MAP D-PHASE Implementation Plan

Editor: Marco Arpagaus, D-PHASE coordinator (marco.arpagaus [at] meteswiss.ch)

Version	Date	Changes
3.0	22.04.2007	- Completed the introduction. - Included (through links …) draft versions on data and alert formats (atmospheric and hydrological models).
2.9	10.04.2007	- Updated chapters on nowcasting tools and online monitoring tools. - Removed chapter on observational data component, since observational data is in the responsibility of every component individually. - Removed table 1, updated / added other tables. - The VP is realised with Next Generation Software. Still to be revised / clarified / changed (by D-PHASE coordinator): - Clean-up for version 3.0. - Include COPS bodies for detailed specification of products / alerts to be visualised (and definition of possible COPS-specific alerts). - Add some information concerning the organisational structure of MAP D-PHASE. - Add section on observational data from Met Services to the evaluation chapter. - Include MeteoSwiss specifications concerning information flow of feedback by forecasters (‘Umsetzungskonzept’; 6.3.2).
2.0	30.10.2006	- Section 2.2.3 and chapter 10 reformulated: new platforms (DA and VP, see extra bullets) and changes in the general rules for the information flow. - Data interface (DI) is now called data archive (DA), since it really only archives all data, alerts, and feedbacks. - The data visualisation platform (DVP) and the warning and feedback platform (WFP) have been merged into one, the visualisation platform (VP). - Clearly separate generation and display of data derived products. - End users may be alerted by a meteorological or hydrological forecaster.
1.1	16.08.2006	- Updated tables 1 and 2, moved tables 1-4 to end of section 2.5. - Clarified distinction / separation between nowcasting tools, observational data, and online monitoring.
1.0	25.04.2006	First (revised) version based on decisions and input from MAP D-PHASE Steering Committee meeting of March 13-14, 2006.
0.n		drafts

colour code:

Blue: Questions to be addressed/answered by the respective “Responsible for detailed specification of …” (see below); i.e., this text will eventually be replaced by the specifications worked out by the responsible MD-body (working group, specific person, …)

Pink: Points to be clarified, text to be refined or things to be completed (by the editor, the participation institutions, specific groups, whoever, …), asap.

Black: Normal (i.e., “final”) text.

Table of content

1 Introduction

1.1 Summary

The main objective of **MAP D-PHASE**, 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 hydrological 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 atmospheric and hydrological ensemble prediction systems with a lead time of a few days, followed by short-range forecasts based on high-resolution deterministic atmospheric and hydrological models for selected regions or catchments, and will be completed with real-time nowcasting tools. 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.

1.2 MAP and D-PHASE

As the first **Research and Development Project** (RDP) of the **World Weather Research Programme (WWRP)**, the **Mesoscale Alpine Programme (MAP)** has seen three phases: a development phase (1993 – 1999; 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 2004, the MAP Steering Committee mandated a working group to explore the possibility and interest in a **fourth phase: *a demonstration phase***. From the many achievements of MAP (Volkert 2005), **forecasting heavy precipitation and related flooding events in the Alpine region** and the associated issues of orographically enhanced precipitation, high-resolution numerical weather prediction, and hydrological processes have subsequently been chosen as the topic for the **MAP Forecast Demonstration Project (MAP FDP)**. The project thereby addresses the entire forecasting chain ranging from observations, ensemble forecasting, high-resolution cloud-resolving atmospheric modelling (km-scale), hydrological modelling, and nowcasting to decision making by end users (civil protection authorities, water management and hydrological agencies, etc.), i.e., it sets up an **end-to-end forecasting system**. To emphasize the main objective of the fourth phase of MAP, the MAP FDP is referred to as **D-PHASE**, which stands for ***Demonstration of Probabilistic Hydrological and Atmospheric Simulation of flood Events in the Alpine region.***

The WWRP endorsed D-PHASE as the second **WWRP Forecast Demonstration Project** (FDP) in October 2005.

The **D-PHASE Operations Period (DOP)** will be **1 June – 30 November 2007.**

1.3 Objectives of D-PHASE

MAP has brought significant progress in the following fields of research that are relevant for D-PHASE:

- **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 hydrological models (Ducrocq et al. 2002, Leuenberger 2005) but also for nowcasting and verification.
- **High-resolution (3 km mesh-size) *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).
- **Hydrological modelling**: coupling of atmospheric and hydrological 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, D-PHASE is setting up a **distributed real-time end-to-end forecasting system** with which it 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 hydrological 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.

1.4 MAP D-PHASE Implementation Plan

The aim of this document, the MAP D-PHASE Implementation Plan (MD-IP) is to serve as handbook for the D-PHASE Operations Period (DOP).

Chapter 2 provides an overview of operational end-to-end forecasting system and is followed by one chapter on operational aspects for each of the components of the distributed end-to-end forecasting system, i.e., atmospheric models, hydrological models, nowcasting tools, forecasters, and end users, respectively. Finally, chapter 8 provides details concerning the evaluation of the real-time system, whereas chapter 9 deals with the technical realisation of the common data archive, the common visualisation platform, and the information flow.

Providers of components of the end-to-end forecasting system should be able to read the chapter specific to their component (i.e., chapters 3 – 7 for atmospheric models, hydrological models, nowcasting tools, forecasters, and end users, respectively), complemented with chapters 2 and 9 for an overview of the operational end-to-end forecasting system and technical issues, respectively, to retrieve most of the relevant information.

2 Operations: Overview

2.1 End-to-end forecasting system

MAP D-PHASE aims at establishing a distributed real-time end-to-end forecasting system for heavy precipitation and subsequent flood events in the Alpine region. It is based on the following items (in chronological order):

- **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 different target regions. These (pre-) alerts will be sent out to all the participants including atmospheric and hydrological modellers, forecasters, and end users.
- 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.
- 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[1]. A poor man's ensemble is constructed from these simulations. The simulations will use a wide range of data-assimilation systems as used by the participating institutions. Also, surface fields from the VERA (Vienna Enhanced Resolution Analysis) are provided for assimilation and online monitoring purposes.
- For the (pre-) alerted events, the output of the high-resolution deterministic atmospheric models is used to drive **hydrological models** if the event affects an impact area (i.e., if one or more participants have established a hydrological modelling system for the area). Output goes to the concerned forecasters and end user(s) and is tailored towards their specific needs. Possibilities of performing hydrological *ensemble* predictions (based on an atmospheric ensemble prediction system, different atmospheric models, stochastic techniques, or parameter perturbations in hydrological models) are explored.
- 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, 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 forecasters. Additionally, quantitative radar estimates of surface precipitation may be used as input for hydrological models.

[1] The high-resolution deterministic models will also be run in absence of an alert to assess false alarm rates etc, unless computing resources restrict model runs to alerted situations.

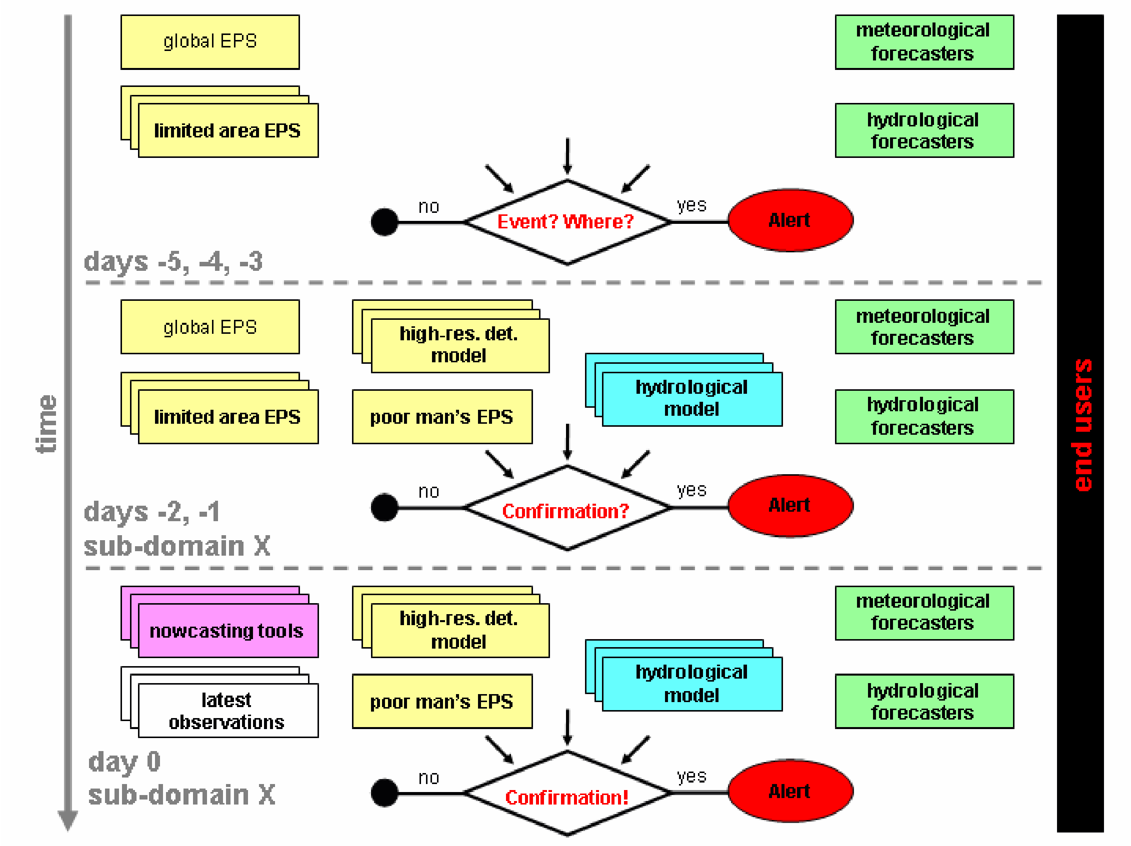

Figure 1 gives a graphical impression of the foreseen forecasting procedure. Real-time observational data are required as input for data assimilation and to drive the nowcasting tools. These are obtained from the existing networks to demonstrate *operational* forecasting capabilities.

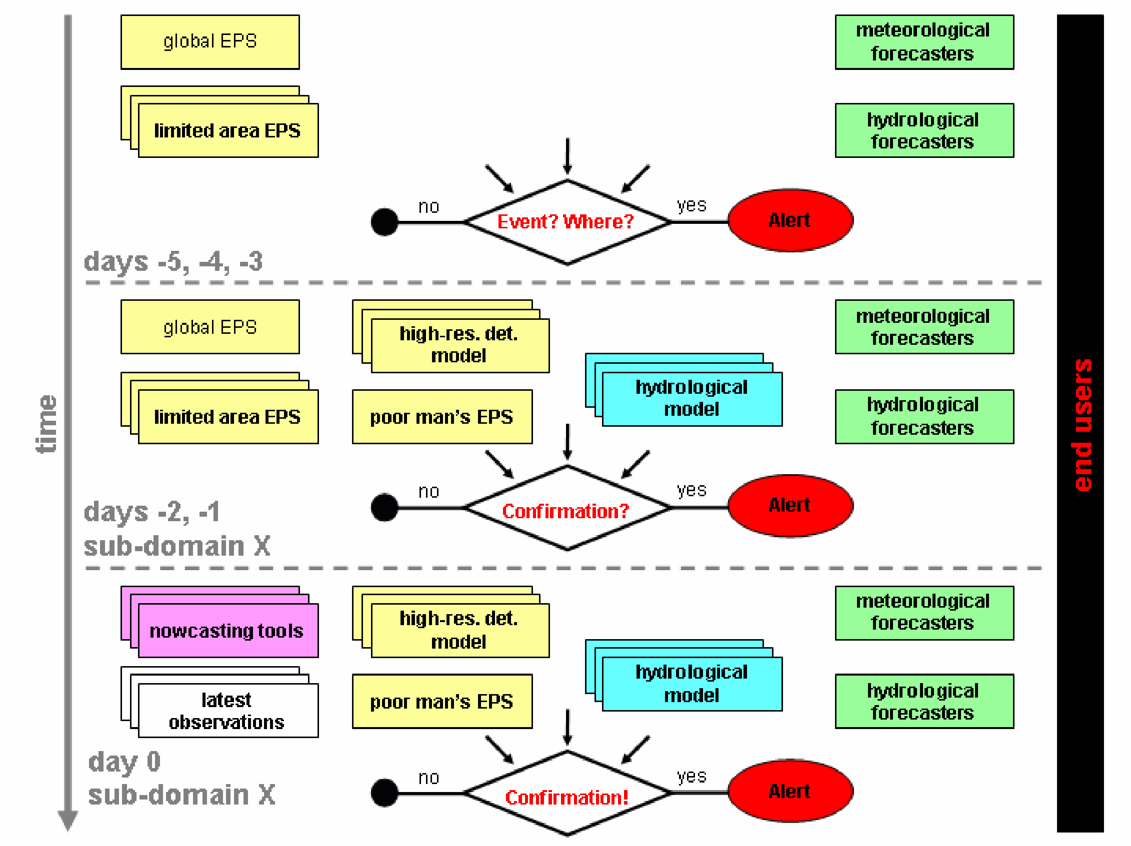

Figure 1: Conceptual sketch of the real-time end-to-end forecasting system.

2.2 Properties of end-to-end forecasting system

In the following subsections, general properties of the end-to-end forecasting system are described. More detailed specifications of the individual components of the end-to-end forecasting system are provided in subsequent chapters (cf. chapters 3 – 7).

2.2.1 Components of the end-to-end forecasting system

The end-to-end forecasting system consists of the following *components*:

– atmospheric models (probabilistic and deterministic)

– hydrological models (probabilistic and deterministic)

– nowcasting tools

– meteorological and hydrological forecasters (also referred to as 'intermediate' users)

– end users

The first three components are thought of as being *automated* (i.e., no or minimal human intervention needed), whereas the latter two are primarily manual in character. Forecasters and end users are collectively referred to as *users*.

2.2.2 Data, alerts, and feedback

To be able to precisely specify the different tasks of the individual components of the end-to-end forecasting system, we try to define the terms 'data', 'alerts', and 'feedback' – which will be heavily used within this document – as clearly as possible:

– **Data** refers to all output of the automated components of the system.
  Examples: direct model output of atmospheric or hydrological model; output of nowcasting tools.

  Atmospheric models, hydrological models, and nowcasting tools (i.e., all automated components …) provide data.

  All products derived from data are visualised on the common visualisation platform (see sections 2.2.3, 3.1.4, 4.1.4, and 5.1.4).

  Except from the nowcasting tools, all data are verified (see section 8.2; nowcasting tools are of course verified by the providers, individually).

– **Alerts** are either post-processed data or the result of a human assessment process, and aim at providing a quantitative and ready-to-use input for decision making of subsequent components in the end-to-end forecasting system.
  Examples: mean precipitation sum for a catchment provided by an atmospheric model based on which one or many hydrological model forecasts are triggered; probabilistic forecast of run-off above a predefined threshold by a hydrological model for the end users; warning for regional precipitation sums above e.g. 100mm/24h by a forecaster.

  Except for the end users, all components provide alerts.

  Except from the nowcasting tools, all alerts are visualised on the common visualisation platform (see sections 2.2.3, 3.2.5, 4.2.5, and 6.2.5).

  Except from the nowcasting tools, all alerts are verified (see section 8.2; alerts from nowcasting tools are of course verified by the providers, individually).

– **Feedback** is a statement or a number of statements concerning the usefulness of the end-to-end forecasting system or some of its components.

  Only the users (i.e., forecasters and end users) provide feedback.

  All feedbacks are assessed (see section 8.3).

2.2.3 Data archive, visualisation platform, and information flow

All data, alerts, and feedbacks are stored on a **data archive (DA)**. Hence, this is the primary source of information for verification purposes.

The data archive (DA) is physically based at the MPI in Hamburg. The responsible for the DA is referred to as MD-DA.

For the technical realisation of the data archive, see section 9.1.

Additional to the DA, a **common visualisation platform (VP)** is set up. It serves three main purposes:

– Real-time visualisation of *alerts* for forecasters and end users (i.e., users) for all the target and impact areas. Among other things, this enables the end users to compare alerts for their own impact area (for which the alerts are provided by the respective responsible forecaster, cf. section 6.2.2) with alerts for neighbouring areas.

– Real-time visualisation of *a predefined set of products* for the meteorological and hydrological forecasters (including the mission planning team within COPS) and the end users. This will enable the forecasters to benefit from all the products available through MAP D-PHASE and should thereby support them in providing forecasts and alerts themselves.

– Interface for (some of) the users to submit their feedback on the available products and alerts, respectively.

The visualisation platform is password-protected. All D-PHASE members (i.e., not only the users) will be provided with a personal password on request.

The visualisation platform (VP) is set up and maintained by Next Generation Software in Salzburg. The responsible for the VP is referred to as MD-VP.

The technical realisation of the visualisation platform is documented in section 9.2.

The general rules for the **information flow** between the components of the end-to-end forecasting system and the data archive and visualisation platform, respectively, are as follows:

– Input data are individually exchanged by the components (i.e., bilateral exchange).

– Output data are pushed to the DA by the components.

– Products derived from the output data are pushed to the VP *and* to the DA by the components.

– Alerts needed as input (for decision, whether something needs to be done) are individually exchanged by the components (i.e., bilateral exchange), or viewed on the VP.

– Alerts produced as output are pushed to the VP *and* to the DA by the components; end users are alerted by a forecaster.

– Feedback is collected on the VP and is pushed to the DA by the VP.

Other important aspects of the information flow are the update-frequency for new information and the exact timing for the delivery of data and alerts. The detailed specifications are provided in the respective sections on information flow.

Exceptions from the general rules for the information flow are explicitly indicated in the respective sections. – For the technical realisation of the information flow, see section 9.3.

2.3 Coordination

The distributed end-to-end forecasting system built up for D-PHASE is largely independent of any extra coordination, since it demonstrates the state of the art of the everyday operational real-time forecasting and warning practice.

2.4 Target and impact areas

The areas for which MAP D-PHASE provides real-time information are different for different parts of the end-to-end forecasting system.

On a large scale, and mainly related to meteorological forecasts and warnings, the *target areas* are within the Alpine region, including the COPS area to the north-west.

On a smaller scale, hydrological models provide forecasts and alerts for *impact areas* such as river catchments or areas specific to an end user.

To be done: Documentation of target and impact areas.

2.5 Participating components and institutions

The following tables provide lists of the participating components, including institution and contact person (s).

All information concerning participating institutions and contributions are preliminary in that they can, in principle, be extended until the beginning of the D-PHASE Operations Period (DOP, June to November 2007).

Atmospheric models:

The participating (limited-area) atmospheric models with model specifications are listed in Table 1 (see below).

Hydrological models:

The participating hydrological models with their impact area and driving models are listed in Table 2 (see below).

Nowcasting tools:

The participating nowcasting tools with their regions covered are listed in Table 3 (see below), as are the monitoring tools (cf. section 8.1).

Forecasters:

The participating forecasters are listed in Table 4 (see below).

End users:

The participating end users are listed in Table 4 (see below), together with their focal point, the respective impact area and the hydrological models provided for the impact areas.

In general, forecasters are the focal point for the end users: Every end user receives alerts and related information from at most one well-defined responsible (hydrological or meteorological) forecaster. There may however be more than one end user related to a single forecaster (cf. section 6.2.2).

Coordinate the end user involvement (and appoint responsible data provider) for large impact areas with more than one end user.

.

Table 1: Participating atmospheric models (*real-time only*; *limited-area* ensemble prediction systems and *high-resolution* deterministic models) with model specifications (computational domain).

	Model name on data archive	Model[2] (ensemble size)	Mesh-size [km, (degrees)]	Number of grid points (S-N, W-E)	Number of vertical levels	Position of rotated Npole [lat, lon]; 'none' for un-rotated grid	Position of lower left corner [rlat, rlon]; italic for un-rotated grid	Forecast range [h]	Initial time(s) [UTC]	Data available[3] [h after initial time (s)]	Institution and Contact person(s)	Tape space [GB][4]		potential problems
												MD[5]	COPS[6]	
limited-area ensemble prediction systems ("ens")	CLEPS	COSMO-LEPS (16)	10 (0.09)	258, 306	40	40, -170	-16, -12.5	132	12	13	ARPA Emilia-Romagna Andrea Montani	358		
	MOGREPS	MOGREPS (24)	25 (0.22)	432, 720	38	37.5, 177.5	-22.49, -46.98	54	06, 18	7	UK Met Office Kelvyn Robertson	75		
	INMSREPS	SREPS (20)	27 (0.25)	164, 384	40	*none*	*24, -65*	72	00, 12	8	INM Daniel Santos	64		
	CSREPS	COSMO-SREPS (16)	10 (0.09)	258, 306	40	40, -170	-16, -12.5	72	12	19	ARPA Emilia-Romagna Chiara Marsigli	199		depends on the availability of the INM SREPS

[2] For the high-resolution deterministic models, the coarser-resolution driving model(s) are also listed (if their output is provided).

[3] Data delivery time may slightly change from forecast to forecast due to operational constraints and available transfer bandwidth.

[4] For formulae used, see below.

[5] Output for D-PHASE domain (43 to 50 N, 2 to 18 E)

	Model name on data archive	Model[2] (ensemble size)	Mesh-size [km, (degrees)]	Number of grid points (S-N, W-E)	Number of vertical levels	Position of rotated Npole [lat, lon]; 'none' for un-rotated grid	Position of lower left corner [rlat, rlon]; italic for un-rotated grid	Forecast range [h]	Initial time(s) [UTC]	Data available[3] [h after initial time (s)]	Institution and Contact person(s)	Tape space [GB][4]		potential problems
												MD[5]	COPS[6]	
	PEPS	PEPS	7 (0.0625)	560, 960		*none*	*35, -30*	42	00, 06, 12, 18	6	EUMETNET SRNWP Michael Denhard	65		
	MPEPS	micro-PEPS	2 (0.02)	500, 650		*none*	*40, 4*	18	00, 03, 06, 09, 12, 15, 18, 21	1.5	DWD Michael Denhard	566		
high-resolution deterministic models ("high-res") and their	COSMOCH7 COSMOCH2	COSMO COSMO	7 (0.0625) 2.2 (0.02)	325, 385 350, 520	45 60	43.0, -170 43.0, -170	-9.75, -16 -4, -5.7	72 18	00, 12 00, 03, 06, 09, 12, 15, 18, 21	2.0 2.0	MeteoSwiss Felix Ament	128 3259	2348	
	LMEURO LMITA	COSMO COSMO	7 (0.0625) 2.8 (0.025)	641, 401 604, 542	50	32.5, -170 32.5, -170	-27.5, -16 -23, -5	72 30	00, 12 00	5 8.5	CNMCA Lucio Torrisi	128 425	311	CIN
	LAMI7 LAMI28	COSMO COSMO	7 (0.0625) 2.8 (0.025)	319, 299 532, 447	40 40	32.5, -170 32.5, -170	-25, -8.5 -21.925, -3.5	72 48	00, 12 00	5 7	ARPA Emilia-Romagna Davide Cesari	128 672	496	
	LME LMK	COSMO COSMO	7 (0.0625) 2.8 (0.025)	665, 657 461, 421	40 50	40, -170 40, -170	-20, -18 -5, -5	78 21	00, 06, 12, 18 00, 03, 06, 09, 12, 15, 18, 21	4-6 1	DWD Michael Denhard	277 2415	1750	

[6] Output for COPS domain (47 to 50 N, 6 to 11 E)

	Model name on data archive	Model[2] (ensemble size)	Mesh-size [km, (degrees)]	Number of grid points (S-N, W-E)	Number of vertical levels	Position of rotated Npole [lat, lon]; 'none' for un-rotated grid	Position of lower left corner [rlat, rlon]; italic for un-rotated grid	Forecast range [h]	Initial time(s) [UTC]	Data available[3] [h after initial time (s)]	Institution and Contact person(s)	Tape space [GB][4] MD[5]	Tape space [GB][4] COPS[6]	potential problems
	ISACMOL	MOLOCH	2.2 (0.02)	290, 340	50	44.7, -171	-1.84, -2.69	39	09[7]	???	ISAC-CNR Silvio Davolio	425	631	GRIB1 (check with ARPA Liguria!); only subset of TIGGE list
	ARPALBOL ARPALMOL	BOLAM MOLOCH	7 (0.06) 2.2 (0.02)	130, 140 194, 200	40 50	45, -171 45, -171	-3.8, -3.9 -1.93, -1.99	36 36	12 12	??? 9	ARPA Liguria Matteo Corazza	35 155	 0	only 3-hourly; only subset of TIGGE list; **sub-domain** (check with ISAC!)
	QBOLAM33 QBOLAM11	QBOLAM QBOLAM	33 (0.3) 11 (0.1)	98, 162 210, 386	40 40	51.5, -167.5 51.5, -167.5	-13.2, -24.3 -9.9, -18.3	60 48	12 00[8]	??? ???	APAT Stefano Mariani	2 42	 31	GRIB1 (check with ARPA Liguria?); only subset of TIGGE list; **sub-domain** (check with ISAC?)
	ALADFR AROME	ALADIN AROME[9]	(0.1) (0.04)	289, 289 160, 216	46 41	*none* *none*	*33.14, -11.84* *43.2, 5.3*	54 30	00 00	??? 7	Météo-France Eric Bazile	18[10] 115	 121	CAPE, CIN

[7] Nested into a 00 UTC BOLAM run, starting at forecast time +09h.

[8] Nested into the 12 UTC run, starting at forecast time +12h.

	Model name on data archive	Model[2] (ensemble size)	Mesh-size [km, (degrees)]	Number of grid points (S-N, W-E)	Number of vertical levels	Position of rotated Npole [lat, lon]; 'none' for un-rotated grid	Position of lower left corner [rlat, rlon]; italic for un-rotated grid	Forecast range [h]	Initial time(s) [UTC]	Data available[3] [h after initial time (s)]	Institution and Contact person(s)	Tape space [GB][4] MD[5]	Tape space [GB][4] COPS[6]	potential problems
											(ALADFR) and Yann Seity (AROME)			
	MM5_9 MM5_3 MM5_1	MM5 MM5 MM5	9 (0.09) 3 (0.03) 1 (0.01)	100, 100 180, 180 220, 250	36 36 36	*none* *none* *none*	???	24 24 24	00, 12 00, 12 00, 12	??? ??? ???	University of Hohenheim Hans-Stefan Bauer, Matthias Grzeschik	21 69 297	 3120	GRIB1 (check with FZK!); **sub-domain** (check with FZK!)
	MM5_60 MM5_15 MM5_375	MM5 MM5 MM5	60 (0.56) 15 (0.14) 3.75 (0.04)	45, 55 73, 77 49, 57	26 26 26	*none* *none* *none*	*34.08, -7.02* *42.10, 2,72* *46.88, 10.18*	72 72 60	00, 12 00, 12 00, 12	10 10 10	FZK IMK-IFU Johannes Werhahn, Andreas Marx	1 25 36	 0	standard MM5 output; only subset of TIGGE list
	WRF60 WRF20 WRF5	WRF WRF WRF	60 (0.52) 20 (0.16) 5 (0.06)	48, 56 64, 64 49, 49	33 33 33	*none* *none* *none*	*34.79, -7.40* *42.07, 3.66* *46.33 ,9.37*	72 72 60	00, 12 00, 12 00, 12	10 10 10	FZK IMK-IFU Andreas Marx	1 19 31	 0	standard WRF output; only subset of

[9] AROME runs on a Lambert projected grid with a mesh-size of 2.5 km with (309, 309) grid points centred at (46.39N, 9.6E). The specifications given in this table refer to the GRIB output on a regular lat/lon grid. The respective numbers for the driving model (ALADFR) are 9.5 km, (300, 300), and (??, ??), respectively.

[10] Data not provided, unless someone explicitly asks for it.

	Model name on data archive	Model[2] (ensemble size)	Mesh-size [km, (degrees)]	Number of grid points (S-N, W-E)	Number of vertical levels	Position of rotated Npole [lat, lon]; 'none' for un-rotated grid	Position of lower left corner [rlat, rlon]; italic for un-rotated grid	Forecast range [h]	Initial time(s) [UTC]	Data available[3] [h after initial time (s)]	Institution and Contact person(s)	Tape space [GB][4] MD[5]	Tape space [GB][4] COPS[6]	potential problems
														TIGGE list
	ALADAT	ALADIN	9.6 (???)	270, 300		*none*	*(centred at 46.26, 17.0)*	48	00, 12	???	ZAMG Yong Wang	103	76	
	CMCGEML CMCGEMH	GEM-LAM GEM-LAM	15 (0.188, 0.135) 2.5 (0.0327, 0.0225)	199, 174 413, 600	58 58	*none* *none*	*2.54, 3.5* *3.98, 0.2*	24 18	00 06	??? ???	Environment Canada Ron McTaggart-Cowan,	13 423	 308	

For the calculation of the required storage space on the data archive (in [Giga-Bytes]), the following formulae have been used:

– for ensemble prediction systems:
(2 bytes [GRIB]) *
(number of grid points [S-N*W-E]) *
(forecast range / 3 + 1 [3-hourly output]) *
(number of runs per day) * (180 days) *
(ensemble size) *
(100 2d fields)

– for PEPS and micro-PEPS:
(2 bytes [GRIB]) *
(number of grid points [S-N*W-E]) *

(forecast range + 1 [hourly output]) *
(number of runs per day) * (180 days) *
(1) *
(37 2d fields)

– for deterministic models driving the high-resolution deterministic models:
(2 bytes [GRIB]) *
(number of grid points [S-N*W-E]) *
(forecast range + 1 [hourly output]) *
(number of runs per day) * (180 days) *
(120 2d fields)

– for high-resolution deterministic models (D-PHASE domain):
(2 bytes [GRIB]) *
(number of grid points [S-N*W-E]) *
(forecast range + 1 [hourly output]) *
(number of runs per day) * (180 days) *
(300 2d fields)

– for high-resolution deterministic models (COPS domain, 1.6.2007 – 31.8.2007):
(2 bytes [GRIB]) *
(number of grid points [S-N*W-E]) *
(forecast range * 4 + 1 [output every 15 minutes]) *
(number of runs per day) * (90 days) *
(840 2d fields)

In case the computational domain of a model is larger than the D-PHASE (43 to 50 N, 2 to 18 E) or COPS (47 to 50 N, 6 to 11 E) domain, respectively, only the *effective* number of grid points needed to cover the domains was used in the above calculation. If on the other hand a model doesn't cover the COPS domain, the estimated tape space is set to zero.

Table 2: Participating hydrological models (*real-time only*).

Model name on data archive [11]	Impact area[12]	Driving model[13]	Institution and contact person(s)
PREVAH (e-hm & d-hm)	Linth at Mollis Verzasca at Lavertezzo	CLEPS, COSMOCH2, COSMOCH7, radar data	ETHZ/WSL Simon Jaun, Massimiliano Zappa
FERW (e-hm & d-hm)	60 (???) sub-basins of Rhine catchment	CLEPS, PEPS, COSMOCH2, COSMOCH7, radar data	BAFU Stephan Vogt
RSYSTEM2 (e-hm & d-hm)	Rhone at Sion Rhone at Porte du Scex Sarine at Laupen	CLEPS, COSMOCH2, COSMOCH7	EPFL Frédéric Jordan
???		CLEPS, COSMOCH7	IST-SUPSI Massimiliano Cannata
???	Ticino at Bellinzona Maggia at Solduno Verzasca at Lavertezzo Tresa at Rocchetta Cassarate at Pregassona Vedeggio at Agno	???	Ufficio dei corsi d'acqua, Dipartimento del Territorio, Cantone Ticino Andrea Salvetti
TOPKAPI (e-hm)	Reno at Casalecchio	CLEPS	ARPA Emilia-Romagna Fabrizio Tonelli
MIKE11 (e-hm)	Taro at Ponte Taro	CLEPS	ARPA Emilia-Romagna Fabrizio Tonelli
DRIFT	???	???	ARPA Liguria Francesca Giannoni
DIMOSOP (e-hm & d-hm)	Oglio at Sarnico Mella at Stocchetta Chiese at Lago d'Idro Sarca at Ponte Pià	CLEPS, ISACMOL	U Brescia Roberto Ranzi

[11] (e-hm) for a hydrological model running in ensemble mode, (d-hm) for a hydrological model running deterministically.

[12] Catchments are named as “river at gauging station”.

[13] If not driven by an atmospheric model, specify input data (e.g., nowcasting tool, observational data, etc.).

Model name on data archive [11]	**Impact area**[12]	**Driving model**[13]	**Institution and contact person(s)**
GEOTOP	Brenta at Sarson	???	U Trento Riccardo Rigon
FEST	Toce at Condoglia Lago Maggiore (?)	???	POLIMI Giovanni Ravazzani
CDRIFT	Lys at Pont St. Martin	CLEPS, COSMOCH2	CIMA Roberto Rudari
GEOMADB	Piave at Segusino	???	ADB-AA Michele Ferri
LARSIMK (???)	Iller at Sonthofen Iller at Immenstadt Zollbrücke Iller at Kempten Lech at Steeg Lech at Vorderhornbach Lech at Füssen Ostrach at Reckenberg	???	WWA Kempten Uwe Ehret
LARSIMW (d-hm)	Isar at Sylvensteinspeicher Isar at Bad Tölz Loisach at Schlehdorf Partnach at Partenkirchen Ammer at Peißenberg	COSMOCH2, COSMOCH7, MM5_375, MM5_15, WRF_5	WWA Weilheim Natalie Stahl
???	Kinzig Murg	???	LUBW Werner Schulz
???	Kamp	???	TUWIEN Günther Blöschl

Table 3: Participating nowcasting and online monitoring tools.

Tool	Coverage[14]	Data format and availability[15]	Institution and contact person(s)
MeteoSwiss NASS (quantitative precipitation estimate based on radar)	Switzerland plus boarder area	png (or gif); link to web-site at MeteoSwiss quantitative numerical data only on bilateral agreement	MeteoSwiss Urs Germann
Piemonte-MeteoSwiss composite (quantitative precipitation estimate based on radar)	Piemonte and Switzerland	png (or gif); link to web-site at MeteoSwiss	ARPA Piemonte / MeteoSwiss Roberto Cremonini / Urs Germann
MeteoSwiss ENASS (ensemble quantitative precipitation estimate based on radar)	Switzerland plus boarder area	only on bilateral agreement (format to be specified)	MeteoSwiss Urs Germann
MeteoSwiss TRT (thunderstorm radar tracking)	Switzerland plus boarder area	png (or gif); link to web-site at MeteoSwiss quantitative numerical data only on bilateral agreement	MeteoSwiss Alessandro Hering
DLR Cb-TRAM (Tracking and monitoring severe convection using multi-channel Meteosat-8 SEVIRI data)	D-PHASE and COPS domain	png (or gif); link to web-site at DLR	DLR Arnold Tafferner
???			CNMCA A. Terzo ???
???			ARPA-SIM ???
VERA (Vienna Enhanced Resolution Analysis) (analysis of surface fields for online monitoring)	D-PHASE and COPS domain	png (or gif); link to web-site at U Vienna quantitative numerical data only on bilateral agreement	U Vienna Manfred Dorninger
NWP minus VERA	D-PHASE and COPS domain	png (or gif); link to web-site at U Vienna	U Vienna

---

[14] Main region. Due to the extension of the underlying observing systems (e.g., radar), some neighbouring regions are also covered, but possible with a reduced data quality.

[15] See sections 5 and 8.1 for details.

(online monitoring for some of the NWP models; surface fields)		quantitative numerical data only on bilateral agreement	Theresa Gorgas
CLEPS versus Satellite (online monitoring of CLEPS versus satellite observations)	D-PHASE and COPS domain	png (or gif); link to web-site at DLR	DLR Christian Keil

Table 4: Participating end user / forecaster pairs (each end user is alerted by only one forecaster, if at all, i.e. there may be more than one end user per forecaster but there is at most one forecaster per end user; cf. section 6.2.2).

Add "---" or "*Visualisation Platform*" in case no forecaster transmits alerts?

End user (contact person)	Forecaster	Impact area	Hydrological models[16]
Fachstelle Naturgefahren, Departement Bau und Umwelt, Kanton Glarus, Schweiz (Jürg Walcher)	WSL	Linth at Mollis	PREVAH
Amt für Abfall, Wasser, Energie und Luft, Baudirektion Kanton Zürich, Schweiz (Matthias Oplatka)	???	???	
Kantonaler Führungsstab St Gallen, Schweiz (Hans-Peter Wächter)	???	???	
Lagezentrum Kantonspolizei Bern, Schweiz (Adrian Berlinger)	???	???	
Wasserwirtschaftsamt Kanton Bern, Schweiz (Jean-Claude Bader)	???	???	
Fachstelle Naturgefahren, Amt für Wald, Kanton Graubünden, Schweiz (Christian Wilhelm)	???	???	
Amt für Wald, Jagd und Fischerei, Kanton Schwyz, Schweiz (Daniel Bollinger)	???	???	
Abteilung Landschaft und Gewässer, Departement Bau, Verkehr und Umwelt, Kanton Aarau, Schweiz (Stephan Suter)	???	???	
Bundesamt für Bevölkerungsschutz, Schweiz (Jürg Balmer)	???	???	

[16] Only hydrological models for the impact area of interest are mentioned. Other potentially useful data such as atmospheric model information and nowcasting tools are not explicitly mentioned. – All information can additionally be retrieved from the visualisation platform.

End user (contact person)	Forecaster	Impact area	Hydrological models[16]
Basler und Hofmann Ingenieure und Planer AG, Schweiz (Heinz Weiss)	???	Sihl at Sihlhölzli	
WSL, Schweiz (Jacques Rhyner)	---	various	---
Service des routes et des cours d'eau Canton de Valais, Suisse (Dominique Bérod)	EPFL	Rhone at Sion Rhone at Porte du Scex	RSYSTEM2 RSYSTEM2
Protection de la population, Canton de Fribourg, Suisse (Philippe Knechtle)	???	???	
Police cantonal Neuchâtel, Suisse (Robert Kaeser)	???	???	
Groupe E SA, Suisse (Alexandre Gal)	???	Sarine at Laupen	RSYSTEM2
Ufficio dei corsi d'acqua, Dipartimento del Territorio, Cantone Ticino, Svizzera (Andrea Salvetti)	WSL	Ticino at Bellinzona Maggia at Solduno Verzasca at Lavertezzo Tresa at Rocchetta Cassarate at Pregassona Vedeggio at Agno	??? ??? ???, PREVAH ??? ??? ???
???	IST-SUPSI (?)	???	???
ARPA Emilia-Romagna, Italia (???)	ARPA Emilia-Romagna	Reno at Casalecchio Taro at Ponte Taro	TOPKAPI MIKE11
ARPA Liguria, Italia (???)	ARPA Liguria	???	DRIFT
ARPA Lombardia, Italia (Roberto Serra)	U Brescia	Oglio at Sarnico Mella at Stocchetta	DIMOSOP DIMOSOP
Consorzio dell'Oglio, Italia (Massimo Buizza)	U Brescia	Oglio at Sarnico Mella at Stocchetta	DIMOSOP DIMOSOP
ENEL, Italia (Giorgio Galeati)	U Brescia	Chiese at Lago d'Idro Sarca at Ponte Pià	DIMOSOP DIMOSOP
Provincia Autonoma di Trento, Servizio Opere Idrauliche, Italia (Bruno Lorengo)	U Brescia	Sarca at Ponte Pià	DIMOSOP
Provincia Autonoma di Trento, Servizio	U Trento	Brenta at Sarson	GEOTOP

End user (contact person)	**Forecaster**	**Impact area**	**Hydrological models**[16]
Opere Idrauliche, Italia (Bruno Lorengo)			
ADB-AA, Italia (Michele Ferri)	ADB-AA	Piave at Segusino	GEOMADB
ARPA Piemonte, Italia (???)	POLIMI	Toce at Condoglia Lago Maggiore (?)	FEST FEST
???	CIMA	Lys at Pont St. Martin	CDRIFT
Berufsfeuerwehr Augsburg, Deutschland (Christian Töpfel)	WWA Kempten	Lech at Haunstetten Lech at Augsburg Wertach at Oberhausen Wertach at Augsburg	??? ??? ??? ???
Bayerisches Staatsministerium für Umwelt, Gesundheit und Verbraucherschutz, Deutschland (Klaus Mayrhofer)	WWA Kempten	Iller at Immenstadt Zollbrücke Iller at Kempten Iller at Wiblingen Lech at Füssen	LARSIMK LARSIMK ??? LARSIMK
WWA Kempten, Deutschland (???)	WWA Kempten	Iller at Sonthofen Iller at Immenstadt Zollbrücke Iller at Kempten Iller at Wiblingen Lech at Vorderhornbach Lech at Füssen Lech at Augsburg Wertach at Augsburg Ostrach at Reckenberg	LARSIMK LARSIMK LARSIMK ??? LARSIMK LARSIMK ??? ??? LARSIMK
Landratsamt Oberallgäu, Deutschland (Erich Stoppel)	WWA Kempten	Iller at Sonthofen Iller at Immenstadt Zollbrücke Iller at Kempten Ostrach at Reckenberg	LARSIMK LARSIMK LARSIMK LARSIMK
E-Werke, Reutte, Deutschland (Lothar Reinstadler)	WWA Kempten	Lech at Steeg Lech at Vorderhornbach Lech at Füssen	LARSIMK LARSIMK LARSIMK
Bundesanstalt für Gewässerkunde, Koblenz, Deutschland (Peter Krahe)	???	???	???
ARSO (Mira Kobold)	???	Sava	---

End user (contact person)	Forecaster	Impact area	Hydrological models[16]
		others?	
DHMZ (Sandra Jurela)	???	Mura at Gorican Drava at Terezino Polje	--- ---

3 Operations: Atmospheric models

Atmospheric models are one component of the end-to-end forecasting system (cf. section 2.1 for an overview of the end-to-end forecasting system).

General properties of the end-to-end forecasting system are described in section 2.2. Specifically, section 2.2.2 describes data, alerts and feedbacks and section 2.2.3 gives an overview of the data archive, the visualisation platform, and the information flow. The technical realisation of the end-to-end forecasting system is specified in chapter 9.

In this chapter, the specific properties of the atmospheric models relevant for operating as an integral part of the end-to-end forecasting system are documented. These are data in- and output as well as the alerts the atmospheric models need to start operating (if any) and the alerts they provide for other components of the end-to-end forecasting system.

The different requirements for limited-area EPSs, high-resolution deterministic models, and the high-resolution EPS are explicitly specified where needed.

Global EPS: No commitment from ECMWF (i.e., ECMWF does not provide output or alerts for the DA and the VP, but IFS data can of course be used individually to e.g. drive limited-area atmospheric models. – The UK Met Office offers to provide data from their global EPS (90 km grid-length, 72 hours, initialised at 00 and 12 UTC), if requested.

3.1 Data

3.1.1 Input data

All atmospheric models take care of their required input data (boundary conditions, observations, etc.) individually.

For the time being, no model foresees to nest into another one of the D-PHASE models.

3.1.2 Output data: information flow

Output of the atmospheric models is pushed to the data archive (DA) by the atmospheric models.

Information on frequency and timing of data delivery of each atmospheric model is provided in Table 1.

3.1.3 Output data: common format

All atmospheric models provide their output data in a common format.

The common format for atmospheric models is GRIB1, with the standard WMO GRIB coding parameters for the variables produced by the models. Detailed specification about the types of variables to be produced and the respective encoding rules are included in the document ip-3.1.3.doc.

3.1.4 Output data: visualisation

A predefined set of products derived from the output data of the atmospheric models is visualised on the common visualisation platform (VP) and at the COPS Operations Centre.

Code (and appropriate documentation) to generate the predefined set of products is provided by Matthias Grzeschik (grz [at] uni-hohenheim.de).

The atmospheric model products for the *D-PHASE domain (see ip-3.1.4.doc)* are pushed to the *visualisation platform (and to the data archive)* and the atmospheric model products for the *COPS domain (see ip-3.1.4.doc)* to the *COPS Operations Centre (and to the data archive)* by the atmospheric models.

Specifications for the atmospheric model products can be found in ip-3.1.4.doc.

The specification how the atmospheric model products are *displayed* on the visualisation platform is given in section 9.2.

3.2 Alerts

All atmospheric models produce alerts for subsequent components of the end-to-end forecasting system. Concerning alerts as input, some of the models require triggers to start operating, whereas other models run in any case at fixed intervals.

More detailed specifications concerning alerts are given in the following subsections.

3.2.1 Alerts needed as input

Limited-area EPSs as well as the high-resolution EPS (the latter may have a threshold on the number of available high-resolution deterministic models available before starting the calculations) do no require alerts as input.

High-resolution deterministic models may need an alert from the limited-area EPSs. If they do, they ensure a real-time bilateral exchange of the respective alerts individually. The alerts are described in more detail in sections 3.2.2 – 3.2.4.

3.2.2 Alerts produced as output: criteria

3.2.2.1 Alerts provided by all models

There are various alerts needed for various components of the end-to-end forecasting system that need to be provided by all the atmospheric models.

To be done: Documentation of alert thresholds for target and impact areas that are used on the VP.

Alerts for deterministic hydrological models:

Responsible for detailed specification of warning criteria for alerts produced for deterministic hydrological models: WG-HEU, task WG-HEU 4.

Responsible for implementation of warning criteria for alerts produced for deterministic hydrological models: atmospheric models, individually.

3.2.2.2 Additional alerts provided by some of the models

Some components of the end-to-end forecasting system need additional alerts.

Alerts provided by limited area EPSs and the high-resolution EPS for ensemble hydrological models:

Responsible for detailed specification of warning criteria for alerts by limited area EPSs and the high-resolution EPS for ensemble hydrological models: WG-HEU, task WG-HEU 13.

Responsible for implementation of warning criteria for alerts by limited area EPSs and the high-resolution EPS for ensemble hydrological models: limited-area EPSs and the high-resolution EPS, individually.

3.2.3 Alerts produced as output: information flow

Note (cf. next section): Code (and appropriate documentation) to generate alerts for atmospheric models is provided by Felix Ament (felix.ament [at] meteoswiss.ch).

Alerts provided by the atmospheric models are pushed to the visualisation platform (VP) as well as to the data archive (DA) by the atmospheric models.

Information on frequency and timing of alert delivery of each atmospheric model is provided in Table 1. – Note that every atmospheric model generates an alert file (xml, see next section) for every new forecast, and *always* pushes the xml file to the VP and the DA, even in case of no alert.

3.2.4 Alerts produced as output: common format

All atmospheric models provide their alerts in a common format.

The common format for alerts is xml. Detailed specifications concerning the xml format for atmospheric model alerts can be found in ip-3.2.4.doc.

Code (and appropriate documentation) to generate alerts for atmospheric models is provided by Felix Ament (felix.ament [at] meteoswiss.ch).

3.2.5 Alerts produced as output: visualisation

All alerts of the atmospheric models are visualised on the common visualisation platform (VP).

To be done: Documentation of how alerts are visualised on the VP.

4 Operations: Hydrological models

Hydrological models are one component of the end-to-end forecasting system (cf. section 2.1 for an overview of the end-to-end forecasting system).

General properties of the end-to-end forecasting system are described in section 2.2. Specifically, section 2.2.2 describes data, alerts and feedbacks and section 2.2.3 gives an overview of the data archive, the visualisation platform, and the information flow. The technical realisation of the end-to-end forecasting system is specified in chapter 9.

In this chapter, the specific properties of the hydrological models relevant for operating as an integral part of the end-to-end forecasting system are documented. These are data in- and output as well as the alerts the hydrological models need to start operating (if any) and the alerts they provide for other components of the end-to-end forecasting system.

The different requirements for ensemble and deterministic hydrological models are explicitly specified where needed.

4.1 Data

4.1.1 Input data

All hydrological models ensure the real-time bilateral exchange of their required input data individually (cf. sections 3.1.2 – 3.1.3, and 5.1.2 – 5.1.3, respectively).

4.1.2 Output data: information flow

Output of the hydrological models is pushed to the data archive (DA) by the hydrological models.

Provide specifications regarding frequency (how often is a new forecast available) and timing (when are the forecasts available) of data delivery for each hydrological model.

Information on frequency and timing of data delivery of each atmospheric model is provided in Table …

Responsible for detailed specification of information flow for output data: WG-DI, task WG-DI 2.

Responsible for implementation of information flow for output data: hydrological models, individually.

4.1.3 Output data: common format

All hydrological models provide their output data in a common format.

The common format for hydrological models is NetCDF. Detailed specification about the types of variables to be produced and the respective encoding rules are included in the document ip-4.1.3.doc.

Responsible for detailed specification of common format of output data: WG-DI, task WG-DI 2 for common data format.

Responsible for implementation of common format of output data: hydrological models, individually.

4.1.4 Output data: visualisation

The following products derived from the output data of the hydrological models are visualised on the common visualisation platform (VP):

Product for models simulating river discharge: River discharge [m^3/s] versus time [hours]; area mean precipitation input added on the inverse y-axis [mm/h]; detailed legend. – Output format should be png (or gif).

Product for models simulating a lake level: Lake level [m] versus time [hours]; area mean precipitation input added on the inverse y-axis [mm/h]; detailed legend. – Output format should be png (or gif).

Need to specify output filenames.

More specifications needed for ensemble hydrological models? Any agreement on colours?

The hydrological models are responsible for the *generation* of the hydrological model products. The hydrological model products will then be pushed to the visualisation platform (and to the data archive) by the hydrological models. The specification how the hydrological model products are *displayed* on the visualisation platform is given in section 9.2.

4.2 Alerts

All hydrological models produce alerts for subsequent components of the end-to-end forecasting system. Concerning alerts as input, some of the models require triggers to start operating, whereas other models run in any case at fixed intervals.

More detailed specifications concerning alerts are given in the following subsections.

4.2.1 Alerts needed as input

Some of the hydrological models may need an alert from the atmospheric models or the nowcasting tools. If they do, they ensure a real-time bilateral exchange of the respective alerts individually. The alerts are described in more detail in sections 3.2.2 – 3.2.4 and 5.2.2 – 5.2.4, respectively.

4.2.2 Alerts produced as output: criteria

All hydrological models provide alerts for the subsequent hydrological forecasters. End users are then alerted by their respective responsible forecasters (cf. section 6.2.2).

To be done: Documentation of alert thresholds for impact areas that are used on the VP.

Alerts for hydrological forecasters:

Hydrological forecasters will use the visualisation platform to assess alerts for different impact regions.

Specify warning criteria useful to the hydrological forecasters, depending on impact area and lead-time. Differentiate between deterministic hydrological models (variable over a threshold) and ensemble hydrological models (probability for a variable to be above a threshold is larger than yet another threshold).

Responsible for detailed specification of warning criteria for alerts produced for hydrological forecasters: WG-HEU, task WG-HEU 8.

Responsible for implementation of warning criteria for alerts for hydrological forecasters: hydrological models, individually.

4.2.3 Alerts produced as output: information flow

Alerts provided by the hydrological models are pushed to the visualisation platform (VP) as well as to the data archive (DA) by the hydrological models.

Provide specifications regarding frequency (how often is a new alert available) and timing (when are the alerts available) of warnings for each hydrological model.

Information on frequency and timing of alert delivery of each atmospheric model is provided in Table …. – Note that every hydrological model generates an alert file (xml, see next section) for every new forecast, and *always* pushes the xml file to the VP and the DA, even in case of no alert.

4.2.4 Alerts produced as output: common format

All hydrological models provide their alerts in a common format.

The common format for alerts is xml. Detailed specifications concerning the xml format for hydrological model alerts can be found in ip-4.2.4.doc.

Responsible for detailed specification of common format of alerts: WG-DI, task WG-DI 10.

Responsible for implementation of common format of alerts: hydrological models, individually.

4.2.5 Alerts produced as output: visualisation

All alerts of the hydrological models are visualised on the common visualisation platform (VP).

To be done: Documentation of how alerts are visualised on the VP.

5 Operations: Nowcasting tools

Nowcasting tools are one component of the end-to-end forecasting system (cf. section 2.1 for an overview of the end-to-end forecasting system).

General properties of the end-to-end forecasting system are described in section 2.2. Specifically, section 2.2.2 describes data, alerts and feedbacks and section 2.2.3 gives an overview of the data archive, the visualisation platform, and the information flow. The technical realisation of the end-to-end forecasting system is specified in chapter 9.

In this chapter, the specific properties of the nowcasting tools relevant for operating as an integral part of the end-to-end forecasting system are documented. These are data in- and output as well as the alerts the nowcasting tools provide for other components of the end-to-end forecasting system.

This section describes the nowcasting tools provided by MeteoSwiss, ARPA Piemonte, DLR, CNMCA and ARPA-SIM as specified in Table 3:

– **MeteoSwiss NASS:** radar-derived quantitative precipitation estimate (QPE), instantaneous rate with 5min resolution as well as accumulation for predefined periods.

– **Piemonte-MeteoSwiss composite:** radar-derived quantitative precipitation estimate (QPE), instantaneous rate with 10min resolution.

– **MeteoSwiss ENASS:** ensemble-QPE to express the uncertainty in radar precipitation estimates (EQPE).

– **MeteoSwiss TRT:** thunderstorm radar tracking for identification, description, tracking and extrapolation of severe convective cells.

– **DLR Cb-TRAM**: tracking and monitoring of severe convection from onset over rapid development to mature phase using multi-channel Meteosat-8 SEVIRI data.

Radar QPE is provided as a time series of two-dimensional precipitation fields with high space-time resolution (1km and 5/10min). The field may be an estimated of the instantaneous precipitation rate (mm/h) or accumulated precipitation for a given period (say, mm in 3, 6, 12, or 24 hours). The uncertainty in radar precipitation estimates can be expressed by means of an ensemble of time series of radar precipitation fields (EQPE), generated from the best estimate for precipitation and a stochastic perturbation congruent with the space-time characteristics of the radar error structure. – The high-resolution real-time QPE from radars can be used as input to hydrological models and for decision making by forecasters and end users.

The tool for identification, characterisation, tracking and extrapolation of severe convective cells (TRT) produces time series of radar images that show the contours of identified cells, cell trajectories, diagnostic information of cells (e.g. hail potential or lightning statistics), and a very short-term forecast of the future position based on the present motion vector. – Cell tracking can be used by forecasters and end users for real-time decision making.

Cb-TRAM is a new fully automated tracking and nowcasting algorithm. Intense convective cells are detected, tracked and discriminated with respect to onset, rapid development, and mature phase. Finally, short range forecasts are provided. The detection is based on Meteosat-8 SEVIRI (Spinning Enhanced Visible and Infra-Red Imager) data from the broad band high resolution visible, infra-red 6.2 µm (water vapour), and the infra-red 10.8 µm channels. Areas of convection initiation, of rapid vertical development, and mature thunderstorm cells (cumulonimbus, Cb) are identified. For the latter, tropopause temperature data from ECMWF operational model analyses is utilised as an adaptive detection criterion. The tracking is based on geographical overlap between current detections and first guess patterns of cells detected in preceeding time steps. The first guess patterns as well as the short range forecasts are obtained with the aid of a new image matching algorithm providing complete fields of approximate differential cloud motion. Based on the so called pyramid matcher an interpolation and extrapolation technique is presented which can also be used to generate synthetic intermediate data fields between two known fields as well as nowcasts of motion and development of detected areas.

NASS accumulations, the Piemonte-MeteoSwiss composite, TRT, and Cb-TRAM are available in real-time through a dedicated web-site, ENASS only on bilateral agreement.

Note that data and alerts of nowcasting products are not verified within MAP D-PHASE (they are of course verified by the providers individually), and that alerts are – mainly for technical reasons – not visualised on the visualisation platform.

5.1 Data

5.1.1 Input data

All nowcasting tools take care of their required input data individually.

5.1.2 Output data: information flow

Since data of nowcasting tools are not verified, quantitative numerical output of the nowcasting tools will not be pushed to the data archive. – It is however available for some of the products on bilateral agreement.

5.1.3 Output data: common format

Since data of nowcasting tools are not verified, the output format of the nowcasting tools in not harmonised.

5.1.4 Output data: visualisation

To reduce possible transfer problems (high update frequency!), QPE and TRT products are available in real-time on a dedicated password-protected web-site, which is accessible from the common visualisation platform (VP) through a password-free link. This dedicated web-site will also feature an archive of the above-mentioned products. – EQPE are exchanged on a bilateral basis only.

5.2 Alerts

The radar-derived QPE may provide useful alerts for subsequent components of the end-to-end forecasting system. – *However, alerts will only be available on bilateral agreement, and they will not be visualised on the visualisation platform (the latter is mainly for technical reasons: too high update frequency!).*

The nowcasting tools themselves do not require any alerts.

More detailed specifications concerning alerts are given in the following subsections.

5.2.1 Alerts needed as input

Nowcasting tools do not need any alerts as input.

5.2.2 Alerts produced as output: criteria

Except for bilateral agreements, no alerts are issued by the nowcasting tools.

5.2.3 Alerts produced as output: information flow

Since alerts of nowcasting tools are neither visualised nor verified within D-PHASE, alerts of the nowcasting tools will neither be pushed to the visualisation platform nor to the data archive.

5.2.4 Alerts produced as output: common format

Since alerts of nowcasting tools are neither visualised nor verified within D-PHASE, no common format for the alerts of the nowcasting tools is defined.

5.2.5 Alerts produced as output: visualisation

No alerts of the nowcasting tools are visualised on the common visualisation platform (VP).

6 Operations: Forecasters

Forecasters are one component of the end-to-end forecasting system (cf. section 2.1 for an overview of the end-to-end forecasting system). Forecasters may thereby be meteorological forecasters or hydrological forecasters.

General properties of the end-to-end forecasting system are described in section 2.2. Specifically, section 2.2.2 describes data, alerts and feedbacks and section 2.2.3 gives an overview of the data archive, the visualisation platform, and the information flow. The technical realisation of the end-to-end forecasting system is specified in chapter 9.

In this chapter, the specific properties of the forecasters relevant for operating as an integral part of the end-to-end forecasting system are documented. These are data input, alerts the forecasters receive from and provide to other components of the end-to-end forecasting system, and feedback.

The different requirements for meteorological and hydrological forecasters are explicitly specified where needed.

6.1 Data

According to the definition of the term ‘data’ (cf. section 2.2.2), forecasters do not provide any output data.

6.1.1 Input data

All forecasters take care of their required input data individually by establishing the appropriate real-time bilateral exchange of data. Most often however, forecasters will only access data by browsing through the products available on the common visualisation platform (cf. sections 3.1.4, 4.1.4, and 5.1.4).

6.1.2 Output data: information flow

Forecasters do not provide data (cf. definition of term ‘data’ in section 2.2.2)

6.1.3 Output data: common format

Forecasters do not provide data (cf. definition of term ‘data’ in section 2.2.2)

6.1.4 Output data: visualisation

Forecasters do not provide data (cf. definition of term ‘data’ in section 2.2.2)

6.2 Alerts

All forecasters produce alerts. Meteorological forecasters mainly provide alerts for the hydrological forecasters (but may also provide alerts for end users interested in meteorological information rather than hydrological information), whereas hydrological forecasters provide alerts for the end users.

Forecasters themselves receive alerts from almost all other components of the end-to-end forecasting system.

More detailed specifications concerning alerts are given in the following subsections.

6.2.1 Alerts needed as input

Forecasters receive alerts from the atmospheric models (cf. sections 3.2.2 – 3.2.5), the hydrological models (cf. sections 4.2.2 – 4.2.5), and the nowcasting tools (cf. sections

5.2.2 – 5.2.5) by assessing the respective information on the common visualisation platform (VP). Additionally, the hydrological forecasters can also view the alerts from the meteorological forecasters (cf. section 6.2.2 – 6.2.5) on the VP.

6.2.2 Alerts produced as output: criteria

Meteorological forecasters provide alerts for the hydrological forecasters and the end users, whereas hydrological forecasters provide alerts for the end users only.

Alerts provided by meteorological forecasters to hydrological forecasters:

Hydrological forecasters will use the visualisation platform to assess alerts for different impact regions.

Specify warning criteria useful to the hydrological forecasters, depending on impact area and lead-time.

Responsible for detailed specification of warning criteria for alerts produced by meteorological forecasters for hydrological forecasters: WG-HEU, task WG-HEU 8.

Responsible for implementation of warning criteria for alerts by meteorological forecasters for hydrological forecasters: meteorological forecasters, individually.

Alerts provided by forecasters to end users:

Forecasters alert the end users for which they are responsible (most often, this will be a hydrological forecaster, but it may also be a meteorological forecaster in case there is no hydrological forecaster or no hydrological information for the area of interest and/or the end user is primarily interested in meteorological information). This implies a one-to-many relationship for some of the forecasters: Every end user receives alerts and related information from a single, well-defined forecaster, but there may be more than one end user attached to a specific forecaster (e.g., in the Lago Maggiore area). For the list of end users and their respective responsible forecaster, refer to Table 4 in section 2.4.

Specify warning criteria useful to the end users, depending on impact area and lead-time. These criteria will be different for every end user, and it will be the end user who will decide what is useful …

Responsible for detailed specification of warning criteria for alerts by forecasters for end users: end users together with their responsible forecaster, individually; WG-HEU, task WG-HEU 9 for collection and documentation of end user specifications.

Additional to the alerts requested by the end user, the forecaster will also make available all other alerts potentially relevant for the end users. This may be alerts from (other) hydrological and/or atmospheric models, from nowcasting tools, or from meteorological forecasters (in case the forecaster is a hydrological forecaster), which the forecaster can all assess on the visualisation platform, as can the end user.

Responsible for implementation of warning criteria for alerts by forecasters for end users: forecasters, individually.

6.2.3 Alerts produced as output: information flow

Alerts provided by the forecasters are pushed to the visualisation platform (VP) as well as to the data archive (DA). This explicitly includes the alerts of the forecasters specifically produced for their end users.

Alerts will be issued when needed.

Responsible for implementation of information flow for alerts to the DA and the VP: forecasters, individually.

Additionally, the forecasters may need to transmit their alerts directly to their end users, according to the specifications provided by the end users.

Responsible for detailed specification of information flow for alerts by forecasters directly to the end users: end users together with their responsible forecaster, individually.

Responsible for implementation of information flow for alerts by forecasters directly to the end users: forecasters, individually.

6.2.4 Alerts produced as output: common format

All forecasters provide their alerts in a common format.

Forecaster alerts are submitted to the VP through a dedicated web-interface.

Responsible for detailed specification of common format of alerts: WG-DI, task WG-DI 10.

Responsible for implementation of common format of alerts: forecasters, individually.

Additionally, the forecasters may need to provide the alerts they directly transmit to their end users in a format specified by the end users.

Responsible for detailed specification of format for alerts by forecasters directly to the end users: end users together with their responsible forecaster, individually.

Responsible for implementation of format for alerts by forecasters directly to the end users: forecasters, individually.

6.2.5 Alerts produced as output: visualisation

All alerts of the forecasters are visualised on the common visualisation platform (VP).

To be done: Documentation of how alerts are visualised on the VP.

6.3 Feedback

Both meteorological and hydrological forecasters provide feedback concerning the value of the products and alerts provided by the end-to-end forecasting system. The web-interface for the forecasters to submit their subjective evaluation of the received products and alerts is provided by the visualisation platform (VP).

More detailed specifications concerning feedback are given in the following subsections.

6.3.1 Feedback: evaluation protocol

The evaluation protocol defines the standardized set of questions the forecasters are requested to answer.

Specify the questions for the evaluation protocol. Separate between quantifiable or ‘multiple choice’ type of questions and unstructured feedback opportunities. Make the evaluation protocol dependent on lead-time and possibly on impact area.

Evaluation protocol for meteorological forecasters:

See ip-6.3.1.doc.

Evaluation protocol for hydrological forecasters:

…

Responsible for detailed specification of evaluation protocol for feedback: WG-HEU, task WG-HEU 16.

Responsible for implementation of evaluation protocol for feedback: MD-VP, task MD-VP 3.

6.3.2 Feedback: information flow

The feedback obtained from the forecasters is pushed to the data archive (DA) by the visualisation platform (VP).

Specify how often the forecasters are requested to provide their feedback (e.g., after certain time intervals or after each alerted event), and work out how the feedback can be ensured.

To be done: Document MeteoSwiss specifications (?).

Responsible for implementation of information flow for feedback: MD-VP, task MD-VP 4.

6.3.3 Feedback: common format

Since feedback is collected through a common visualisation platform, the format of the different feedback reports is automatically identical.

Responsible for detailed specification of common format for feedback: WG-HEU, task WG-HEU 15.

Responsible for implementation of common format for feedback: MD-VP, task MD-VP 5.

7 Operations: End users

End users are one component of the end-to-end forecasting system (cf. section 2.1 for an overview of the end-to-end forecasting system).

General properties of the end-to-end forecasting system are described in section 2.2. Specifically, section 2.2.2 describes data, alerts and feedbacks and section 2.2.3 gives an overview of the data archive, the visualisation platform, and the information flow. The technical realisation of the end-to-end forecasting system is specified in chapter 9.

In this chapter, the specific properties of the end users relevant for operating as an integral part of the end-to-end forecasting system are documented. These are data input, alerts the end users receive from other components of the end-to-end forecasting system, and feedback.

7.1 Data

According to the definition of the term ‘data’ (cf. section 2.2.2), end users do not provide any output data.

7.1.1 Input data

In general, end users do not receive any input data. However, some end users may possibly access data by browsing through the products available on the common visualisation platform (cf. sections 3.1.4, 4.1.4, and 5.1.4).

7.1.2 Output data: information flow

End users do not provide data (cf. definition of term ‘data’ in section 2.2.2).

7.1.3 Output data: common format

End users do not provide data (cf. definition of term ‘data’ in section 2.2.2).

7.1.4 Output data: visualisation

End users do not provide data (cf. definition of term ‘data’ in section 2.2.2).

7.2 Alerts

End users do not produce any alerts. They however receive alerts from their responsible forecaster.

7.2.1 Alerts needed as input

End users are alerted by their responsible forecaster (c.f. sections 6.2.2 – 6.2.4). Additionally, end users may also view the alerts from the atmospheric models (cf. sections 3.2.2 – 3.2.5), the hydrological models (cf. sections 4.2.2 – 4.2.5), the nowcasting tools (cf. sections 5.2.2 – 5.2.5), and the meteorological forecasters (cf. section 6.2.2 – 6.2.5) by assessing the respective information on the common visualisation platform (VP).

7.2.2 Alerts produced as output: criteria

End users do not provide alerts within the D-PHASE framework (i.e., alerts produced by the end users are not within the scope of this project).

7.2.3 Alerts produced as output: information flow

End users do not provide alerts within the D-PHASE framework (i.e., alerts produced by the end users are not within the scope of this project).

7.2.4 Alerts produced as output: common format

End users do not provide alerts within the D-PHASE framework (i.e., alerts produced by the end users are not within the scope of this project).

7.2.5 Alerts produced as output: visualisation

End users do not provide alerts within the D-PHASE framework (i.e., alerts produced by the end users are not within the scope of this project).

7.3 Feedback

End users provide feedback concerning the value of the products and alerts provided by the end-to-end forecasting system. The web-interface for the end users to submit their subjective evaluation of the received products and alerts is provided by the visualisation platform (VP).

More detailed specifications concerning feedback are given in the following subsections.

7.3.1 Feedback: evaluation protocol

The evaluation protocol defines the standardized set of questions the end users are requested to answer.

Specify the questions for the evaluation protocol. Separate between quantifiable or ‘multiple choice’ type of questions and unstructured feedback opportunities. Make the evaluation protocol dependent on lead-time and possibly on impact area.

Responsible for detailed specification of evaluation protocol for feedback: WG-HEU, task WG-HEU 16.

Responsible for implementation of evaluation protocol for feedback: MD-VP, task MD-VP 3.

7.3.2 Feedback: information flow

The feedback obtained from the end users is pushed to the data archive (DA) by the visualisation platform (VP).

Specify how often the end users are requested to provide their feedback (e.g., after certain time intervals or after each alerted event), and work out how the feedback can be ensured.

Responsible for detailed specification of information flow for feedback: WG-HEU, task WG-HEU 14.

Responsible for implementation of information flow for feedback: MD-VP, task MD-VP 4.

7.3.3 Feedback: common format

Since feedback is collected through a common visualisation platform, the format of the different feedback reports is automatically identical.

Responsible for detailed specification of common format for feedback: WG-HEU, task WG-HEU 15.

Responsible for implementation of common format for feedback: MD-VP, task MD-VP 5.

8 Evaluation

This chapter describes different evaluation procedures. The first section specifies the online monitoring tools, whereas the following two sections specify the objective and subjective (offline) evaluation of data and alerts of the end-to-end forecasting system, respectively.

8.1 Online monitoring

(Note difference of online monitoring tools as compared to nowcasting tools: monitoring tools do not provide alerts, whereas nowcasting tools do.)

This section describes the online monitoring tools provided by U Vienna and DLR as specified in Table 3. – No further online monitoring tools are currently defined.

8.1.1 Input data

All online monitoring tools take care of their required input data individually.

8.1.2 Output data: information flow

Quantitative numerical output of the online monitoring tools will not be pushed to the data archive. – It is however available for some of the products on bilateral agreement.

8.1.3 Output data: common format

The output format of the online monitoring tools in not harmonised.

8.1.4 Output data: visualisation

To reduce possible transfer problems (fairly high update frequency!), a predefined set of products derived from the output data of each online monitoring tool is visualised on a dedicated password-protected web-site, which is accessible from the common visualisation platform (VP) through a password-free link.

VERA:

- Products: Surface fields such as mean sea level pressure, pressure tendency, 2D winds, streamlines, potential temperature, equivalent potential temperature, and moisture flux divergence for D-PHASE and COPS domain.
- Frequency and timing: Hourly (higher frequency in principle possible, depending on observational data availability), 20-30 minutes after observation time (depending on number of observations available).

NWP minus VERA:

- Products: Some selected difference fields of forecast minus analysis (VERA) for a limited number of NWP models (COSMOCH2, others not yet defined) for D-PHASE and COPS domain.
- Frequency and timing: Hourly, 20-30 minutes after the hour.

CLEPS versus Satellite (Meteosat-9):

- Products: Synthetic satellite imagery and calculation of forecast quality measure (FQM) of forecast and observed satellite imagery for all members of CLEPS for D-PHASE and COPS domain.
- Frequency and timing: Hourly, approximately 30 minutes after the hour.

8.2 Offline verification

The offline verification aims at objectively verifying the output data of the atmospheric models, the hydrological models, and the nowcasting tools as well as the quantitative alerts of all the components of the end-to-end forecasting systems (i.e., alerts from atmospheric models, hydrological models, nowcasting tools, and forecasters).

Offline verifications planned:

- atmospheric models:
  - U Vienna / Dorninger: VERA of surface fields to determine representativity of surface stations ('finger prints')
  - U Vienna / Dorninger: PBL analysis with 3d VERA
  - …
- …

Agree on scores to be used.

Responsible for detailed specification of offline verification: WG-VER, task WG-VER 3.

Responsible for realisation of offline verification: WG-VER, task WG-VER 4.

8.2.1 Input: data

All data necessary for the offline verification (i.e., all output data provided by the components of the end-to-end forecasting system) can be retrieved from the data archive (cf. sections 3.1.2 – 3.1.3, 4.1.2 – 4.1.3, and 5.1.2 – 5.1.3).

8.2.2 Input: alerts

All alerts necessary for the offline verification (i.e., all alerts provided by the components of the end-to-end forecasting system) can be retrieved from the data archive (cf. sections 3.2.2 – 3.2.4, 4.2.2 – 4.2.4, 5.2.2 – 5.2.4, and 6.2.2 – 6.2.4).

8.3 Assessment of forecaster and end user feedback

The assessment of the forecaster and end user feedback aims at identifying the value of the end-to-end forecasting system and its individual components to the intermediate (i.e., forecasters) and end users, respectively.

Feedback from meteorological forecasters:

During the DOP, the atmospheric forecasters will, among other things, have access to many more atmospheric model forecast products (i.e., visualised data and alerts) than are routinely available. Apart from having multiple models of the same type (i.e., deterministic or probabilistic models with similar mesh-size), the most interesting models will be the new high-resolution deterministic models (mesh-size of the order of 1-3 km) as well as the limited-area ensemble prediction systems, both of which are not currently available in the operational environment of many meteorological services.

To assess the value of the (new) D-PHASE products *for the forecasters*, a *subjective evaluation* by the forecasters themselves (see section 6.3.1) is set up. It addresses the following questions:

- What benefit can be drawn from the high-resolution deterministic models
  - as compared to the limited-area models (mesh-size O(10 km))?

  - as compared to the global models (mesh-size O(30 km))?
- What benefit can be drawn from the limited-area ensemble prediction systems as compared to the deterministic models?
- Is there any advantage (or disadvantage) in having more than one model of the same type available? – Specifically:
  - Do many different deterministic models help to build confidence for the individual forecasts? Or are ensemble prediction systems more appropriate for that? – What about different ensemble prediction systems?
  - Is the need or desire of the forecasters for additional model information more pronounced for high-impact weather than for ‘average’ meteorological situations?
  - Are the forecasters able to effectively use the vast amount of data and extract the essential facts without loosing relevant information? Are the ensemble prediction systems (e.g., the micro-PEPS, which incorporates all high-resolution deterministic models) sufficient for that, or are other post-processing tools needed to condense the information?
- Considering high-resolution deterministic models, limited-area ensemble prediction systems, and multiple models (of the same type):
  - What is the single most important (new) information?
  - Are the visualised data (‘plots’) more important than the alerts generated by the models?
  - Which of these new products support the forecasters best in their decision making process?
- What is the relative importance between (new) model forecasts and nowcasting or observational information, for different lead times?

For all the above, the emphasis is on quantitative precipitation forecasts and its quality (location in space and time, amounts, etc.).

The evaluation by the forecasters is deliberately subjective, and is hence not intended to replace the objective verification (see section 8.2), but rather to complement it. Although the comparison between subjective perception and objective verification of different products will be very interesting, the main aim of the subjective evaluation by the forecasters is to document the forecasters benefit in using the D-PHASE products, and to hence provide an orthogonal view on the value of (some of the products of) the MAP D-PHASE end-to-end forecasting system. Moreover, the results of the subjective evaluation will allow to plan and optimise the use of different modelling and nowcasting systems in the forecasting offices of the meteorological services, and will certainly be a valuable input to identify priorities for future developments.

Feedback from hydrological forecasters:

…

Feedback from end users:

…

Responsible for detailed specification of feedback assessment: WG-VER, task WG-VER 5.

Responsible for realisation of feedback assessment: WG-VER, task WG-VER 6.

8.3.1 Input: feedback

All feedback provided by the forecasters and end users can be retrieved from the data archive (cf. sections 6.3 and 7.3)

9 Technical realisation

In this chapter, the technical realisation of the end-to-end forecasting system is specified. This includes things such as hard- and software, networks, bandwidth, etc.

The properties of the end-to-end forecasting system are described in section 2.2. Specifically, section 2.2.3 describes the general role of the data archive and the common visualisation platform, respectively. The detailed specifications of the individual components of the end-to-end forecasting system and their respective input and output of data, alerts, and feedback, respectively, is described in chapters 3 through 7.

9.1 Data archive

The data archive (DA) is physically based at the MPI in Hamburg. The responsible for the DA, referred to as MD-DA, is Claudia Wunram (cops [at] zmaw.de).

What extra coordination (beyond what is already being realised in collaboration with COPS) is needed with projects such as THORPEX/TIGGE/ETReC07, Beijing 2008 RDP, COST 731, etc.? And what benefit can be drawn from these as well as other similar projects such as PREVIEW, Risk-AWARE, AMPHORE, etc.?

Note: The DA will not be able to guarantee a 24h service. Hence, all real-time applications should not involve the DA.

9.1.1 Storage and retrieval of data

Data is pushed to the data archive by the components of the end-to-end forecasting systems (see respective sections on information flow). The data will later be retrieved from the data archive for verification purposes.

In this section, the following technical issues have to be specified:

- How (protocol, network, etc) and where (internet address, directory structure, etc) the data are stored.
- How (protocol, network, etc) and where (internet address, directory structure, etc) the data can be retrieved.

Responsible for detailed specification of the technical realisation of storage and retrieval of data: MD-DA in collaboration with MD-Co and COPS-Co, task MD-DA 7.

Responsible for implementation of the technical realisation of storage and retrieval of data: MD-DA, task MD-DA 1.

9.1.2 Storage and retrieval of alerts

Alerts are pushed to the data archive by the components of the end-to-end forecasting systems (see respective sections on information flow). The alerts will later be retrieved from the data archive for verification purposes.

In this section, the following technical issues have to be specified:

- How (protocol, network, etc) and where (internet address, directory structure, etc) the alerts are stored.
- How (protocol, network, etc) and where (internet address, directory structure, etc) the alerts can be retrieved.

Responsible for detailed specification of the technical realisation of storage and retrieval of alerts: MD-DA in collaboration with MD-Co and COPS-Co, task MD-DA 7.

Responsible for implementation of the technical realisation of storage and retrieval of alerts: MD-DA, task MD-DA 1.

9.1.3 Storage and retrieval of feedback

Feedback is pushed to the data archive by the common visualisation platform (see respective sections on information flow). The feedback will later be retrieved from the data archive for the assessment of the evaluation protocols.

In this section, the following technical issues have to be specified:

- How (protocol, network, etc) and where (internet address, directory structure, etc) the feedback are stored.
- How (protocol, network, etc) and where (internet address, directory structure, etc) the feedback can be retrieved.

Responsible for detailed specification of the technical realisation of storage and retrieval of feedback: MD-DA in collaboration with MD-Co and COPS-Co, task MD-DA 7.

Responsible for implementation of the technical realisation of storage and retrieval of feedback: MD-DA, task MD-DA 1.

9.2 Visualisation platform

The visualisation platform (VP) is realised with Next Generation Software. It is physically based in Salzburg. The responsible for the VP, referred to as MD-VP, is Gerhard Kittel (d-phase [at] ng-software.at).

Products and alerts are pushed (in real-time!) to the common visualisation platform by the components of the end-to-end forecasting systems (see respective sections on information flow). Feedback collected on the visualisation platform is pushed to the data archive by the visualisation platform.

This section specifies the technical realisation of the common visualisation platform (storage of products and alerts, display of products and alerts, feedback form (software), transfer of evaluation protocol to data archive, etc).

Responsible for detailed specification of the technical realisation of common visualisation platform: MD-Co in collaboration with MD-VP, task MD-Co 8

Responsible for implementation of the technical realisation of common visualisation platform: MD-VP, task MD-VP 1.

9.3 Information flow

This section specifies the technical realisation of the information flow, i.e., the flow of data, alerts, and feedbacks. It will necessarily deal with issues such as networks, performance, security, redundancy, and backups.

Responsible for detailed specification of the technical realisation of information flow: MD-DA in collaboration with MD-VP, task MD-DA 3.

Responsible for implementation of the technical realisation of information flow: MD-DA in collaboration with MD-VP, task MD-DA 4.

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. Walser, 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, *Meteologische 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.

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.

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 mountaineous 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.

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. Pöttschacher, 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-facetted 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.

List of acronyms

ADB-AA	Autorità di bacino dei Fiumi dell’Alto Adriatico, Italy
APAT	Agenzia della Protezione dell'Ambiente e per i servizi Tecnici, Italy
ARPA Emilia-Romagna	Agenzia Regionale Prevenzione e l'Ambiente dell'Emilia-Romagna – Servizio IdroMeteo, Italy
ARPA Liguria	Agenzia Regionale per la Protezione dell’Ambiente Ligure – Centro Funzionale Meteo Idrologico di Protezione Civile, Italy
ARPA Piemonte	Agenzia Regionale per la Protezione dell'Ambiente del Piemonte
ARSO	Agencija Republike Slovenije za okolje, Slovenia
BAFU	Bundesamt für Umwelt, Switzerland
CIMA	Centro di Ricerca Interuniversitario in Monitoraggio Ambientale, Italy
COPS	Convective and Orographically-induced Precipitation Study; Intensive Observation Period of the Priority Program 1167 "Quantitative Precipitation Forecast" of the German Research Foundation, June – August 2007, south-western Germany and north-eastern France; http://www.uni-hohenheim.de/spp-iop
COPS-Co	COPS Coordinator (Andreas Behrendt; behrendt [at] uni-hohenheim.de)
COPS-Ch	Chairman of the COPS ISSC (Volker Wulfmeyer; wulfmeye [at] uni-hohenheim.de)
CNMCA	Centro Nazionale di Meteorologia e Climatologia Aeronautica, Italy
DHMZ	Državni hidrometeorološki zavod, Croatia
D-PHASE	**D**emonstration of **P**robabilistic **H**ydrological and **A**tmospheric **S**imulation of flood **E**vents in the Alpine region; a WWRP Forecast Demonstration Project in the framework of MAP (and hence also referred to as MAP D-PHASE)
DA	Data Archive
DFG	Deutsche Forschungsgemeinschaft
DLR	Deutsches Zentrum für Luft- und Raumfahrt, Germany
DWD	Deutscher Wetterdienst, Germany
Environment Canada	Environment Canada, Canada
EPFL	Ecole Polytechnique Fédérale de Lausanne, Switzerland
ETHZ	Eidgenössische Technische Hochschule Zürich, Switzerland
FZK IMK-IFU	Forschungszentrum Karlsruhe, Institut für Meteorologie und Klimatologie, Germany
INM	Instituto Nacional de Meteorología, Spain
IP	Implementation Plan
ISAC-CNR	Istituto di Scienze dell'Atmosfera e del Clima, Consiglio Nazionale delle Ricerche, Italy
IST-SUPSI	Scuola Universitaria Professionale della Svizzera Italiana – Istituto Scienze della Terra, Switzerland
LUBW	Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg, Germany
MAP	Mesoscale Alpine Programme; a WWRP Research and Development Project
MAP D-PHASE	WWRP Forecast Demonstration Project in the framework of MAP; see also ‘D-PHASE’
MD	MAP D-PHASE; only for internal use
MD-	MD, (optional) prefix for MD specific acronyms
MD-Ch	Chairman of the MD-SC (Mathias Rotach; mathias.rotach [at] meteoswiss.ch)

MD-Co	MD Coordinator (Marco Arpagaus; marco.arpagaus [at] meteoswiss.ch)
MD-DA	Person responsible for the MD Data Archive (Claudia Wunram, cops [at] zmaw.de)
MD-SC	MD Steering Committee
MD-VP	Person responsible for the MD Visualisation Platform (Gerhard Kittel; d-phase [at] ng-software.at)
Meteoalarm	Warning platform established within the EUMETNET framework (formerly known as EMMA); http://www.meteoalarm.eu
Météo-France	Météo-France, France
Meteorisk	EU (INTERREG IIIB Alpine Space) funded project; http://www.meteorisk.info
MeteoSwiss	Federal Office of Meteorology and Climatology MeteoSwiss, Switzerland
MPI	Max Planck Institute for Meteorology, Germany
POLIMI	Politecnico di Milano, Italy
QBOLAM	Quadrics BOlogna Limited Area Model
SRNWP	Short Range Numerical Weather Prediction, EUMETNET Programme
TUWIEN	Technische Universität Wien, Austria
UK Met Office	UK Met Office, United Kingdom
VP	Visualisation Platform
WMO	World Meteorological Organization; http://www.wmo.int
WG	Working Group
WG-DI	WG Data Interface
WG-DP	WG Data Policy
WG-HEU	WG Hydrology and End Users
WG-VER	WG Verification
WSL	Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft, Switzerland
WWA Kempten	Wasserwirtschaftsamt Kempten, Germany
WWA Weilheim	Wasserwirtschaftsamt Weilheim, Germany
WWRP	World Weather Research Programme; http://www.wmo.int/web/arep/wwrp
ZAMG	Zentralanstalt für Meteorologie und Geodynamik, Austria