The Mesoscale Alpine Programme

MAP newsletter

no. 16
march 2002

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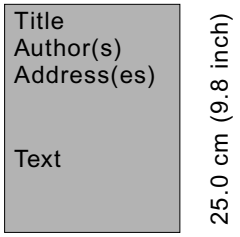
ISSN 1424-4853

The MAP newsletter invites short articles on MAP-related topics. **Contributions** to the MAP newsletter should be sent to the Editor Andrea Rossa. **Please deliver your text (graphs included) in a camera-ready format** (pdf or ps in A4 format, see templates at the MAP Data Centre), and be sure that figures are suitable for black and white reproduction.

Your contribution must not exceed 2 pages!

Camera-ready format:
16.0 cm (6.3 inch)



Deadline for contributions to the MAP newsletter No. 17:
September 16, 2002 (to appear in October 2002)

Editorial

"In between – but close to the other shore" might be an appropriate snapshot of the current state of MAP. The field measurements are already far behind, the first wave of overview and introductory papers has surfaced in the peer reviewed journals, and a large number of articles are currently in the review process: almost forty alone in the planned special issue of the Quarterly Journal (see "QJRMS Special Issue on MAP-SOP results" on page 9). Others are already embarking on new journeys (see "MEDEX: Outline of the project, links to MAP" on page 5 and see "News from FACT" on page 13).

This year marks the first time that an annual MAP meeting will literally reach the other shore. Judging from the program, the meeting in Park City, which is combined with the AMS Mountain Meteorology Conference, will be *the* chance to step back from one's particular styptics) of the field phase data, fit it like a puzzle piece into the larger whole of orographically modified atmospheric flow, and regain the big picture.

All, who periodically visit the MDC website, will have noticed that even more than two years after the SOP new data keep arriving. This reflects on the great efforts involved in collecting data from a multitude of providers while simultaneously ensuring good quality of the data. Inga Groehn reports in this issue on some of the quality control efforts within MAP.

A MAP SOP reanalysis has begun at the ECMWF to provide the community with one unified data set for the numerical modeling efforts. An improvement of the forecasting capabilities in the Alps and other mountains around the world has always been a central raison d'être for MAP.

The autumn issue of the MAP newsletter will break with tradition by not containing extended abstracts from the annual MAP meeting. Instead we will focus on taking stock of the MAP SOP data set and provide an overview of data from the from the various target areas, large observational platforms, and the before mentioned reanalysis.

Georg Mayr

Summary of the second MSC Meeting

Andrea Rossa, MeteoSwiss, 8044 Zurich, Switzerland

Most of the items on the agenda of the second MAP Steering Committee (MSC) meeting, held 15-16 November 2001 in Milano Linate, Italy, are separately addressed in this issue of the MAP newsletter, so that there remain but a few issues to mention here.

In general, the MSC has been active to set the course of MAP for the next couple of years. Creation of value on the SOP data comes already from the reanalysis project for the SOP data (see "The MAP-SOP reanalysis project" on page 9), while dissemination of MAP results is tackled via a special issue (see "QJRMS Special Issue on MAP-SOP results" on page 9) and the MAP publication list which is in the process of being set up at the MDC (see "MAP Publications" on page 11). The next two annual MAP Meetings are joint to the AMS Conference on Mountain Meteorology this year, and the International Conference on Alpine Meteorology, ICAM 2003, next year.

In particular, the future of the MDC beyond 2002 was discussed, since the MDC funding through EUMETNET (EMN) programme MAP-NWS will have ended. The MSC emphasized that a continuation of the MDC beyond 2002 for at least three years is absolutely essential at this stage. Consequently, the Programme Office (PO) is interacting with EMN Coordination Officer Claude Pastre on a MAP-NWS follow up programme. The idea is to have a new contract for the period 2003 to 2005 on a lower funding level covering the expenses for 1 person unit at the MDC and 0.2 person unit at the PO. The MDC will remain at ETH (as today), but be transferred to an operational institution by the end of this follow up programme. A proposal will be submitted to the EMN Council Meeting in April.

MAP and WMO

Philippe Bougeault, Météo France, 31057 Toulouse, France

The Mesoscale Alpine Programme is regularly discussed within WMO meetings: In the recent period it was the case at the WWRP/SSC meeting in Geneva (October 2001) and at the Commission of Atmospheric Sciences in Oslo (February 2002). The Scientific Steering Committee of the World Weather Research Program had its 4th meeting in Geneva, 23-26 October 2001. The progress within MAP was reviewed, and the WWRP was pleased with our overall results and efforts to set up a program in Societal Impacts. The resolution adopted is reproduced below:

"The committee continues to be impressed with the progress of MAP on all fronts, including the quality and rate of research publications and the appointment of impacts and applications members to its Science Steering Committee. The latter action ensures an appropriate emphasis on coordination with the hydrological aspects of the programme and the quantification of future benefits to be derived by Members. It is expected that MAP will be a major participants in the upcoming international QPF Conference, where mature results from several investigations in "wet MAP" are likely to be presented …"

At the XIIIth session of the Commission for Atmospheric Sciences (Oslo, 11-20 Feb 2002), results of MAP where presented to 40 WMO official delegations as part of the WWRP Science Report. The MAP data policy was again cited by the Secretary General GOP Obasi as "the example to follow". The Commission also encouraged MAP to continue its efforts to integrate research on societal impacts and forecast value.

MEDEX: Outline of the project, links to MAP

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Introduction

MEDEX, the MEDiterranean EXperiment on cyclones that produce high impact weather in the Mediterranean, is a Research and Development Project (RDP) framed in the World Weather Research Programme (WWRP) of the World Meteorological Organisation (WMO), after the official endorsement of its first phase by decision of the Science Steering Committee (SSC) for WWRP, in October 2000.

At present, WWRP consists of five RDP (MAP, In-Flight Icing, International Tropical Cyclone Landfall Project, THORPEX and MEDEX) and a few Demonstration Projects. All the RDP in WWRP are oriented to the better understanding and the improvement of the forecasting of high social impact weather phenomena. There are some convergences between some of these projects. In particular, MEDEX has convergences with THORPEX and MAP. In this paper the main aspects of MEDEX are outlined and some links between MEDEX and MAP are shown.

MEDEX: outline of the project

In spite of the usually pleasant weather, the Mediterranean area is quite frequently affected by sudden events of extreme adverse weather, often producing high social impacts. The reduction of the dramatic consequences of these extreme weather events is the ultimate motivation of the MEDEX proposal. Improving forecasts of such events is a necessary, though not sufficient, condition for the above achievement.

Although not all the extreme weather events in the Mediterranean are related to cyclones and most of the cyclones do not produce extreme weather, it is plausible to assume that Mediterranean cyclones influence most of the high impact phenomena, at least in an indirect way. Preliminary statistical results (Fig. 1, Jansa et al., 2001) show that around 90% of the heavy rain events (in a variety of areas of the Western Mediterranean) have a cyclone in its vicinity. Most of them in such a location that some kind of influence of the cyclone on the heavy rain generation and location can easily be inferred.

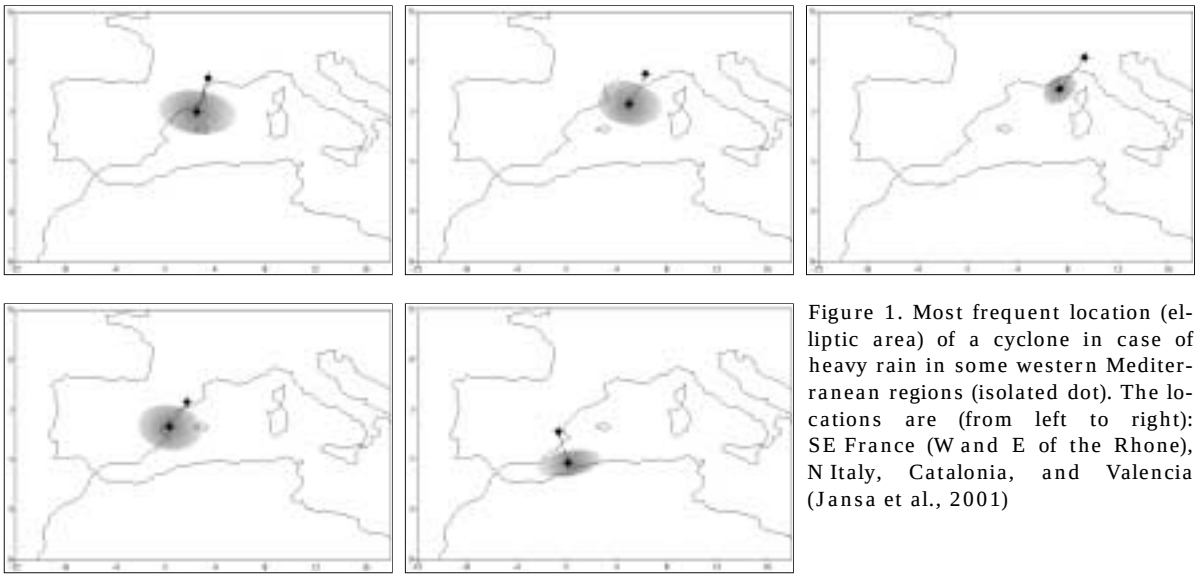

Figure 1. Most frequent location (elliptic area) of a cyclone in case of heavy rain in some western Mediterranean regions (isolated dot). The locations are (from left to right): SE France (W and E of the Rhone), N Italy, Catalonia, and Valencia (Jansa et al., 2001)

According to the cited study, most of the cyclones that accompany heavy rain are not strong and deep baroclinic systems, but shallow orographic or thermal depressions.

Therefore, in order to focus the project on a tractable near term scientific objective, *the main general objective of MEDEX is stated to be the improvement of knowledge and forecasting of cyclones that produce high impact weather in the Mediterranean area.* Cyclone is understood in the most general sense of the word, that is, including shallow depressions.

Directed towards the general objective, several specific objectives have been identified for the phase 1 of the project (*MEDEX Science Plan Phase 1*, available at www.inm.es/MEDEX):

- To implement an initial approach to a dynamically oriented climatology of the cyclones that produce high impact weather in the Mediterranean. Working in a systematic way, we want to know the type of cyclonic structures that appears related to high impact weather events of different kind, in different areas within the Mediterranean area, as well as the percentage of high impact weather events that may or may not be related to cyclones. This is a necessary step to evaluate the potential impact of the improvement of the forecasting of cyclones on the prediction of the high impact weather itself. It is also necessary to know how representative the work on particular cases will be.

- To determine and rank the multiple geographical and meteorological factors that act in the generation and evolution of the different types of cyclones that produce high impact weather in the Mediterranean. The skill of NWP models to predict the Mediterranean cyclones has to be connected with the determined factors.

- The identification of sensitive areas where better initial conditions may likely lead to improved forecasts. In general, the inaccuracy in the initial conditions can be a source of error of the numerical prediction. It is necessary to know the areas, levels and magnitudes for which the analysis error produces most significant errors in the prediction of the cyclones. Closely connected with the former objective is an assessment of the impact of better defined initial conditions in sensitive areas.

To face the first of these objectives, daily objective analyses and daily GTS and non-GTS rainfall and wind data will be used. The second and third objectives will be based on a set of selected events, covering the period 1995-2003. All available data for the selected periods will be used and data of coincident campaigns included. Neither a field phase, nor the deployment of extraordinary means of observation are foreseen for the MEDEX first phase. 27 events have already been pre-selected for the period 1995-2000, ranging from Portugal to Israel. A specific MEDEX Data Base is being organised to collect the data to be used.

MEDEX phase 1 is foreseen to finish by the end of 2004. The feasibility of a second phase (perhaps including field measurements) will be studied before that.

MEDEX links to MAP

The primary scientific objectives of the Mesoscale Alpine Programme (MAP) have been published in the MAP Design Proposal (1996) as:

- 1a: To improve the understanding of orographically influenced precipitation events and related flooding episodes involving deep convection, frontal precipitation and runoff;

- 1b: To improve the numerical prediction of moist processes over and in the vicinity of complex topography, including interactions with land-surface processes.

- 2a: To improve the understanding and forecasting of the life-cycle of Foehn-related phenomena, including their three-dimensional structure and associated boundary layer processes.

- 2b: To improve the understanding of three-dimensional gravity wave breaking and associated wave drag in order to improve the parametrization of gravity wave drag effects in numerical weather prediction and climate models

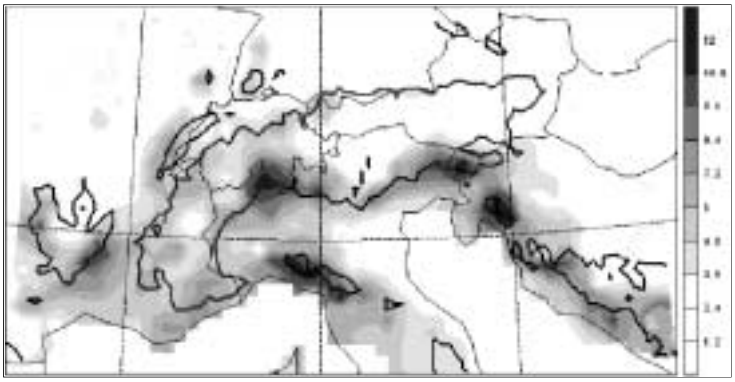

Figure 2. Climatological frequency of heavy precipitation (over 20 mm/day) over the Alps during the month of October. Colour coding shows percentage of days (after Frei and Schär, 1998).

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- 3: To provide data sets for the validation and improvement of high-resolution numerical weather prediction, hydrological and coupled models in mountainous terrain.

The scientific objectives 1a and 1b together are referred to as *wet MAP*, objectives 2a and 2b were termed *dry MAP*. There is a connection between MEDEX and *dry MAP*, because some Foehn related phenomena and wave drag effects, the formation of low level PV banners included, can be a seed for Mediterranean cyclones, some of them producing high impact weather. But the following thoughts will be mainly focused on the link between MEDEX and *wet MAP*.

Geographically, MAP concerns the Alpine Region. The target territory for MEDEX is the whole Mediterranean area. Obviously, the southern slopes of the main Alps (in Switzerland and Italy) and some other areas in South-Eastern-France, Northern-Italy, Slovenia or Croatia are common territory for both projects, MAP and MEDEX. Heavy precipitation (in the common area) is then a common topic of interest for MAP and MEDEX, although the focus of both projects differs.

As stated in the document *Scientific Objectives* (MAP Data Centre, http://www.map.ethz.ch), the largest amounts of precipitation in the Alps occur during autumn on their southern slopes. Climatologically, the rainfall is mostly concentrated over slopes exposed to air trajectories coming from the Western Mediterranean or the Adriatic sea (Fig. 2, Frei and Schär, 1998). Typical mesoscale weather systems and flow features that favour heavy and long lasting precipitation in the south of the Alps are *Mediterranean depressions* and fronts (e.g. Sénési et al., 1996). The role of the Mediterranean cyclones (or depressions) in organising an inflow of wet and warm Mediterranean air to feed heavy precipitation in Alpine and non-Alpine Mediterranean locations has been identified for several particular events, including some of the most important cases that were selected for the preliminary phase of MAP (see Jansa et al., 1995, and Jansa et al., 2000, for a summary).

Statistically, in 84% of 77 events of heavy precipitation in Ticino, Liguria, Lombardia and Piemonte there is a cyclone within a radius of 600 km from the heavy rain site, mostly located as indicated in Fig. 1 (up-right corner). For South-Eastern-France (W and E of the Rhone river, up-left and up-centre in Fig. 1) the numbers are 90% of 195 events and 91% of 120 events. Part of the concomitance of cyclones and heavy rain could be by chance, not causal, since in fact the presence of depressions in the Mediterranean is quite frequent. But their relevance becomes more evident by comparison with the frequency of the presence of a depression within 600km for a random sample of days (with or without rain), which is only 38% from S-Switzerland and N-Italy and 56% from SE-France (Jansa et al., 2001; or preliminary view in Jansa et al., 1996).

As a consequence, a complete understanding of some of the most significant wet-MAP related weather events during the field phase of MAP, probably also requires understanding of the mechanisms that lead to a Mediterranean cyclo-

Figure 3. MSL pressure, 20-Sep.-99 at 06 UTC (MAP IOP 2; left) and 07-Nov.-99 at 00 UTC (MAP IOP 15; right).

genesis, prior to and associated with the heavy rain event.

Three of the 27 pre-selected MEDEX events (1995-2000) are also MAP IOPs: IOP2B (20-22 Sep. 1999), 5 (2-5 Oct. 1999) and 15 (6-9 Nov. 1999). In the first case, a secondary low in the Mediterranean (L in Fig. 3) intensifies the feeding current (arrow in Fig. 3) towards the Alps. 300 mm/24 h and floods were registered in the Lago Maggiore area. IOP 15 is an archetype of deep Mediterranean lee cyclone, which produced very strong winds and/or heavy rain in areas of Spain, France, Italy, Croatia and even Greece. Valuable additional information about these cases is available in the MEDEX Data Base.

Final remark

The scientific objectives for MEDEX and MAP are clearly distinct. For MEDEX the objective is the Mediterranean cyclogenesis. For MAP it is the orographic perturbation of the air flow. But there are derived common topics of interest: in particular, heavy rain in the Mediterranean Alpine area is a main consequence of both, the Mediterranean cyclogenesis and the orographic perturbation of the air flow. MAP is not totally complete without a reference to the Mediterranean cyclogenesis and MEDEX is not totally complete without considering the orographic enhancement of the precipitation. It is mutually beneficial to maintain contact between both projects. In this sense, MEDEX remains open to additional participation. Interested scientists or institutions may contact the MEDEX coordinator. To know more about MEDEX: http://www.inm.es/MEDEX.

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The MAP-SOP reanalysis project

Philippe Bougeault, Météo France, 31057 Toulouse, France,
(with input from Christian Keil, ECMWF)

The need for a "reference reanalysis" of the MAP SOP, taking benefit of all the additional observations and the most recent version of a modern assimilation system was discussed by the MSC at its first meeting in Schliersee. We agreed on general directions for such an effort, and a small subgroup (R. Benoit, P. Binder, P. Bougeault, A. Buzzi, E. Richard, and C. Schär) was tasked to issue an appropriate announcement of opportunity. This AO was published in July 2001. It was calling for offers to produce two kinds of deliverables:

- 1) Quality-controlled special observations of MAP, under a format well adapted to data assimilation (such as BUFR);
- 2) A standard reanalysis of the whole MAP-SOP, to be made available to research groups via the MDC.

MAP will contribute funds to this project. The deadline for offers was set to 15 September 2001, and three offers were received. The ECMWF offer was selected by the MSC at its 2nd meeting (Milano, November 2001), for the following reasons:

- guaranty of rapid delivery of the products;
- maximum use of satellite data over the Mediterranean area;
- the MAP community is already well aware of ECMWF formats and procedures.

The project has now started at ECMWF, and data are currently acquired from the MDC, converted to BUFR format and archived. The supplementary conventional data comprise roughly 3000 additional surface stations, the enhanced radiosonde network with some stations reporting with three hourly frequency, more than a dozen wind profilers and flight data of 8 research aircraft including various dropsonde measurements.

Meanwhile, control experiments with the latest 12h-4D-Var global data assimilation system (T511 IFS model resolution) are performed for dedicated episodes within the SOP. In these control experiments, the additional MAP observations broadcasted via the GTS in real time are blacklisted to be able to identify the impact of the additional data in the forthcoming re-analysis. Preliminary investigations of the observations statistics for radiosondes across Europe show a considerable improvement of the background and analysis departures compared with those of the ECMWF operational suite in 1999. Furthermore it becomes obvious, that the usage of satellite data of autumn 1999 (MAP SOP) in conjunction with the current IFS version Cycle 24R3 necessitates an adaptation of the bias correction for some satellite instruments in the data assimilation system. This preparatory work will allow to perform the MAP re-analysis later this year.

QJRMS Special Issue on MAP-SOP results

Philippe Bougeault, Météo France, 31057 Toulouse, France

At the first meeting of the MSC (Schliersee), it was decided to launch a Special Issue of a respected journal on the results of the MAP-SOP. QJRMS was selected after a survey of conditions offered by various journals. The deadline for submission of papers was extended to 31 January 2002 and we finally received 37 papers, which is more than expected, but a clear testimony of the size and activity of the MAP community. The manuscripts have been processed

in a very professional way by the office of the QJ, and the review process is now under progress. In view of the number of manuscripts submitted, the QJRMS Editor has accepted to rise to 500 the maximum number of pages for the special issue. Even with this enlarged limit, it is going to be a real challenge to publish all these manuscripts in due time.

The guest editors for this Special Issue of the QJ are Philippe Bougeault, Bob Houze, Rich Rotunno, and Hans Volkert.

"SOP" 2001 – A dull season

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An evaluation of MAP related events was carried out for the MAP season 2001 (September 7 to November 15) in the same manner as with the strawman scenario, the evaluation of the actual MAP-SOP in 1999 and the MAP-season 2000 (see, MAP Newsletter 10, 1999, MAP Newsletter 12, 2000, US MAP Field Phase Report, 2000, MAP Newsletter 14, 2001). Luckily, MAP-SOP did not take place in 2001. Whereas the previous two years each had a bulk of MAP related weather events, an experiment in 2001 would have resulted in never ending down days and rather in a waste of resources. Table 1 gives an overview of the 2001 events in a similar fashion as in the MAP Newsletter 12 and 14.

Remarkable is the very little number of days with Foehn in the Rhine valley, gap flow in the Wipp valley and heavy precipitation South of the Alps. The number of days with Foehn and gap flow was even less than the minimum in the previous decade. Only PV-banners south of the Alps occurred more often than in 1999 and 2000 due to a pronounced northwesterly large scale flow regime early to mid September. After the beginning of October hardly any MAP related weather event took place. Autumn and winter 2001/2002 brought a widespread drought to many of the Southern Alps regions.

Table 1 Number of days with MAP related weather events, calculated from a "half day" based evaluation.

days with	10y-mean (1989-98)	minimum (1989-98)	maximum (1989-98)	SOP-1999	'SOP'-2000	'SOP'-2001
PV-streamers	3.3	1.0	9.0	7.5	10,0	3,5
Foehn in Rhine Valley	16.4	9.5	28.0	23.0	27,5	6,0
Gap flow in Wipp Valley	17.4	8.0	28.5	20.0	26,0	5,0
Heavy precipitation S-Alps	7.2	2.0	20.5	11.5	13,5	4,0
Gravity Waves	5.6	1.0	10.5	12.5	10,0	3,5
PV-banners	5.4	1.0	10.5	12.5	10,0	3,5
PV-banners South of Alps	2.6	0.0	6.5	2.5	1,5	3,5
Possible IOPs (Periods)	10.9	7	17	17	13	13
without MAP-event	40.1	25	52	36	25	46
with 1 or more events	29.9	18	45	34	45	24
with 2 or more events	19.0	8	30	24	31	12
with 3 or more events	5.9	2	13	11	18	1
with 4 or more events	3.5	1	9	10	10	0

MAP Publications

Mathias W. Rotach, IACETH, 8057 Zurich, Switzerland

Since the beginning of the Mesoscale Alpine Programme (MAP) a large number of publications have been produced treating all sorts of aspects related to MAP. In order to compile all these publications so that present and forthcoming researchers have easy access and overview, the MAP Data Centre (MDC) runs a database containing all the necessary information. This little note should help you to find your way through the database – be it as an author, who wants her or his publication to appear in the data base or be it as a user, who is interested to find as many papers as possible on a specific aspect of MAP.

1 Organization of the Database

As usual in a 'list of publications' the basic information that is attached to each publication contains the name(s) of the author(s), year of publication, title, publisher (journal or media), issue/volume or date, page numbers. In addition, the user may constrain his or her search by a number of additional attributes.

Key words: Each publication can have a number of key words in order to easily identify the area of research covered. A list of possible key words has been produced by representatives of MAP working groups and projects. The use of exactly these suggested key words is not mandatory. However, if somebody searches the database the list may give a hint, which key words an author may have used. On the other hand, an author providing his/her information on a particular publication may want this paper to be found by prospective users. Therefore, it is again advisable to check the list of suggested key words and to select the most appropriate ones.

Peer reviewed or not: Some people may be interested in only selecting peer reviewed literature on a particular subject. Therefore an attribute 'citation index' (yes/no) is attached to each publication. This attribute is currently based on the list of journals as in the *Institute of Scientific Information* (ISI) database. Note, however that the current list of 'citation index=yes'-journals has been produced by a round-table screening and is by far not exhaustive. Therefore, if you should, as an author, submit a publication (see below) in a journal which is not in the list but clearly belongs to the group of peer reviewed journals, please inform the MDC to adjust the list.

Scientific or popular: Articles or papers may have appeared either in a scientific journal or, alternatively, in media for a more popular audience. Note that conference proceedings or publications in, e.g., the *map newsletter*, clearly count as scientific publications even if they do not belong to the group of peer reviewed articles (see above). Therefore an additional attribute is given to each entry: 'sc' stands for scientific and 'po' for popular.

Country of authors: In a separate list, the *country of affiliation* of all the authors is compiled for each publication. For this list, we use the 'internet convention' (Table 1) in order to have indices of equal length.

Table 1 Identification of Countries in the MAP publication's database.

Country	Index
Austria	at
Canada	ca
China	cn
Croatia	hr
Czech Republic	cz
France	fr
Germany	de
Hungary	hu
Italy	it
Russia	ru
Slovakia	sk
Slovenia	si
Spain	es
Switzerland	ch
USA	us
United Kingdom	uk

2 Submission of information

In general, the database is updated by country representatives (see Table 2) on a regular basis (at least yearly). This means that possible authors get a call for submitting information by these persons when an update is due or seems necessary. Therefore, authors *should not, in general, send their information directly to the MDC.* One notable exception is the case of an author stemming from a country not represented in Table 2. These authors may either contact one of the individuals as listed in Table 2 or directly the MDC for further information. The preferred way of submitting the information is through a pre-specified excel table that will normally be provided with the call for submitting an update.

Table 2 Country representatives responsible for updating the MAP list of publications

Country	Name	e-mail
Austria	Reinhold Steinacker	reinhold.steinacker@univie.ac.at
Canada	Robert Benoit	Robert.Benoit@ec.gc.ca
France	Evelyne Richard	rice@aero.obs-mip.fr
Germany	Klaus Peter Hoinka	klaus.hoinka@dlr.de
Italy	Andrea Buzzi	A.Buzzi@isao.bo.cnr.it
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United Kingdom	Adrian Board	asbroad@meto.gov.uk
USA	Ronald Smith	ronald.smith@yale.edu

FORM Activities: Status Report

Hans Richner, IACETH, 8093 Zurich, Switzerland

The FORM Working Group held its last semi-annual meeting in Bad Ragaz 8-9 November 2001. Twenty-one participants from Austria, France, Germany, Liechtenstein and Switzerland joined at the picturesque Hotel Wartenstein overlooking most of the Rhine Valley Target Area. In an almost familiar setting, we spent two days in a relaxed atmosphere exchanging information on the latest activities, discussing the results, and suggesting new activities. The fact that there was minimal time pressure allowed true and constructive discussions.

After a brief review of the MAP presentations at the DACH-MT 2001 in Vienna, all groups represented at the meeting informed about their activities and newest results. In this discussion it became very obvious, that a number of previously unresolved issues could be cleared thanks to the close cooperation among the researchers.

Examples for problem-stricken topics are the remotely sensed wind speed over the valley floor (comparison scidar - radiosonde - lidar) and the flow splitting near Sargans (comparison observation - model). Another important discussion was the definition of various terms related to Foehn; based on the experience, new observations, and expertise these could be further refined. At the end of the meeting an action list was compiled. This list includes the preparation of specific data for use by other groups for their own evaluation.

With respect to the upcoming MAP Meeting 2002 (June 17 to 21, 2002, Park City, UT, U.S.A.), a strategy was discussed that would allow to present the activities of the FORM WG in an appropriate fashion.

The group unanimously decided to keep its semi-annual meetings. It is foreseen that the fall

meeting will regularly be organized by Switzerland in Bad Ragaz, while the spring meetings will be arranged by one of the other countries involved in FORM. The next FORM WG Meeting will be held May 21 and 22, 2002 in Lannemezan, France, upon invitation of Meteo France.

The minutes of the FORM WG Meetings, as well as some of the presentations made there, can be downloaded from http://www.map.ethz.ch/form/minutes/minutes.html.

News from FACT

Peter Parson, ZAMG, 6020 Innsbruck, Austria

A first FACT - Workshop in Alpine Forecasting was organized by ZAMG in Innsbruck 7 - 9 November 2001. Participants: Scientists from the National Weather Services ZAMG, Meteoswiss and DWD, from the universities of Munich, Vienna, Innsbruck and Modena, forecasters from the NWSs of Switzerland, Austria, Germany, Slovenia and Italy, from Austro Control and from many regional services in Italy (South Tyrol, Trentino, Veneto, Lombardia, Piemonte and Liguria). Main topic: Limited Area Models and Operational Forecasting. You find the agenda of this successful meeting and the summaries of the presentations on the FACT home page: http://www.map2.ethz.ch/fact/index.htm

So FACT has its own home page now, kindly supported by Hans Hirter and Claudia Schmengler. The part is dedicated to meteorological education and training will be open to the public, the other part (a “forum”) will be used for communication between forecasters (eg. forecast alerts, data exchange). This is very likely to be password protected for the members of FACT.

Until now FACT is an informal working group of forecasters and scientists supported by many NWS of the Alps and by the Map Steering Committee (MSC). However, it has turned out, that FACT will need an official frame in future. A fruitful and continuous collaboration of forecasters from different countries and connections with other projects have to be ensured by formal agreements between the participating institutions. Therefore FACT should become an EUMETNET project.

At the second meeting of the MAP Steering Committee in Milano Linate, November 15-16, 2001, Peter Binder kindly agreed to help to formulate an official EUMETNET - project for FACT.

MAP Data Centre Status

Hans Hirter, IACETH, 8093 Zurich, Switzerland

MAP Site Map

With the new concept of the MAP Web interface (see MAP newsletter no. 14) the user will reach the data and information area with fewer clicks than before. However, finding the right information on a complex site like the MAP Website is sometimes a time consuming act. With the new site map we hope to improve the score of hits. Figure 1 shows the site map which gives a better overview from the point of the user. The structure of the MAP Web Site itself was not changed.

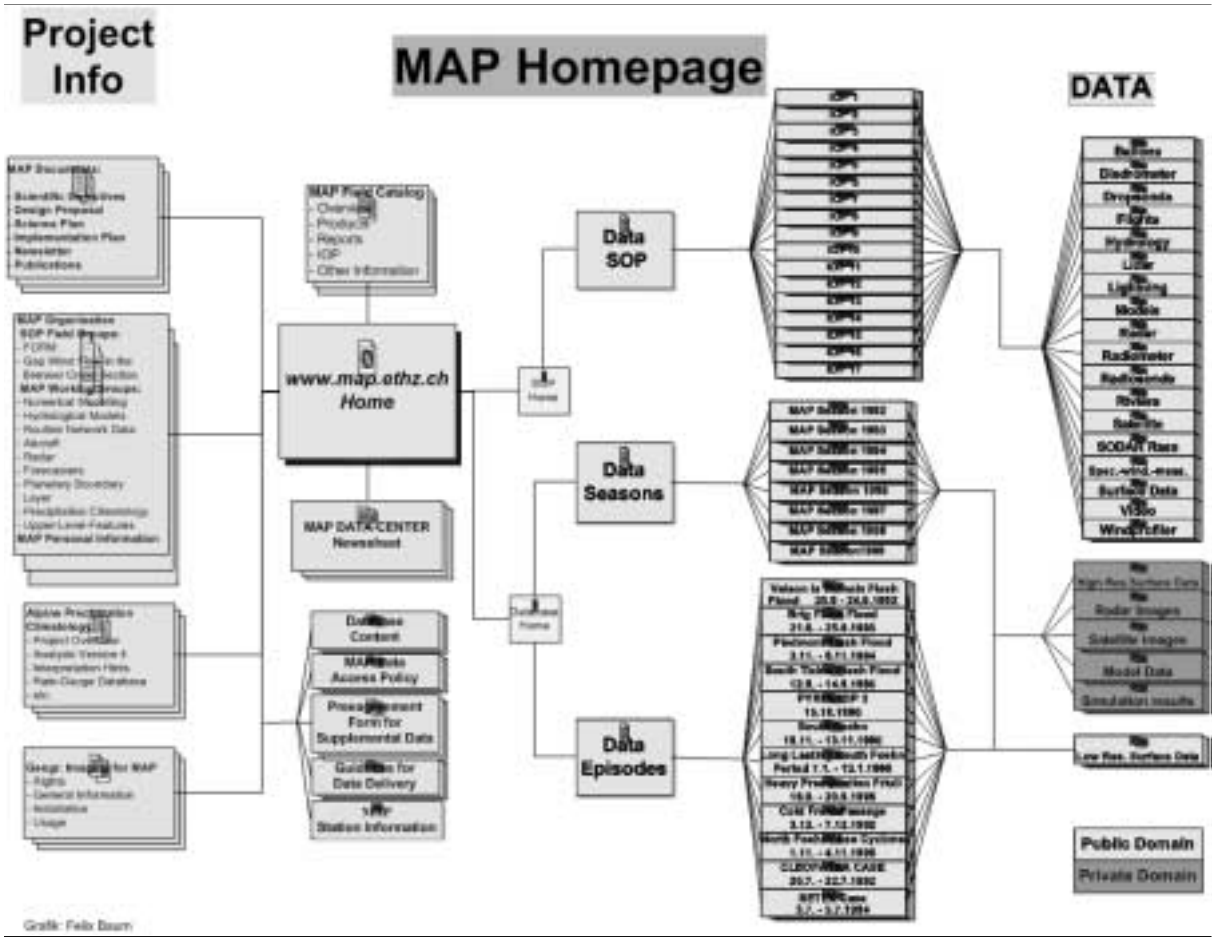

Figure 1. MAP Site Map.

The MAP Home Page is located in the centre; on the left side is the project information and on the right side is the data area. A line between boxes represents a link from one webpage to the next one. The MAP Site Map in PDF-format can be downloaded from http://www.map2.ethz.ch/map-doc/sitemap.pdf

MAP Data Centre access statistic

In the last 13 months there was a lot of Internet traffic at MDC. On average, the MDC had 8014 requests per day or 2'905'990 accesses in the last year. Counting the various pages on our site, we got 2'230 requests for pages per day or 808'704 requests for pages per year. Figure 2 shows the monthly traffic in the last year. The average data transfer rate was 184 Mbytes per day or 65'264 Mbytes per year.

In November the MDC was contacted by different search engines; in this particular case on the 3rd and 4th. This explains the tremendous difference between "requests" and "requests for pages". The number of "requests" means the total number of files downloaded from our server (including graphics), and the number of "requests for pages" just counts the various pages on our site.

The number of distinct hosts (the number of different computers from which requests came) was 18'269 hosts. The domain report list contains more than 100 different countries from which files were downloaded. Table 2 shows the top-twenty domains of computers which requested files. If we look at this list a little closer, we find countries all over the world like Israel, Saudi Arabia, India, China, Malaysia, Taiwan, Australia, Peru, Costa Rica...

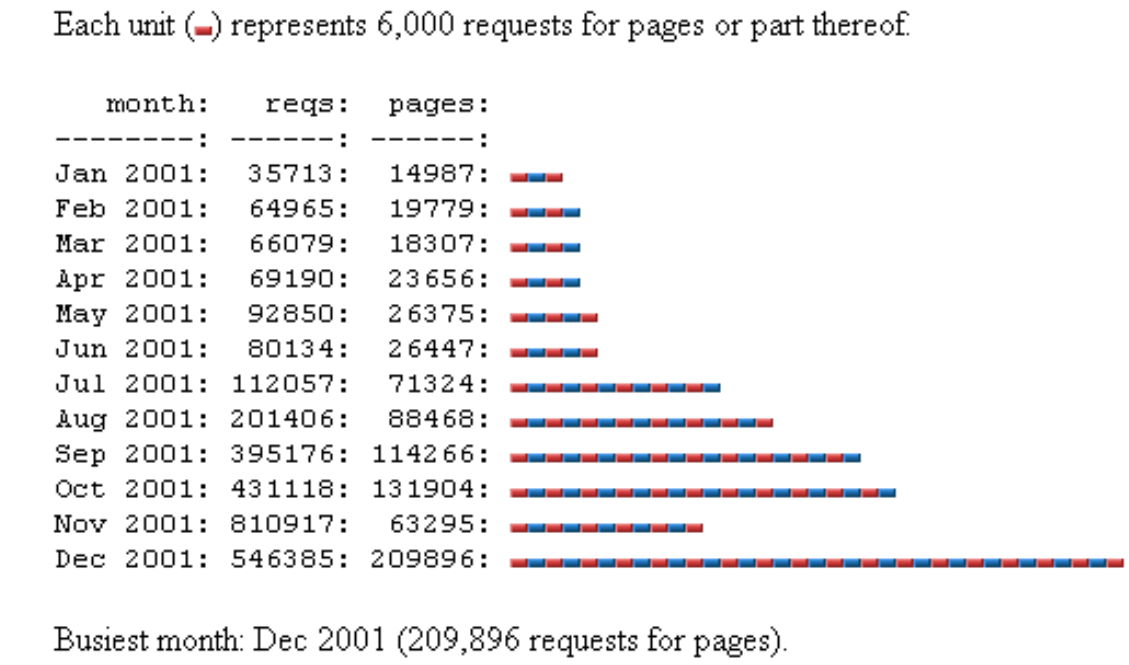

Figure 2. Monthly Web traffic at MDC in 2001.

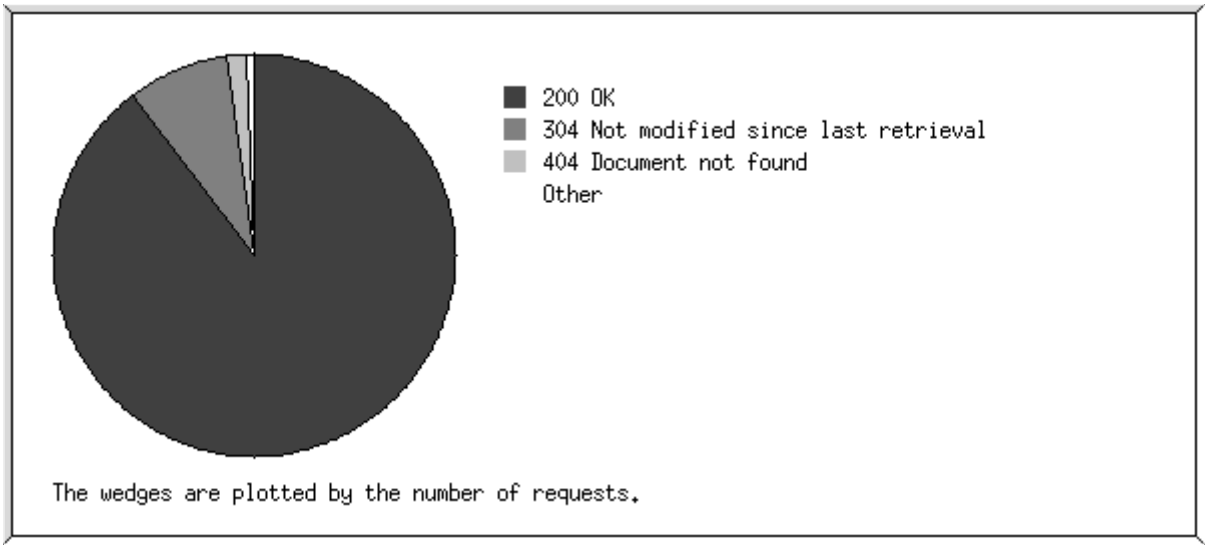

Figure 3. HTTP status codes of requests.

The top-two browsers with the largest numbers of requests are Netscape with 409'000 and Internet Explorer with 500'000 requests. It is the first time that Internet Explorer has more request than Netscape. As for the operating systems, we detected 637'000 requests from Windows, 235'000 request from UNIX, and 22'000 request from Macintosh systems. But the major part was an unknown operation system. The operation system of search engines and surfers which access the MDC through a firewall give no information about their operating system. Based on this, we decided to develop our Web interface primarily for Internet Explorer and Netscape and to give up some fancy features and fonts.

Despite all efforts there are illegal requests to our site. Figure 3 shows the HTTP status codes. One fact is the problem with invalid addresses in the search engines. Most of the requests 'Document not found' came from invalid entries in the different search engines. It is no secret that some public search engines host many old web pages with dead links.

Table 1 Top twenty domains of computers which requested files.

requests	%bytes	domain
1943329	49.08%	.ch (Switzerland)
272275	11.28%	.com (Commercial)
294375	8.69%	.net (Network)
138326	3.34%	.it (Italy)
97954	2.23%	.fr (France)
64978	1.44%	.edu (USA Educational)
54226	0.92%	.at (Austria)
25410	0.61%	.de (Germany)
21057	0.53%	.ca (Canada)
14961	0.36%	.si (Slovenia)
17138	0.34%	.uk (United Kingdom)
9115	0.23%	.es (Spain)
7519	0.17%	.gov (USA Government)
4844	0.13%	.int (International)
4922	0.13%	.se (Sweden)
4027	0.11%	.mil (USA Military)
3837	0.07%	.nl (Netherlands)
2981	0.06%	.be (Belgium)
2818	0.06%	.jp (Japan)
1133	0.04%	.dk (Denmark)

WG-ROUND and DAQUAMAP report

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Introduction and Motivation

Instead of organising a WGROUND-meeting during the last MAP-Meeting in Schliersee, Germany, a second workshop on quality control of meteorological data in MAP was planned and was finally held in Vienna, Austria on 21st-22nd of February 2002. 19 persons from 9 institutions in 6 countries participated.

As the DAQUAMAP-project is still going on until the end of this year, data providers and users of the quality control results had the opportunity during this workshop to express their needs and make comments. But also the possibility to exchange experience about the use of various quality control tools has been used.

In the following a brief summary of the scientific presentations and the main results of the Working Group discussions will be presented.

Short summary of scientific presentations (in chronological order)

The first scientific presentation about MAP-SOP Alpine Precipitation Analysis (see for more information: http://www.map.ethz.ch/NL15/FreiHaeller.pdf) was given by Esther Häller from the Institute for Atmospheric Science at the ETH in Zurich, Switzerland (MAP data centre). The daily precipitation observations 06-06 UTC from the MAP database in a high-resolution rain-gauge network (about 5000 stations) over the SOP were analysed and the results outlined. A new version of MAP-SOP Alpine Precipitation Analysis was announced and will be done again in the future by Christoph Frei and Esther Häller. Then e.g. ITAMAP2.0[1] and HZB[2] (about

[1] The data set of non-GTS surface hourly gathered during the MAP field phase

880 stations more than in the present version) will be included.

An area quality control was presented by Radim Tolasz from the Czech Hydrometeorological Institute in Ostrava – Poruba. The tool used is CLIDATA and results are visualised on a GIS. The method itself (catchword: empirical probability) and its advantages were presented and examples were shown.

The spatial quality control method for temperature data in the Czech Republic 1961-2000 was described by Vít Kveton, Prague.

The focus of the whole afternoon session was on DAQUAMAP. At first, Christian Häberli gave a presentation about the method which is applied in DAQUAMAP (and VERA). Then, the two DAQUAMAP-homepages were presented. The two homepages are identical with two exceptions: The homepage at http://www.univie.ac.at/IMG-Wien/daquamap/ includes information for the data providers. There they have the possibility to check the DAQUAMAP-results of their institute before they are published on the other DAQUAMAP-homepage in the password protected MAP area on the MDC (http://www.map.ethz.ch/mm-doc/daquamap/daquamain.html). In some cases very helpful additional comments from the data providers are included. In the second half of the workshop, the participants checked out the DAQUAMAP-results of their institution. This was a good occasion to ask questions and discuss the results thoroughly.

In the following discussion it was proposed to have a special workshop about the interpretation of the DAQUAMAP results of the SOP for the regional weather services in Northern Italy.

Esther Häller from the MAP data centre gave a lecture on the status of the SOP data base. (For information see http://www.map.ethz.ch/sop-doc/sop_info/sop_info.htm; → Surface-Data). The data base contains a very large and heterogeneous collection of data from many different data providers. As a consequence there exists a high variation in the quality of the data. But only a superficial and formal quality check of the data is done by the staff at MDC. It was pointed out that it is not the objective of the MAP data centre to perform a quality control. For routine network data this is rather the task of DAQUAMAP. If a database user detects suspicious data she or he should contact the MDC rather than the data provider directly. The staff at MDC will forward the trouble report to the data provider and ask for remedy action. If a database user contacts the data provider directly, it is not assured that detected data problems will also be corrected in the MDC. Details of the procedure for error reporting will be documented by the MDC during the following weeks and will be made available on the internet.

As a preparatory work for the DAQUAMAP, Inga Groehn has performed a "data availability check" in January 2002. For each station the mean value of the SOP for station pressure, mean sea level pressure, station temperature and dew point was calculated. Based on these results, a "gross error test" revealed that e.g. for a couple of stations geopotential heights are stored in the mean sea level pressure field of the data base. Further on, a "number-of-measurements-"and a "double-datasets"-test were performed. There are some stations which have only very few measurement data in the data base. In the meantime most of the errors have already been solved including a reload of GTS data from the MARS archive at ECMWF. Important to mention is that now all data of the SOP are in one single data base table which was not the case before.

A still open task of WGROUND is that the data providers check whether all data they delivered to the MDC are stored correctly in the MAP database. This work will be carried out during the next few months as soon as the "data availability check" is redone. For this purpose it is essential that data providers apply for a MAP password from the MAP program office (http://www.map.ethz.ch/map-doc/DataAccessPolicy.htm).

Reinhold Steinacker gave a short overview of the latest developments of the applied methods in DAQUAMAP and VERA[3]. A replacement for the

[2] Hydrographisches Zentralbüro, Austria

[3] **V**ienna **E**nhanced **R**esolution **A**nalysis: http://www.univie.ac.at/IMG-Wien/vera/

operational finite element 2D version for scalar and vector quantities by a regular grid version was outlined.

Summary of Working Group Discussion

One important objective of WGROUND is to maintain and complete the inventory of hydrometeorological stations in the Alpine Region. A lot of work and time have already been into the inventory of hydrometeorological stations in the Alpine Region. Nevertheless, work is still ongoing (never ending?), e.g. missing heights, duplicates, ...

The suggestion was made to add information about measuring systems during SOP, e.g. for rain gauges because this would be helpful for the interpretation of the analyses.

This would be possible for the German Weather Service (DWD), Environmental Agency of the Republic of Slovenia (HMIS), and the Austrian Central Institute of Meteorology and Geodynamics (ZAMG). For Italy it is only possible for the GTS stations. For the Czech Hydrometeorological Institute (CHMI) and for MeteoSwiss it is easy feasible. For the HZB[2] (Austria) the measurement systems are already known. As nobody from France attended this workshop it was not possible to make a statement for the French Weather Service.

Another topic was the quality control of rain gauges and how to mark suspicious data. There was agreement that it would be very valuable to have more information about the checking and correction practices. Before contacting the data providers again, it should be checked out, how much of this information is already available with other projects (e.g. GPCC).

It was part of the objectives of this workshop to discuss the future of WGROUND. The participants agreed that it will be helpful also in the future to have a platform to exchange experience and methods for quality control. On the WGROUND-Homepage there is an (incomplete) overview of all different quality control checks of the members (http://www.univie.ac.at/IMG-Wien/daquamap/qualres.htm)

It was recognized, that the results and experiences of this working group might be also helpful for future activities or projects. (e.g. MAC[4], UNIDART[5], ECSN[6], ...). For this purpose a representative of the WGROUND should act as a rapporteur between the members of WGROUND and the members of e.g. ECSN. It was pointed out that it is not necessary that all institutions participating in WGROUND are members of ECSN or EUMETNET[7].

The project DAQUAMAP will end 2002. The final results will be:
A summary for each station (already available)
A list containing the bias for each station detected by the DAQUAMAP algorithm
Flags for all measurements in the MDB detected as 'gross error' by the DAQUAMAP algorithm

A project DAQUAMAP II was created in order to correct the dry bias in the humidity measurements of the radiosoundings performed during the SOP.

In the next weeks a more detailed report of the workshop will be put on the WGROUND-Homepage http://www.univie.ac.at/IMG-Wien/daquamap/wgroundmain.html.

[4] **M**esoscale **A**lpine **C**limate
[5] A **Uni**form **Da**ta **R**equest In**t**erface
[6] **E**uropean **C**limate **S**upport **N**etwork
[7] The network of European Meteorological Services

Ongoing Activities and Future Events

Activities within MAP

date	event
May 21-22, 2002	5th FORM Meeting, in Lannemazan, France
Jun 17-21, 2002	MAP Meeting 2002 and AMS Conference on Mountain Meteorology, Park City UT, USA (http://www.ametsoc.org/AMS/meet/FAINST/10mount02.html)
Jun 22, 2002	MAP Steering Committee (MSC) Meeting 3, Park City UT, USA
Aug 26-30, 2002	Summer School on Mountain Meteorology, Trento, Italy (http://www.unitn.it/ssmm)
Sep 6, 2002	MAP IGP Meeting 9, Reading, UK
Oct 31-Nov 1, 2002	6th FORM Meeting, in Bad Ragaz, Switzerland (Rhine Valley)
May 19-23, 2003	MAP Meeting 2003 and Int. Conference on Alpine Meteorology (ICAM), Brig, Switzerland (http://www.icam2003.ch)

Future events related to MAP

date	event
May 13-16, 2002	13th Conference on Applied Climatology, Portland, OR, USA (http://www.ametsoc.org/AMS/meet/FAINST/portland02.html)
Jun 3-7, 2002	11th Conference on Cloud Physics, Ogden, UT, USA (http://www.ametsoc.org/AMS/meet/FAINST/ogden02.html)
Jul 15-19, 2002	15th Symposium on Boundary Layers and Turbulence, Wageningen University - Wageningen, The Netherlands (http://www.ametsoc.org/AMS/meet/FAINST/15BLT02.html)
Aug 12-16, 2002	15th Conference on Numerical Weather Prediction, San Antonio, TX, USA (http://www.ametsoc.org/AMS/meet/FAINST/sanantonio02.html)
Aug 12-16, 2002	19th Conference on Weather Analysis and Forecasting, San Antonio, TX, USA (http://www.ametsoc.org/AMS/meet/FAINST/sanantonio02.html)
Aug 12-16, 2002	21st Conference on Severe Local Storms, San Antonio, TX, USA (http://www.ametsoc.org/AMS/meet/FAINST/sanantonio02.html)
Sep 2-6, 2002	International Conference on Quantitative Precipitation Forecast (QPF), Reading, UK (http://www.met.rdg.ac.uk/qpf)
Nov 18-22, 2002	2nd European Conference on Radar Meteorology (ERAD), Delft, The Netherlands (http://www.copernicus.org/erad/index2002.html)

TRIPLE-DOPPLER RADAR OBSERVATION OF A HEAVY RAIN EVENT OVER LAGO MAGGIORE REGION

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1. Introduction

During the Intensive Observation Period 2B (18 - 21 September 1999) of the Mesoscale Alpine Programme (MAP), a frontal cloud system with embedded convective elements swept across northern Italy in association with a trough over northern Europe which rapidly moved eastward. This caused a heavy rain event over the Lago Maggiore region on 19-20 September. During this period, observations were conducted with the French Ronsard radar located near Novara at [45.460N, 8.517E, 155 m MSL], the Swiss SMA operational radar at Monte-Lema [46.042N, 8.833E, 1625 m MSL] and the US NCAR S-POL Doppler and Polarimetric radar near Vergiate at [45.720N, 8.730E, 280 m MSL] in order to investigate the mechanisms of orographically induced heavy precipitation events with special emphasis on their dynamics and microphysics. The radar baseline being relatively wide, with a distance of about 75 km between Ronsard and Monte-Lema (S-POL is located approximately in the middle), the maximum area where the three-dimensional precipitation and wind fields can be retrieved with a high spatial and temporal resolution and high accuracy by combining data from these three ground based Doppler radar is relatively large. As depicted in Fig.1, it corresponds to a domain of 150 km per 150 km centered on [45.70N, 8.60E], i.e, approximately on the southern tip of the Lago Maggiore. This region encompasses very different terrains with the very flat Pô valley to the south, the hilly Piedmont, the high alpine peaks with Monte-Rosa at more than 4000 m altitude, Lago Maggiore and the deeps valleys of Toce and Ticino rivers.

This paper presents a space-time analysis of the flash-flood producing system observed by the three ground-based Doppler radar between 1900 UTC on 19 September and 1100 UTC on 20 September. For that, an intercalibration of the reflectivity data have been realized by considering the S-band S-POL data as being non attenuated unlikely both the other C-band radar data. On the other hand, the radar-derived three-dimensional wind field have been obtained from an improved version of the real-time and automated multiple-Doppler analysis method (RAMDAM, Chong et al., 2000) which was used in the Project Operation Center during MAP SOP.

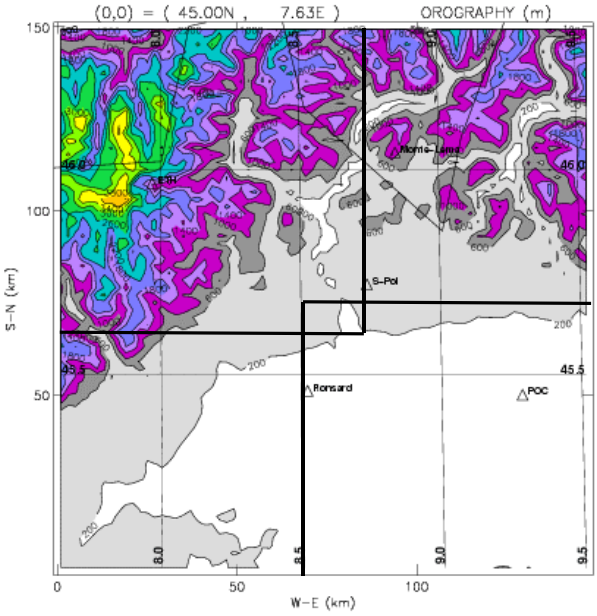

Fig. 1: Array for ground-based triple-Doppler radar observations during MAP (isohypses every 200 m).

2. Environmental conditions

IOP 2B was associated with one of the most intense rainfall events of the whole Special Observing Period and it shows characteristics that were frequently observed during other IOPs (IOP 3, IOP 5) and previous flooding situations as the historic Piedmont flood of November 1994 (Buzzi et al. 1998, Ferretti et al., 2000). Also it should be representative of the heavy orographic precipitation events in the Lago Maggiore region. In particular, as observed on the METEOSAT infrared images over Western Europe from September 19th at 18 UTC till the 20th at 12UTC (not shown), the synoptic conditions are marked by the passage of a large north-south oriented frontal system over the Alps. Ahead of the cold front which was located approximately over central France around 00 UTC on the 20th according to the analysis by the limited area Swiss model (not shown), strong southerly to southeasterly flow was blowing in the low levels. Also, over the Pô valley and

along the southern flank of the western Alps, there was a convergence of winds carrying warm and moist air from both the Mediterranean to the South and the Adriatic to the East. Such conditions, commonly observed, are obviously very favourable to the development of precipitation.

More precisely, information about the thermodynamic characteristics of the air flowing from the south toward the Alps can be deduced from the radiosounding launched at Milano-Linate with a frequency of one every sixth hour. The first four ones, from 18 UTC on the 19th till noon on the 20th, show very similar profiles with a moist troposphere and moderate convective instability. The CAPE value was less than 500 J/kg, but there was very little convective inhibition in the low levels. The equilibrium temperature level was at about 200 hPa and the 0°C isotherm was located between 700 and 650 hPa. During the afternoon and the evening of the 20th, in association with the arrival of the cold front, the thermodynamic conditions changed remarkably: convective instability vanished due to cooling and drying in the lowest levels and the tropopause level went down to about 300 hPa. This is consistent with the non-observation of significant precipitation by the radar after 14 UTC on the 20th.

3. Evolution of the precipitating system

3.a Mean Characteristics

Some information on the organization of precipitation during IOP 2B can be deduced from the reflectivity images from each radar (not shown). In particular, the influence of the orography is significant since precipitation remained almost stationary over the southern flank of the Alps with maximum reflectivity values up to 50 dBZ and a mean value around 30 dBZ while a slighty different situation was observed in the southern part of the domain, i.e., over the Pô valley where more or less intense cells alternate with stratiform echoes or no precipitation at all. In order to better emphasize the influence of orography on the organization of precipitation we represent on Fig.2a and 2b the time evolution of the mean reflectivity observed by the three ground based Doppler radar over two distinct domain included in the target area (Fig.1): the first one is a domain of 90 km per 90 km centered at [46.00N, 8.10E] so that it concerns only observations over the mountains and the second is a domain of 75 km per 75 km centered at [45.40N, 9.00E] so that it concerns only observations over the plain. It is interesting to note that the structure of precipitation is more homogeneous over the mountains with a moderate and quasi constant vertical development during the whole IOP whereas, over the plain, three major convective situations can be distinguished (around 23 UTC, 05 UTC and 10 UTC) with a well marked period of minimum of reflectivity between these three events. Nevertheless, a maximum of precipitation can be observed over the mountainous area between 23 UTC on the 19th and 01 UTC on the 20th. This maximum occurred one hour after the stronger precipitation observed during the first convective event over the plain. In order to better understand this situation we superimposed on Figs 2a and 2b the mean horizontal wind vector obtained from a VAD (Velocity Azimuth Display, Browning and Wexler, 1968) analysis on the two distinct part of the target area. For the representation, we identify the altitude axis and the time axis with the south-north direction and the west-east direction respectively. Then, the persistent south-southeasterly flow observed at low levels may favour the moving of cells from the Pô valley toward the Alps and, consequently, maintain the convective activity over the windward slopes of the mountains. This can explain the continuous precipitation over the orography as well as the delay between the maximum of reflectivity observed over the plain and over the mountainous area.

It is also worth noting that the flow turns clockwise with altitude and more particularly between 01 UTC and 05UTC over the relief (Fig. 2a) and 00 UTC and 03 UTC over the plain (Fig. 2b) which corresponds to the period of less precipitation. This phenomenon is more accurate over the plain. Finally, it is to be noted that wind intensity increases with altitude and keeps similar values during all of the considered period.

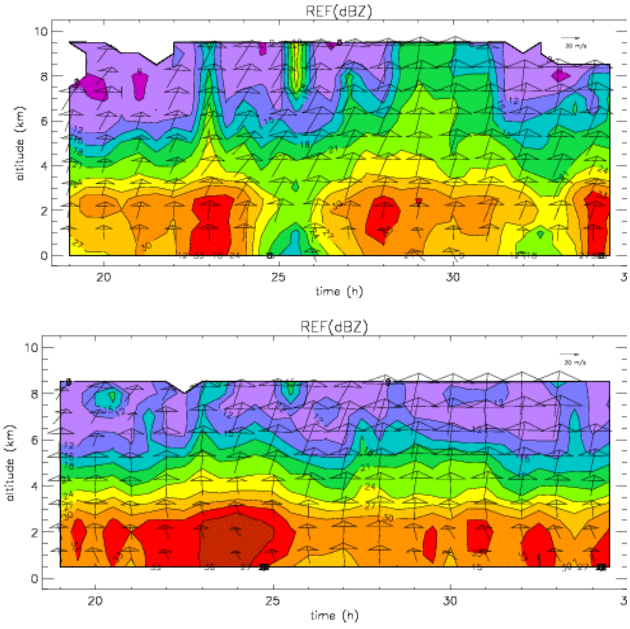

Fig.2: Mean reflectivity structure and superimposed mean wind vector evolution over the plain (a) and the mountainous area (b) between 19 UTC on the 19th and 11 UTC (indicated by 35) on the 20th.

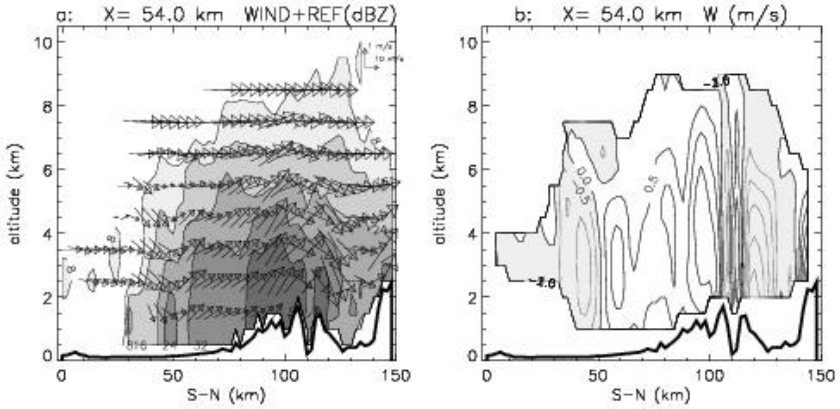

Fig.3: (a) Wind (scale in the upper right) and reflectivity (contours every 8dBZ) for the meridian cross-section at X=54 km and 00 UTC on the 20th; (b) associated vertical velocity contours (every 0.5 ms^{-1}).

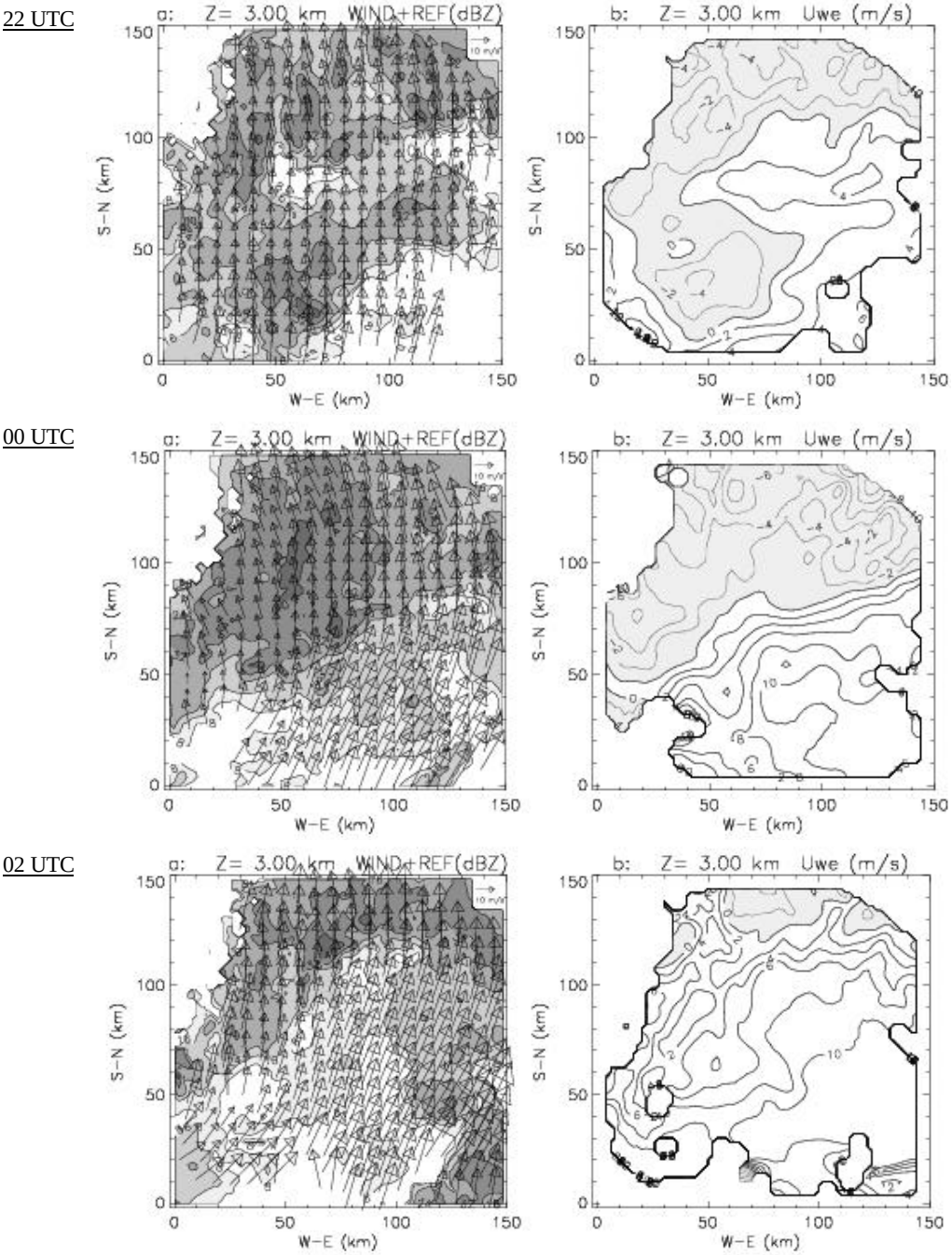

Fig.4: (a) Horizontal cross-section at 3 km altitude through the 3D retrieved wind field superimposed on the radar reflectivity values (contours every 8dBZ) at 22 UTC, 00 UTC and 02 UTC; (b) associated contours of the West-East component of the wind (every 2 ms^{-1}).

3.b Three-dimensional analysis of precipitation and wind fields

An examination of series of 3D wind and precipitation fields (not shown) retrieved over the target area through the RAMDAM procedure permits to verify that the same situation prevailed between 19 UTC on the 19th and 11 UTC on the 20th: it can be observed a strong south to southeasterly flow impinging on the mountains near Lago Maggiore and producing rain of non very spectacular intensity but of very long duration. In particular, as shown on the vertical cross-section along the South to North direction at X= 54 km and 00 UTC (Fig.3), the strongest precipitation and vertical motions occurred above the first upward slopes of the Alps, just north of Lago Maggiore, with minima above the downward slopes. This good agreement between subsidence (or upward motions) and decreasing (increasing) reflectivity values clearly shows the influence of orography on the modulation of precipitation with a enhancement-attenuation cycle. Then, the precipitation pattern progressively moves north-eastwards along and over the mountain barrier probably caused by the eastward progression of the cold front.

Figs 4a and 4b respectively show the horizontal flow at 3 km altitude along with the reflectivity pattern, and the associated structure of the longitudinal component of wind at 22 UTC, 00 UTC and 02 UTC. These three period respectively correspond to the beginning, the maximum and the end of the most intense precipitation event observed in the target area. It is to be noted that the evolution of the easterly component of the wind (contours in dashed lines on Fig. 4b) and of the reflectivity pattern are remarkably similar: both intensify over the upwind slopes of the mountains till 00 UTC and then decrease. The stronger precipitation occurred where and when the easterly component of the flow is greater with, however, a preferential location at the southern flank of the Alps. As supposed by Ferretti et al. (2000), it is possible that unstable air lifted by the sideways-"L" shape of the western Alps produce positive vorticity through latent-heat induced vortex stretching. Then, the induced easterly wind perturbations towards the concave part of the sideways-"L" corresponding to the Piedmont region may retard the eastward movement of the cold front and also favour further lifting of instable air. This can explain the enhancement of the orographic precipitation over the upper part of the Pô valley.

4. Conclusion

The radar-derived wind and precipitation fields from triple-Doppler radar observations over Lago Maggiore region, trhough the RAMDAM procedure, clearly show the influence of orography on the modulation of vertical motions and precipitation with a enhancement-attenuation cycle. As expected, the largest reflectivity values are associated with predominantly upward motions on the first windward slopes of the Alps where water vapour is likely to condense into cloud droplets and rain drops or, more likely, into ice crystals and snow aggregates. But, in order to obtain fuller information on the precipitation microphysics, polarimetric data from S-Pol radar have now to be considered.

As previously reported by Ferretti et al. (2000), for a previous case of intense rainfall event in the Lago Maggiore region, the presented space-time analysis of wind and precipitation fields permit to emphasize that the highest precipitation observed during IOP 2b are associated with low-level easterlies. This easterly flow perturbation may be instrumental in retarding the eastward progression of the cold front and probably explain the continuous character of orographic precipitation. It also seems that the convective cells appearing over the Pô valley and then transported toward the Alps play an important role in the enhancement of precipitation over the Lago Maggiore region. Finally, according to the predominantly south-westerly flow at upper levels and the progression of the cold front, the precipitation pattern moves eastwards along the Alps. Consequently, the generation, the enhancement and the maintain of precipitation in the Lago Maggiore region highly depends on the direction of the winds. In order to better understand all these observations, a thermodynamic study is planned, in particular through an estimation of the different terms of the water budget and its evolution (with the helps of Doppler and polarimetric data), and with comparisons with results from non-hydrostatic numerical model simulations.

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