

MAP D-PHASE

A Forecast Demonstration Project in the framework of MAP

Proposal to the WWRP-SSC

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Summary

The main objective of the MAP Forecast Demonstration Project (MAP FDP) is to demonstrate the benefits in forecasting heavy precipitation and related (flash) flood events, as gained from the improved understanding, refined atmospheric and hydrologic modelling, and advanced technological abilities acquired through research work during the Mesoscale Alpine Programme (MAP). Specifically, an end-to-end forecasting system for Alpine flood events will be set up to demonstrate state-of-the-art forecasting of precipitation-related high-impact weather. This system will include probabilistic forecasting based on ensemble prediction systems with a lead time of a few days, followed by short-range forecasts based on high-resolution atmospheric and hydrologic models for selected regions or catchments, and completed with real-time nowcasting and high-resolution observational information. Throughout the forecasting chain, warnings will be issued and re-evaluated as the potential flooding event approaches, allowing forecasters and end users to alert and make decisions in due time.

Establishing such an end-to-end forecasting system will bring scientists, operational forecasters, and end users together, in order to learn about and appreciate their respective needs, to exchange comprehension of predictability and forecast uncertainty, and to exploit the potential of state-of-the-art forecast capabilities.

Being a real-time demonstration project, dissemination of user-oriented forecast information in a timely manner is important, as is the evaluation of the delivered forecasts and products by the end users and decision makers. Close collaboration with THORPEX (WWRP) and Meteorisk (an EU INTERREG III project) is foreseen to facilitate the exchange of model and observational data between the project partners and to effectively communicate warnings and related information to the end users and decision makers. Within the overall framework of THORPEX, it is planned to employ the operational network of EUCOS and perform additional soundings (targeted observations within ETRC07) if feasible and beneficial. A close collaboration is furthermore established to COST 731 (Propagation of uncertainty in advanced meteorological forecast systems, European Cooperation in the field of Scientific and Technical Research).

The MAP forecast demonstration period (June to November 2007) coincides with the intensive observation period of the COPS project (Convective and Orographically-induced Precipitation Study, June to August 2007), a potential WWRP RDP. This will allow exploiting synergies in terms of high-resolution atmospheric forecasting, logistics, data exchange, observing systems, and model evaluation.

1 Background and Motivation

As the first Research and Development Project of the World Weather Research Programme (WWRP), the Mesoscale Alpine Programme (MAP) has seen three phases so far: a Development Phase (Binder and Schär 1996) when the plans were made and the project was designed, the Field Phase with the Special Observing Period (SOP; Bougeault et al. 2001) in autumn 1999, and the Analysis Phase (Volkert 2005) that is still ongoing and has brought a wealth of exciting new results and insight in alpine meteorology.

In its 6th meeting on January 23/24 2004 in Reading (UK) the MAP Steering Committee (MSC) discussed the feasibility of a MAP Forecast Demonstration Project (MAP FDP) and mandated a working group, chaired by M. Rotach (MeteoSwiss), to further explore the possibility and interest in such a project. A first workshop with 19 participants from eight countries came to the conclusion that the interest in such a project was large and essentially all National Weather Services of the Alpine countries as well as numerous hydrological services and universities were ready to contribute. In its subsequent meetings in Bartlett (USA), Erding (Germany), and Zadar (Croatia), the MSC acknowledged the progress of the working group and expressed its encouragement to proceed in the chosen direction.

2 FDP Proposal

2.1 Objectives

From the many achievements of MAP (Volkert 2005), flood forecasting and the associated issues of orographic precipitation, high-resolution numerical weather prediction, and hydrological processes have been chosen as the topic for the Forecast Demonstration Project (Rotach 2004, Rotach 2005). Hence, the overall objective of the MAP FDP will be *to demonstrate the ability of forecasting heavy precipitation and related flooding events in the Alpine region* due to improved knowledge concerning the basic processes steering such events and advances in observational and numerical technologies stemming from research work performed during MAP. The project will address the entire chain ranging from observations, ensemble forecasting, high-resolution cloud-resolving atmospheric modelling (km-scale), hydrologic modelling, and nowcasting to decision making by end users (civil protection authorities, water management and hydrological agencies, etc.), i.e., it is foreseen to set up *an end-to-end flood forecasting system*. To emphasize the main objective of the 4th phase of MAP, the proposed FDP, will be referred to as MAP D-PHASE, which stands for **Demonstration of Probabilistic Hydrological and Atmospheric Simulation of flood Events in the Alpine region**. It is foreseen that appropriate modelling technologies will be employed for the various steps of the end-to-end forecasting system (see section 'Forecast procedure' below).

MAP has brought significant progress in the following fields of research that are relevant for the present project:

- Mechanisms of orographic precipitation events, including the ability of numerical weather prediction models to appropriately simulate dynamical and microphysical properties of precipitating systems in mountainous regions (e.g. Medina and Houze 2003, Rotunno and Ferretti 2003, Bousquet and Smull 2003).
- Precipitation fields from radar networks in complex terrain (Germann et al. 2005): the radar fields are instrumental not only for assimilation in mesoscale atmospheric

and hydrologic models (Ducrocq et al. 2002, Leuenberger 2005) but also for nowcasting and verification.

- High-resolution (3 km) *operational* mesoscale modelling used in the decision making process for the operational field-phase decisions during the SOP (Benoit et al. 2002, Benoit et al. 2003) and high-resolution numerical weather prediction in hindcast mode (Richard et al. 2003, Buzzi et al. 2004, Richard et al. 2005).
- Hydrologic modelling: coupling of atmospheric and hydrologic models to establish the link to the needs of the end users (Bacchi et al. 2003, Ranzi et al. 2003).
- Ensemble prediction approach: Research studies on the feasibility of small-scale ensemble forecasts especially in the area of heavy precipitation forecasting (Molteni et al. 2001, Marsigli et al. 2001, Walser and Schär 2004, Walser et al. 2004).

All these components contribute to the ability of forecasting heavy precipitation events in complex terrain, the residence times of the precipitated water in the various water bodies such as rivers, lakes, or ground water, and hence the ability to adequately predict water levels and runoff for timely warnings. Previous events of heavy precipitation in the Alps (and elsewhere in mountainous terrain) have demonstrated their devastating potential in harming both human lives and property. There is no doubt that heavy precipitation events belong to the group of *high-impact weather* events. Also, these events are of international scale – simply due to the fact that the original driving meteorological system(s), when first being identified on the medium-range forecast, may well finally lead to flooding in different countries, dependent on the actual development.

As more specific objectives, MAP D-PHASE aims at

- assessing the degree of predictability for precipitation and flood events as a function of event size, precipitation amount, event character (e.g. convective versus stratiform), and lead time;
- demonstrating the potential of operational high-resolution atmospheric models in capturing the relevant processes responsible for heavy precipitation events in complex terrain;
- demonstrating the ability of hydrologic models to provide a timely and skilful forecast of runoff and water levels;
- assessing the prospects of very short-term prediction of heavy precipitation and severe convection over orography, using tailored heuristic techniques and real-time observations from radar, automated surface networks, soundings, and satellite (nowcasting);
- establishing a better link between atmospheric and hydrological scientists on the one hand and the actual end users on the other hand. This includes matching the improved possibilities from the hydro-meteorological models with the relevant needs of the end users.

These specific objectives will be specified in some more detail below.

2.2 Forecast procedure

The MAP FDP aims at establishing a (real-time) end-to-end forecasting system for heavy precipitation events. It will contain the following steps:

1. *Probabilistic forecast* of rain intensity and spatial distribution for lead times between 2 and 5 days. This will allow issuing pre-alerts (including amount and probability) for affected regions. This pre-alert will be sent out to all the participants including atmospheric and hydrologic modellers and end users.
2. In the days following a pre-alert, the warnings may be re-iterated, refined (in space, time, or amplitude), or discontinued. This will also be based on the probabilistic modelling approach.
3. If a pre-alert is maintained up to two days ahead of the potential event, short-range (up to 48 hours lead time) *high-resolution deterministic forecasts* are performed using all the atmospheric models covering the likely affected region. Possibly, a poor man's ensemble will be constructed from these simulations. The simulations will use a wide range of data-assimilation systems as used by the participating institutions. The initialization of the models will further be supported by adaptive observations (extra soundings performed by or in collaboration with the EUCOS program of EUMETNET). Also, surface analysis fields from the VERA (Vienna Enhanced Resolution Analysis, Steinacker et al. 2000) analysis will be provided for assimilation and validation purposes.
4. For the pre-alerted events, the output of the high-resolution deterministic atmospheric models is used to drive *hydrologic models* if the event affects an *impact area* (i.e., if one or more participants have established a hydrologic modelling system for the area). Output goes to the concerned end user(s) and is tailored towards their specific needs. Possibilities of performing hydrological ensemble predictions (based on either different atmospheric models, stochastic techniques, or parameter perturbations in hydrologic models) will have to be explored.
5. Very short-range forecasting (0 to 6 hours lead time, i.e., *nowcasting*) will be done with existing nowcasting tools at the various involved forecasting centres. This includes, where available, provision of latest high-resolution observations, nowcasting based on high-quality radar data (e.g., automatic tracking of convective cells and automatic short-term alerts for heavy precipitation), and specific warnings by bench forecasters. Additionally, quantitative radar estimates of surface precipitation may be used as input for hydrologic models.

Figure 1 gives a graphical impression of the foreseen forecasting procedure. Steps 3 to 5 will require local input data (for data assimilation in steps 3 to 4 and to drive the nowcasting procedures in step 5). These will be obtained from the existing networks to demonstrate *operational* forecasting capabilities. In collaboration with EUCOS, we hope to establish a supplemental network of radio sounding stations, which can be activated in case of a pre-alert. Tables 1 and 2 below list the presently involved atmospheric and hydrologic models for steps 1 to 3 and step 4, respectively. Table 3 in Appendix 1 provides a list of all participating institutions with their respective contributions to the MAP Forecast Demonstration Project.

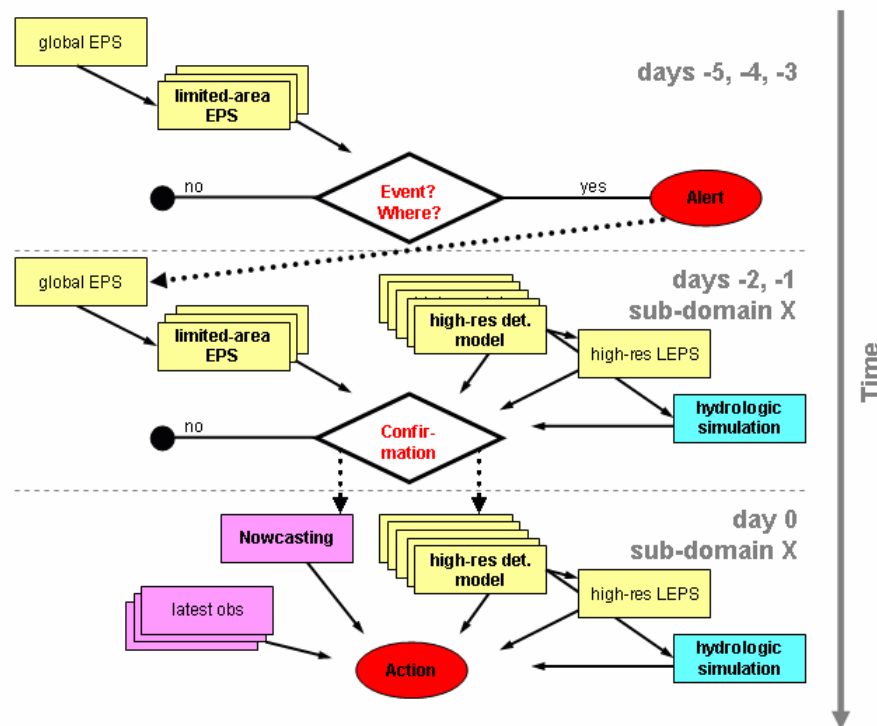


Figure 1: Conceptual sketch of the end-to-end forecasting system for MAP D-PHASE.

	Model	Mesh-size	Forecast period	Institution
ensemble forecast systems	COSMO-LEPS	10 km	132h	ARPA-SIM, DLR
	MOGREPS	25 km	36h	UK Met Office
	GEM-LAM	10 km	48h	Environment Canada
	PEPS	7 km	48h	EUMETNET SRNWP
deterministic high-resolution models	aLMo	2-3 km	18h	MeteoSwiss
	LAMI	2.8 km	48h	ARPA-SIM
	LAMI-CNMCA	3 km	48h	UGM-CNMCA
	MOLOCH	2 km	24-36h	ISAC-CNR, ARPAL-CMIRL
	MM5 and WRF	1 km	36h	University of l'Aquila-CETEMPS
	AROME	2.5 km	48h	Météo-France, University Paul Sabatier
	LMK	2.8 km	18h	DWD
	MM5 and/or WRF	1 km	12-24h	University of Hohenheim
	ALADIN-Austria	9.6 km	48h	ZAMG
	GEM-LAM	2.5 km	24h	Environment Canada

Table 1: Atmospheric models (limited-area ensemble systems and deterministic high-resolution models) with their mesh-size and forecast period.

	Model	Impact area	Institution	End user identified
hydrologic models	PREVAH	Lago Maggiore	ETHZ	to be determined
	Lago Maggiore sea level prediction	Lago Maggiore	IST-SUPSI	Regional civil protection agency
	TopKapi	Reno River and Secchia River in Emilia-Romagna region	ARPA-SIM	Emilia-Romagna Functional Centre for Civil Protection
	DRIFT	Liguria	ARPAL-CMIRL	Liguria Functional Centre for Civil Protection
	DIMOSOP	Selected catchments in the Lago Maggiore region	U Brescia	Consorzio dell'Oglio (Oglio River Water Authority)
	WATFLOOD	Lago Maggiore	Environment Canada	to be determined

Table 2: Hydrologic models with their impact area.

2.3 Practical implementation

MAP D-PHASE will coordinate the following tasks, activities and procedures:

All the output from the atmospheric models needs to be available in a common format for the hydrologic modellers and / or nowcasting procedures. Similarly, local observational data must be provided in a standard format to facilitate access by all the modelling groups involved. This will be accomplished by means of a centralized and password-protected data interface. Efforts are underway to benefit from the respective endeavours and plans pursued and offered by the THORPEX programme through its TIGGE (THORPEX Interactive Grand Global Ensemble) data centres and regional campaigns (i.e., ETReC07, the European THORPEX Regional Campaign 2007).

Concerning warnings for the end users, benefit will be taken from the INTERREG III B Meteorisk project and its information platform (<http://www.meteorisk.info>). The possible follow-up project Meteorisk II will include a strong contribution from MAP D-PHASE to ensure that the needs of modellers, forecasters, and end users participating in the MAP FDP are being taken care of and implemented into the next version of the information platform.

The interested end users include a series of national and regional hydrometeorological agencies and water resource authorities. Some centralized coordination of the end user involvement will be needed for the major target areas (in particular in the Lago Maggiore region). Much of the contact with the end users will need to take place in the local language and exploit existing channels between weather services and end users. The coordination performed by MAP D-PHASE will allow foreign research and forecasting institutions to become involved with these end users.

2.4 Societal impact

The overall strategy of the project will be to first establish a firm contact to the end users¹ and assess their actual needs concerning the required forecast products with respect to time, space, and threshold amounts. The contacts will also be used to communicate ideas regarding probabilistic products and inherent uncertainty of the predictions, to define the required time lines and to establish effective ways of communicating relevant information. These needs will determine some of the details in the forecast procedures as described above.

On the other hand, end users will have the opportunity to benefit from a real-time demonstration of a state-of-the-art forecasting system for precipitation-related high-impact weather. Specifically, a first attempt will be made to provide real-time probabilistic hydrologic forecasts for selected catchments that address the uncertainty inherent in the atmospheric and hydrologic processes leading to heavy precipitation and flooding.

Establishing (continuing) these contacts, defining needs and possibilities for forecasting heavy precipitation events, and setting up concrete procedures to guarantee the exchange will be the main task of the working group 'end users' (see below, 3.2).

2.5 Evaluation

The verification and evaluation system for MAP D-PHASE has to serve several purposes. DMO (direct model output), PPP (post processing products) and EP (end products) represent different levels of a forecast system and require different evaluation strategies and measures. Additionally, the economic value of the entire system will be evaluated.

For the set up of the system the experience of the participants will be employed, findings from the WWRP Sydney 2000 Forecast Demonstration Project (Keenan et al. 2003, Ebert et al. 2004) will be taken into account, and a close liaison with the WWRP/WGNE Joint Working Group on Verification will be established.

A first focus is put on standard verification measures for deterministic and probabilistic forecasts in the short and medium range for meteorological as well as hydrological simulations. These will be implemented for continuous as well as categorical parameters. The standard verification procedure will not only be performed on a 'post event' basis for studying the model performance for the whole event but also in a 'real-time' mode. This mode supports the forecasters in their decision as to which forecast model he can rely on in the nowcasting approach. One central feature of the evaluation process involves the definition of the true state of the observed weather. Therefore, high-resolution surface observations, radar, and satellite data will play a crucial role in the real-time mode. The question concerning availability and representativeness of the data, especially in complex terrain, leads to the issue of point vs. area-averaged verification. Recently developed analysis schemes that are independent from forecast models will be used to address this problem.

The verification procedure as described in the previous paragraph is intended to reveal the quality of the forecast. However, a successful forecast does not necessarily have any value to its final user. Therefore, it is the second task of the verification system to evaluate the potential economic value of the forecasts. This necessitates a special

¹ Note that a first Italian end user workshop (with some Swiss contribution) in the framework of MAP D-PHASE has already successfully taken place on November 11, 2004, in Brescia, Italy.

effort to strengthen the dialogue and collaboration with the end users since the forecaster can not have solid knowledge of the economic implications and risks of particular weather events. The economic value of forecast information in different situations has to be evaluated on a case-by-case basis. An overall evaluation of the decision making process with the end users will try to establish what benefit had been obtained from what component of the warning system. So it will be possible to learn for each of the components (atmospheric medium range and short range modelling, hydrologic modelling, nowcasting) what quality (skill) it presently has and what importance the end users put on its improvement. For this last task, experience from the MAP SOP will be employed in generalizing the bench evaluation performed at MeteoSwiss (Benoit et al. 2002) for the atmospheric forecasters to the entire chain of end (or 'middle') users in the flood forecasting system.

Due to the involvement of different end users and hence different impact areas, the statistical evaluation has to be made very carefully. In principle, the system as a whole can be assessed through contingency tables (event forecast: yes/no; event occurred: yes/no) irrespective of the locality. However, the actual outcome will possibly be biased due to small sub-samples from specific regions with specific problems. Concentrating on one impact area alone, on the other hand, would prevent a number of participants from contributing and also limit the number of potential end users and applications.

2.6 Time table

The demonstration period of MAP D-PHASE will last from *June to November 2007*. This encompasses the 'classical' MAP Special Observing Period (SOP) in autumn and the preceding summer season. The former ensures that full advantage can be gained from the improvements and developments during MAP and the latter is motivated to benefit from synergies and common interests with the *Convective and Orographically-induced Precipitation Study (COPS)*², the field phase of the international 'Quantitative Precipitation Forecast' research project covering areas in south-western Germany and north-eastern France.

Further milestones are:

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|---|--|
| • Definition of user needs | May 2006 |
| • Test cases defined | May 2006 |
| • Ensemble systems tested | August 2006 |
| • High-resolution atmospheric models tested | November 2006 |
| • Hydrologic models tested | February 2007 |
| • Nowcasting tools ready | February 2007 |
| • Test suite ready | February 2007 |
| • Evaluation protocols ready | February 2007 |
| • Training | March to May 2007 |
| • Demonstration period
comprising COPS field phase | June to November 2007
June to August 2007 |
| • Evaluation, Analysis, Publications | 2008 and later |

² See the COPS WWRP RDP proposal for details.

3 FDP Management

3.1 MAP D-PHASE Steering Committee

The following people have agreed to serve in the MAP D-PHASE Steering Committee (MD-SC):

Mathias Rotach, MeteoSwiss, Switzerland (chair)
François Bouttier, Météo-France, Toulouse, France
Andrea Buzzi, ISAC-CNR, Bologna, Italy
Manfred Dorninger, University of Vienna, Vienna, Austria
Ken Mylne, UK Met Office, Exeter, United Kingdom
Roberto Ranzi, University of Brescia, Brescia, Italy
Evelyne Richard, University Paul Sabatier, Toulouse, France
Christoph Schär, ETHZ, Zurich, Switzerland
Michael Staudinger, ZAMG, Salzburg, Austria (representing Meteorisk)
Hans Volkert, DLR, Oberpfaffenhofen, Germany (chairman of the MSC)
Volker Wulfmeyer, University of Hohenheim, Stuttgart, Germany (representing COPS)

Additional members (e.g. representatives for THORPEX, COST 731, and ECMWF) might be considered as actual needs become apparent.

3.2 MAP D-PHASE Working Groups

In addition to the MAP D-PHASE SC, four working groups (WGs) have been formed:

- WG End Users (WG-EU; chair: Roberto Ranzi, University of Brescia) brings together the different levels of (end) users, which may be 'actors' (such as forecasters, using MAP D-PHASE products and producing forecasts for subsequent users) or 'users' (such as civil protection agencies), or both, and establishes contacts between the end users and the atmospheric and hydrologic modellers. It defines the needs of and makes available the information on the state-of-the-art of flood forecasting and its potential possibilities to the end users.
- WG Verification (WG-VER; chair: Manfred Dorninger, University of Vienna) takes care of the evaluation protocols and is responsible for the validation and verification methodology to be adopted.
- WG Data Interface (WG-DI; chair: Christian Keil, DLR) is defining the needs and exploring the possibilities with respect to data collection, storage, and distribution. The centralized data interface will be the main source for the real-time dissemination of all kinds of forecast information (i.e., observations, model output, nowcasting information, etc.). Additionally, the Meteorisk information and warning platform (<http://www.meteorisk.info>) will be utilized to distribute alerts to the end users.
- WG Data Policy (WG-DP; chair: Mathias Rotach, MeteoSwiss) takes care of all the legal matters related to the exchange of data.

3.3 MAP D-PHASE Community Advisory Group

MAP FDP foresees a Working Group End Users (WG-EU, see 3.2) that responds to the intentions of a Community Advisory Group (CAG). Namely it is planned to obtain, from the various categories of end users, their needs and specific requirements concerning the information content, timing, etc., for their optimum reaction. To this end it is therefore proposed not to establish yet another committee (i.e., a CAG) unless it

should turn out that the WG-EU has not the capacity to cover one (or several) of the potential tasks of a CAG.

3.4 MAP D-PHASE Project Coordinator

To support the chairman of the MAP D-PHASE SC (Mathias Rotach, MeteoSwiss) in coordinating the MAP D-PHASE related efforts, MeteoSwiss has funded the position of a *project coordinator*. Marco Arpagaus (MeteoSwiss) is acting as MAP D-PHASE project coordinator since 1st July 2005.

Acknowledgements

The following institutions are acknowledged for funding some of the efforts relating to the MAP D-PHASE:

- MeteoSwiss: MAP D-PHASE Project Coordinator for 3 years (50% position).
- German Research Foundation (DFG): Funding for data storage, data transfer, and visualization will be requested from the DFG within the collaboration with COPS. If successful, the data archive will be available at the Model & Data Group at the Max Planck Institute for Meteorology in Hamburg, Germany, and will be established in close collaboration with THORPEX and conform with the TIGGE data centre specifications.
- INTERREG (pending): Meteorisk follow-up project.
- COST 731 / Swiss State Secretariat for Education and Research (pending): Two PhD positions for hydrologic ensemble prediction and heuristic probabilistic nowcasting tools, respectively.
- EUCOS (EUMETNET) is willing to make available some funds for possible additional soundings during the demonstration period.

Additional funding for activities at the level of individual forecasting agencies, research projects, and end users come from a wide range of international, national, and regional sources.

References

- Bacchi, B., R. Ranzi, and E. Richard (Editors), 2003: Hydrometeorological processes and floods in the Alps. *Hydrology and Earth Systems Sciences*, **7**, 783-948.
- Benoit, R., C. Schär, P. Binder, S. Chamberland, H. C. Davies, M. Desgagne, C. Girard, C. Keil, N. Kouwen, D. Lüthi, D. Maric, E. Müller, P. Pellerin, J. Schmidli, F. Schubiger, C. Schwierz, M. Sprenger, A. Walsler, S. Willemse, W. Yu, and E. Zala, 2002: The real-time ultrafinescale forecast support during the special observing period of the MAP. *Bulletin of the American Meteorological Society*, **83**, 85-109.
- Benoit R, N. Kouwen, W. Yu, S. Chamberland, and P. Pellerin, 2003: Hydrometeorological aspects of the Real-Time Ultrafinescale Forecast Support during the Special Observing Period of the MAP. *Hydrology and Earth System Sciences*, **7**, 877-889.
- Binder, P. and C. Schär, 1996: MAP Design Proposal. Available online at <http://www.map.meteoswiss.ch/map-doc/proposal.htm>.
- Bougeault, P., P. Binder, A. Buzzi, R. Dirks, R. Houze, J. Kuettner, R. B. Smith, R. Steinacker, and H. Volkert, 2001: The MAP special observing period. *Bulletin of the American Meteorological Society*, **82**, 433-462.
- Bousquet, O. and B. Smull, 2003: Observations and impacts of upstream blocking during a widespread orographic precipitation event. *Quarterly Journal of the Royal Meteorological Society*, **129**, 391-409.
- Buzzi A., S. Davolio, M. D'Isidoro, and P. Malguzzi, 2004: The impact of resolution and of MAP reanalysis on the simulations of heavy precipitation during MAP cases, *Meteorologische Zeitschrift*, **13**, 91-97.

- Ducrocq, V., D. Ricard, J.-P. Lafore, and F. Orain, 2002: Storm-scale Numerical Rainfall Prediction for Five Precipitating Events over France: On the Importance of the Initial Humidity Field. *Weather and Forecasting*, **17**, 1236-1256.
- Ebert E., L. Wilson, B. Brown, P. Nurmi, H. Brooks, J. Bally, and M. Jaeneke, 2004: Verification of Nowcasts from the WWRP Sydney 2000 Forecast Demonstration Project. *Weather and Forecasting*, **19**, 73–96.
- Germann, U., G. Galli, and M. Boscacci, 2005: Radar precipitation measurements in the Alps – big improvements triggered by MAP. Proceedings of ICAM/MAP 2005, Zadar, Croatia, 23-27 May 2005, 226-230. Available online at <http://meteo.hr/ICAM2005/proceedings.html>.
- Keenan, T., P. Joe, J. Wilson, C. Collier, B. Golding, D. Burgess, P. May, C. Pierce, J. Bally, A. Crook, A. Seed, D. Sills, L. Berry, R. Potts, I. Bell, N. Fox, E. Ebert, M. Eilts, K. O'Loughlin, R. Webb, R. Carbone, K. Browning, R. Roberts, and C. Mueller, 2003: The Sydney 2000 World Weather Research Programme Forecast Demonstration Project: Overview and Current Status. *Bulletin of the American Meteorological Society*, **84**, 1041–1054.
- Leuenberger, D., 2005: High-Resolution Radar Rainfall Assimilation: Exploratory studies with Latent Heat Nudging. Ph.D. thesis ETH Zurich, Switzerland, Nr. 15884. Available online at <http://e-collection.ethbib.ethz.ch/cgi-bin/show.pl?type=diss&nr=15884>.
- Marsigli, C., A. Montani, F. Nerozzi, T. Paccagnella, S. Tibaldi, F. Molteni, and R. Buizza, 2001: A strategy for high-resolution ensemble prediction. Part II: Limited-area experiments in four Alpine flood events. *Quarterly Journal of the Royal Meteorological Society*, **127**, 2095-2115.
- Medina, S. and R. A. Houze, 2003: Air motions and precipitation growth in Alpine storms. *Quarterly Journal of the Royal Meteorological Society*, **129**, 345-371.
- Molteni, F., R. Buizza, C. Marsigli, A. Montani, F. Nerozzi, and T. Paccagnella, 2001: A strategy for high-resolution ensemble prediction. Part I: Definition of representative members and global-model experiments. *Quarterly Journal of the Royal Meteorological Society*, **127**, 2069-2094.
- Ranzi, R.; B. Bacchi, and G. Grossi: 2003, Runoff measurements and hydrological modelling for the estimation of rainfall volumes in an alpine basin, *Quarterly Journal of the Royal Meteorological Society*, **129**, 653-673.
- Richard, E., S. Cosma, R. Benoit, P. Binder, A. Buzzi, and P. Kaufmann, 2003: Intercomparison of mesoscale meteorological models for precipitation forecasting. *Hydrology and Earth System Sciences*, **7**, 799-811.
- Richard, E., A. Buzzi, G. Zängl, N. Ascencio, R. Benoit, S. Chiao, R. Ferretti, C. Hohenegger, C. Keil, Y-L. Lin, C. Marsigli, S. Medina, and C. Schär, 2005: Quantitative precipitation forecasting in mountainous regions – pushed ahead by MAP. Proceedings of ICAM/MAP 2005, Zadar, Croatia, 23-27 May 2005, 65-69. Available online at <http://meteo.hr/ICAM2005/proceedings.html>.
- Rotach, M. W., 2004: The upcoming MAP Forecast Demonstration Project (FDP). *MAP Newsletter*, **19**, 6-8. Available online at <http://www.map.meteoswiss.ch/map-doc/newsletter.htm>.
- Rotach, M. W., 2005: MAP D-Phase. 2nd SRNWP Workshop on Short Range Ensemble Prediction Systems, 7-8 April 2005, Bologna, Italy. Available online at http://srnwp.cscs.ch/Lead_Centres/2005Bologna/Agenda.htm.
- Rotunno, R. and R. Ferretti, 2003: Orographic effects on rainfall in MAP cases IOP 2b and IOP 8. *Quarterly Journal of the Royal Meteorological Society*, **129**, 373-390.
- Steinacker, R., C. Häberli, and W. Pötschacher, 2000: A Transparent Method for the Analysis and Quality Evaluation of Irregularly Distributed and Noisy Observational Data. *Monthly Weather Review* **128**, 2303-2316.
- Volkert, H., 2005: The Mesoscale Alpine Programme (MAP) – a multi-faceted success story. Proceedings of ICAM/MAP 2005, Zadar, Croatia, 23-27 May 2005, 226-230. Available online at <http://meteo.hr/ICAM2005/proceedings.html>.
- Walser, A. and C. Schär, 2004: Convection-resolving precipitation forecasting and its predictability in Alpine river catchments. *Journal of Hydrology*, **288**, 57-73.
- Walser, A., D. Lüthi, and C. Schär, 2004: Predictability of precipitation in a cloud-resolving model. *Monthly Weather Review*, **132**, 560-577.

Enclosures

CVs of the proposers.

Appendix 1: Participating institutions

Type	Name	Contact person	Contribution	Comments
National / Regional Weather Service	MeteoSwiss	M. Arpagaus U. Germann	aLMo (a); Swiss radar nowcast	
	ARPA-SIM	T. Paccagnella	COSMO-LEPS (a); LAMI (a); TopKapi (h); radar data	Also Functional Centre for Civil Protection
	UGM-CNMCA	G. Frustaci	LAMI-CNMCA (a)	
	ARPAL-CMIRL	E. Trovatore	MOLOCH (a); DRIFT (h)	Also Functional Centre for Civil Protection
	Météo-France	F. Bouttier	AROME (a)	Collaboration with U Paul Sabatier
	DWD	M. Denhard	LMK (a)	
	ZAMG	Y. Wang	ALADIN-Austria (a)	
	UK Met Office	K. Mylne	MOGREPS (a); post-event simulations with Unified Model (a)	
	Environment Canada	S. Gravel	GEM-LAM (a); WATFLOOD (h)	
University	ETHZ	C. Schär B. Ahrens	PREVAH (h); process studies on atmospheric predictability	Collaboration with WSL (M. Zappa)
	IST-SUPSI	S. Seno	Lago Maggiore sea level prediction (h)	
	ISAC-CNR	A. Buzzi	MOLOCH (a)	
	U Brescia	R. Ranzi	DIMOSOP (h)	<i>Real-time</i> application conditioned to availability of funds in 2006; otherwise selected event- based and post- processing of flood events
	U Trento	D. Zardi	Post-event simulations with a hydrologic model; process studies	
	U Aquila- CETEMPS	R. Ferretti	MM5 (a); WRF (a)	

Type	Name	Contact person	Contribution	Comments
	CIMA	A. Parodi N. Rebora	Post-event simulations with LAMI (a); RainFARM: post-event stochastic downscaling of deterministic and probabilistic atmospheric model outputs for hydrological purposes	Collaboration with ARPA-SIM
	U Paul Sabatier	E. Richard	Post-event simulations with AROME (a) and Meso-NH (a)	Collaboration with Météo-France
	U Hohenheim	H.-S. Bauer	MM5 (a) and/or WRF (a)	<i>Real-time</i> operation dependent on success of pending DFG proposal
	U Vienna	R. Steinacker	VERA analysis	
	U Vienna	M. Dorninger	Real-time model validation	
	U Ljubljana	J. Rakovec	Post-event simulations with COAMPS (a) and/or AROME (a)	Collaboration with Meteorological Office of Environmental Agency of Slovenia
Research institution	DLR	C. Keil	COSMO-LEPS (a)	
EUMETNET	SRNWP	M. Denhard	PEPS (a)	
	EUCOS	J. Caughey	Extra observations	

Table 3: Participating institutions (not including indirect contributions from the COPS, THORPEX, Meteorisk, and COST 731 communities); (a) denotes an atmospheric model, whereas (h) stands for a hydrologic model.