.de
(presenter at Interpraevent '96)

Dr. Peter Binder, Schweiz. Meteorologische Anstalt, Krähbühlstrasse 58, CH-8044 Zürich; *email:* pbi @ sma.ch
(chairman of the MAP *Core and Implementation Group*)

Dr. Robert Benoit, RPN Dorval, 2121 Trans-Canada N., Suite 564, Dorval, Quebec H9P 1J3, Canada; *email:* robenoit @ rpn.aes.doe.ca

Dr. Philippe Bougeault, CNRM, Météo France, 42, av. G. Coriolis, F-31057 Toulouse; *email:* Philippe.Bougeault @ meteo.fr
(chairman of the MAP *Scientific Steering Committee*)

Dr. Andrea Buzzi, Fisbat–CNR, Via Gobetti 101, I-40129 Bologna; *email:* buzzi @ atmos1.bo.cnr.it

Dr. Georg Mayr, Meteorologisches Institut der Univ., Innrain 52, A-6020 Innsbruck; *email:* georg @ ertel.uibk.ac.at

Prof. Christoph Schär, Atmosphärenphysik ETH, Hönggerberg HPP, CH-8093 Zürich; *email:* schaer @ atmos.umnw.ethz.ch

Prof. Reinhold Steinacker, Institut für Meteorologie, Univ. Wien, Silbergasse 45/7, A-1190 Wien; *email:* Reinhold.Steinacker @ univie.ac.at