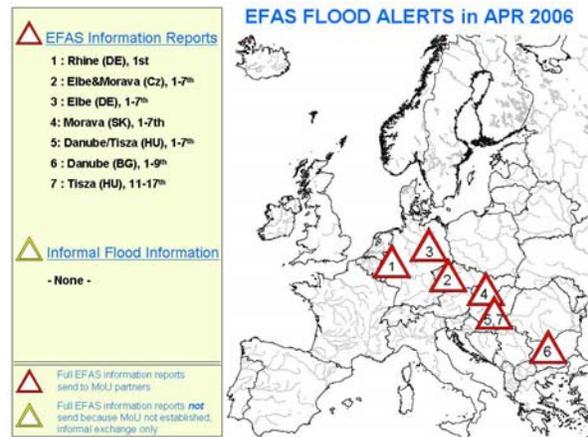




European Flood Alert System 4th Annual Report 2006

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1. Overall EFAS objectives

Following the disastrous floods in the Elbe and Danube in August 2002, the European Commission launched an activity on the development of a European Flood Alert system (Communication (COM(2002)-481 final)). A prototype of such a system (acronym EFAS) should be developed and tested during Framework 6 and include a number of novel features that are usually not provided by National Water Authorities and that would be beneficial both for the European Commission as well as the Member States. These features include

- simulations of discharge across Europe providing comparable results across Europe.
- flood simulations and forecasts based on more than one weather forecast
- use of meteorological Ensemble Prediction Systems as input into the flood simulation model allowing to estimate the uncertainty in combined meteorological and hydrological forecast

EFAS, once fully developed and tested, would represent a powerful tool for the European Commission and the Member States for monitoring hydrological conditions across Europe, analysing climatology and trends over the past years in a consistent and homogeneous way, and for forecasting possible future trends when coupled with seasonal forecasts and climate change model output. Furthermore, through the trans-boundary nature of the EFAS simulations it is anticipated that exchange of flood forecasting experiences, data, and research results would be favoured.

The work on EFAS started in January 2003 based on experience gained during the competitive EFFS project (European Flood Forecasting System, 2000-2003) (Gouweleeuw et al., 2004) financed by DG Research. The system is to be built together with meteorological services and Water Authorities of the Member States. The Elbe and the Danube catchments have been selected as pilot catchments representative of typical trans-national catchments.

2. Specific objectives for the EFAS activity in 2006

Many of the objectives for 2006 were initiated already during the year 2005. For example, the EFAS system was set-up relatively robust during 2005 and did not need too much attention for the pre-operational running during 2006. Also, the hardware had been improved already during 2005, so that not much development could be expected during the year 2006. The five principle objectives for 2006 were

- a) Maintain the pre-operational system as it was set-up during 2005 and continue the pre-operational flood forecasting activity
- b) Prepare the next prototype version 4 with
 - a. improved calibration for EFAS
 - b. research on the best operational EFAS set-up
 - c. web-based reporting
- c) Research on the performance of the operational system
 - a. case study analysis
 - b. quantitative analysis
 - c. feedback analysis
- d) Collection of static and dynamic hydro-meteorological observed data
 - a. Finish in-house collection for Elbe and Danube river basins
 - b. EU-Parliament/DG ENV: EU-FLOOD-GIS
 - c. IDABC/DG ENTR: Europeanwide real-time discharge data
- e) Maintenance and development of the EFAS partner network

3. Achievements of specific objectives for 2006

3.1. Maintain the pre-operational system as it was set-up during 2005 and continue the pre-operational flood forecasting activity

The pre-operational EFAS was set-up quite robust during 2005 and therefore ran without too much maintenance in 2006. The model set-up in terms of model, parameter maps, threshold maps, observed input data and forecast data (see 2nd Annual Report 2004) was essentially not changed. In the case of ECMWF forecasting data even the grid same resolution of 40 km was kept although ECMWF had increased the grid spacing in October 2005 already. This had the advantage that the results from 2005 and 2006 remained comparable and allowed direct comparison. It also finally allowed the analysis of a full year of EPS based forecasts and their performance from mid year onwards.

The pre-operational forecasting activity was maintained and again brought to its limits during the snowmelt driven floods in spring 2006. While floods were forecasted in French rivers, the Rhine, the Elbe and Danube tributaries at the same time, the team continued to function and in total 141 external reports were sent of which about half were sent during March and April alone. The biggest problems that occurred during 2006 related to the forecasting were the irregular arrival of the observed meteorological data. Either the data were not delivered, or the database was down, or other problems with the transfer occurred. Overall the EFAS activity performed well and stable during 2006. Figure 3.1 illustrates schematically the EFAS system as operated in 2006:

The figure illustrates the manifold data that are needed to run the EFAS system. First of all there are the weather forecasts necessary to drive the flood forecasts. These are provided by the Deutsche Wetterdienst (DWD) and the European Centre for Medium Range Weather Forecasting (ECMWF). ECMWF provides both the deterministic forecasts as well as the 50 members plus control run from the Ensemble Prediction System (EPS). Second there are the observed meteorological data necessary to calculate the best initial conditions. Because these are delivered with a delay of about 2 days, the forecasted data are used to fill up the initial conditions until the start of the flood simulation. Currently the DWD forecasting data are used to fill up the gap for the DWD based forecasts and the ECMWF deterministic data are used to fill the gap for the ECMWF based forecasts, both deterministic and EPS runs. In order to run the Lisflood model, a number of static maps are needed to provide information on topography, channel network, landuse, soil, etc. These are available as European datasets at the JRC and needed for each run. Finally historic data are needed for EFAS for calibration purposes – the prototype version for 2006 was based on some very simplistic calibration – and for the calculation of the – model internal – thresholds. This principle has been explained in detail in the previous annual reports and has proven to be a useful concept.

The calculation of the thresholds is an offline process that is typically not repeated. Once the thresholds have been established they remain fixed. On a daily basis first the initial conditions are calculated with a daily time step. The reason for this is that the underlying data are only available as daily data. The gap between the last available observed data and the start of the flood simulation, typically 2 days, is filled up with forecasted data and the filling up is done with an hourly time step. Once the initial conditions are prepared and the weather forecasts have arrived, the data are pre-processed and input to the LISFLOOD model. In this case the hourly time step is used for the deterministic forecasts and the daily for the EPS. Once all flood forecasts have been calculated they are analysed and processed and then compared against the thresholds. Should the forecasts exceed the model internal thresholds and qualify certain criteria, e.g. more than 5 collated river pixels need to

exceed the thresholds and the upstream area needs to be larger than 4000 km², etc, then an internal alert is issued. In this case, the forecaster checks back in previous forecasts if the situation is persistent or a new development. If it is a new development the internal alert remains but the next forecasts are awaited to make a decision. Should the signal be persistent and the tendency be confirmed from the previous forecasts EFAS enters into an active alert. If the river basin is covered by a Memorandum of Understanding, EFAS information reports are sent out. At the end of 2006 about 80% of all large trans-national river basins have signed up for the EFAS partner network.

Forecasts are checked twice a day and protocolled in a logbook. In case of an external alert typically several forecasters work together to draft the reports and send them out. Since 2006 the EFAS information reports are also sent to internal representatives of DG JRC and DG Environment, Civil Protection. These reports are clearly labeled as “For European Commission internal use only”, are for information only, and are not to be distributed to external services.

EFAS 2006 – schematic view

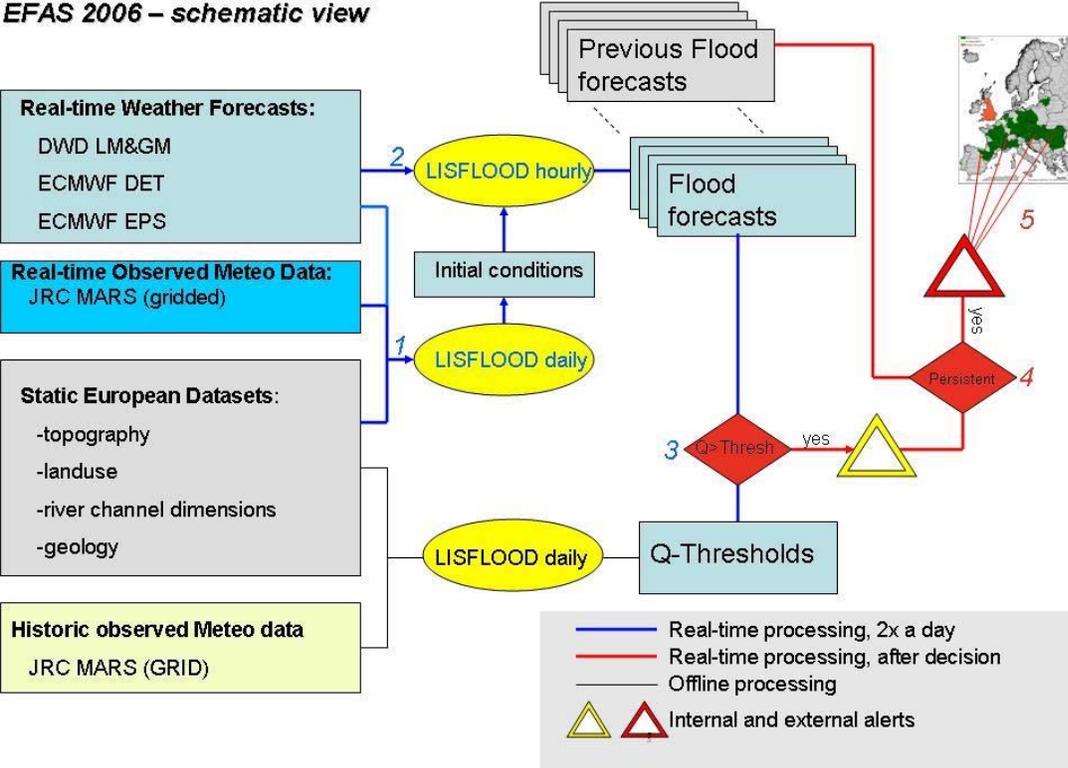


Figure 3.1 Schematic view of the EFAS system in 2006

During 2006, EFAS received 1 Giga Bytes of forecasting data daily that need to be stored and processed before it can be used as input for the LISFLOOD model. The downloading time is longest for the ECMWF data which takes ca. 2 hours for the low resolution forecasts. This downloading time was also a contributing factor not to download the highest resolution data – in this case the forecasts would not be ready in the afternoon at an acceptable time. It is planned that the JRC should get a JANET connection which would reduce the downloading time considerably. Until then the ECMWF data will be downloaded resampled to 40 and 80 km respectively. It has to be noted, however, that the results are a product of the higher resolution model but resampled to the coarser grid. This means that the forecasts benefit from the higher resolution.

The flood forecasts have different run times depending on the input. The longest are the EPS which take about 40 minutes after all the data are prepared and on a daily time step. The daily output of EFAS amounts to 25 GBytes per day.

In 2006 the main data problems were again associated with the delivery of the observed data. Delays of more than 2 days, particularly over the weekends, were observed around 50 times. Because of server shutdown for maintenance, EFAS did not run for 4 days during 2006. This was announced to the EFAS partner network in due time. Table 3.1 summarises the statistics of the EFAS performance in 2006.

Table 3.1 EFAS performance statistics for 2006

Input data (2x51 EPS (80km), 2xECMWF det (40km), 2x DWD lokal (7km), 2xDWD global (40km), observed meteo gauging data	1 GBytes/day
Ouput data (2x European run 5km)	25 GBytes/day
Downloading time	2 h/forecast ECMWF (low resolution)
Run time	20 min (DWD-h) 25 min (ECMWF-h) 40 min (EPS – daily!)
Data delivery problems (delay, corrupt, not available)	5 days – forecasting 50 days – observed data
Failures, shut downs	4 days: serer maintenance

It should also be noted that the meteorological models are frequently updated, e.g the model physics, at a rate of once or twice a year. The DWD updated the model physics of LME and GME for example in April 2006. These updates can of course have influence on the performance of the models to predict rainfall. Therefore, even if the EFAS setup has remained unaltered, the changes in the meteorological models can introduce a trend in the flood forecasting performance.

3.2 Prepare the next prototype version 4

3.2.1 Improved calibration set-up for EFAS

An improved calibration is crucial for EFAS. The prototype version 3 that was active during 2006 was still based on the very simplified calibration exercise made in 2004, the old model version in which errors in the coding for example with regard to the soil freezing components have still not been rectified. Because EFAS forecasts are based on the principle of threshold exceedance (see 2nd Annual report 2004) the model could not be updated without also re-calculating the thresholds. It was decided that this would only really justify the effort if the model was being recalibrated at the same time. For different reasons the improvements could not be implemented for 2006.

The calibration exercise consisted of three steps: the development of an automated calibration routine, correction and improvements of the underlying base maps, and finally the calibration with better quality meteorological input data and more discharge data.

3.2.1.1 Automatic calibration routines

Two automatic calibration routines were developed. The Feyen (LF) method is a modified Shuffled Complex Evolution Metropolis (SCEM-UA) global optimization algorithm (Feyen et al., 2006) that automatically calibrates the model against discharge observations. In addition to optimized parameter sets the resulting posterior parameter distribution reflects the uncertainty about the model parameters after taking into account the discharge observations, and forms the basis for making probabilistic flow predictions. To overcome the computational burden the optimisation has been implemented using parallel computing on a linux cluster.

The method of Szabo (JS) (Pintér-Szabó, 1985a-b and Pintér-Szabó-Somlyódy, 1986) is a hybrid method combining a derivate-free, adaptive partition-based search (APS) and downhill simplex algorithm (DSA; Nelder-Mead, 1965). The algorithm works in two steps: first, the APS algorithm offers an adaptive global search on the whole closed set of the feasible parameters; second, the incorporated DSA offers a local-search scheme starting from the “best” parameter vectors, which were detected in the previous phase by the APS. The program runs on windows platform.

Both routines (JS and LF) were tested and applied during the year. The calibration for the set-up of the next version of the prototype has been essentially based on the Szabo method which is computationally less demanding than the Feyen method. The disadvantage is that it runs on windows platform only and does not make use of the linux cluster.

Figure 3.2 illustrates the difference between uncalibrated and calibrated (JS) simulation for the Ebro river basin. Due to the climatic conditions in the Ebro an extremely high agricultural (~ 6000 hm³/year), industrial (~ 250 hm³/year), and urban (~ 506 hm³/year) water demand exists, leading to a strong regulation of the river (~ 138 dams in the whole catchment) and a high extraction of water from the basin (a total of almost 40% of the annually available water). This strong regulation and extraction, additionally to the low resolution of the available precipitation data and the coarse numerical discretisation used in the LISFLOOD model make the calibration very difficult.

Despite these difficulties and the low number of meteorological stations currently available for this catchment, the calibration brings considerable improvement for the simulations (Figure 3.2). Nevertheless, without the inclusion of at least the major dams and without consideration of an irrigation loss function, also the calibrated model is not able to smooth out peaks related to rainfall but that in reality does not reach the channel.

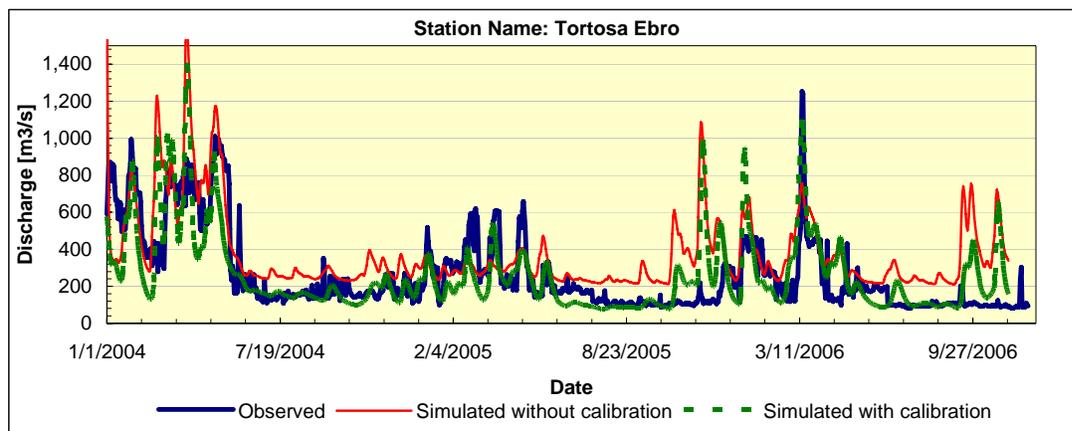


Figure 3.2. Results of the calibrated (green dashed) and uncalibrated (red thin solid) simulations as compared to observed discharge (blue thick solid) for the Ebro river basin from 2004 to 2006

3.2.1.2 Updating of EFAS maps

Another important step in the calibration exercise was to update the underlying maps used for EFAS. Throughout the years a number of irregularities in the maps have been identified in both the 5km and the 1km maps that needed to be addressed. For example errors in the ldds where parts of the rivers drained into the wrong river basin or at wrong sections of the river were repeatedly identified (figure 3.x). A detailed report has been done by K. Bodis (Bodis, 2007). A summary of this work and report is presented in the following.

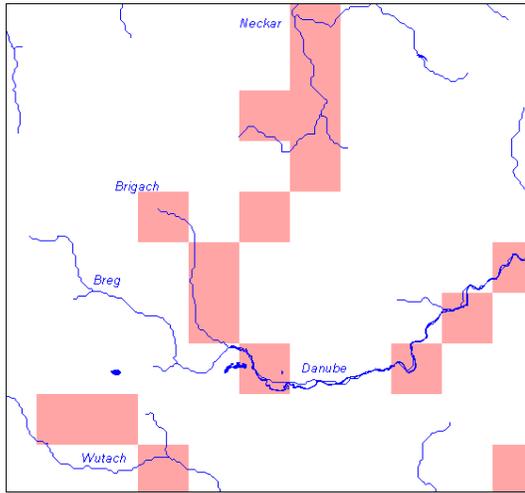
Local Drain Direction maps

The Local Drain Direction (LDD) maps (1 km and 5 km) provide the flow network for the flood model. The 1km maps were found acceptable compared to the available vector-based digital maps and the reference analogue maps. The 5 km LDD was more problematic. Since there is no related Digital Elevation Model or reference river network in this resolution all the errors were discovered visually or by tracing back strange model responses. About 220 points were modified manually, mainly in the Danube Basin, and in the case of the upper zones of a few other rivers (Table 3.2), especially close to the catchment borders.

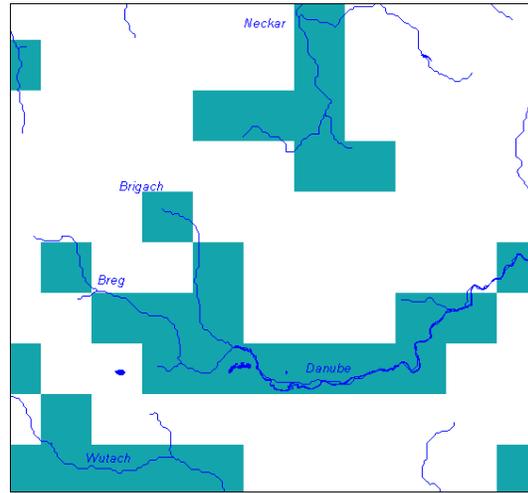
Table 3.2 Number of modified LDD values in 5 km resolution

Danube Basin	modified points	Other Basins	modified points
Danube	73	Sarine	20
Berettyo	21	Meric Nehri	16
Stryj-Latorica	15	Rhine	8
Hornad	13	Elbe	5
Tisza-Prut	12	Severn	1
Savinja-Sava	11		
Tur	8		
Tisza-Iza	6		
Morava	5		
Solta	2		
Temes	2		
Tisza-Begej	2		

The following figures (Figure 3.3-3.5) show a few examples of more significant corrections have been done. Panel A shows the original maps and panel B the corrections. In some cases the modifications of flow directions had influence in discharge between the main river basins (Danube-Rhine, Tisza-Wistula, Rhine-Rhone).

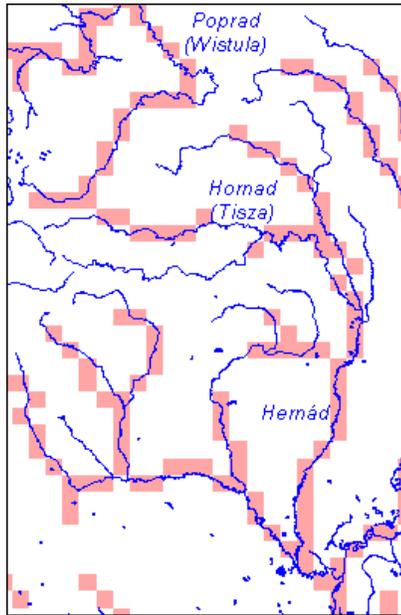


A) The Danube flowed backwards and then continued in the Neckar

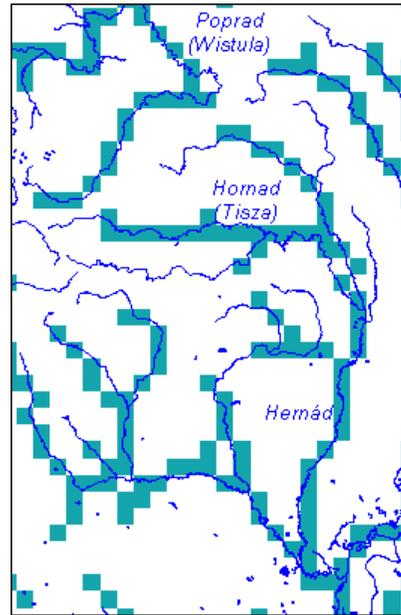


B) The upper streams and tributaries of the Danube have been corrected

Figure. 3.3 The upstream region of Danube and Neckar rivers in Germany (Baden-Württemberg) before and after the correction

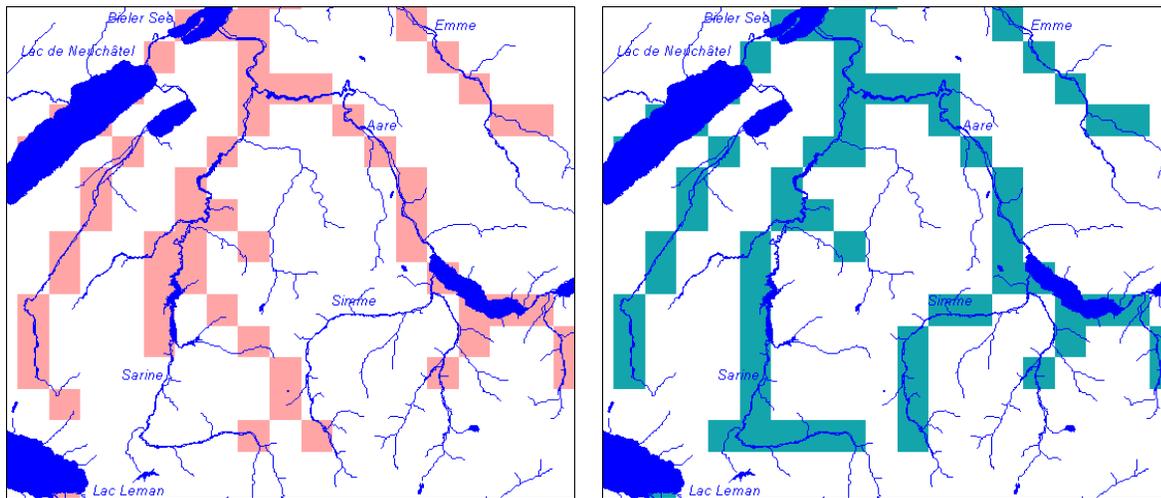


A) The Hornád river (Tisza Catchment) flowed backwards into the Poprad river (Wistula Catchment)



B) The upper part has been corrected but still some problems occurred (Bodva river)

Fig. 3.4 The divide of tributaries of Danube and Wistula in Slovakia before and after the correction.



A) The tributaries of upper-course of Rhine showed unrealistic pattern B) The main streams have been corrected

Fig. 3.5 Close to the divide of Rhine and Rhone rives in Switzerland before and after the correction.

Digital Elevation Model

The previously applied GTOPO30-based global digital elevation model (DEM) was replaced by an SRTM-based DEM that was prepared (format conversion, void filling, projection, resampling) within the Institute for Environment and Sustainability of the Joint Research Centre.

Gradient map

The former surface gradient map inherited the errors from the source GTOPO30 DEM. In spite of the fact that the gradient values of some areas were replaced by gradient values based on the more precise national data (Figure 3.6), it did not provide a consistent European coverage.

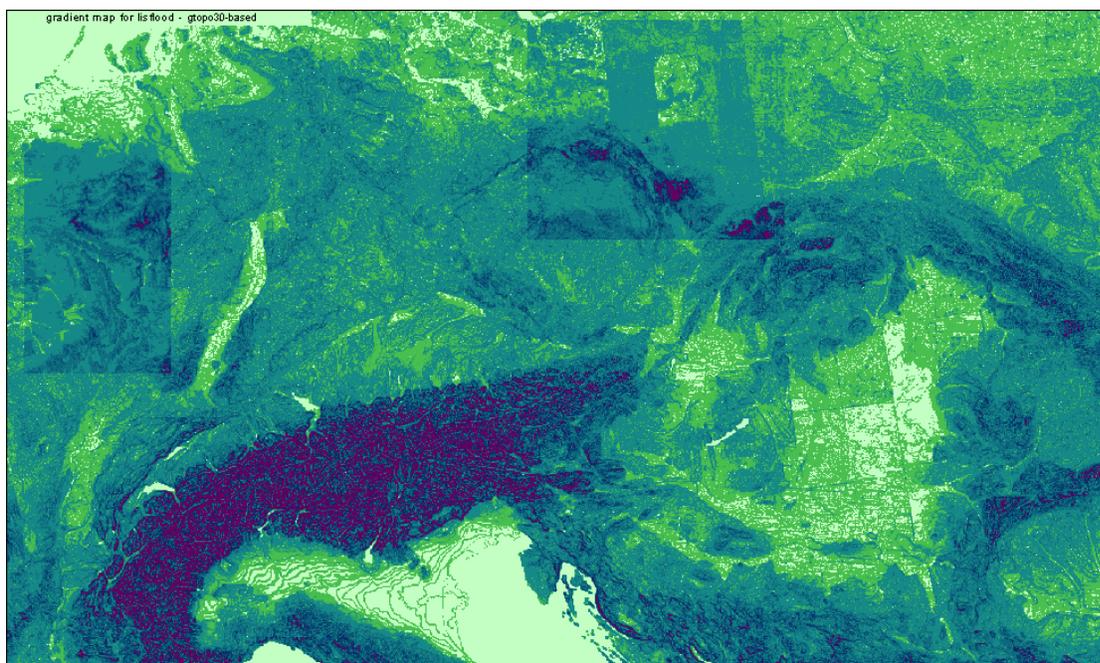


Figure 3.6 The former surface gradient map as a derivative of GTOPO30 and national DEMs

Following numerous GIS operations this map was replaced by the one was derived from the mentioned SRTM-based DEM.

Channel length maps

The original maps of channel length had uniform values; in 1 km resolution the model channel length was defined in 1500 metres, in 5 km resolution each pixel had the value of 7095 metres. These values gave very rough approximation and did not reflect the spatial diversity of the network. New calculations have been done based on reference vector river networks and statistical GIS operations for both (1 and 5 km) resolutions. The results provide a more realistic model of the channel network: the new pixel values are between 600 and 1600 m (1 km resolution) and 600 and 7095 m (5 km resolution). The differences, especially regarding the spatial pattern of the values between the old and the new dataset are significant

Channel width maps

The previous dataset of channel widths usually contained very high values (Table 3.3) and changes were required at least along the main rivers of the two investigated river basins (Danube, Elbe).

The available sources of the new data were different in the case of the different rivers (Figure 3.7).

Table 3.3 Modification of channel width values and their relations

River	Source	Method	Total sum of old values	Total sum of new values	Ratio
Danube Basin	cross-sections	interpolation between measured values	2692 km	1383 km	51 %
Tisza	cross-sections	interpolation between measured values	219 km	85 km	38 %
German Elbe	cross-sections	interpolation between measured values	201 km	142 km	70 %
Saale	Image2000	measurement and interpolation	11 km	6 km	54 %

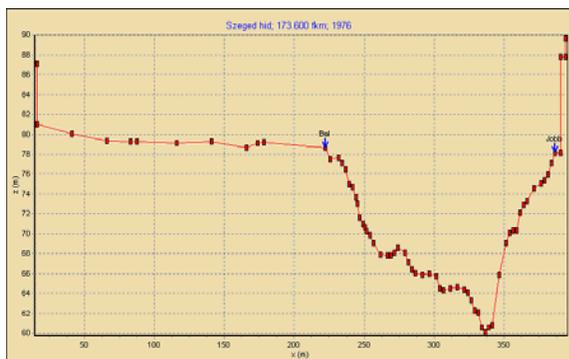


Figure 3.7 Estimating channel width value based on cross-sections (Tisza River) and Image2000 (Saale)

The changes were done only along the main tributaries of Danube and Elbe rivers in both (1km, 5 km) dataset. All the other values were kept from the previous maps.

Channel depth maps

The source of new channel depth maps (1km, 5 km) were the measured and then interpolated values in the case of the Danube and its main tributaries. Changes have been done only for these rivers, the other pixels inherited the old values from the chanbnkf.map datasets (1 km, 5 km).

Channel Manning-value maps

Changes were done only within the Danube Basin: Cell-value Main rivers= 0.03, Cell-value other= 0.05

Gauging station positions

Another important and time consuming check that needed to be done on a point by point basis is the position of the stations on the river network. In many cases the conversion from lat/long into the EFAS projection does not project the station onto the river networks. Stations that fit onto the 5km network do not necessarily lie on the 1km river network and vice versa.

Figure 3.8 illustrates only for France the number of stations that needed to be shifted because the conversion from national coordinates to EFAS coordinates were not correct. Of course, shifting gauging station positions is not always trivial. In case a station is situated between two rivers, for example, more information on the station is needed before it can be attributed clearly to a river section.

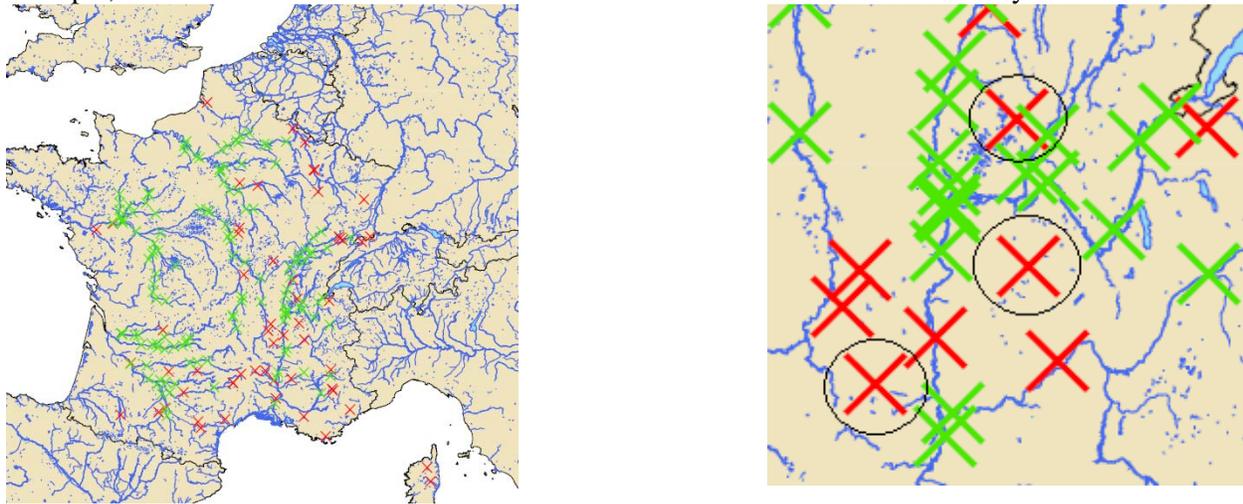


Figure 3.8 Map of France illustrating the position of the discharge gauging stations that lay on the 5km river network (green crosses) and those that were offset from the 5km river network (left). On the right a zoom is shown illustrating the difficulties to assign automatically to which river section the station belongs. The stations that cannot be clearly identified are encircled.

Map extensions

Finally, during the past years several maps were created through different procedures and for different applications resulting in a set of maps with often slightly different dimensions, in particular in the coastal areas. This has been rectified and all maps have now the same extent. In addition to the new maps routines to automatically extract maps upstream of a point have been created to facilitate the extraction of new maps for individual catchments.

3.2.1.3 Calibration of individual catchments

For the calibration a number of decisions were taken before the individual river basins were calibrated.

- a) The most recent updated Lisflood version (van der Knijff, 2006) is being used but the polder and reservoir options are not being activated
- b) The most updated and corrected maps at the start of the calibration are used. The calibration should be based on meteorological input data that is also available for the simulation of the initial conditions later during the flood forecasting. In other words, the model is not being calibrated on high resolution national data if these data are not available in real-time to calculate the initial conditions at the onset of the flood simulations.

The updated Lisflood model

A detailed description of the Lisflood model is available in the handbook by van der Knijff which is available on the EFAS server. Since the current EFAS is still running with the model version of 2004, there are numerous changes that have been introduced in the meantime and that are now being incorporated. Not all changes will be activated, however, for example polder or reservoir routines. Apart from numerous smaller bug fixes, restructurings and optimizations, the main changes to the previous code that will be activated in the next prototype version are:

- Updated LISFLOOD source code and settings file to new wrapper and corresponding xml structure.
- Loss term for lower groundwater zone (makes it possible to simulate groundwater losses)
- Possibility to calibrate on potential evapo(transpi)ration using user-defined multiplier (default:1)
- Corrected error related to potential evaporation rate of intercepted water. This is now equal to **open** water evaporation (a **shaded** water surface evaporation was used before, and this resulted in interception losses **decreasing** with **increasing** Leaf Area Index (this should really be the opposite, which it is now)
- Corrected erroneous calculation of Frost Index
- Added possibility to perform kinematic wave channel routing using sub-time-step (defined as DtSecChannel)
- Added Snowfall Correction Factor, which is a multiplier for snow (accounts for undercatch of snow precipitation)
- Added option to compute pF values from soil moisture and to report pF maps and timeseries for each time step

In addition the model has a number of options that will not be activated in the next prototype version but which are anticipated to be included as soon as sufficient data are available.

- Timestep of reservoir routine now user-defined as well (DtSecReservoirs)
- Added optional simulation of lakes
- Added optional simulation of polders (both regulated and unregulated)
- Added options for calculating and reporting water levels (works for both kinematic and dynamic wave stretches)
- Optional dynamic wave routing, using detailed cross-section data

The input maps

The input maps are all stored on the server, in a protected directories accessible to everyone to read but not to modify. Both original maps with original extent as well as reference maps for EFAS that all

have the same spatial extent are being stored.

The meteorological input data

Contrary to the current EFAS prototype (2005/2006), the new calibration was entirely based on the available *station* data from the JRC MARS database and not, like previously, based on the gridded data.

The important difference in quality between MARS grid data and the MARS station data was already previously pointed out when comparing the data to high resolution data. Figure 3.9 illustrates results of a comparison between high resolution data collected from national services, the MARS Grid data and the MARS station data. The area for which the analysis has been done is shown in the top panel of Figure 3.9. The mean rainfall computed over this area from the high resolution network, the Mars grid data (blue) and the MARS stations data (different interpolation methods) (middle). It is obvious that the precipitation derived from the MARS stat database underestimates the mean rainfall (in mm/day) in the years before 1994. This is directly related to the lower number of stations which results in missing rainfall more localized rainfall events. This becomes even more apparent when looking at the relative root mean square error (bottom). The relative RMS of the MARS grid data is much higher than for the interpolated station data.

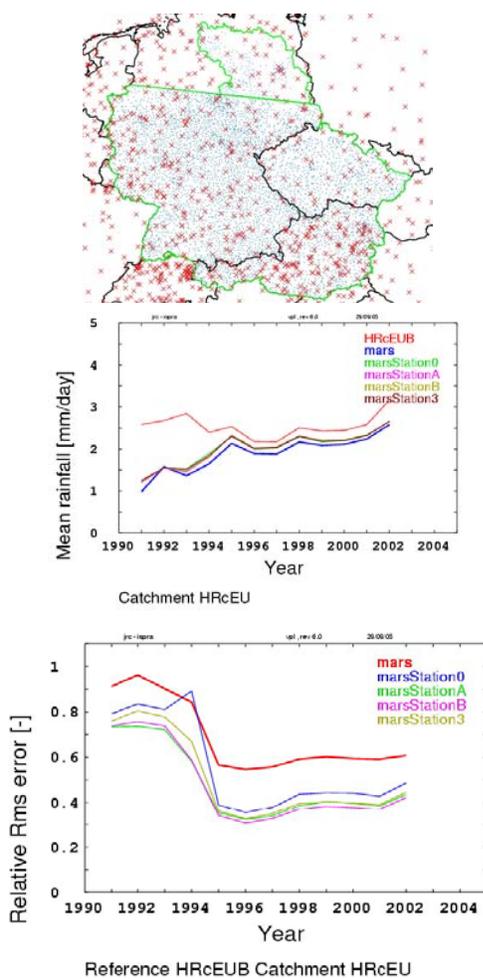


Figure 3.9 Map of study area (top), mean rainfall in mm/h over the study area as derived from the high resolution network, the MARS station data and the MARS grid data (middle), as well as the average root mean square error (bottom) for the year 1990 to 2004. For the station data results for different interpolation routines are shown.

The weather station data stored in the JRC-Mars data base (called also Mars Station data) are available from the year 1975 up to now. The number of yearly available stations is shown in Fig. 3.10. The stations contain observed variables labeled such as precipitation and temperature as well as derived data such as evaporation or calculated radiation. A station does not necessarily contain the full set of the weather variables and the data are not necessarily available every day. In case the station data of a day is missing, the missing values are filled up from a reference weather table. The EFAS activity has been granted access to the station data, provided that the station data themselves are not being published in a recognizable form.

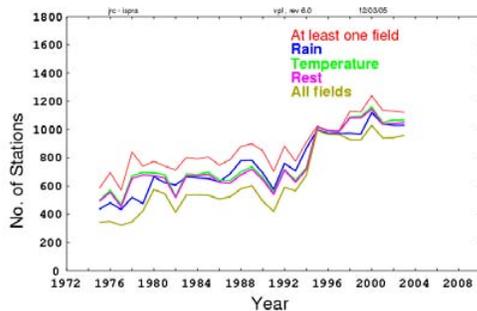


Fig. 3.10a –Yearly Available Stations from WEATHER_STATION table

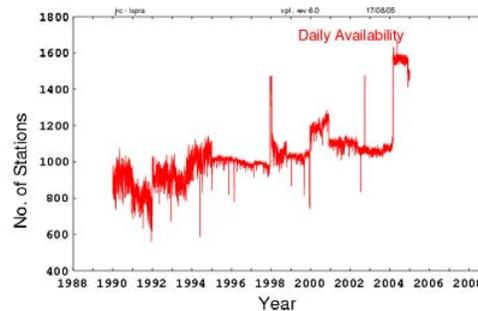


Fig. 3.10b – Rain station daily availability

The number of daily available precipitation stations from 1994 to 2000 is shown in Fig. 3.10b. It is apparent from this figure that there is a strong variability in the number of daily available stations. Generally the number of stations has improved significantly in 1995, and from 2004 onwards there has been a drastic increase in number of stations from about 1000 to about 1600. The reason for the variability is that the JRC MARS unit regularly attempts to fill their database with additional historic and realtime data. Consequently the number of stations changes with a tendency for increased number of stations.

Figure 3.11 illustrates the spatial distribution of precipitation stations in 1990 and 2004.

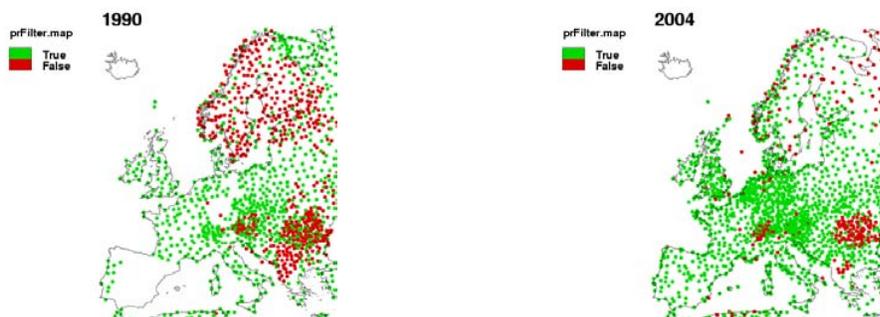


Figure 3.11 Illustration of the spatial distribution of precipitation gauging stations in the JRC MARS data base for the year 1990 (left) and the year 2004 (right). In green are all stations with an acceptable value in terms of quantity and reporting, in red all those that should be rejected.

The lack of reliable data in Northern Europe in 1990 in Norway, Sweden, Finland, Lithuania, Estonia as well as in the Balkan countries is apparent. The improvements in 2004 are clearly visible. Further it

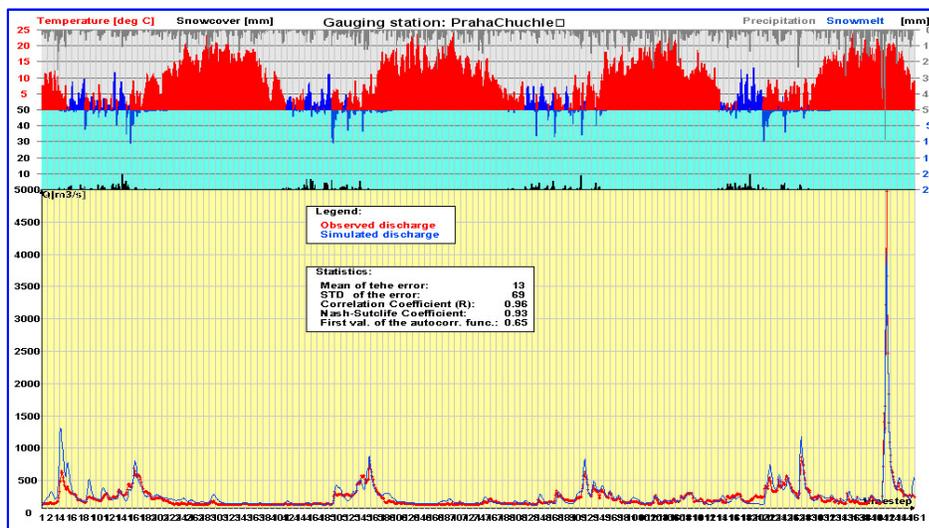
is obvious that the number of stations has increased almost throughout Europe and in particular in Spain.

Obviously the varying quality of the input data causes uncertainty in the model calibration and the subsequent calculation of thresholds and return periods. For example, if the model is calibrated on good data but then applied to poor quality data, this may result in too low discharges and subsequently in a shift in the thresholds. However, clearly the situation has already improved as compared to the 2005/2006 EFAS set-up and the ongoing data collection within the framework of the ETN-R and EU-FLOOD-GIS projects should improve the situation further over the coming years.

The calibration was performed on a daily time step since this is the unit for which most discharge data are currently available. An attempt to make break down of the daily data to 6 hourly data, with the rationale that the meteorological forecasting data are available with an hourly resolution and the forecasts will be run on a 6hourly time step, did not show convincing results. Therefore the calibration remains based on daily data and daily time steps until sufficient hourly discharge data are available.

For the Elbe river basin a calibration matrix of different time steps and grid resolutions was established and run through. These results are described in Section 3.2.3

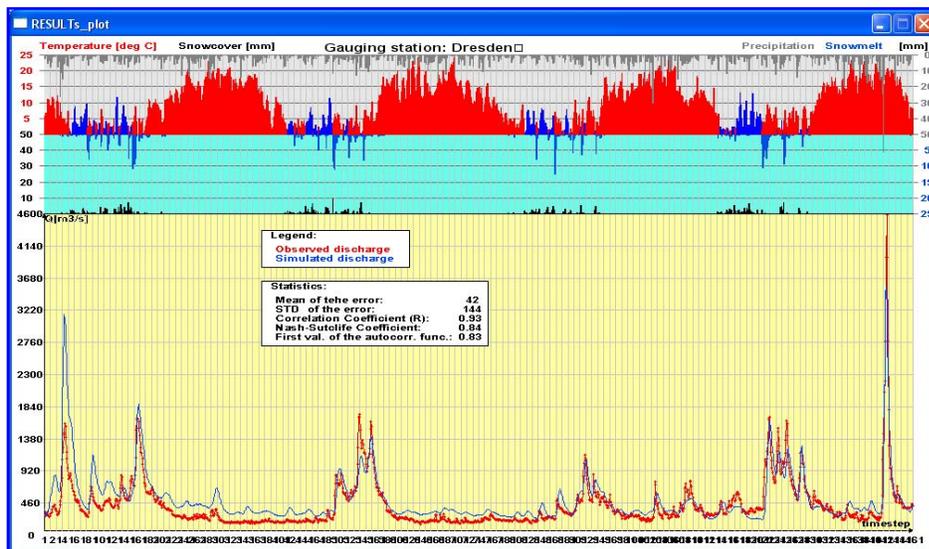
Examples of calibration results are shown in Figure 3.12 for the Elbe and the Danube, a summary of results for the other river basins is given in Annex B.



Elbe at
Prague
(Cz) 1998-
2002

Nash-
Sutcliffe:
0.93

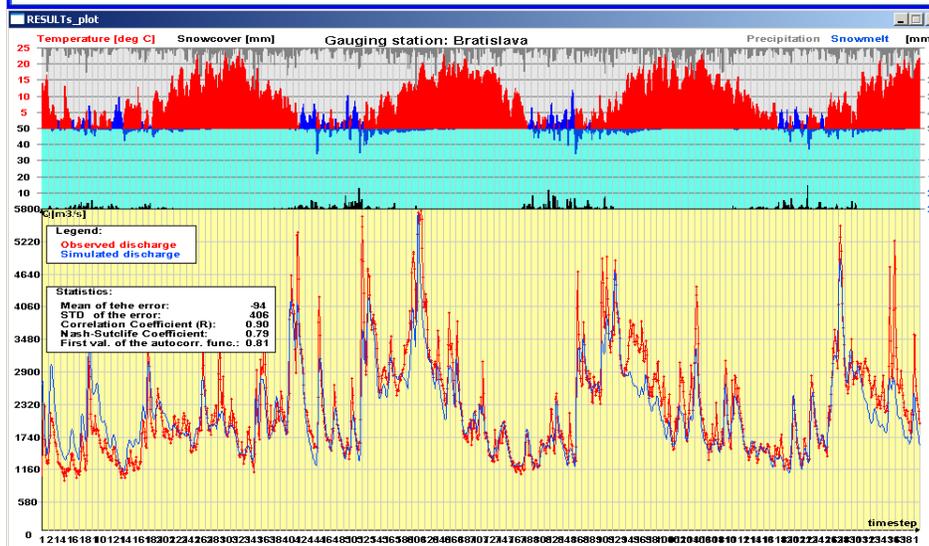
Correlation
coefficient:
0.96



Elbe at
Dresden
(DE) 1998-
2002

Nash-
Sutcliffe:
0.84

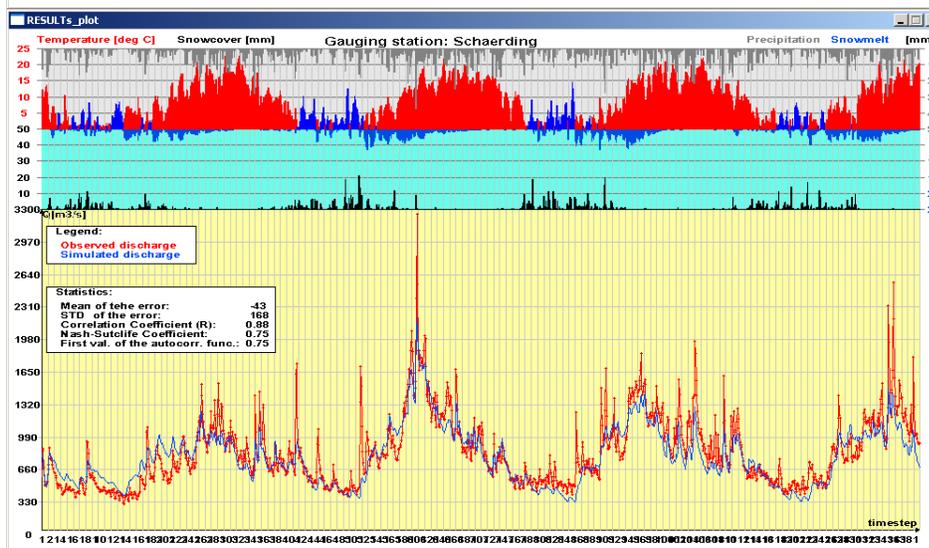
Correlation
coefficient:
0.93



Danube at
Bratislava
(SK) 1997-
2002

Nash-
Sutcliffe:
0.79

Correlation
coefficient:
0.90



Inn at
Schaerding
(DE) 1997-
2002

Nash-
Sutcliffe:
0.75

Correlation
coefficient:
0.88

Figure 3.12 Examples of the calibration for the pilot river basins Elbe and Danube. Observed discharges are shown as red line and the simulated ones as blue lines. The y-axis shows discharges in m³/s and the x-axis the number of time steps, in days, starting on the date indicated in the right hand column. Nash-Sutcliffe and correlation coefficient are also listed on the right hand side.

It is anticipated that the calibration exercise will be completed by end of January 2007 with an intermediate set of calibration maps for EFAS. By this time all river basins for which Memoranda of Understanding exist have been calibrated carefully and in addition all basins for which sufficient data exist. For the remaining river basins some average parameter set will be assumed. Further calibration with then be linked to model, map and data improvements.

3.2.2. Research on the best operational EFAS set-up

An important part of the research directed towards operational research in 2006 was the calibration of the Elbe river basin in different configurations of daily and 6 hourly time steps, 1km and 5km grid spacings, and different types of input data (national high resolution data, MARS station data and MARS grid data). The aim of the research was to assess the difference in quality for the flood simulation and to determine the best possible set-up and to determine the optimum set-up for the next version of EFAS prototype. Results shown in this section are simulation results for the full river basin calculated with the calibration maps. Input data are the meteorological data only – discharge inflow inputs are not shown.

Figure 3.13 illustrates the Elbe river basin and the discharge stations used for this exercise.

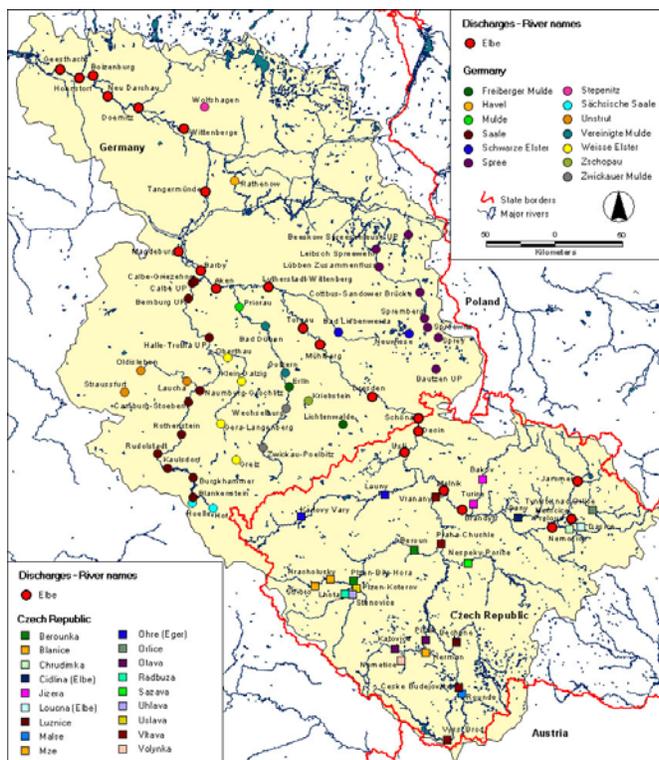


Figure 3.13 Map of the Elbe river basin and its tributaries and the discharge stations used during the calibration study

3.2.2.1 Impact of quality of input data

Figure 3.14 illustrates clearly the difference in the station density between the data collected from the national services (left) and the stations available in the JRC MARS database (right)

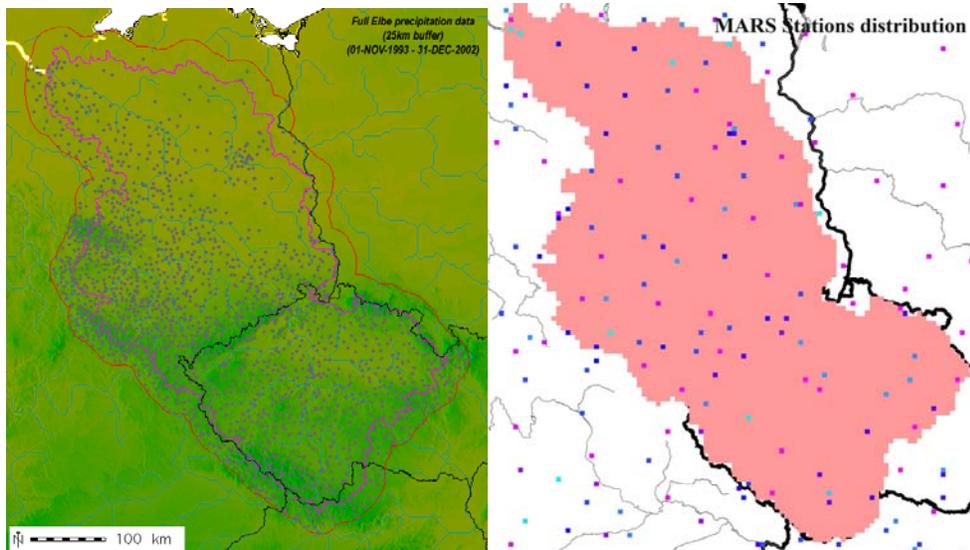


Figure 3.14 Station density of national data (left) and of JRC MARS station data network for the Elbe river basin available for the calibration exercise

Figure 3.15 shows an example of the differences between the different hydrographs for the station Dresden at 1km resolution based on different input data.

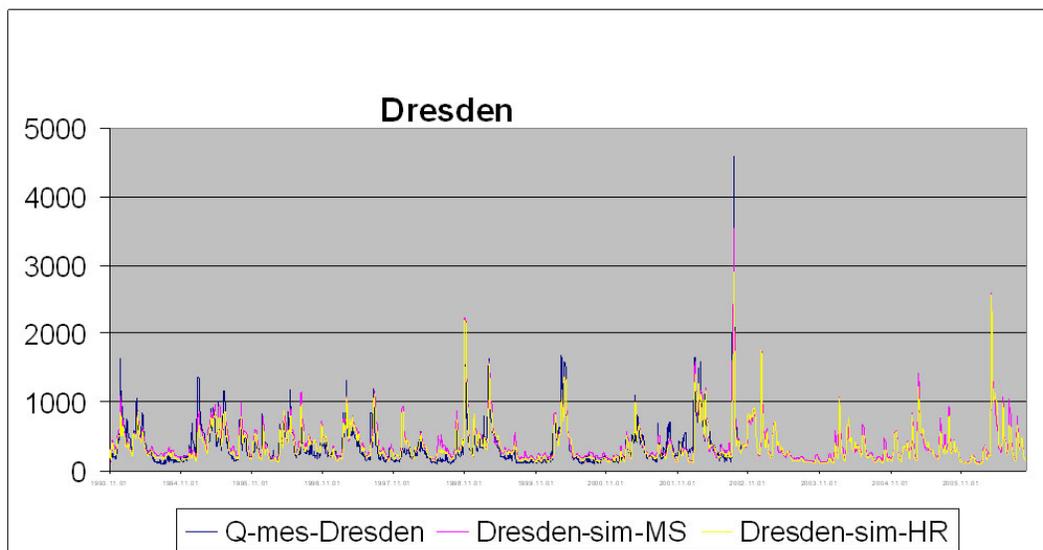


Figure 3.15 Observed and simulated discharges for Dresden from 01.11.93 to 01.06.2006. The observed discharges are blue, the simulated discharges based on MARS station data are in magenta and in yellow the discharges simulated with high-resolution data on 1km grid resolution

The results become clearer when zooming into a flood period. Figure 3.16 shows a zoom into the 2002 flood at Dresden. In both cases the timing of the peak is very well simulated. With the high-station density data also the peak discharge is almost simulated, whereas based on the JRC MARS data the peak is underestimated.

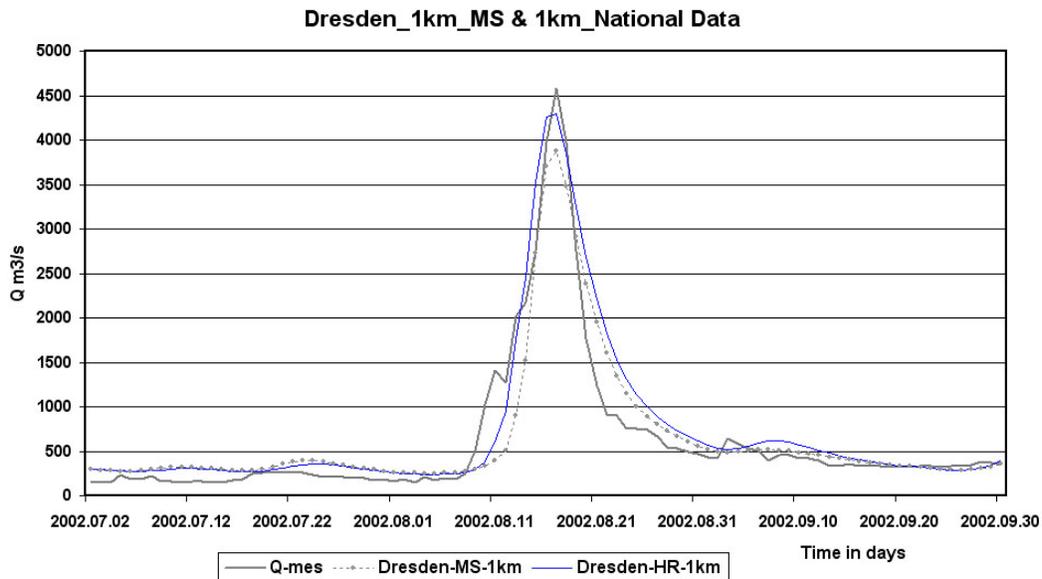


Figure 3.16 observed and simulated discharges for Dresden on 1km from 02.07.2002 until 30.09.2002. Discharges based on high resolution data are printed as blue line and those based on JRC MARS data as dotted grey line.

The same pattern is also observed on the 5km grid resolution, as illustrated at the example of Prague. Again, the quantity is underestimated with both simulations, but more with the JRC MARS station data than with the high-density network stations. The timing is in both cases very good (Figure 3,17)

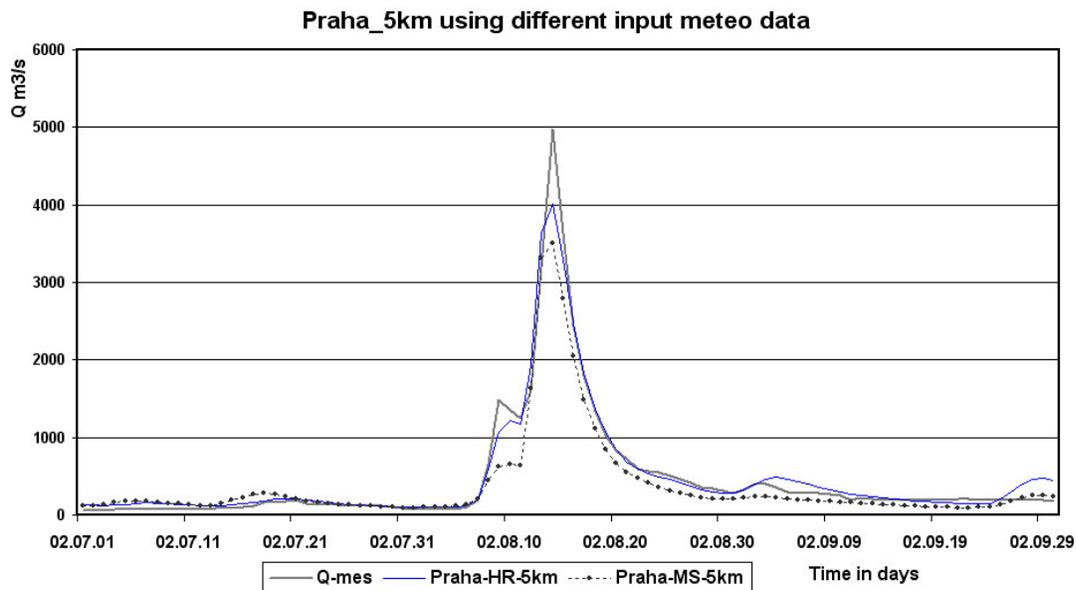


Figure 3.17 observed and simulated discharges for Prague on 5km from 02.07.2002 until 30.09.2002. Discharges based on high resolution data are printed as blue line and those based on JRC MARS data as dotted grey line.

3.2.2.2 Impact of grid resolution

As in the previous 5km set-up every grid cell is a channel cell. The difference in grid resolution between a 5km (blue) and a 1km (red-beige) set up for the larger channels is illustrated in figure 3.18. It shows clearly that the assumption that a 25km² area typically includes a channel is valid.

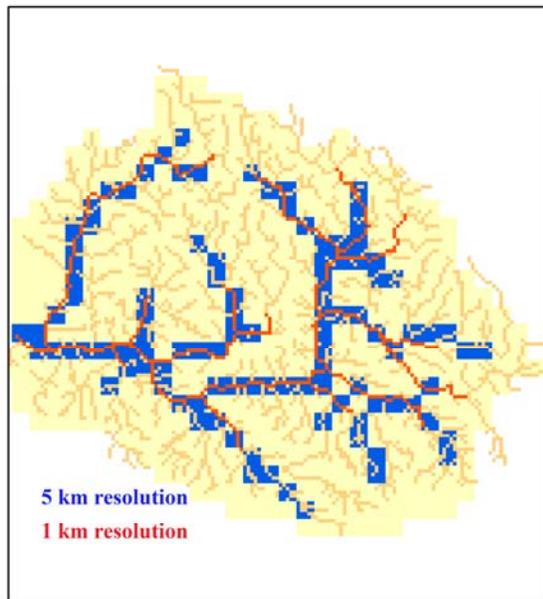


Figure 3.18 Illustration of different grid resolutions for the 1km (orange-red) and the 5km simulations (blue)

Direct comparison between 1km and 5km grid resolutions with the same input data shows that the 1km simulations perform better than the 5km simulations. Figure 3.19 and 3.20 (zoom) show that for Dresden the simulation on the 1km are better than on the 5km. The differences are mostly in the major peaks whereas for the smaller peaks the differences are small. Timing is good in both cases.

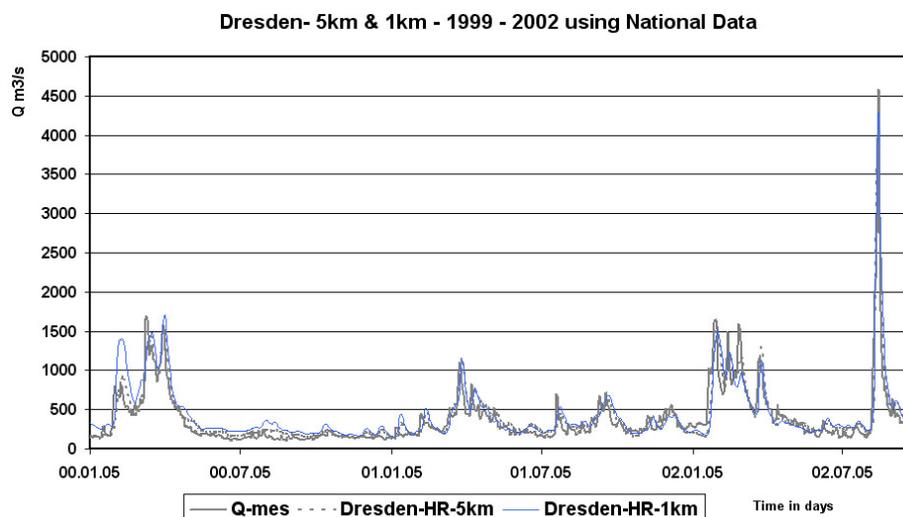


Figure 3.19 Observed (solid grey) and simulated discharges for Dresden on 5km (dashed) and 1km (solid green) for Dresden for the period from 01.01.2000-01.09.2002

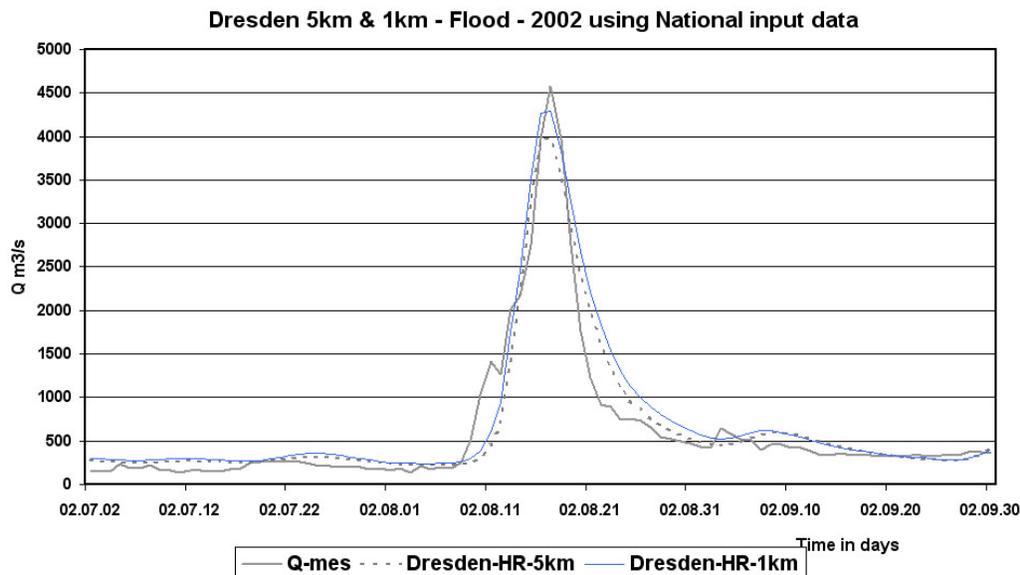


Figure 3.20 Zoom into figure 3.xx for the July-September 2002 for Dresden where observed (solid grey) and simulated discharges for Dresden on 5km (dashed) and 1km (solid green) are shown.

It seems that the finer grid representation on 1km yields better results than the 5km set-up in terms of quantity. The timing of the peak is the same in both cases. There is not much difference in baseflow and dynamic of the curves.

3.2.2.2 Impact of reservoirs

One of the big drawbacks of EFAS is that major structures such as reservoirs and big lakes are currently not included. This is due to a lack of data, hopefully this will change with the establishment of the EU-FLOOD-GIS but it is doubtful that within the near future sufficient data are available. Even if the data were available, the inclusion of reservoirs would make the calibration much more complicated, and the manual steering of reservoirs before and during floods will always introduce a high degree of uncertainty into the results.

However, figure 3.21 illustrates the performance of the model for the Ohre/Eiger river in the CZ Republic without (top) and with (bottom) including reservoirs.

The Nechranice reservoir in Ohre River Basin has been taken as an example. This subcatchment covers about 5200km². In the first simulation the reservoir was not included. The model is not able to simulate the observed hydrograph well in this case although the Nash Sutcliffe coefficient is relatively high with 0.81. In particular the peaks are overestimated and the base flow is mostly too high. Including the reservoir improved the results considerably with regard to the peaks. For the same parameter set, the Nash Sutcliffe coefficient increased to 0.83. The base flow, although slightly improved, remains mostly too high. It is possible that including more detailed information about reservoir operation could potentially further improve the model performance and subsequently flood predictions. The results indicate clearly that inclusion of reservoirs could potentially improve the simulation results.

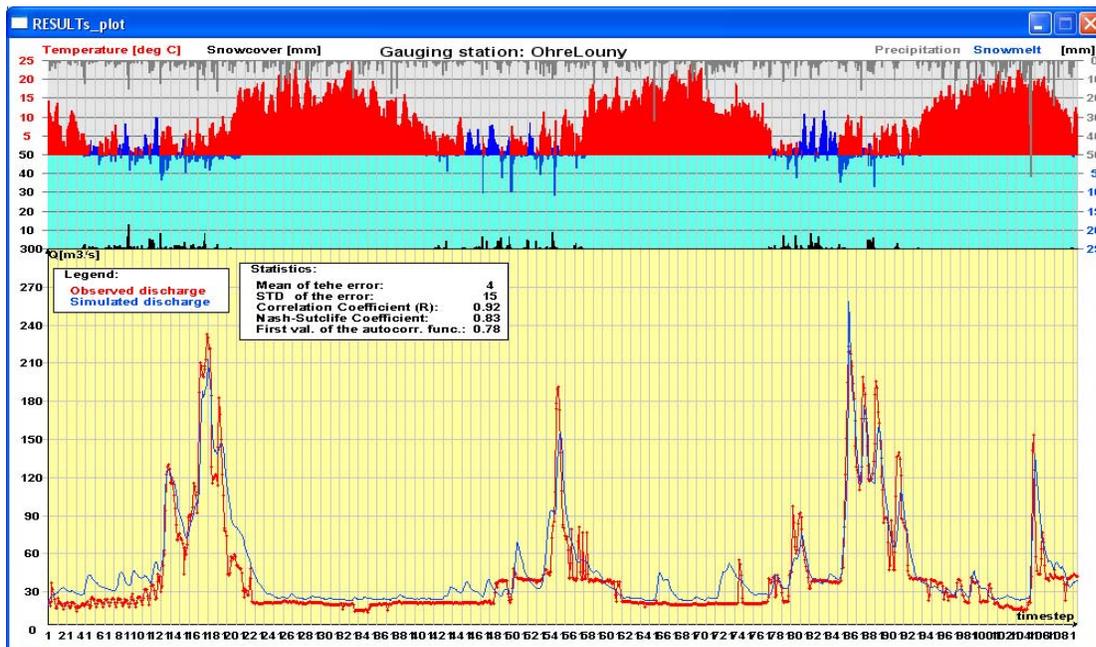
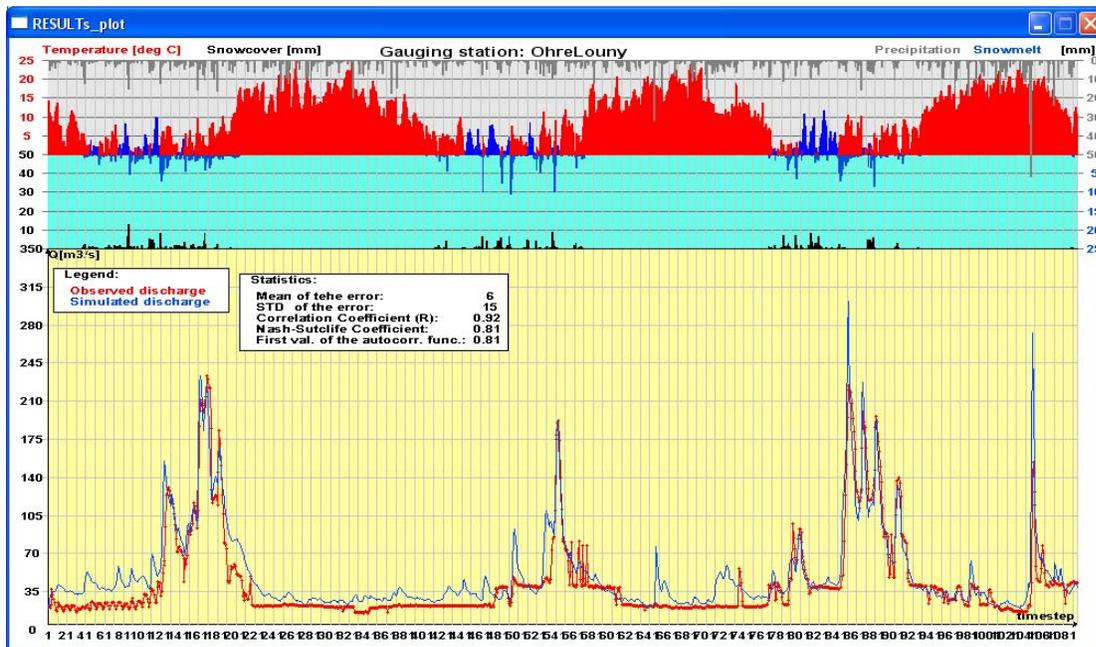


Figure 3.21 Simulation of Eger/Ohre (Cz) river at the Louny gauging station without (top) and with (bottom) reservoirs. The observations are shown in blue and the simulations in red.

More detailed studies on this would be necessary, however, and probably for each reservoir special study cases would have to be performed.

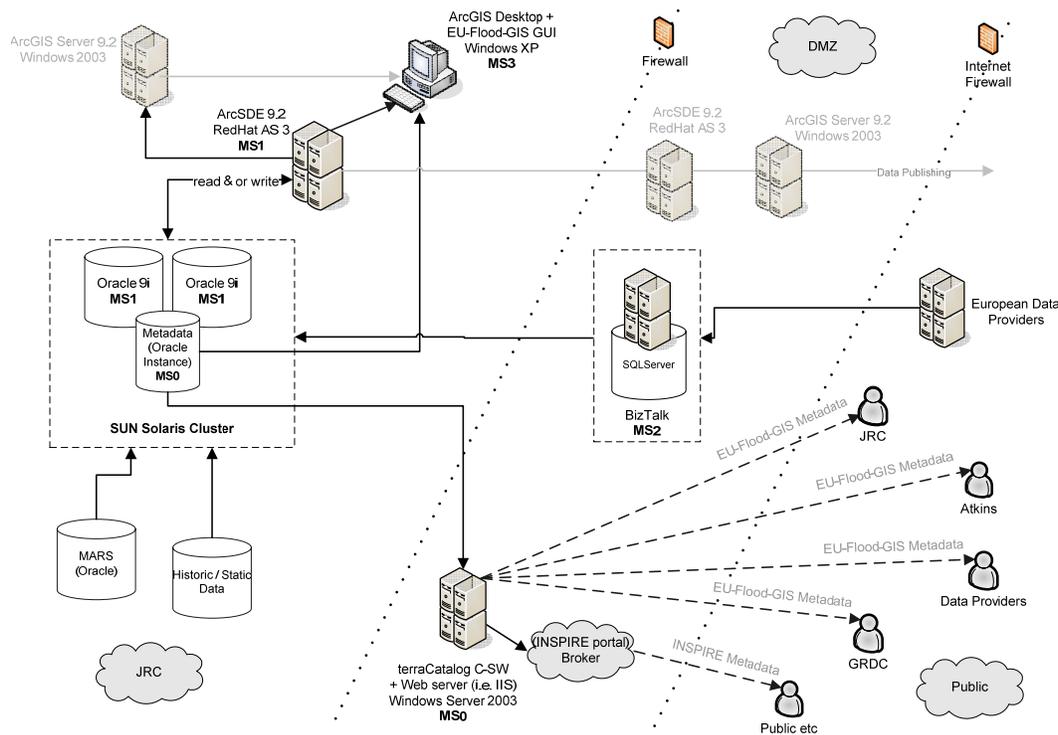
3.2.2 The EU-FLOOD-GIS (EU Parliament)

The EU-FLOOD-GIS contract was launched end of June 2006. In total 10 proposals were submitted but one was found not to be conform. The remaining were evaluated according to the award criteria and ranked. The proposal that won was the most advantageous in terms of price/value ration was the one by the company Atkins. The selection documents passed the PPAG – a JRC internal control group

for large contracts – without any problems. Atkins started effectively working on the EU-FLOOD-GIS contract from July onwards after the kickoff meeting on 24/25th July. Due to the close linkage to the ETN-R project the start of the project was somewhat slower than anticipated because several negotiations were necessary to coordinate the two projects in a way that not too much overlap occurred and the data providers are not contacted too often for the same type of information.

The EU-FLOOD-GIS proposal ranked around a Microsoft software for data collection called Biztalk. Atkins had implemented BizTalk successfully in the Ozonweb application for the European Environment Agency (EEA). After the kickoff meeting on 24-25th July a demonstration meeting for BIZTALK capabilities was arranged at Kopenhagen at the EEA on the 29th September. An additional 2-day meeting was scheduled at the JRC on 4-5th December to identify the JRC hardware environment and needs with regard to the EU-FLOOD-GIS for EFAS, Inspire and other users.

The proposed system structure is given in figure 3.22.



FiFigure 3.22

Proposed EU-FLOOD-GIS system design structure embedded into JRC architecture.

Atkins started the collection for the metadata catalogues through a network of their Europeanwide offices. In addition several meetings were held to identify the needs for the EU-FLOOD-GIS system, the existing JRC hardware infrastructure and INSPIRE requirements.

All in all the developments are positive and the proposal for a sound system infrastructure was presented. The data catalogues were delivered in February 2007 with more than 30000 data points for hydrological and meteorological data.

Figure 3.23 gives an overview of the data collection status beginning of 2007. This map was presented at the 2nd EFAS enduser workshop held on the 22nd January at the JRC in Ispra. From this date to the final delivery of the metadata database several gaps were filled, e.g. for Italy and Germany, while for the Czech Republic data were at least promised.

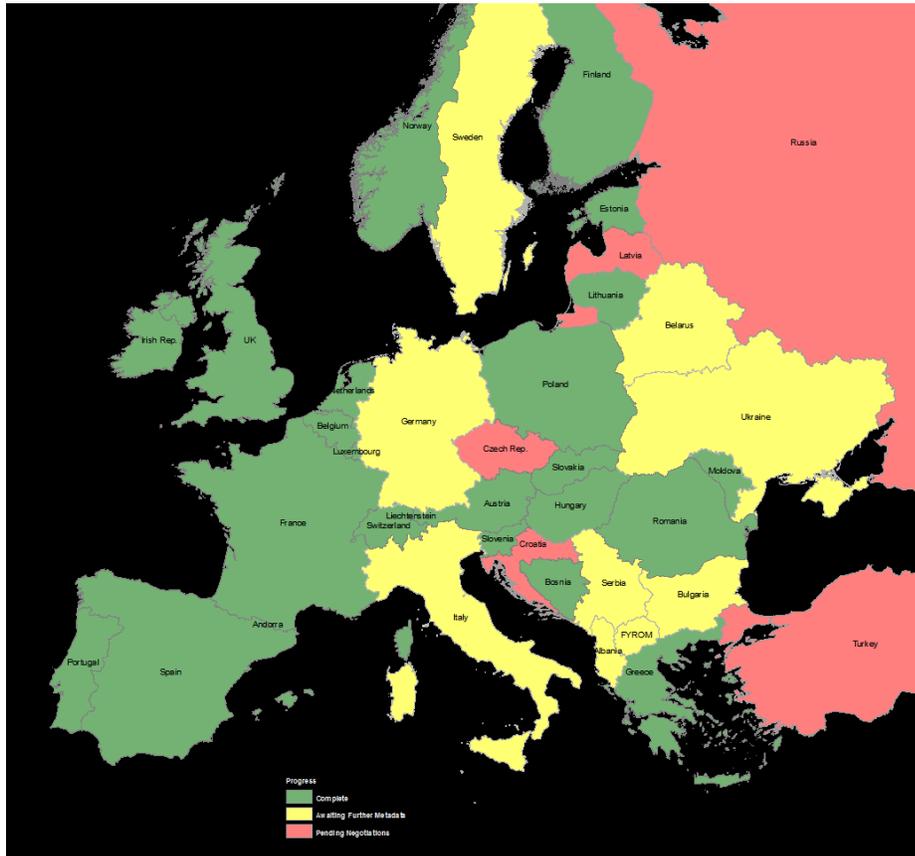


Figure 3.23 Status of metadata collection for the EU-FLOOD-GIS project at the beginning of 2007 where green means “complete”, yellow “awaiting further metadata” and red “ Pending negotiations”.

3.2.3 The ETN-R project (IDABC/DG Enterprise)

The ETN-R project had a head start of several months before the EU-FLOOD-GIS project. While the EU-FLOOD-GIS will be collection different types of hydrological and meteorological data, the ETN-R projects focuses only on near-real time river discharge data.

The chosen approach of the GRDC is to organize workshops with the potential data providers. During these workshops both EFAS and the need for ETN-R are explained to the providers and also bi-lateral discussions are foreseen to clarify any problematic issues. It was decided to approach not all data providers at the same time but to do it in two phases. In 2006 one workshop was held on 7th & 8th September in Koblenz, the second one is scheduled for April 2007. The response to the workshop was mostly positive and several providers have agreed to participate in the project. As could be expected, however, some providers are difficult to convince or to get in contact with. Figure 3.24 illustrates the ETN-R basins and their attribution to Phase 1 (dark green) and Phase 2 (shaded only) workshops.

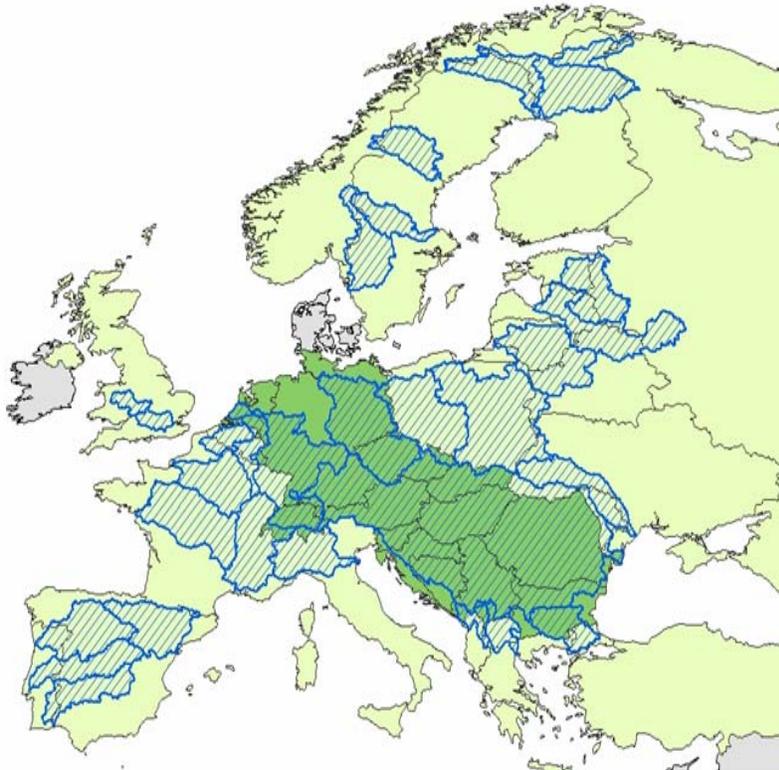


Figure 3.24: Illustration of ETN-R river basins and their attribution to Phase 1 (dark green) and Phase 2 (shaded only) workshops.

In parallel to the contacting of the providers, the layout for the prototype for the ETN-R data collection system is under development. One of the big challenges of the project is that the data are not provided in harmonized data formats.

3.3 EFAS partner network

During 2006 new Memoranda of Understanding were signed with

- LFUKA (DE, Rhine) –Jan
- SAIH-EBRO (ES, Ebro) – Jan
- RIZA (NL, Rhine&Meuse)-Jan
- CHMI (CZ, Elbe and Morava)- Feb
- ARPA (IT, Po) – Mar
- France (Schapi, Loire, Seine, Garonne, Rhone)-Apr
- HIC (BE, Meuse)-Jun
- Austria (AT, Danube)-Jul
- Romania (RO, DANube)-May
- Slovenia (SI, Drava, Sava)-May

Figure 3.25 illustrates the distribution of the EFAS partner network at the end of 2006. The negotiations with UK are still pending. Further research into the performance of EFAS in particular for UK catchments will be undertaken in 2007.

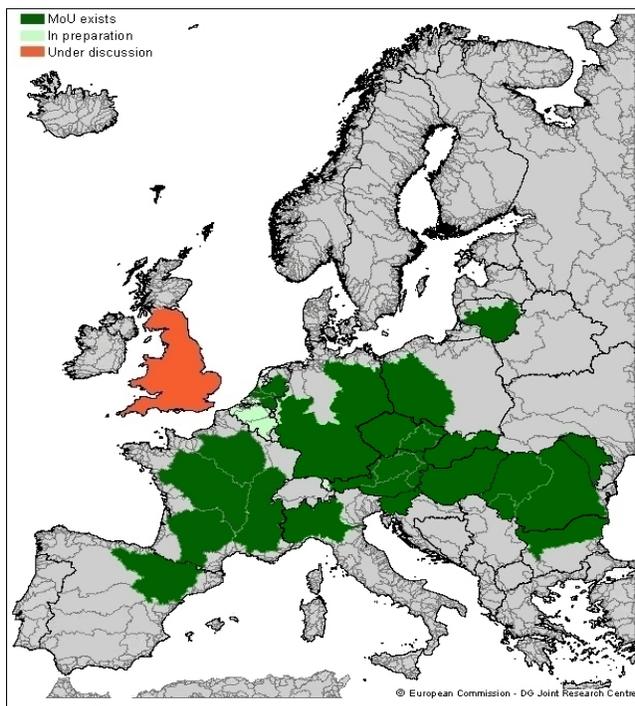


Figure 3.25 Overview of the progress of the EFAS partner network by the end of 2006

By the end of 2006 the renewal of the EFAS Memorandum of Understanding were launched. The renewal has been extended for three years until mid 2009 or until EFAS has been transferred to an operational body. Except for the LFUKA, the water authorities for the Rhine/Neckar in Germany, all MoU's have been accepted for renewal.

4. EFAS Forecasting results 2006

The winter 2005/2006 was exceptional in the sense that temperatures were below average from November to March over large areas in Europe. This is illustrated in Fig. 4.1 which shows the deviations of temperature from the climatological mean (19961-1990). The unusual long period of colder temperatures resulted in high accumulations of snow, particularly in the mountainous regions, and mostly the Alps and the Karpatian mountains. When the temperature finally increased in April, it became warmer rather suddenly and the consequent snowmelt produced flooding in several large transnational river basins. While for the Rhine the floods did not exceed 5-year return periods, the Elbe and the Danube experienced floods of 100 year return periods.

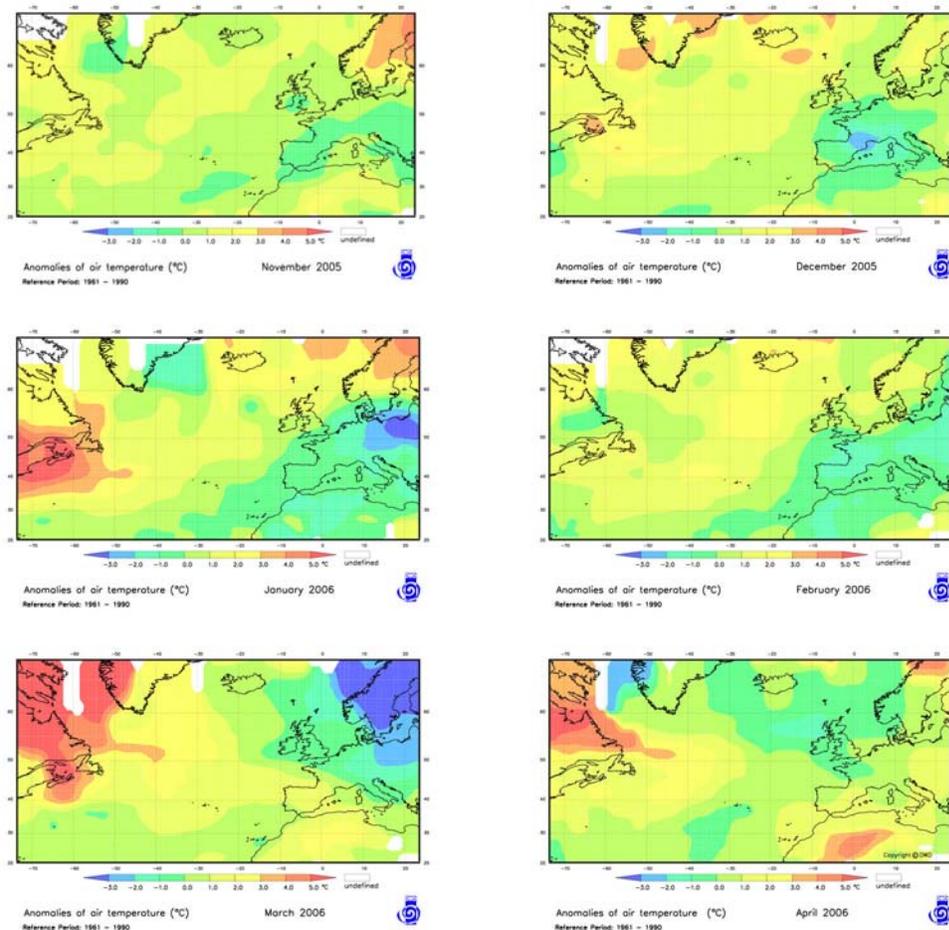


Fig. 4.1: Deviation of monthly air temperature from the climatological average (1961-1990) from November 2005 to April 2006. .Source of data from Deutscher Wetterdienst (www.dwd.de)

The reason for the colder than average winter were the frequent northern to eastern winds that brought cold and dry continental air to Central Europe. The milder westerly winds were comparatively rare and of shorter duration. Also March was colder than average and heavy snowfalls were observed in the South of Germany, in regions leading to record high snowfalls. For more information on the winter 2005/2006 literature and information can be found at the websites of the meteorological services, e.g. the DWD (<http://www.dwd.de>).

Measuring snow correctly is a difficult task because factors such as wind, water content, and snow melt have a strong influence on the result. Also snow depth can only be measured at points and then needs to be extrapolated. Therefore quantity of snow available for melting is a variable with a big

uncertainty attached. Operational flood forecasting services with tributaries in mountainous areas are aware of this problem and often use a number of different methods of estimating snow and snowmelt. In EFAS snow is not (yet) assimilated from observed data but instead derived from the observed precipitation which is converted into snow depending on temperature. In-house studies on high-resolution simulations have shown that the quantity of snow is systematically underestimated in EFAS mainly due to two factors: first the precipitation network is coarse in the mountains and the interpolated data comparatively poor, and second, the zero degree temperature is corrected with height. The height, however, is the average height from the 5km DEM. If the topographic gradients are large, e.g. like in the Alps, this can lead to underestimation of snow and snowmelt. Temperature zoning is one of the possibilities explored in EFAS at the moment to compensate partially for this effect.

Subsequently the 5km pre-operational EFAS installed currently is very likely to underestimate snow. It is difficult, however, to quantify the underestimation without insitu measurements or other data of comparison. The snowmelt floods this year showed, however, clearly that snowmelt overall was underestimated in EFAS, and also allows a coarse estimation of the underestimation factor. For most rivers with tributaries from the Alps, the Bohemic and Ore Forest region, Sudetic mountains and Karpathian mountain range the discharges were systematically underestimated. This had of course impact on the EFAS flood forecasts: while initially the onset of the floods in the Elbe and Danube tributaries were correctly forecasted, the highest alert threshold was not exceeded and the discharges dropped too early below the EFAS flood thresholds. This was particularly true for the second phase of the floods when most snow in EFAS had already melted and could therefore not continue to feed the flood waves.

The combined snowmelt and rainfall driven floods affected mostly the Danube and the Elbe river basins during long periods in March and April. Again record high flood peaks with return periods of more than 100 years were observed. In both Danube and Elbe the flood wave traveled through the full river basin with devastating effects. In Romania the dykes broke and caused much flood damage and evacuations. Because of the very flat flood peak the waters stayed unusually high which caused extra strain on the protection measures. In the Elbe the downstream areas the water levels were even higher than during the 2002 floods because there were no dyke breaks in the Cz and upstream German parts. But also other rivers such as the Rhine or upper Rhone reported high waters, even if big flooding did not occur.

Despite the drawbacks of the current system, the snowmelt floods 2006 were a great success for EFAS from the operational point of view (in total more than 50 reports were sent to partner organizations), the start of the floods (particularly the start of the Elbe and Danube floods in the Czech Republic were very well forecasted several days in advance), from an impact point of view (in Slovakia the EFAS reports were used operationally and brought added value to the flood forecasts, also in Germany the EFAS reports were used in Sachsen for discussion with politicians). The snowmelt floods also highlighted a number of short-comings of the EFAS pre-operational system that are now being addressed to improve the system:

- i) from the model point of view the static input maps are being revised as well as the dynamic inputs related to snow, a new calibration is under way, and the 1km pilot set-ups in Elbe and Danube can now be used to refine the system also for snowmelt (so far the system was rather tuned for heavy summer rain floods);
- ii) from the operational point of view the way EFAS reports are sent will be revised. From now on reports will be sent immediately to all downstream authorities and not, as it has been so far, according to affected MoU authority.
- iii) the operational team reached again its limits in dealing with all the reporting. The system will be automated more in the future making external reporting easier and less time consuming.

Figure 4.2 illustrates the number of forecasted and confirmed flood events and the number of external reports during the year 2006. The highest number of EFAS external reports accumulate in March and April with 77 external reports.

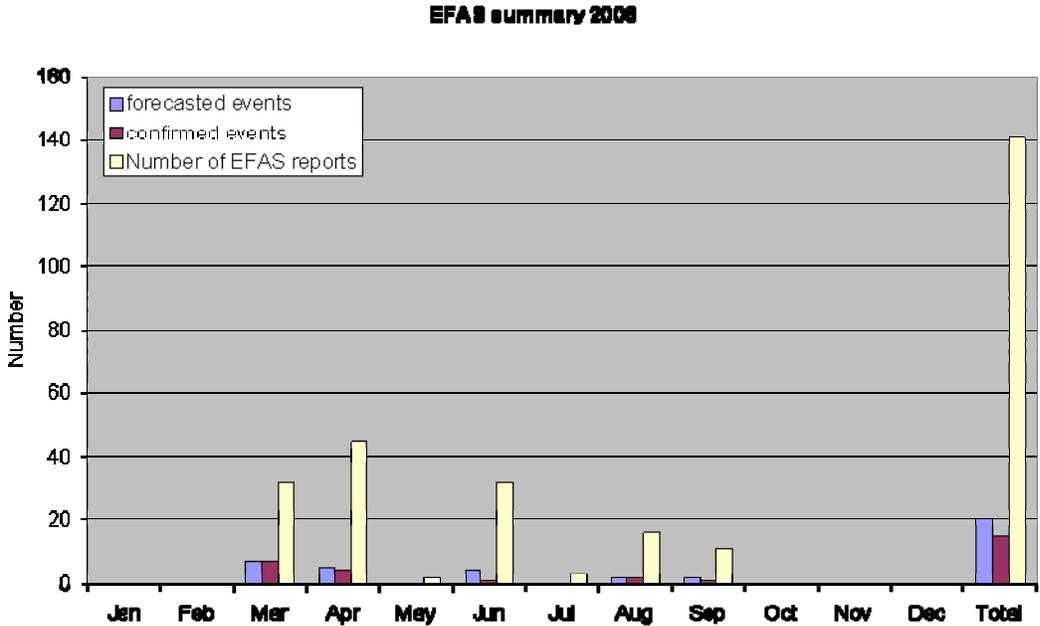


Figure 4.2 Number of EFAS forecasted events (blue bars), confirmed events (red bars) and number of sent EFAS reports (yellow bars) as a function of Months in 2006.

In total about 141 reports were sent during the whole year for 20 forecasted events of which 15 were confirmed. The EFAS reports were sent also through 17 weekend days, which means that typically in addition to the weekend forecaster also 1 or 2 more staff were on weekend duty. This was a heavy working load for the operational EFAS team which managed to support the activity not only during the week but also weekends and holidays.

Nevertheless, errors occurred because of the heavy workload and the gravest one was probably that for the Morava river, which was reported to the Czech Republic as early as 25th March, was not reported at risk of flooding to the Slovakian authorities. Only when the flood peak was expected within 48 hours the Slovakian authorities were informed. This was a pity because the forecasts for the Morava were very good both in magnitude and timing and the Slovakian authorities reported that they would have benefited from the forecasts.

Partially this problem had occurred because EFAS information reports were sent at that time not to all authorities in the river basin at the same time but only if the flood wave was reported to reach to administrative authority. As a consequence the downstream authorities, e.g. in the Elbe – Brandenburg – only received the information reports when the flooding was already ongoing and they were already informed about it. After the March/April floods this policy was changed and the alert reports are sent immediately to all partner authorities in the river basin. This has also the advantage that the workload for the EFAS team is reduced since only 1 report needs to be drafted. The advantage of a webbased information system to which the partners can log on themselves to check the EFAS results became apparent during this exercise.

May 2006																																
Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
EXTERNAL ALERTS																																
Moldova - Prut and Dneestr																																1
HU-SK-RO- Danube tributaries																																1

June 2006																																
Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
EXTERNAL ALERTS																																
Moldova - Prut and Dneestr		2	3	4	5	6	7	8F																								
HU-SK-RO - Danube tributaries		2	3	4	5	6	7	8F																								
CZ-DE-Elbe																													1	2	3	
CZ-AT-SK-HU-RO(later)-Danube																													1	2	3	
PL-DE-Oder																													1	2	3	

July 2006																															
Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
EXTERNAL ALERTS																															
CZ-DE-Elbe		F																													
CZ-AT-SK-HU-RO(later)-Danube		F																													
PL-DE-Oder		F																													

August 2006																															
Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
EXTERNAL ALERTS																															
Oder PL										1	2	3	4F																		
Vistula PL (with Oder)									1	2	3	4	5	6	7	8	9	10	11	12F											

September 2006																															
Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
EXTERNAL ALERTS																															
Po River IT													1	2	3	4	5F														
Loire - Garonne FR																				1	2	3	4	5	6F						

Oct-Dec no alerts

Figure 4.3: Summary of full EFAS Information Reports listed by months.

4.2 Feedback from end users to EFAS information reports

After the last EFAS information report, the authorities receive a feedback questionnaire (Annex 1). While verbal communications typically include subjective elements, the feedback questionnaires are the most quantitative measure for assessing the potential impact of EFAS information for the receiving authorities. However, some authorities prefer to communicate per email or personal communications, e.g. communications to the detached national experts or the EFAS team. This is particularly true in the wake of a flood crisis when the authorities have little time for additional work.

In the next sections the analysis of 9 feedback questionnaires are summarised in tables and the equivalent feedback through other means described.

4.2.1 Performance of EFAS forecasts

The feedback questionnaires show that for the reporting period the hit rate for EFAS information reports floods or bankful conditions i(~ EFAS high alert) s higher than the false alarm rate. The observed river levels were high in the majority of the cases and at least local flooding took place in smaller upstream areas. Although the precise location of the floods are often difficult to determine without having access systematically to real-time discharge measurements, the problematic areas were usually quite well embraced by EFAS forecasts.

Table 4.1: Correctness of EFAS forecasts

Question	yes	no
For the river basins flagged in the EFAS reports flooding was observed?	6	4*
For the river basins flagged in the EFAS reports the river level reached bankful conditions somewhere in the river basin?	6	2
River levels were mainly:		
High and critical	1	
High but not critical	6	
Only moderately increased or normal	3	
Regarding timing, EFAS forecasts were		
Mainly correct in time	8	
Mainly too late		
Mainly too early	1	

In terms of timing it appears that the forecasts were quite good in upstream areas of around 50000 km² and less. For larger upstream areas the timing worsens. This problem became particularly apparent during the snowmelt floods in 2006, where the flood wave travelled through the full Elbe and Danube river basin. Several reasons were identified for this and the model and its underlying maps are currently under revision to solve the too fast propagation of the flood wave downstream.

4.2.2 Use of EFAS forecasts during operations

EFAS reports were mainly used as a basis for discussion in the forecasting team and to arrange working schedules. They are found useful as early warning information and as additional information to local forecasters (Table 4.2)

Table 4.2 Usefulness of EFAS information reports

Question	yes	no
Do you find EFAS information reports useful	10	
Flood ensemble prediction system information is given in the form of maps counting the number of ensemble forecasts generating discharges exceeding critical flood level thresholds.	10	
Do you find this information useful?		
Were the EFAS reports used in some way by the flood forecasting team?	8	2 <i>(in one case the reports arrived too late because of technical problems with the receiving mail server)</i>
Did the EFAS reports effectively help you?	8	2 <i>(in one case there was no earlier information than from local sources)</i>

4.2.3 Trade-off between false alarms and early warning time

According to the feedback, most partners prefer to have the EFAS reports rather earlier even if this may increase the number of false alarm rates (Table 4.3). This is in line with reports from partners that a “missed” early warning has more negative consequences than false early alarms, because of the lack of preparation time.

Table 4.3: EFAS strategy to reduce false alarms

Question	yes	no
The first EFAS report is produced when high or severe flood threshold levels have been exceeded at least for 3 consecutive EFAS forecasts. This can decrease the false alarm rates but also shortens the leadtime.	6	3
Would you like to receive the reports earlier although this may mean an increase in false alarm rates?		
At present, the first report is sent when at least one of our meteorological forecasts (DWD and ECMWF) results in high severe flood levels. Would you prefer to receive the first EFAS report only when both meteorological forecasts indicate them?	1	8

4.2.4 Visualisation of EPS based results and level of probabilistic information provided

From the analysis of the questionnaires and other feedback it can be concluded that the information in the EFAS information reports is now sufficiently clear (Table 4.4, 4.5). Some more information on EPS spread and other hydrological information is desired by some partners while others are content with the overview presentation of results. Often EFAS information reports arrive too late and earlier reports would be appreciated. The announcement of a web-based information system where the partners can connect to the EFAS webpages themselves any time they want has been welcomed by all partners. This would then also reduce the problem of late EFAS information reports. The EFAS team will reduce reporting to sending simple warning summaries out while the partners can then check the details themselves.

Table 4.4: Using EPS in flood forecasting

Question	Yes	no
Flood ensemble prediction system information is given in the form of maps counting the number of Ensemble Forecasts (EPS) generating discharges exceeding critical flood level thresholds. Do you find this information useful?	9	
Would you like to have more information on Flood Ensemble Prediction System, i.e., more EPS results as, for instance, the spread of the forecasted hydrographs, statistical information for each leadtime, or others?	5	4
If Yes, which information?	EPS spread, statistical information for each leadtime, more hydrologic information	

Table 4.5: Editorial aspects of EFAS Information Reports

Question	Yes	no
Is EFAS information clearly stated	8	1
Is all information necessary	9	
Would you suggest improvements of the EFAS reports	1	8

4.3 The spring 2006 floods – case studies

The spring floods in Elbe and Danube were studied in detail for the Cz part of the Elbe and for the Morava. Two detailed case studies have been performed and submitted for publication to international journals.

4.3.1. The Morava case study

The Morava catchment is located in Central Europe, with area of approximately 27,000 km² and total length of 352 km (Figure 4.4). The Morava River is one of the largest tributaries of the Danube River. It flows through three countries: the Czech Republic (catchment area of 22,000 km²; 82.5% of total size), Austria (3,675 km²; 14%) and Slovakia (980 km²; 3.5%). There are two main hydrologic sub-catchments within the Morava catchment: the Morava river upstream catchment (up to the confluence with the Dyje River; a right side tributary) and the Dyje River catchment (area of 13,404 km², mainly in the Czech Republic). Structural measures, hydropower plants, weirs, reservoirs and dykes are found within the catchment.

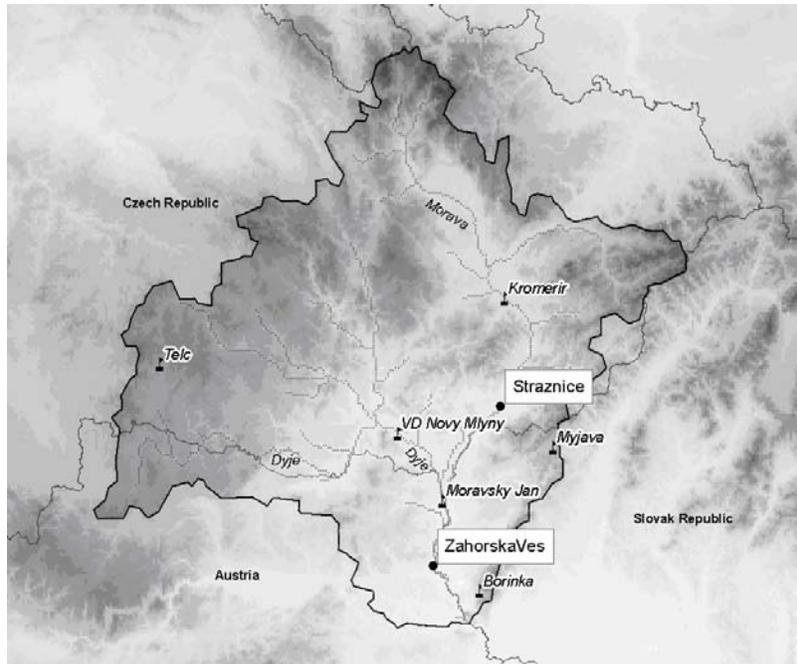


Figure 4.4. Schematic view of the Morava river basin, tributary to the Danube.

From 29th March to 09th April 2006, the Morava catchment was again hit by severe floods and high river water levels caused by rainfalls associated with snow melting due to a significant and rapid raising of temperatures. During the event, a state of emergency was declared in the southern Moravian region in the Czech Republic and along the Morava River in Slovakia. Observed discharges in northeast Austria were greater than the 100-year flood and a dyke break at the right bank of the Morava River forced hundreds of people to evacuate. The media reported several deaths and the displacement of hundreds inhabitants, as well as huge economic losses with settlements and agricultural lands flooded.

Runoff was mainly driven by the melting of high amounts of snow accumulated during the winter period in the tributary catchments, as a consequence of a rapid increase of air temperature in the period 25th-27th March. From 25th-31st March, the runoff became even more intense due to point rainfall amounts of up to 17 mm in 24 hours. In general, water levels started to rise on 21st March.

Figure 4.5 shows the results of EFAS forecasted threshold exceedances from 20th March to 08th April 2006 at the Zahorska Ves station. For the simulations based on the deterministic weather forecasts, it is shown in sequential boxes, each box representing 24 hours of lead time, the highest EFAS threshold exceeded for each forecast date (rows from 20th March - 2006032006 to 08th April - 2006040800) and at each lead time (boxes). In EPS-based flood forecasts the temporal box diagrams show the number of simulations above EFAS High threshold (EPS>HAL).

It can be seen that even if exceedances of high thresholds were not simulated by the deterministic forecasts (red boxes in the DWD and ECMWF diagrams) in the earlier forecasts (starting on 21st-22nd March for the 10-day ECMWF forecasts and on 24th-25th March for the 7-day DWD forecasts), there was already a signal of a probability of reaching high stages in the EPS-based simulations: 21-37 out of 51 simulations for the 29th-30th March already on 21st-22nd March. The signal in EPS-based forecasts was persistent, with increasing probabilities as the forecast dates got closer to the event: more than 25 simulations out of 51 exceeding high thresholds with lead times of 6-7 days and more than 35 simulations for lead times 4-5 days.

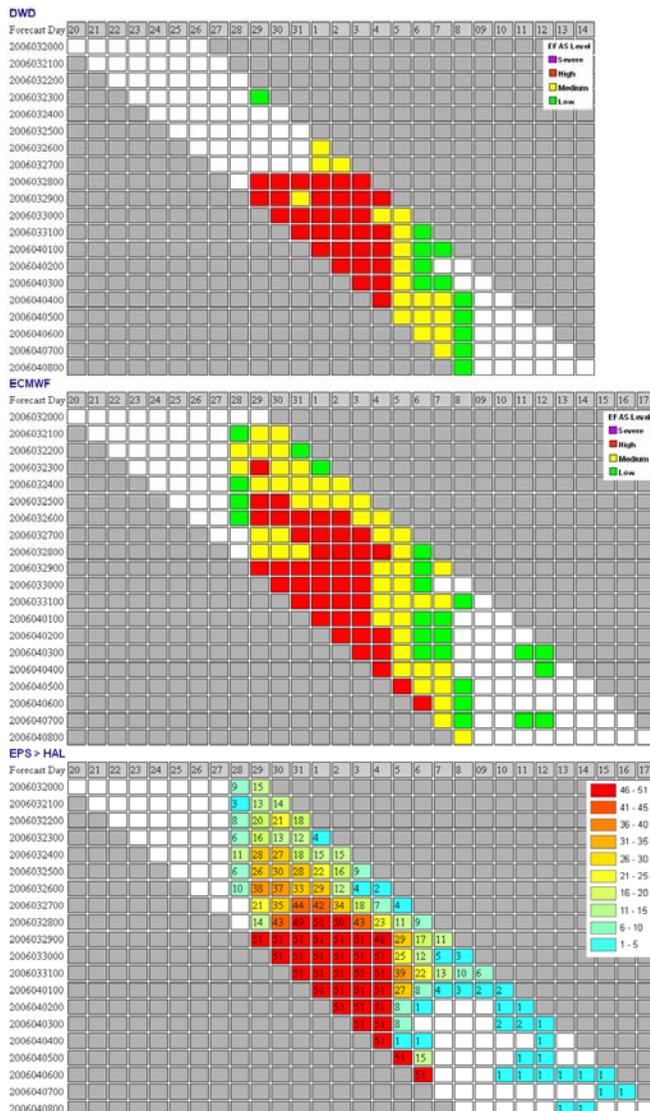


Figure 4.5: History of EFAS forecasted levels at the Zahorska Ves station in the Morava River for forecast dates from 20th March 00:00 to 08th April 00:00 (rows). EFAS forecasts are based on DWD deterministic weather forecasts (top), ECMWF deterministic weather forecasts (middle) and ECMWF-EPS probabilistic weather forecasts (bottom). The dates for which the forecasts apply are show in the top of each diagram (columns); each box corresponds to a 24-hour lead time. For DWD and ECMWF, the boxes show the EFAS level reached by forecasted discharges. For EPS-based forecasts, the number of EPS above EFAS High Flood Threshold ($EPS > HAL$) is shown.

Observed and forecasted flood ratios are plot for the Straznice and Zahorska Ves locations (Figures 4.6). The results show that the time period during which discharges exceed the flood levels (flood ratios greater than one) are comparable in the forecasted and observed ratios. For this flood event, forecasts based on ECMWF-EPS performed better than those based on the deterministic weather forecasts, while, among the deterministic forecasts, the ECMWF-based forecasts performed better than the DWD-based forecasts: forecasted flood ratios are closer to the observed ones.

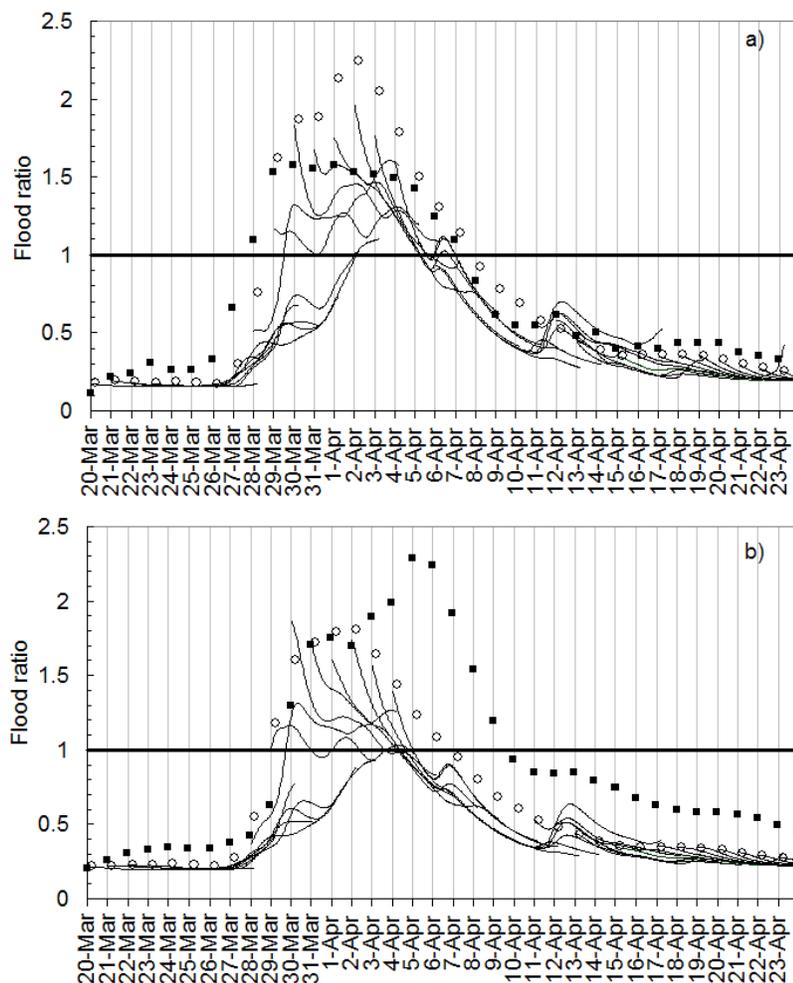


Figure 4.6: Flood ratios for the March-April 2006 flood event in the Morava River at a) Strážnice station and b) Zahorska Ves station: ratio between EFAS forecasted discharges based on DWD midnight 7-day weather forecasts and EFAS high threshold (thin lines), ratio between EFAS simulated discharges with observed meteorological data and EFAS high threshold (circles), ratio between observed discharges and local warning stage (squares).

Overall the analysis shows that EFAS forecasts based on probabilistic weather ensembles were able to detect an earlier and persistent signal of probability of flooding: 12-20 simulations out of 51 indicated a probability of flood (discharges above EFAS high flood threshold) with 8-10 days in advance in downstream Morava (Slovakia/Austria border). With such a lead time, deterministic-based forecasts were at most indicating an increase in river discharges (discharges above EFAS medium or low thresholds) and exceedances of high thresholds were only forecasted at the most upstream parts of the catchment: simulations based on deterministic weather forecasts showed a persistent signal for 29th-30th March only from the forecast starting on 25th March onwards (i.e., 4-5 days in advance) for ECMWF-based forecasts and from the forecast starting on 28th March onwards (i.e., 1-2 days in advance) for DWD-based forecasts. EFAS results on the exceedances of high flood thresholds well forecasted the core period of the flood event (29th March-6th April). However, although observed discharges at gauging stations were close or event greater than the 100-year flood, exceedances of the EFAS severe threshold were not forecasted. This highlights the dependence of the critical values used in EFAS on the period of simulation used to derive the thresholds (14 years only). Future studies aim at investigating closely the relation between EFAS critical thresholds and those defined locally by the national hydrological services on the basis of more accurate data and longer discharge time series. Despite some drawbacks of the current system (coarse calibration, coarse resolution input data, lack of hydrological modeling of retention structures along rivers) the flood event was well captured by EFAS. More detail and information on this study can be found in the full publication by Kalas et al. (2006).

4.3.2. The Vltava case study

From 27th March to 10th April 2006, the Elbe river basin was hit by severe flooding due to high amounts of snow melting and rainfall. Strongly affected were the areas at the Czech/German border and because the dykes mostly did not break during this flood, downstream of Dresden water levels rose higher than observed during the last major flood in 2002.

The Czech part of Elbe river Basin covers about two thirds of the whole Czech Republic, with a total area of 51,100 km². The Czech part of the basin has three main subcatchments: Vltava (28,048 km²), Upper Elbe (13,111 km²) and Ohre/Eger (5,614 km²). The Vltava is one of the major tributaries of the Elbe river and the longest river in the Czech Republic (Figure 4.7).

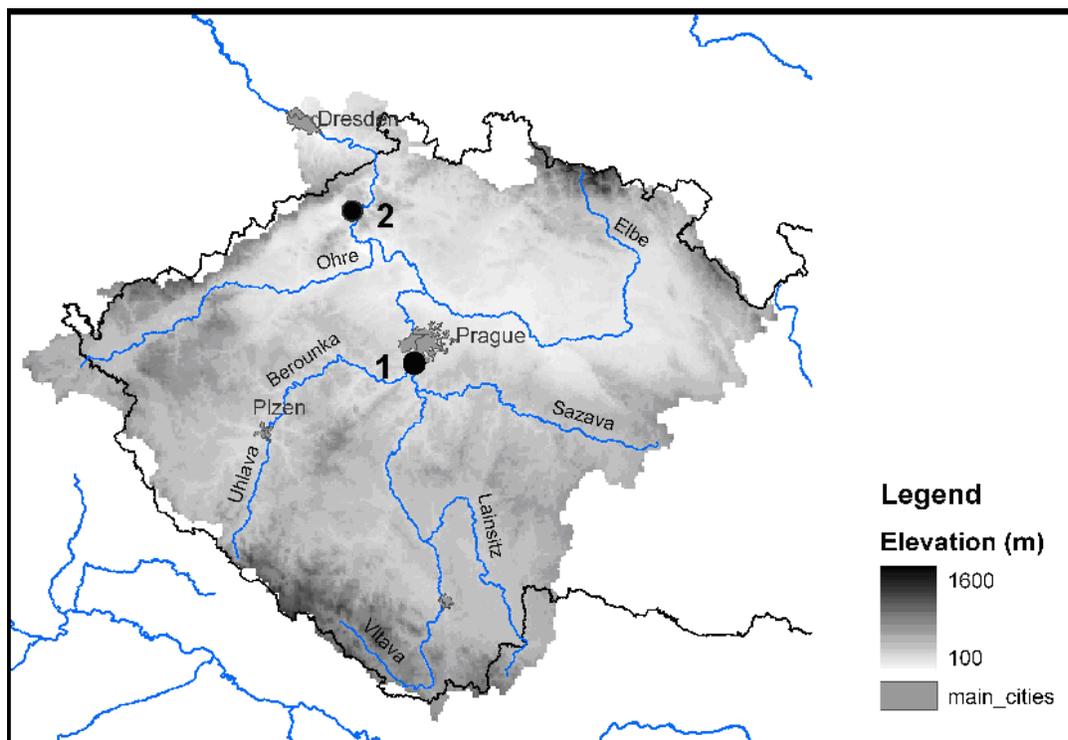


Figure 4.7 The Vltava subcatchment of the Elbe river basin.

The months of March and April 2006 were characterized by a high number of alerts captured by the EFAS pre-operational forecasting system across several major transnational European river basins including the Elbe, the Danube, the Rhine, the Oder and the Rhone. More than 50 EFAS information reports were compiled and sent to different national authorities operating in the Danube, Elbe and Rhine basins. The last week of March and the first week of April were especially busy, with a peak of 5 EFAS information reports being produced per day on the 31st March and 01st April.

For the Vltava River, a total of 14 EFAS Information reports were sent to the Czech Institute CHMI from 25th March to 07th April 2006. The EFAS Information reports summarise flood information based on the deterministic DWD and ECMWF weather forecasts, as well as on ECMWF-EPS weather forecasts. In the first report, the simulations were indicating the exceedance of EFAS high thresholds in the Elbe tributary Vltava for the 29th March onwards (i.e., 4-5 days in advance) by both deterministic forecasts and by a high number of members of the EPS system (more than 40 out of 51). A history of the exceedances of EFAS alert levels since the midnight forecast of 20th March at selected points in the Vltava and in the Elbe rivers was also shown, indicating that the forecasted signal was more persistent in the upstream parts of the catchment and less conclusive downstream of Prague. The reports that followed the first one kept on updating the forecasted situation and gave information on the forecasting of decreasing discharges, focusing on the date for which discharges were forecasted to be below EFAS High threshold. In the last report, EFAS simulated discharges were steadily decreasing in the Vltava and in the Elbe rivers and, although a small secondary peak was forecasted for the 11th-12th April, discharge values were below EFAS high threshold.

Concerning the impact of EFAS reports, the Czech authorities reported in their feedback that EFAS reports were useful as early warning information and as overview information from neighbouring countries. The forecasts were declared “mainly correct in time”. However, they also stated that these advantages are mitigated for the Czech Republic since; first, they have already “all the NWS [numerical weather system] outputs available”, covering and even anticipating the effective early warning from EFAS, and second, “due to the geographical position of the Czech Republic, there is

nearly no inflow from abroad” and thus, although interesting, information from neighboring countries “is not that important” for operational forecasting. Obviously, if EFAS had not been restricted by the 30000 km² rule imposed by the ECMWF council, the early warning could have been sent much earlier.

Figure 4.8 shows observed and simulated discharges for the Elbe river basin based on the EPS forecasts.

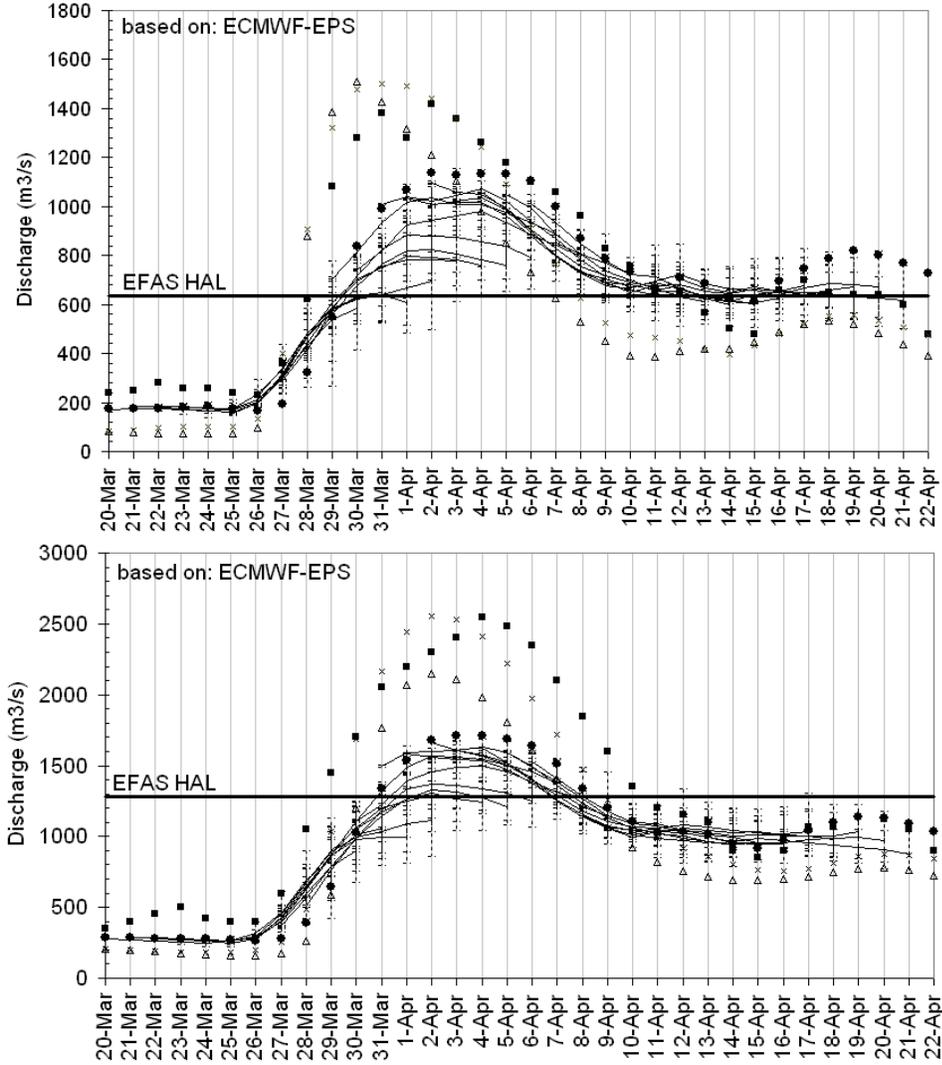


Figure 4.8 : EFAS forecasted discharges based on ECMWF-EPS midnight 10-day weather forecasts (thin lines), EFAS simulated discharges with observed meteorological data (dots), national observed discharges (squares) and LISFLOOD simulations with 5-km resolution (triangles) and 1-km resolution (crosses) in the Vltava River at a) Praha-Mala Chuchle station and b) Usti nad Labem station from 20 March to 23 April 2006. EFAS High Alert Levels are indicated. Forecasted discharges are represented by the median value (lines) and the 10% and 90% quantiles (dotted bars) estimated from 51 predictions.

The operational EFAS simulations based on the probabilistic ECMWF-EPS forecasts could roughly reproduce the pattern of the hydrographs and forecast in advance the increasing of discharges and their peaks (Figure 4.8). However, even based on ECMWF-EPS forecasts, EFAS simulations were not able to correctly simulate the magnitude of the peak discharges: differences of 300m³/s to 800 m³/s can be found between the forecasted peaks and the discharges observed by the national authorities (squares in

the figures). The fast decreasing of discharges and the lower magnitude of flows can be related to a large number of factors, including: a small amount of input snow available to the rainfall-runoff transformation in the hydrological simulations of snow melting, the effect of the cascade of reservoirs in the Vltava River in flood propagation and volume retention and/or the effect of coarse resolution (5-km) and poor calibrated hydrological modeling. Recalibration of the model improved the results – in hindcast most – considerably.

The analysis shows that EFAS forecasts based on probabilistic weather ensembles were better able to detect an earlier and persistent signal of probability of flooding: 12-27 simulations out of 51 indicated a probability of flood (discharges above EFAS High alert level) with 8-10 days in advance in the Vltava River downstream Prague. With such a lead time, deterministic-based forecasts were at most indicating an increase in river discharges (discharges above EFAS Medium or Low alert levels) and high levels only at the most upstream parts of the catchment or in a non-persistent way: simulations based on deterministic weather forecasts showed a persistent signal for 29th-30th March only from the forecast starting on 29th March onwards (i.e., only 0-48 hours in advance).

Although high levels were well forecasted for the core period of the flood event (29th March-8th April), EFAS forecasts predicted weaker discharge peaks and simulated a faster flood propagation than the one that was actually measured by local discharge gauging stations. When applying observed meteorological input data to a higher resolution hydrologic modeling, with better calibrated parameters, a significant improvement was observed in the simulations. It appears clear that a great benefit could be expected from the introduction of a finer calibration of the hydrologic LISFLOOD model in EFAS forecasting system to better capture the magnitude of floods.

Concerning the timing of flood peaks, even the high resolution and well calibrated simulations showed an advanced time to peak of approximately two days. The effects of the cascade of reservoirs in the Vltava River upstream Prague (river regulation structures not included in the simulations here presented) need to be closely investigated and could explain some of the differences between simulated and observed hydrographs. Additionally, more detailed studies need also to be performed on a better reproduction of the flood volume and on the quantification of the part of runoff due to snow melting, the physical process dominating this type of flood event.

5. Research on the operational performance of EFAS

During the year 2006 extended research has been performed on the operational EFAS results. These results were obtained through statistical analysis from an 11 months period from June 2005 to May 2006. The results have been summarized in a report delivered to ECMWF and have been prepared and published as a EUR report (Thielen, Bartholmes and Ramos et al., 2006). The report submitted to the ECMWF council has been a great success. It convinced the ECMWF scientific board that EFAS can provide useful results for upstream areas smaller than 30000 km². The ECMWF council accepted the proposal from the ECMWF advisory board to allow EFAS reporting according to the hydrological situation without constraints on upstream area. The 48h constraint has neither been questioned nor renegotiated. In the following only a brief summary is being presented. For more detail the EUR report (EUR 22560 EN) can be consulted.

The research performed on the operational performance of EFAS was tier-fold and consisted of

- i. **Enduser perception on the usefulness of EFAS information reports.** The impact of EFAS information reports in the local operational flood forecasting centres is analysed with respect to hit/false alarms, perception of the enduser concerning the usefulness of the information and also the clarity of its presentation in EFAS reports, as well as its effective dissemination. The analysis is based on feedback questionnaires, which are systematically sent out after the last EFAS Information Report for an event, on discussions during technical EFAS workshops (the first one was held in January 2006), as well as on any other personal or informal email communications.
- ii. **In-depth case study analyses of selected events and statistical evaluation of flood-prone periods.** Case studies in EFAS serve to understand the potential capabilities of EFAS results for early warning for different types of flood events. They are also used to identify interpretation and decision rules for individual forecasts (deterministic and EPS forecasts), as well as for combined forecasts (using the ensemble of all EFAS forecasts in a complementary way). The case studies focus on the Danube catchment which experienced repeatedly different types of flooding events in summer 2005 and spring 2006.
- iii. **Quantitative analyses of different verification (skill) scores on an European scale.** The aim is to evaluate the skill of EFAS hydrologic forecasts under different aspects of deterministic, probabilistic and combined forecasting. Statistical methods are used and scores are computed to assess the performance of EFAS forecasts. Analyses of hit and false alarm rates for a period from June 2005-May 2006 are performed and the Brier score and the Brier skill score are calculated.

The study aimed at analysing the usefulness of EFAS results not under just one specific aspect, but in its totality of using all the available input data (currently, deterministic DWD and ECWFMF weather forecasts and ECMWF-EPS probabilistic forecasts) for issuing a combined early flood alert.

5.1. Enduser perception of EFAS information reports

Feedback from partner organisations on the EFAS information reports is generally very positive. It appears that the hit rate of EFAS for forecasting flood events and/or bankful conditions is considerably higher than its false alarm rate. The receiving partner organisations are glad with the EFAS information reports as well as with the quality of the reports. The EFAS information is used actively by most organisations as additional information for orientation and occasionally even for the decision making process. The use of the reports seems to depend largely on the leadtime. As pre-warning

information EFAS reports mainly serve to increase the preparedness at the local water authority level. As soon as the event takes place, it serves as additional information, as outlook for second flood waves and also as support to the decision making process and discussion with civil protection authorities (and politicians). Partner organisations are very keen to gain more experience with EFAS information reports.

Improvements are needed in the dissemination of the EFAS information reports. Earlier dissemination by sending all reports directly also to all downstream authorities (even if their administrative borders are not yet affected) could increase the preparedness for flood events in particular in the downstream areas. This strategy has already been adopted in the latest flood event. Further, more automation in the production of the EFAS information reports and putting daily information on a web-restricted webpage will probably gain valuable time in the future.

5.2 In-depth case study analyses and statistical evaluation of summer 2005 and spring 2006 flood forecasts in the Danube catchment

Figure 5.1 summarises the flood events taking place in the Danube river basin during 2005 as reported by media and other sources, e.g. Dartmouth observatory. Floods were concentrated particularly in the lower Danube tributaries during spring-summer 2005.

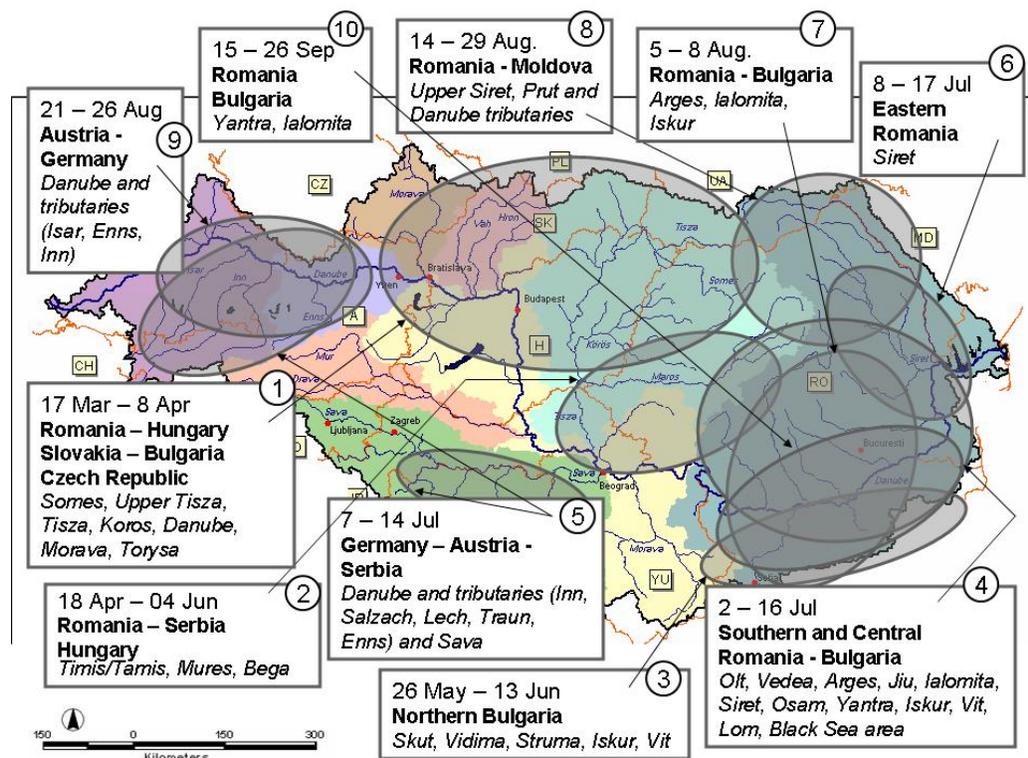


Figure 5.1: Summary of major flood events or high water level occurrences in the Danube River Basin during 2005 (based on the Flood Archive of the Dartmouth Flood Observatory, on information from national authorities and on the JRC-EMM European Media Monitoring).

In comparison, the number of days where EFAS initial conditions exceeded the EFAS high alert during the July and August months of 2005 are shown in figure 5.2. It can be seen that the model captured well the areas of repeated flooding during these months.

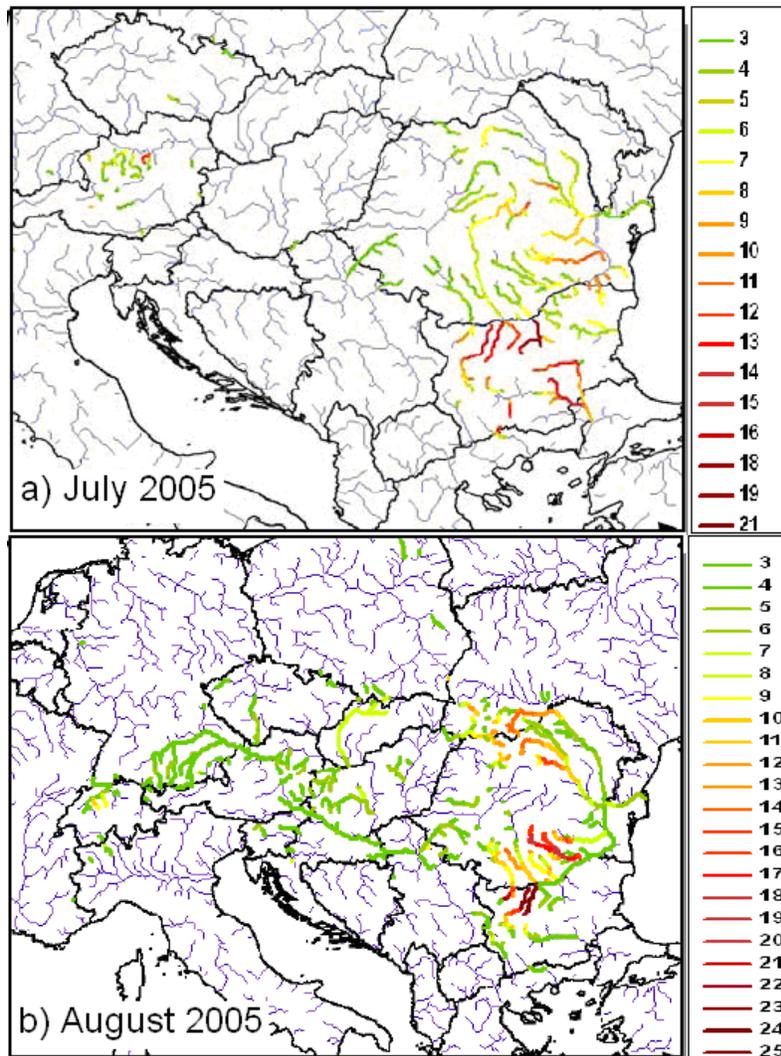


Figure 5.2: Number of days EFAS simulations based on observed meteorological data exceed the EFAS High alert level during a) July and b) August 2005.

For the period from July 2005 to October 2005 statistical analysis on hits, false alarms and missed events was performed for the 70 locations indicated in Figure 5.3. The selected points are associated with a wide range of upstream areas, from 1,000 km² to 660,000 km². About 50% of the points have upstream areas less than 12,000 km² and 85% less than 40,000 km².

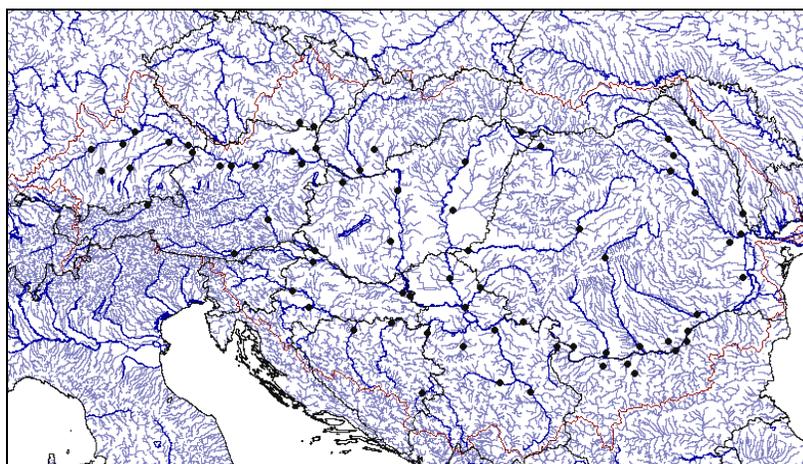


Figure 5.3: Map of 70 locations in the Danube River and its main tributaries.

Results shown in Figure 5.4-5.5 show examples of hit, misses and false alarm rate analysis for the months July and August.

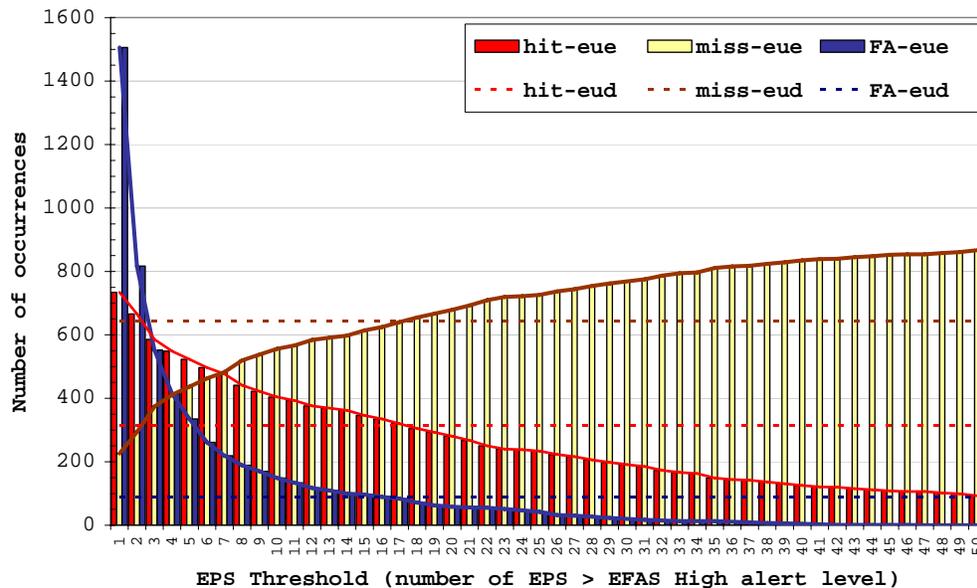


Figure 5.4: Hit, Miss and False Alert curves for deterministic-based forecasts (eud) and probabilistic-based forecasts (eue) for EFAS forecasts in July 2005.

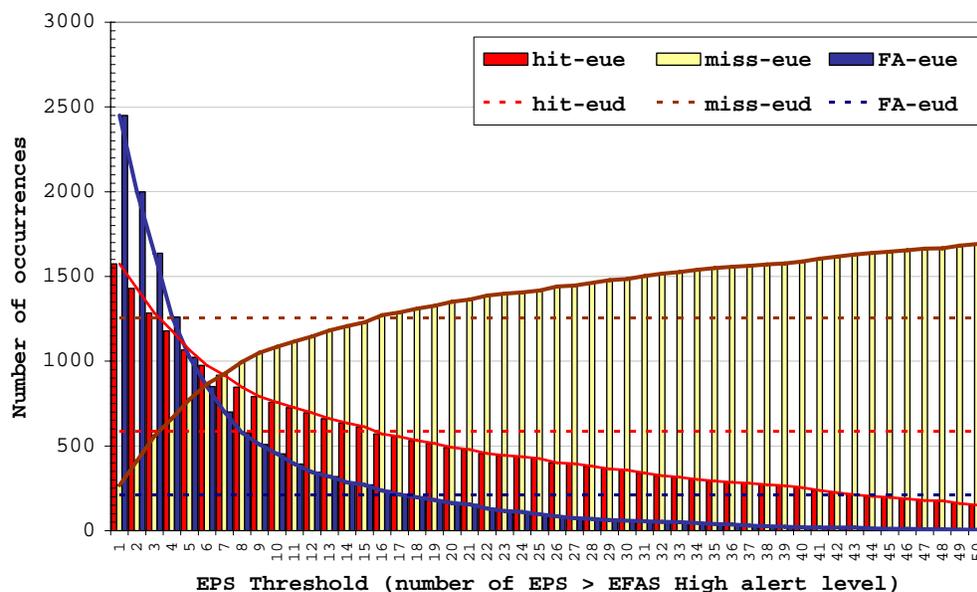


Figure 5.5: Hit, Miss and False alert curves for deterministic-based forecasts (eud) and probabilistic-based forecasts (eue) for EFAS forecasts in August 2005.

The results show that:

- the most flood prone months of July and August follow the typical expected curves of hit, misses and false alerts as a function of EPS criteria to define a forecasted event.

- Based on July-September data, if one waits for having more than 5 EPS above EFAS high levels, the *eue* hits become more important than the *eue* false alerts. However, when waiting for more than 7-10 EPS, the *eue* misses become more important than the *eue* hits. A threshold around 5-10 EPS simulations above high alert levels seems therefore to be a good compromise between hits, misses and false alerts in EPS-based forecasts.
- Also based on July-September data, the EPS threshold around 15-20 EPS simulations appears to be the one above which the *eue* hit-rate becomes smaller than the *eud* hit-rate. It shows therefore that if the system waits to have more than 15-20 EPS above high alert levels to issue a warning, the EPS-based simulations partially and statistically lose their additional value in increasing the successful early forecasting of flood events.

The additional value of EPS-based flood forecasts to increased preparedness was investigated by statistically evaluating the gain in preparedness (in days of lead time) of the *EUE* hits comparatively to the preparedness one can get from the analyses of *EUD* hits. Since EFAS is a system for medium-range forecasts, only lead times greater than 3 days were considered. The gain in preparedness was computed for the period from July to October 2005 and for different “EPS-Threshold”, N_{th} (number of EPS above EFAS High alert level). The results obtained for $N_{th} = 5$ and $N_{th} = 20$ are presented in Figures 5.6 and 5.7 respectively.

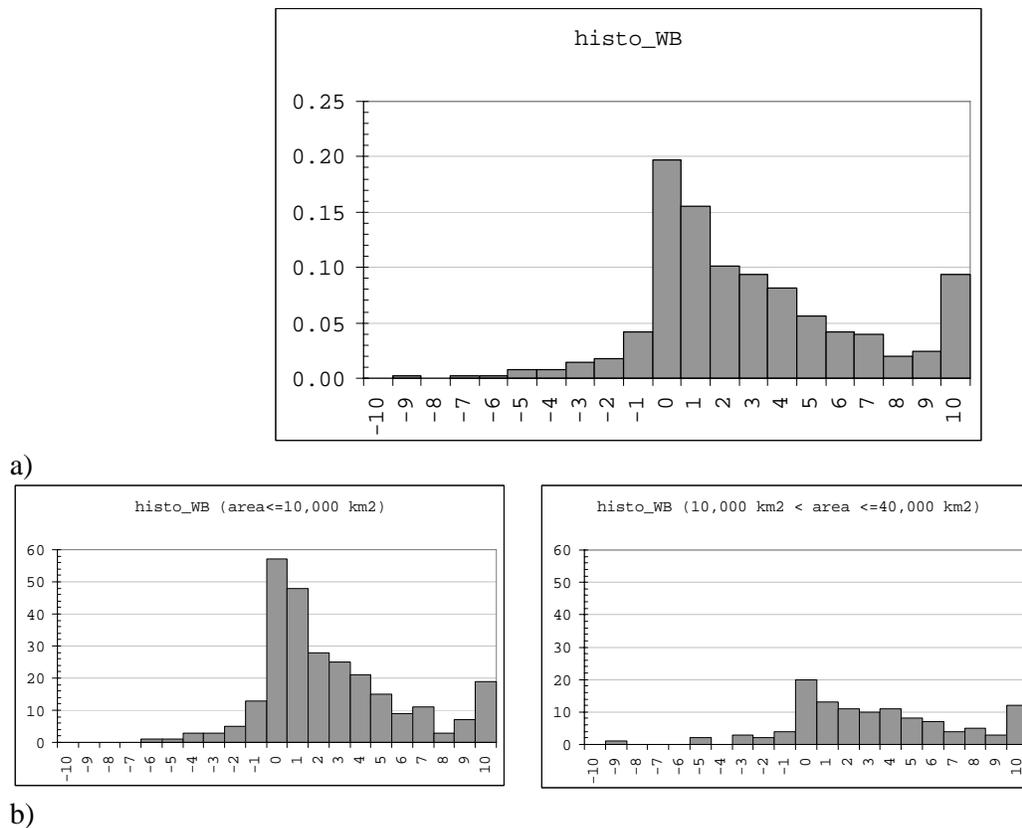
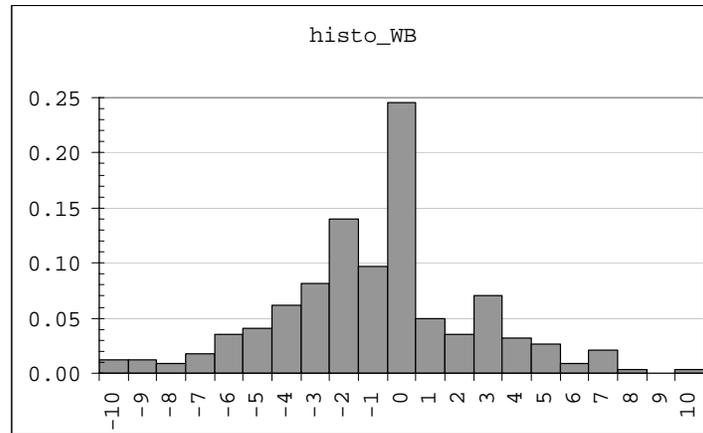
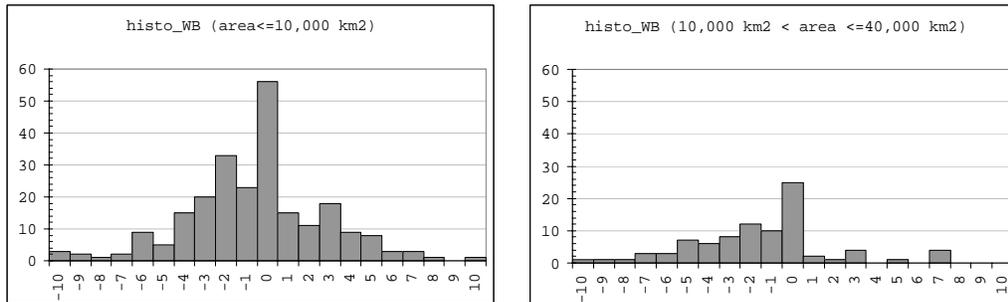


Figure 5.6: Gain (+) or Loss (-) in preparedness when comparing EFAS simulations based on EPS to those based on ECMWF deterministic forecasts for EPS-Threshold $N_{th} = 5$ (minimum number of EPS above EFAS High alert levels) for July to October 2005 in the Danube catchment: a) relative frequency considering all 70 points, and b) number of occurrences for points in small upstream areas (left) and larger upstream areas (right). X-axes in days of lead time.



a)



b)

Fig. 5.7 Gain (+) or Loss (-) in preparedness when comparing EFAS simulations based on EPS to those based on ECMWF deterministic forecasts for EPS-Threshold $N_{th} = 20$ (minimum number of EPS above EFAS High alert levels) for July to October 2005 in the Danube catchment: a) relative frequency considering all 70 points, and b) number of occurrences for points in small upstream areas (left) and larger upstream areas (right). X-axes in days of lead time.

The results show that:

- there is an important gain in lead time when considering at least 5 EPS simulations above EFAS high levels to define a forecasted event (Figure 5.6): the area under the positive part of the histogram is greater than the area under the negative part. The histogram of gain is less skewed for bigger areas and shows a more uniform positive gain. One can also see that for the same number of locations in each upstream area stratification (30 points at each sample), the number of occurrences (observed flood events forecasted by EFAS with more than 3 days in advance) for smaller areas is significantly higher.
- The general behaviour of the histogram of gain when considering at least 20 simulations above EFAS high levels to define a forecasted event opposes to the previous case (Figure 5.7): the area under the negative part of histogram is greater than the area under the positive part. For this EPS-threshold, the gain in lead time that EFAS can get from EPS-based simulations is less important. Most frequently there is no gain in preparedness compared to the deterministic-based forecasts.

5.3 Quantitative analyses of EFAS forecasts using different verification (skill) scores

For this study the results obtained from statistical analyses of EFAS forecast data for the whole of Europe on a $5 \times 5 \text{ km}^2$ grid were evaluated. The analyses are based on an 11-month period starting in July 2005. The quantitative approach assesses the performance of EFAS forecasts with regard to hit and false alarm rates, leadtime and upstream area. The improvement of forecast performance regarding

the use of persistence criteria is analysed. Furthermore, potential gain in leadtime of EFAS-EPS forecasts over EFAS deterministic forecasts is investigated.

5.3.1 Definitions

For this study certain definitions are important. In general, the following terminology has been adopted by the EFAS team:

Persistence for this study is defined as

- **Persistence in deterministic forecasts:** forecasts at time t and at time $t-1$ have discharges exceeding HAL in the same pixel. In this case the difference between t and $t-1$ is 12 hours. This is a persistence criterion that is already used in the semi-operational EFAS.
- **Persistence in EPS forecasts:** forecasts at time t and time $t-1$ have at least 5 EPS exceeding HAL in the same pixel. In this case the difference between t and $t-1$ is 24 hours as only the 12:00 EPS forecast were run over the whole analyzed period.
-

For *deterministic forecasts* are defined:

- **PH:** a positive hit means that both forecast and proxy have exceeded the EFAS high alert threshold
- **FA:** a false alarm means that the exceedance of the EFAS high alert threshold was forecasted but not simulated in the proxy
- **ME:** a missed event means that the proxy exceeded the EFAS high threshold but it was not forecasted.
- **CR:** correct rejections, meaning that both forecast and proxy are not exceeding the EFAS high alert, are not considered in this analysis.

Following these definitions a number of questions could be raised and answered. Some of them are described below but the majority is described in the EUR report (Thielen, Bartholmes, Ramos et al., 2006).

5.3.2. Probability distribution

If the probability distribution function was linear (see Eq 5.1) and 25 EPS out of 51 represented 50% probability for an event to happen, this result was obvious. However, looking at the EPS bins it becomes clear that the distribution of EFAS-EPS forecast results is slightly different from the expected one.

$$\text{Prob. EPS}_{\text{linear}} \text{ in } \% = \frac{1}{51}(nEPS) \quad \text{Eq. 5.1}$$

In figure 5.8 these results are shown as a cumulative distribution function of *Hit ratio_{EPS}* (see Eq.5.2) for a leadtime of 4 days (L03)¹.

$$\text{Hit ratio}_{EPS} = 100 * nPH / (nFA + nPH) \text{ [in \%]} \quad \text{Eq. 5.2}$$

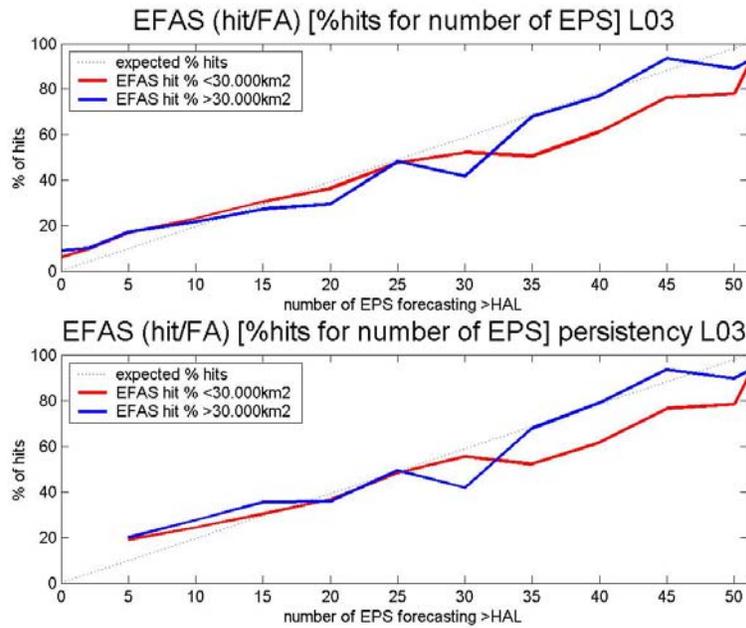


Figure 5.8 : Percentage of hits defined as $nPH/(nFA+nPH)$ shown on the y-axis for different EPS bins shown on the x-axis for a leadtime of 4 days (L03). Results for upstream areas less than 30.000 km^2 are shown in red and larger than 30.000 km^2 are shown in blue. The top diagram shows unconditioned results and the bottom diagram results conditioned on persistency of at least 5 EPS.

A linear probability distribution function as defined in (Eq 5.1) is represented by a straight diagonal line, plotted as grey dotted line in Figure 5.8.

Results for all lead times show, however, that there is a bias in lower EPS bins towards higher probabilities and in higher EPS bins towards lower probabilities. The probability of a hit with 5 EPS is of the order of 20% for a leadtime of 4 days, whereas 30 EPS have a lower probability than 60%. From 35 EPS onwards and for large upstream areas, the distribution follows more or less the linear probability distribution for the large upstream areas. For the smaller upstream areas there is a lower probability associated with higher EPS numbers compared to the linear distribution. A similar tendency can be found for other leadtimes as well (see Annex).

5.3.3. Effect of persistence on the reduction of false alarm rates

To analyse the effect of persistence in more detail the *Relative Hit ratio* 2_{EPS} was chosen:

$$\text{Relative Hit ratio}_{EPS}: \text{Ratio} = (nPH/nFA)_{EFAS} / (nPH/nFA)_{linear} \quad \text{Eq. 5.3}$$

The *Relative Hit ratio* can be interpreted as:

> 1: the forecasts have a higher probability to get a hit (for the respective EPS bin) than the linear reference distribution would let expect.

< 1: the forecasts have a lower probability to get a hit (for the respective EPS bin) than the linear reference distribution would let expect.

In figure 5.9 this score (Eq. 5.3) is plotted against the EPS bins for leadtime 4 days (L03). The grey dotted reference line at 1.0 marks the points where the single ratios $(nPH/nFA)_{EFAS}$ and $(nPH/nFA)_{linear}$ would be the same, i.e. the forecasted distribution follows equation 5.1.

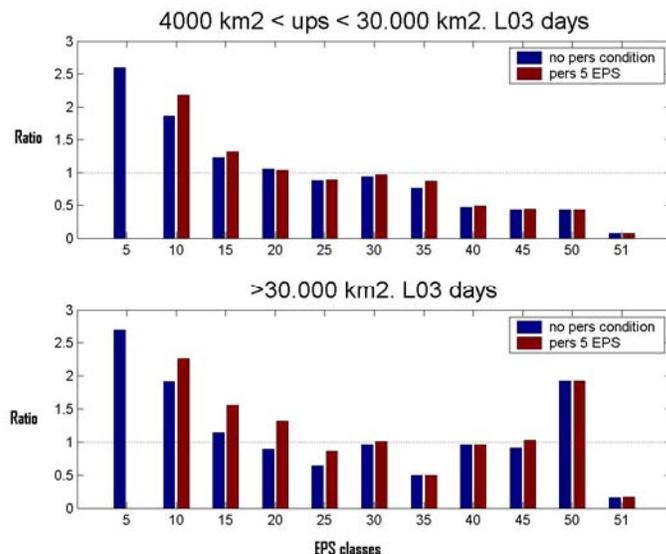


Figure 5.9: Relative Hit ratio $(nPH/nFA)_{EFAS} / (nPH/nFA)_{linear}$ on the y-axis for different EPS bins shown on the x-axis. Blue bars are unconditioned, red bars are conditioned on persistence of > 5 EPS.

The figure shows three important results:

- 1) Conditioning the EFAS forecasts on persistence mostly raises significantly the probability to get a hit. The improvement is particularly important in the lower bin classes and up to 25 EPS whereas it has little effect in larger bin classes. This result is also consistent for other leadtimes.
- 2) Up to 15 EPS there is clearly more skill than would be expected if the distribution was linear (Eq 5.1). This is also true for other leadtimes..
- 3) For smaller upstream areas the ratio as compared to the linear distribution decreases steadily with increasing EPS bins. This is different for the larger upstream areas, where the distribution of the ratio on the bin classes is u-shaped: after a local minimum around 25-35 EPS, the ration increases again.

5.3.4 EFAS skill as a function of upstream area classes

Figure 5.10 shows *Relative Hit ratio*_{EPS} (Eq. 5.3) but only for EPS bin 10:[8-12] and EPS bin 25:[23-27]¹ for different upstream areas ranging from 500 km² to larger than 30.000 km². The results are shown for 2 leadtimes 4 days (L03) and 5 days (L04). Again the reference ratio from the linear distribution is shown as line at 1.0.

¹ These bins differ slightly from the ones used in the previous part. 2 bins that had exactly 10 and 25 EPS members as mean were chosen for this visualization.

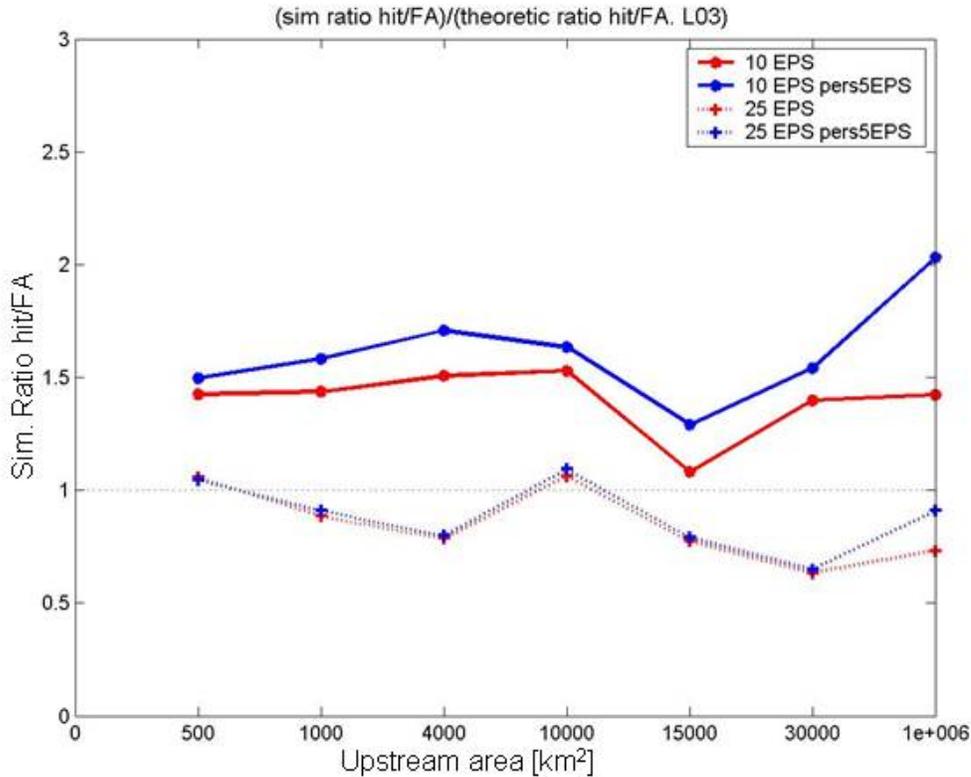


Figure 5.10: Relative Hit ratio $(nPH/nFA)_{EFAS} / (nPH/nFA)_{linear}$ for EPS bins 10 and 25 plotted over upstream area for leadtime 4 days. The full lines show the results for the 10 EPS bin and the dotted the results for the 25 EPS bin. The blue lines are with conditioning on persistency, the red without

Figure 5.10 shows clearly that:

- a clear cut-off line for the ratio of hit to false alarms depending on upstream area cannot be identified. When looking at the ensemble of all results the best skill can even be found in the smaller upstream areas. Results, not shown in this report, indicate that only for very small upstream areas of much less than 500 km^2 a tendency can be identified.
- For the 10 EPS bin the ration of hit to false alarms is mostly larger than the reference values, whereas for the EPS bin of 25 it varies around 1. This confirms the results in previous findings that 25 EPS roughly correspond to a 50% probability, whereas a smaller number of EPS has a higher probability than a linear distribution.

5.3.5. Evaluation of Brier skill score

The Brier score (BS) and the Brier skill score (BSS) are used to assess the skill in probabilistic forecasts. The Brier score is a measure of mean-square error of probability forecasts for a binary (yes/no) event. The Brier score (BS_f) of the forecast t is defined as

$$BS_f = \frac{1}{N} \sum_1^N (p - o)^2 \quad \text{Eq. 5.4}$$

where p refers to the probability with which an event is forecasted and o to the binary value of the observation ($o = 1$ if event observed and $o = 0$ if not observed). N is the total number of forecast dates. The Brier score indicates a perfect forecast if BS equals 0. Unfortunately, it is difficult to interpret in absolute terms and hence the Brier skill score (BSS) is being computed. In the BSS the Brier score of the forecast is compared against the Brier score of a reference climatology (BS_{clim}).

$$BSS = 1 - \frac{BS_f}{BS_{\text{clim}}} \quad \text{Eq. 5.5}$$

Thus the interpretation of the skill is strictly related to the reference: i.e. is the current forecast better or worse than assuming climatology. A BSS of 0 indicates that the forecast is not better than the reference forecast, while BSS values > 0 indicate that the forecast is better than the reference. Hamill et al. (2005) have shown that the interpretation of BSS is very sensitive to the choice of the reference climatology.

In the case of EFAS the choice of suitable climatology is not trivial, because strictly speaking there is no climatology to compare the results to. EFAS forecasts run with EPS only since a 12-13 months period. Using the simulations with observed meteorological data as reference introduces also a bias into the analysis because the data sets are not consistent. Observed data can, in any case not be used. It has therefore been decided to follow a suggestion of Legg and Mylne (2004) who propose to confront the Brier score of rare events with a forecast that always forecasts “no event”. In this case the climatic Brier score becomes:

$$BS_{\text{clim}} = \frac{1}{N} \sum_1^N (0.0 - o)^2 \quad \text{Eq 5.6}$$

The EFAS high alert threshold corresponds roughly to a 1-2 year return period. If this justifies the “no event” criteria can be debated – but as could be any other climatology.

It should further be noted that for this analysis Brier scores of correct rejections are not included, i.e. if nothing happened during the whole period and the forecast never indicated any probability ($\Rightarrow BS = 0$) for an event, then this was not counted.

The following diagram (Figure 5.11) shows the relative frequency (y-axis) of Brier skill scores (x-axis) for different upstream areas at a leadtime of 4 days not conditioned (top) and conditioned on persistence on 5 EPS (bottom).

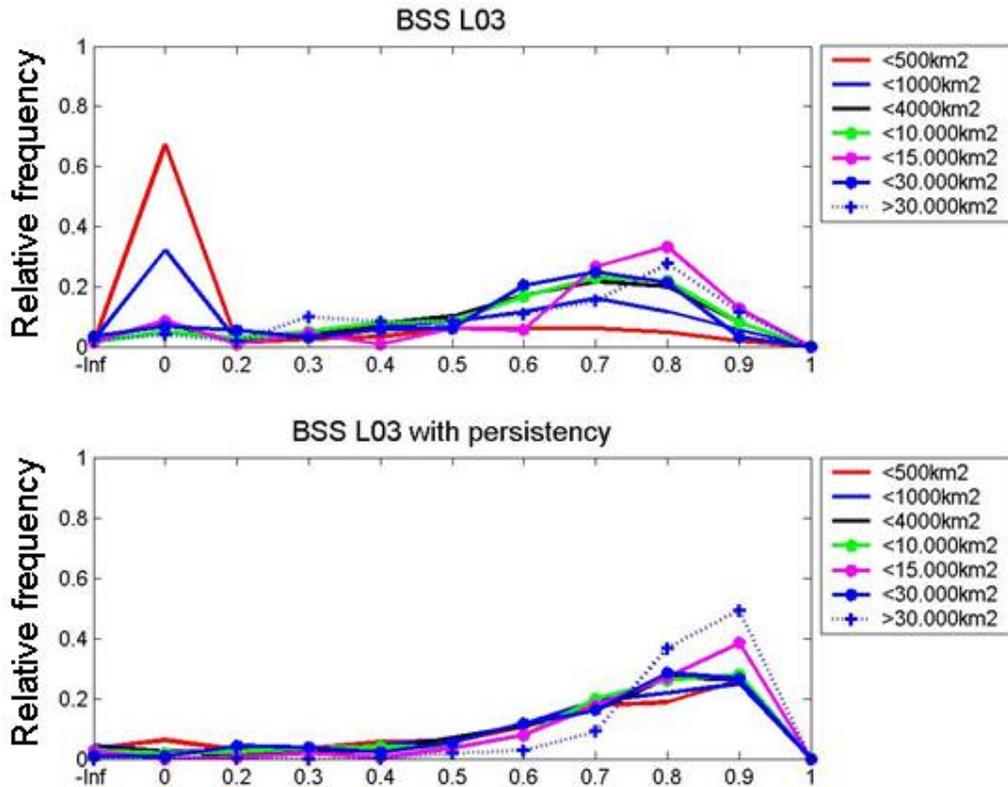


Figure 5.11: Relative frequency (y-axis) of Brier skill score (x-axis) distribution of EFAS EPS forecasts for different upstream areas for a leadtime of 4 days

The most striking feature of Figure 5.11 is the benefit of introducing persistence in EFAS. In this case the high number of BSS around zero in small upstream areas is totally eliminated (in this case of leadtime 4 days up to 4000 km²) and the whole distribution of BSS is shifted to higher skills.

Interesting for EFAS applications is also the spatial distribution of the forecast skill. Figure 5.12 shows a map of Europe with BSS for leadtime 4 days and figure 5.13 shows a map of Europe with BSS for leadtime 10 days.

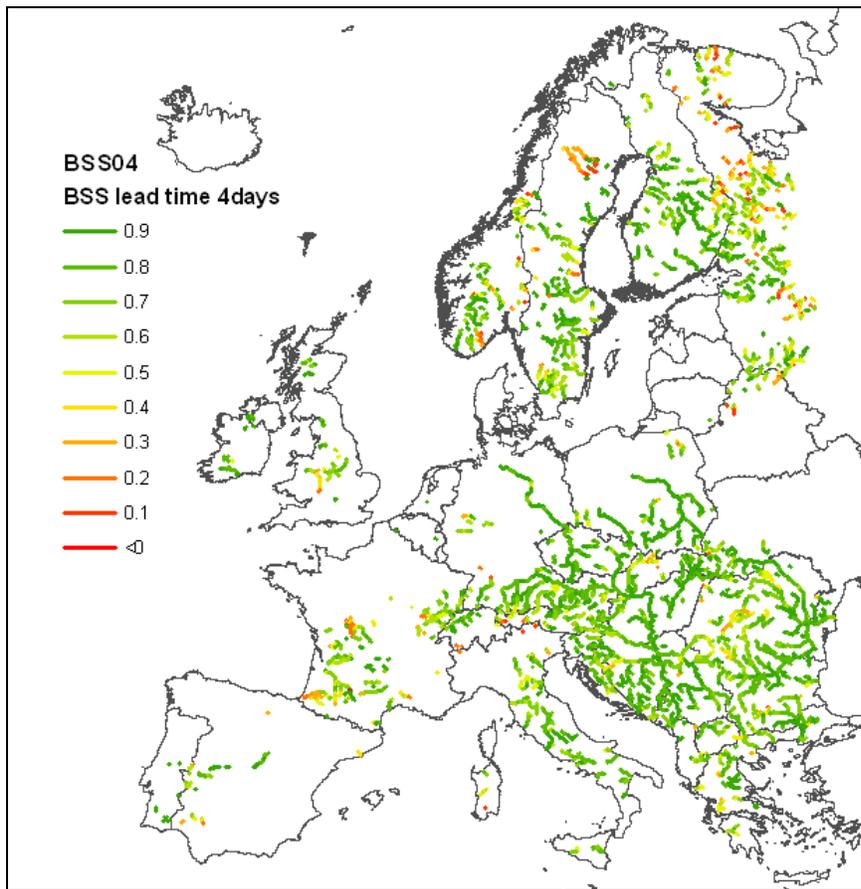


Figure 5.12: Spatial distribution of BSS conditioned on persistency (5 EPS) for lead time 4 days

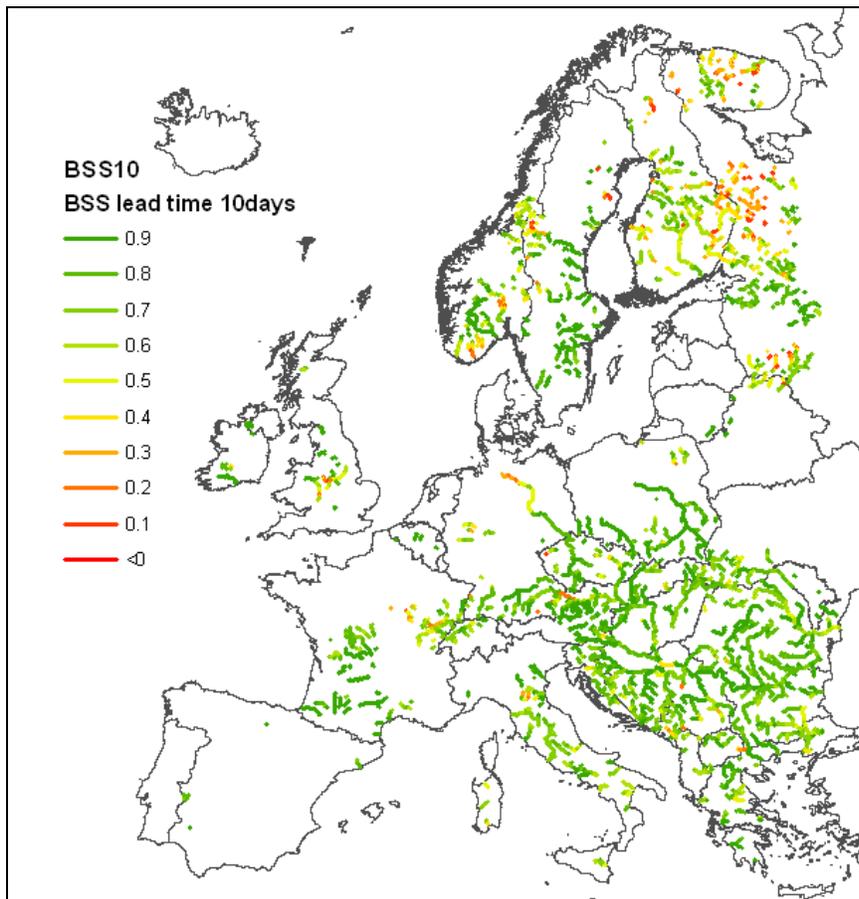


Figure 5.13: Spatial distribution of BSS conditioned on persistency (5EPS) for lead time 10 days

The results of figures 5.12-13 show that the BSS is only defined for those areas where floods took place or were forecasted (with at least 5 EPS) during the reporting period. It also shows that in large areas where no floods took place also no floods were forecasted (with more than 5 EPS). Furthermore, after 10 days of leadtime there is still skill in the forecasts.

5.3.6. EFAS results as a function of leadtime

For EFAS forecasters it is important to know at what rate the skill of the forecasts decreases with increasing leadtime. This section analyses these results for the probabilistic and the deterministic results. Again, the analysis focuses on two classes of upstream areas, with $4000\text{km}^2 < \text{ups} < 30.000\text{ km}^2$ and $30.000\text{ km}^2 < \text{ups}$.

In Figure 5.14 the mean of the BSS is shown as function of leadtime and for the two upstream area classes and only conditioned on persistence of 5 EPS.

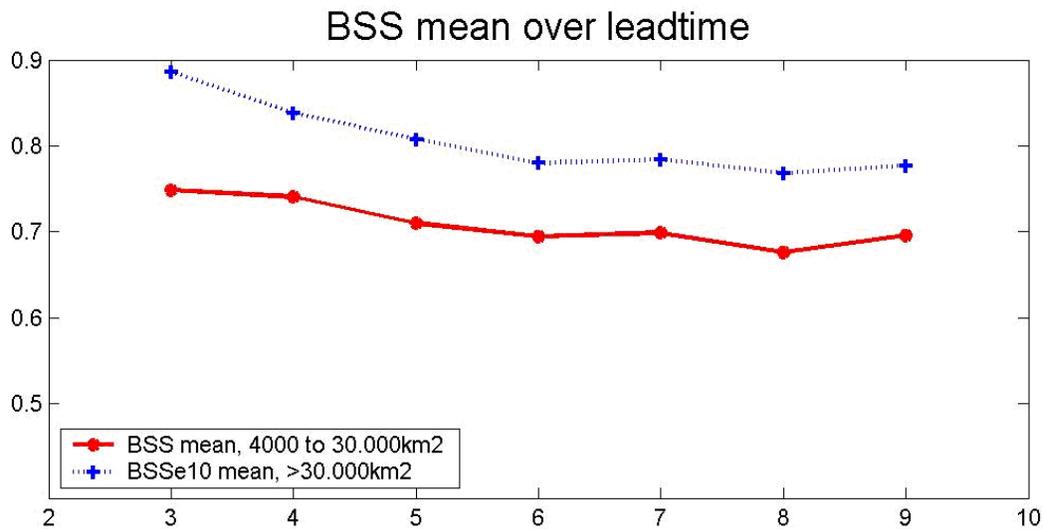


Figure 5.14 : Mean BSS (y-axis) as a function of leadtime (x axis) and upstream area. Upstream areas of $4000 \text{ km}^2 < \text{ups} < 30.000 \text{ km}^2$ is shown in red and $\text{ups} < 30000 \text{ km}^2$ shown in blue.

Figure 5.14 clearly illustrates a number of interesting results.

- EFAS EPS based on persistence and using the no event criteria as climatology is skilful even at very long leadtimes
- The skill decreases (almost) steadily with increasing leadtime
- The skill is slightly lower for the smaller upstream areas than for the larger upstream areas. However, it still remains skilful for both classes.

5.3.7 Conclusions on statistical analysis

The statistical analysis, pixel by pixel, of 11 months of EFAS-forecast data revealed most of all the usefulness of conditioning EFAS forecasts on a persistence criterion. If the persistence is based on a minimum number of EPS or on the deterministic forecast it always results in a considerable improvement of skill and reduction of false alarm rates. Other criteria can be envisaged and will be investigated in the future (i.e. a combination of EPS based and deterministic criteria could be envisaged).

If persistence is not taken into account, the forecasts for small upstream areas below 4000 km^2 reveal little to no skill. Conditioned on persistence, however, also the small scale areas reveal as much skill as the larger areas.

The probability distribution of EFAS-EPS members exceeding the EFAS high alert threshold is not a linear distribution like in equation 5.1. From the current analysis it can be estimated that the probability of an event to happen for the lower EPS bins up to 20 is higher than expected from the linear probability distribution.

In terms of leadtime, there seems to be a large potential of gaining lead time when using EFAS-EPS over the deterministic forecasts.

The comparison between the performance of EFAS based on different deterministic weather forecasts shows that EFAS ECMWF deterministic forecasts performed better as for all upstream areas there were more hits than False Alarms up to 5 days of lead time while this was not the case for the EFAS–DWD forecast.

5.4. Exploratory research within the framework of PREVIEW

The COSMO-LEPS system has been used in the PREVIEW project to dynamically downscale the global VAREPS forecasts provided by ECMWF. One of the rationales for using COSMO-LEPS instead of simpler, purely statistical downscaling methods is that the COSMO model is better capable to simulate small-scale phenomena, and can thus provide some extra, valuable information on the top of the global VAREPS system.

This section discusses results obtained by COSMO-LEPS system, a high-resolution EPS based on the boundary conditions from the EPS system and run with the LokalModell of the Deutscher Wetterdienst, for the period September-November 2004, when the population of the mesoscale system was set to 10 members. More specifically, COSMO-LEPS is compared to the ECMWF EPS to assess whether it can add valuable information to the one produced by the ECMWF EPS. When comparing the two ensemble systems one should bear in mind the two ensemble systems differ both in membership (10 for COSMO-LEPS and 51 for the EPS) and resolution (10 km for COSMO-LEPS and 80 km for the EPS). To assess the impact of ensemble size, COSMO-LEPS is compared to the full-size EPS, and to 10-member EPS consisting of the 10 Representative Members used to define the COSMO-LEPS initial and boundary conditions (Marsigli et al 2001, Molteni et al 2001). To alleviate the fact that COSMO-LEPS has a higher resolution, both systems are verified on the same 1.5 degree grid: for each 1.5 degree box, grid point forecasts are aggregated and averaged. The aggregation of the forecast values is performed considering different features of the forecast probability distribution within the box. Similarly, observations within a box are treated, as the forecast values, as aggregated values (Marsigli et al 2005).

The comparison is performed over a geographical region that includes Germany, Switzerland and Northern Italy, considering 24-h precipitation (accumulated from 06:00 to 06:00 UTC), verified against observations from a very dense network of rain-gauges (about 5000 observations per day).

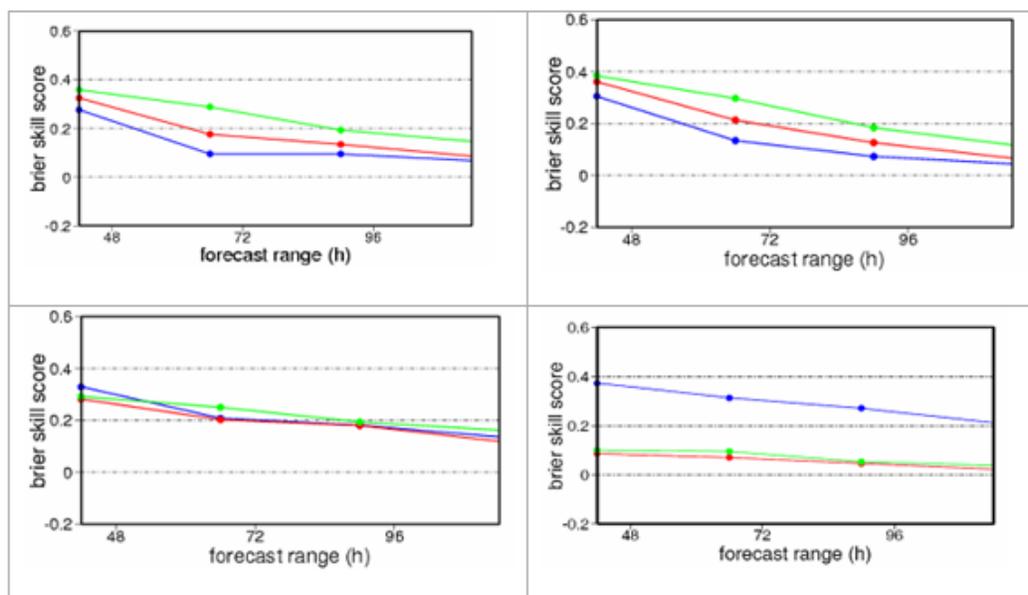


Figure 5.15. Brier Skill Score relative to the event “precipitation exceeding 10mm/24h” for different forecast ranges. Top left: average values; top right: 50th percentile; bottom left: 90th percentile; bottom right: maximum values. Blue lines are relative to the COSMO-LEPS system, red lines to the small-size EPS and green lines to the full-size EPS.

Figure 5.15 shows the Brier Skill Scores for different measures of precipitation distribution and for 3 different forecasting systems: COSMO-LEPS (10 members), full-size EPS (51 members), small-size EPS (10 members). Results confirm that forecast accuracy strongly depends on the type of measure which used to assess it. Considering average precipitation, EPS performs better than the mesoscale system (top-left panel), indicating higher skill in predicting the total amount of precipitation deployed over a large area. On the other hand, if attention is focused on the prediction of maximum values, COSMO-LEPS BSSs are higher (bottom-right panel). This is probably due to the better capability of the mesoscale system to forecast precipitation peaks accounting for minor localisation errors. Results based on the prediction of the 50th percentile (Fig. 5.15, top-right panel) are similar to those obtained for average precipitation, while results based on the prediction of the 90th percentile (i.e. the of the precipitation distribution) shows that both COSMO-LEPS outperforms the other two systems, again possibly due to its higher horizontal resolution.

Overall, these results indicate that the 3 systems (51m-EPS, 11m-EPS and COSMO-LEPS) have comparable skill if predicting precipitation when measured using the metrics described above.

Using the different input data for flood simulations allows differentiating their advantages under certain conditions. Figure 5.16 shows a flood forecast with leadtime of 4 days for the different input data: EPS (red), VAREPS (blue), COSMO-LEPS (Green), deterministic ECMWF (green dashed), deterministic DWD (red dashed), simulated discharge with observed meteorological input data (purple solid line) and finally observed discharges (light blue solid line). It is clear from figure 5.16 that only COSMO-LEPS captures the peak discharge while both EPs and VAREPS underestimate.

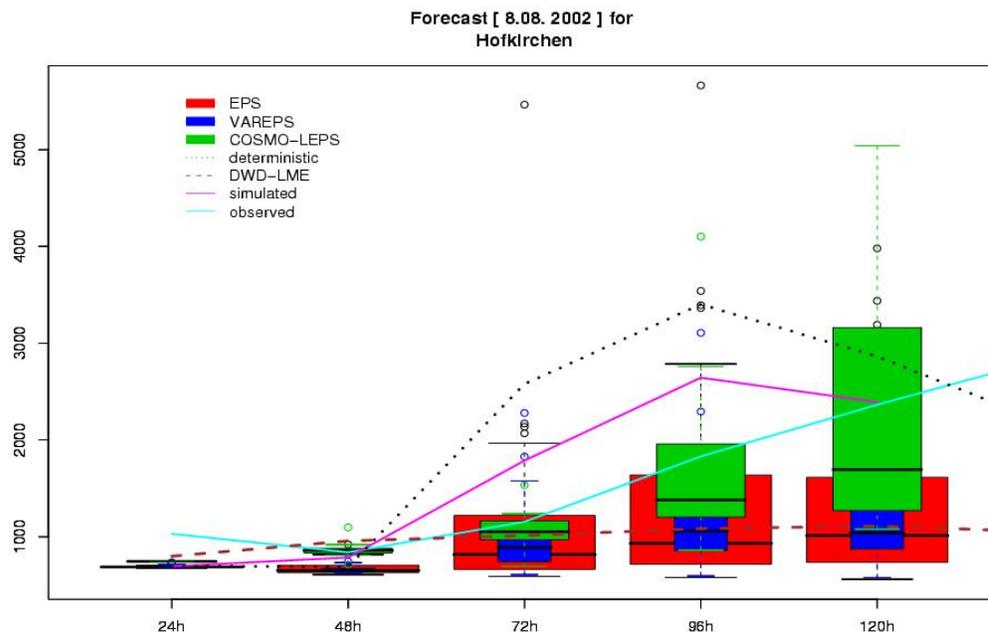


Figure 5.16 4-day discharge forecast for Hofkirchen starting on 08.08.2002 based on inputs from ECMWF-EPS, ECMWF-VAREPS, COSMO-LEPS, deterministic forecasts from ECMWF and DWD. Further the simulated discharges based on observed meteorological data are shown as well as the observed discharges.

A different way of exploring the data is by looking at the probability density functions illustrated in Figure 5.17.

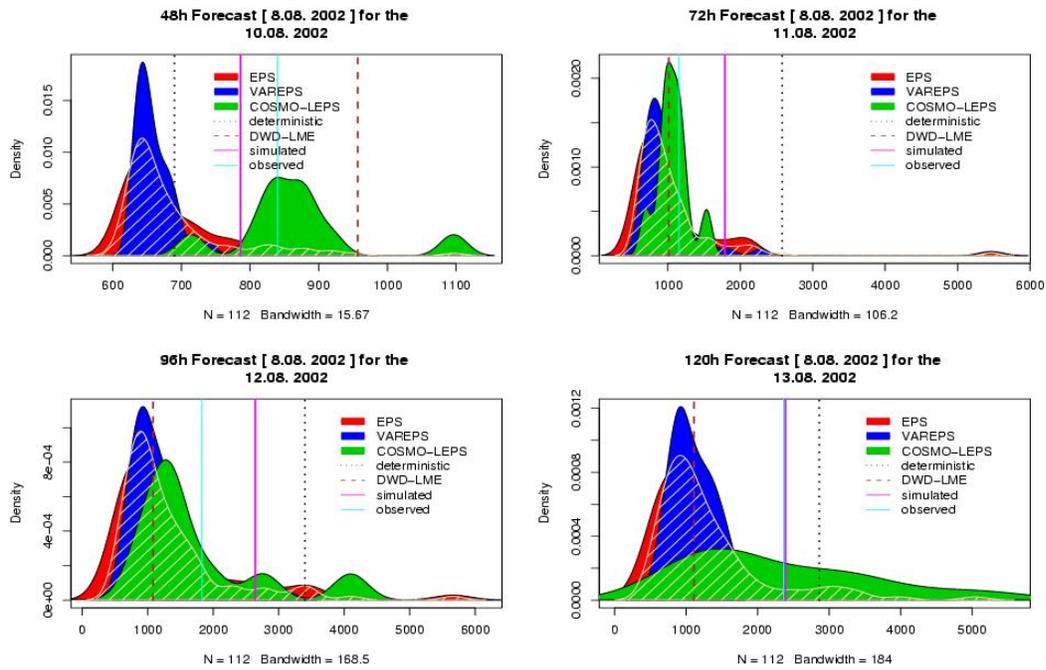


Figure 5.17 Probability density functions of the three ensemble forecasts EPS, VAREPS and COSMO-LEPS as a function of leadtime for 48 h (tl), 72 h (tr), 96 h (bl) and 120 h (br).

One aim of the research is to see if by using Bayesian model averaging it would be possible to calculate the probability of the event to happen by staying within reasonable uncertainty bounds. Figure 5.18 illustrates such an approach. In this case the HQ_{50} is $3700 \text{ m}^3/\text{s}$ and the probability to reach this threshold is 60% ($Q > HQ_{50}$) = 0.6).

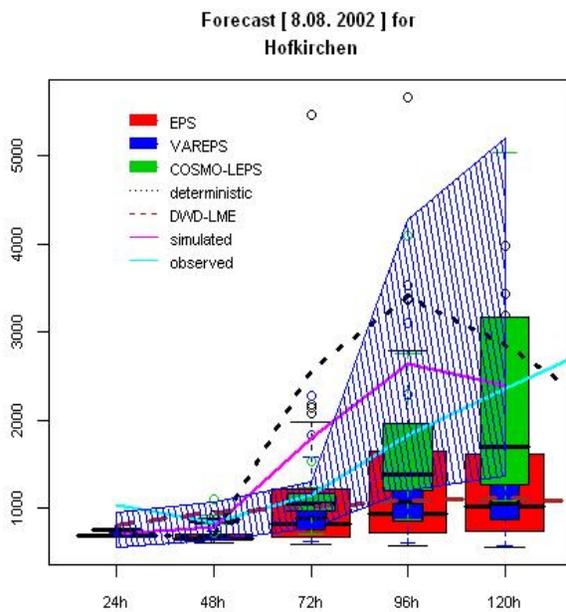


Figure 5.18 Illustration of Bayesian averaging for a 4 day forecast starting at 08.08.2002 for Hofkirchen (Danube).

6. Main problems encountered

During 2006 no major problems were encountered. The biggest ones during the reporting period were related to the reception of observed meteorological data. During about 50 days the data were delayed and the initial conditions estimated for longer time periods than necessary. A strong communication link has been established between the JRC Mars group (agrifish unit) in order to shorten this delay as much as possible.

In certain cases the downloading of corrupted meteorological data files caused problems in the forecasting when resulting missing values propagated through the forecasting and the next initial conditions. Special checks to capture such cases and prevent the spreading of the error have been implemented.

Other problems were related to the Webserver that was not synchronized properly between the internal and external webserver. As a consequence the access to the EFAS information from outside the centre was not always accessible. This option was used during the Christmas period when EFAS forecasts were done remotely through internet. At the end the information of the old webpage was used to check the forecasts. If reports had had to be written this would have been clumsy. Some problems have been identified and are being checked.

Further, notorious disk space problems were also present during 2006, in particular during the time of re-analysis. The lack of easily available disk space was a problem and caused many delays.

6. Way forward: suggestions to bring the EFAS prototype to an operational system

In order to make EFAS a truly operational system a number of requirements need to be met as listed below. The list is indicative and only the most important ones listed.

6.1. Issues that need addressing before EFAS can be an operational service

1) *Improve model simulations*

- **Collect high-resolution meteorological data** available at a temporal resolution of at least 6 hours both for long-term historic time series. The more data points available the better for the calibration and the calculation of the initial conditions. Required data density may differ depending on climatological zone hydrological regime. The density of the stations should in any case not be less than 2500 stations for Europe (current station network) and ideally approach 10000 stations if possible.
- **Collect sufficient discharge data**, ideally also available at 6 hourly time intervals for the calibration of the model. Data in real-time would help to assess the quality of the forecasting model. Sufficient data should be available and a minimum of In case the discrepancy between observed discharges and simulated discharges are little, possibly updating could be envisaged.
- **Improve static maps used in EFAS**. Already for the next prototype version much work has been invested into the correction of the static maps used for LISFLOOD in EFAS. Landuse, topography, soil, and all channel maps have been corrected where appropriate. Much work remains to be done, however, for all channel related maps. The drainage network is sometimes faulty, e.g. entire sub-catchmentes do not drain into the right river at the right location. River width and river lengths have been corrected wherever high resolution data were available, however, this was only done for Elbe and Danube. For many of the other European rivers these data are not available. River width could potentially be estimated from satellite data or be collected within the frame of the EU-FLOOD-GIS database.
- **Facilitate calibration runs**. Currently and for the new prototype the calibration exercise has been prepared per catchment and set-up on individual PC's. The reason for this is that the JS method only runs on PC. Ideally the data should all be centrally stored and routines implemented that allow easily rerunning calibrations for individual catchments by making optimum use of the existing computer power. This can either be done by running the calibration on the linux cluster instead of individual PC's (e.g. optimize LF method or adapt JS method for the cluster) or by pulling together free PC CPU time into a windows cluster and distribute tasks.
- **Model improvements**. Adapt the model better to the needs of the flood forecasting, possibly with improved routings, taking into account observed discharges, etc.
-

2) **Improve flood forecasting through cleaned and modified NWP data**

- **Correct for weather forecasting biases** of the individual weather forecasts (DWD, ECMWF and potentially others) on the European scale as a function of geographical area and season. Use the information on the bias to correct the weather forecasts and improve the input data (Research)
- **Apply downscaling techniques** where necessary to improve the spatial and temporal resolution of the weather forecasts as input into the flood forecasting model (Research). Use dynamic downscaling whenever possible, e.g. COSMO-LEPS and potentially HIRLAM for the deterministic ECMWF to get better input during the first few days of

forecast (Research)

- Possible attempt *weighting of NWP inputs* with regard to historic performance (Research)

3) Improve probabilistic component in EFAS

- *Foster probabilistic exploration on flood forecasts.* During the first development phase of EFAS still the deterministic component and analysis has been favoured. The next prototype should become entirely probabilistic driven. For this the proper probability distribution function should be calculated and probabilities shown (instead of n EPS/N). Different ways of dealing with probabilistic forecasts should be explored and tested e.g. Bayesian averaging.
- *Include more probabilistic forecasts*, e.g. COSMO-LEPS and/or the GFS forecasts, VAREPS data

4) Improved EFAS interface and interaction with end-user

- *Dynamic web-based interface* where the user can interact with the forecasts, e.g. select information points, combine information from different data sources, calculate different statistics on their river basin, ...
- *Active discussion forum* allowing the different users to discuss issues and/or make suggestions
- *Active help desk* allowing the user to ask questions, retrieve data,

5) Improved hardware

- *ensure that best hardware and software options* are available for EFAS and not working with old structures or equipment. Sufficient disk space and fast disks need to be available
- *stabilize hardware, data transfer* and access to server also during weekends, independent power circuits
- have access to *fast internet connections* (JANET)

6.2 Roadmap for future operational EFAS

2007&2008:

- Getting the system ready for transfer
 - improved system set-up
 - Improved and tuned hydrological model
 - Bias removal and downscaling techniques for meteorological forecasting data.
 - Incorporation of real-time discharge data into the system (either for accuracy checking or updating)
 - Research on better use of probabilistic flood forecasting
 - Research on uncertainty cascading in flood forecasting
- Collect real-time and high-resolution data (EU-FLOOD-GIS and ETN-R projects)
- Identify potential operational entity

2009

- Transition period at new operational entity
 - Put into place the coordination of the new office

(1-2 responsible)

- investigate hard-and software needs
- prepare contacts (MoU's)
- prepare data contracts for real-time data flows
- budget overview
- negotiations with data providers and endusers

2010

- Transfer
- Parallel services at new operational office and JRC for 6-months transition period

2011-2014

- Research at the JRC into different aspects of EFAS
- Research

7. EFAS team 2006

Organisation

Guido Schmuck (Unit Head)

Ad de Roo (Action leader Weather driven Natural Hazards)

Forecasting, development and research team

Jutta Thielen (*EFAS task leader, forecasting, research and development*)

Jens Bartholmes (*EFAS technical responsible, forecasting, research and development*)

Konrad Bogner (*research within the PREVIEW project and forecasting*)

Luc Feyen (*calibration, research on uncertainty and forecasting*)

Simone Gentilini (*data processing and programming*)

Giovanni Laguardia (*research on soil moisture and forecasting*)

Davide Muraro (*forecasting and web development*)

Stefan Niemeyer (*research on soil moisture and forecasting*)

Maria-Helena Ramos (*exploratory research and forecasting*)¹

Peter Salamon (*calibration, research on bias removal and forecasting*)²

Johan van der Knijff (*model and tool development and forecasting*)

Pilot catchments

Meike Gierk (*Data collection and calibration of Elbe with high-resolution data*)

Milan Kalas (*Data collection, calibration of Danube, software development and forecasting*)

Janos Szabo (*Data collection, software development and calibration of Danube*)

Karl Wachter (*Data collection and calibration of Danube*)³

Jalal Younis (*Data collection, Elbe calibration, research on best operational set-up for the next prototype, EMM, and forecasting*)

GIS support

Katalin Bodis (*Map processing and correction and maintenance of EFAS webpage*)

Data management

Rado Bonk⁴ (*Development and maintenance of databank*)

IT support

Mauro del Medico (*specific IT support for WDNH and EFAS*)⁵

(Stefano Venturini (*LMU IT support*))

Carlo Antoniotti (*LMU data base*)

Giorgio Liberta (*LMU webservice*)

¹ left December 2006; ² arrived November 2006, ³ left November 2006, ⁴ Left October 2006

⁵ also participating in development

8. Documents produced within the context of EFAS in 2006

8.1 Peer-reviewed publications related to EFAS:

Luc Feyen et al., Parameter optimisation and uncertainty assessment for large-scale streamflow simulation with the LISFLOOD model, *Journal of Hydrology* (2006), doi:10.1016/j.jhydrol.2006.07.004.

Milan Kalas, M.H. Ramos, J. Thielen and G. Babiakova (submitted) Evaluation of the medium-range European flood forecasts for The March-April 2006 flood in the Morava river; submitted to *Journal of Hydrology and HydroMechanics* (2006)

8.2 Conference proceedings related to EFAS:

Kalaš M., Wachter, K., Szabó, J. A., Bódis, K., Niemeyer, S., van der Knijff, J. & de Roo, A., 2005: Setup, calibration and testing of the LISFLOOD model for the Upper Danube River basin on 1km. *Geophysical Research Abstracts*, Vol. 7, 09183, 2005, SRef-ID: 1607-7962/gra/EGU05-A- 09183, European Geosciences Union 2005.

Kalaš, M., Feyen, L., Vrugt, J.A., 2006: Semi-distributed calibration of a rainfall-runoff model for the Morava catchment using global optimization. *Proceedings of the XXIII Conference of the Danubian Countries on the Hydrological Forecasting and Hydrological Bases of Water Management*, 28-31 August 2006, Belgrade, Republic of Serbia, CD-ROM, 12p.

Thielen J., Bartholmes J., Ramos M-H., Kalas M., van der Knijff J. & de Roo A., 2006: Added value of ensemble prediction system products for medium-range flood forecasting on European scale. In: *Proceedings of the workshop "Ensemble Predictions and Uncertainties in Flood Forecasting"*, International Commission for the Hydrology of the Rhine Basin (CHR), Bern Switzerland, 30-31 March 2006, p.77-82.

8.3 Reports

J. Thielen (Ed.) (2006) The benefit of probabilistic flood forecasting on European scale - Results of the European Flood Alert System for 2005/2006, European Commission EUR report EUR22560EN, European Commission, 2006

8.4 EFAS Bulletins

EFAS bulletin2006_1- Jan/Feb
EFAS bulletin2006_2 – Mar/Apr
EFAS bulletin2006_3 – May/Jun
EFAS bulletin2006_4 – Jul/Aug
EFAS bulletin2006_5 – Sep/Oct
EFAS bulletin2006_6 – Nov/Dec

EFAS yearbook2006 (collection of individual bulletins including a summary)

9. Summary and Conclusions

Overall the year 2006 has been very successful for EFAS both from the operational as well as the research side. The forecasting system ran smoothly and without too many problems with the same set-up as in the previous year. Over 140 reports were sent out and many positive feedbacks received. This persistent set-up produced consistent results that could be analysed in a statistical way. The dramatic spring floods in Danube and Elbe during March and April 2006 proved once again that an operational EFAS could represent a truly added value for the national forecasting centres.

The floods also allowed identifying certain shortcomings of the model that could be addressed during the year. Much work was invested in correcting base maps and model processes that were not accurately coded in the LISFLOOD model. Based on this work the new calibration of the system was started in 2006 and finalized early 2007.

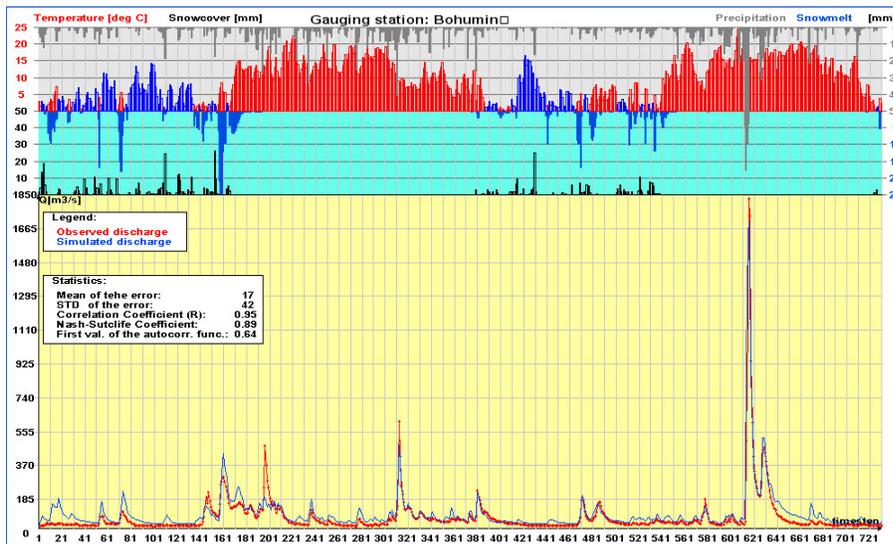
The biggest achievement during 2006 was the research work that was performed on the operational EFAS results. A large report containing information on the performance of EFAS was delivered to the ECMWF council and was received very positively. As a consequence EFAS got the green light to go ahead and is not more flexible in its reporting schemes. This research work has been intensified throughout the year and interesting results have been obtained. Some of them are briefly demonstrated in this annual report but much more can be found in the specific reports. This research has been complemented with targeted work on the Danube river basin within the framework of Preview and with work on combined uncertainty, e.g. in the Meuse river basin.

Much work has also been invested in preparation of the new prototype, not only from the calibration point of view but also the interface point of view. A webbased user interface has been developed which will be tested by the partner organizations during 2007. This interface will allow the endusers to view the forecasting results directly and at the same time have more interaction with the endusers, e.g. through online feedback and discussion forums.

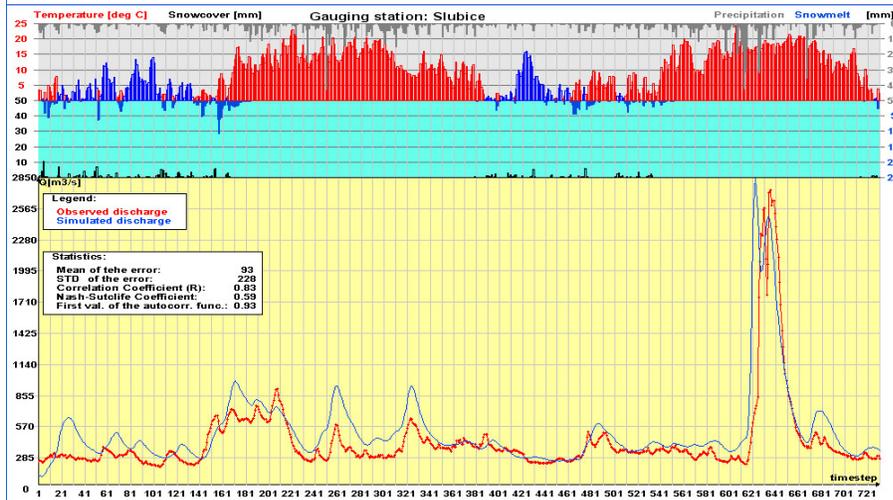
Data collection has been started through two big projects, the EU-FLOOD-GIS project and the ETN-R project. Both projects delivered promising results during the first 6 months.

The work during 2006 has been tremendous and is the results of a big team effort.

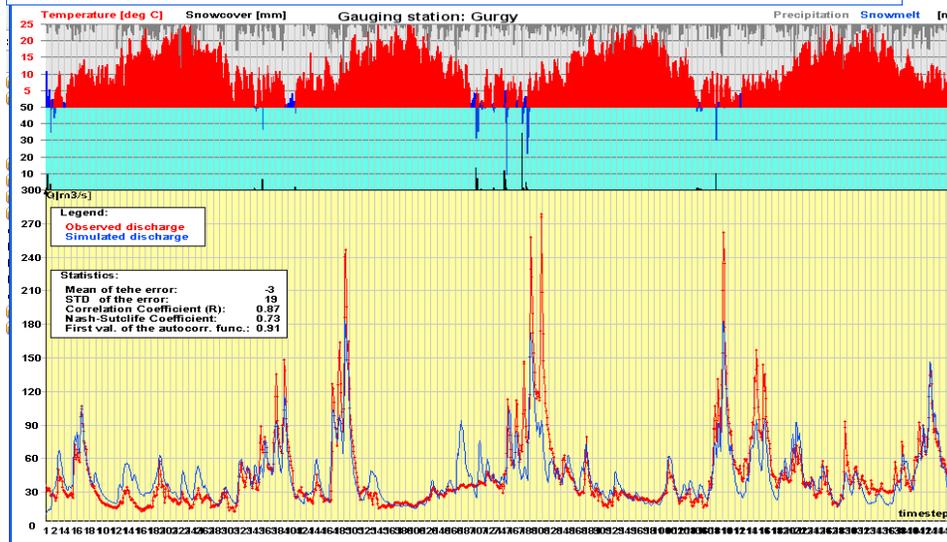
Annex A: Examples of the calibration results for the EFAS 2007 for different river basins



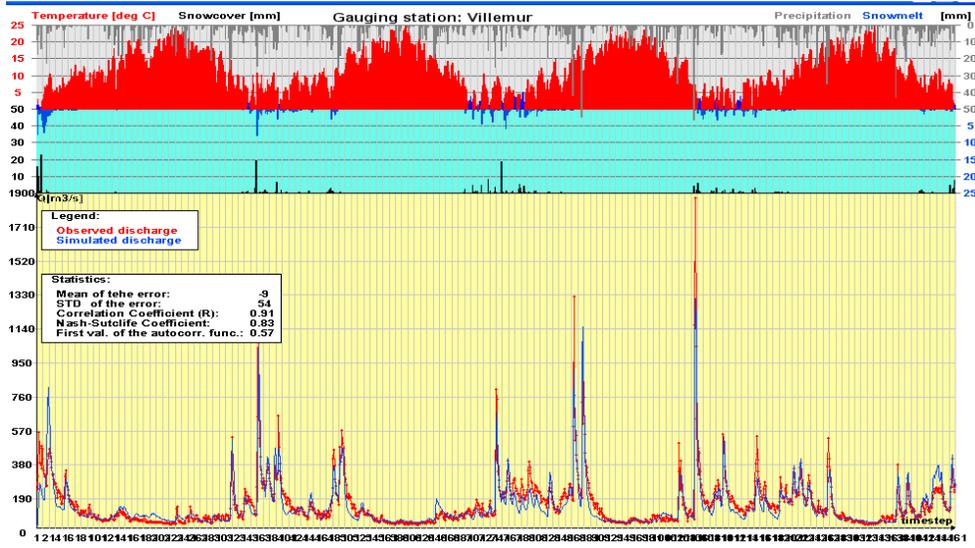
Odra at Bohumin (1996-1997)



Odra at Slubice (1996-1997)



Seine at Gurgy, 1996-1999)



Gironde at Villeneuve (1996-1999)

Annex B. Text of renewed EFAS Memorandum of Understanding

Memorandum of Understanding

No. XXXXXXXXXXXXXXXXXXXX

between the

Institute for Environment and Sustainability

and the

XXXX Institute

on

The development of a European Flood Forecasting System

The European Community, represented by the Commission of the European Communities, represented for the purpose of signing this Memorandum of Understanding by Mr. Manfred Grasserbauer, Director of the Institute for Environment and Sustainability, of the Joint Research Centre,

on the one part,
and

The xxxx institute

on the other part

Hereinafter referred to individually as “the Party” or collectively as ‘the Parties’.

PREAMBLE

Whereas it has been observed that in Europe the numbers of severe floods have been increasing over the past decades.

Whereas the Parties wish to establish a mutually beneficial relationship;

Whereas both Parties recognise strong complementary assets between their facilities and their testing and simulation methodologies and are aware of the necessity to share the knowledge arising from the JRC research activity on the development and testing of a European Flood Alert System (EFAS).

Whereas the activities and the organisational structure of both Parties shall form the subject matter of this Memorandum;

Whereas the Parties in accordance with the present Memorandum will encourage joint and co-operative initiatives relevant for the EFAS activity.

In consideration of the above, the Parties hereby agree to the following:

ARTICLE 1 - Subject and Scope of the Collaboration

1.1 Subject of the Memorandum of Understanding (MoU) is the future collaboration between the Parties in the field of: "Development and testing of a European Early Flood Alert System" ("the Field")

1.2 The Parties have expressed their intention to hold a meeting once per year in principle for presentation of the respective activities. The date and place will be decided by mutual agreement.

1.3 Aim of the collaboration is to co-ordinate as far as possible the research activities in the fields of common interest, as identified hereafter, in order to avoid duplication and enhance efficiency.

1.4 Discussions between the Parties have resulted in the identification of the following area of common interest: Improvement in Flood Forecasting.

The exact definition of these fields will be done within a Technical Annex to this Memorandum of Understanding. The Technical Annex may be revised at the annual meeting.

1.5 In case the Parties decide, under this MoU, to implement joint projects, they shall, prior to starting work and on a case-to-case basis, conclude in advance, a specific written collaboration agreement related to the joint project. These collaboration agreements will cover technical, legal (including the responsibilities of each Party and intellectual property rights) and financial aspects as far as necessary.

ARTICLE 2 - MODALITIES OF CO-OPERATION

The modalities of co-operation can i.a. be the following:

Identification of specific fields of common interest

Exchange of information

Stimulation and establishment of a platform to promote, discuss and co-ordinate activities related to the Field and the results thereof.

Exchange of research personnel;
Joint organization of meetings, symposia and workshops;
Exchange of information and academic materials;
Exchange of results of research programs.

ARTICLE 3 - COSTS

- 3.1 Each Party shall bear its own costs in connection with the implementation of this MoU.
- 3.2 There will be no transfer of money between the Parties in connection with this MoU.
- 3.3 This MoU does not establish legally binding obligations on the part of any of its signatories. All cooperative activities undertaken by the Parties are subject to the availability of appropriated funds. The Parties are entering into this MoU with the express understanding that the MoU itself does not give rise to a claim for compensation for services against any of the respective governments or institutions.

ARTICLE 4 - CONFIDENTIALITY

- 4.1 With respect to all information concerning the activities of the Parties relating to this MoU (whether in oral, written or computerised form) disclosed in confidence to one Party by the other, the said Party will not use any such information for any purpose other than the implementation of its obligations under this MoU.
- 4.2 Each Party will keep and/or treat the information as confidential and not disclose it to any outside third entity without a prior written consent of the concerned Party.
- 4.3 Confidentiality of information exchanged in connection with this MoU shall be maintained for a period of five (5) years after the termination of the Memorandum of Understanding.
- 4.4 In the case of accidental disclosure of the information by unforeseen matters such as robberies, the Party concerned shall not be held liable according to this Article.
- ### ARTICLE 5 - ENTRY INTO FORCE, DURATION AND RENEWAL

The MoU will be in effect from the date of the signature by the last Party until the transfer of the operational service from the Joint Research Centre to an other body or by the 30.06.2009 the latest.

It can be prolonged or modified only by written amendment signed by the duly authorised representatives of each Party.

ARTICLE 6 - TERMINATION OF THE MEMORANDUM OF UNDERSTANDING

Where a Party to this MOU wishes to end its : Collaboration, it may do so by providing the other Party written notice to that effect at least two (2) months before the intended date of withdrawal.

ARTICLE 7 - Administrative provisions

Technical Annex to the Memorandum of Understanding
between
the Joint Research Centre, hereinafter referred to as the "JRC",
and
the Swedish Meteorological and Hydrological Institute (SMHI), Environment and Safety Service
Division referred to as the "SMHI"

The development of a European Flood Forecasting System

Background

Following the disastrous floods in the Elbe and Danube in August 2002, the European Commission initiated the development of a European Flood Alert System (Communication [COM(2002)-481]). A prototype of such a European Flood Alert System (hereinafter referred to as 'EFAS') is at present being developed and tested at the Weather Driven Natural Hazards Action in the Institute for Environment and Sustainability of the EC Joint Research Centre.

The prototype of EFAS produces early flood alerts on European scale and includes a number of novel features aiming to provide the National Water Authorities with additional useful information, such as Simulation of multiple flood forecasts using weather predictions from several meteorological organizations including ECMWF². This may allow the local flood forecaster to situate the local forecasts within the EFAS ensemble and also give an indication of the expected flood risk beyond the usual 48 h.

Translation of uncertainty from meteorological forecasts including Ensemble Prediction System (EPS) into flood risk probability.

EFAS is being successfully developed in close collaboration with meteorological services and Water Authorities of the EU Member States.

Regular meetings will be held once a year. More information can be found on the EFAS webpage <http://efas.jrc.it>

Terms of reference

Status of EFAS

The Agency has understood that EFAS is in developing and testing stage and is therefore to be considered as an experimental product which is under continuous validation.

While being in experimental stage, all EFAS results are treated as a research output. There is no liability of the JRC for any action taken based on EFAS products.

For developing and testing purposes EFAS is running in pre-operational mode 7 days a week, but the JRC does not guarantee that forecasts are provided as the system may have to be reconfigured and tested at irregular intervals. The JRC has no obligation to inform the Agency of the status of EFAS in real-time mode.

Products of EFAS

EFAS simulations are based on operational meteorological forecasts provided to the JRC in real-time mode by several meteorological organizations including ECMWF.

Bi-monthly reports on the status of the project and a summary of EFAS results during the reporting period are produced by the JRC and provided to the Agency.

² European Centre of Medium Range Weather Forecasting

If a flood situation is simulated by EFAS more than 48 h in advance, the JRC can inform the Agency with a special EFAS update for the following catchments: Meuse, Scheldt

The Agency agrees

not to redistribute the EFAS information

to test the additional benefit of EFAS products for local flood forecasting

to provide qualitative and/or quantitative feedback on the EFAS information

to inform the JRC if a flood alert level has been exceeded and there has been no special EFAS report.

European Commission

EUR 23044EN – Joint Research Centre – Institute for Environment and Sustainability

Title: European Flood Alert System – 4th Annual Report

Author(s): Jutta Thielen and Jens Bartholmes (Eds)

Luxembourg: Office for Official Publications of the European Communities

2007 – nnnn pp. – x cm

EUR – Scientific and Technical Research series – ISSN 1018-5593

Abstract

Following the disastrous floods in the Elbe and Danube in August 2002, the European Commission launched an activity on the development of a European Flood Alert system (Communication (COM(2002)-481 final)). A prototype of such a system (acronym EFAS) should be developed and tested during Framework 6 and include a number of novel features that are usually not provided by National Water Authorities and that would be beneficial both for the European Commission as well as the Member States. These features include

- simulations of discharge across Europe providing comparable results across Europe.
- flood simulations and forecasts based on more than one weather forecast
- use of meteorological Ensemble Prediction Systems as input into the flood simulation model allowing to estimate the uncertainty in combined meteorological and hydrological forecast

EFAS, once fully developed and tested, would represent a powerful tool for the European Commission and the Member States for monitoring hydrological conditions across Europe, analysing climatology and trends over the past years in a consistent and homogeneous way, and for forecasting possible future trends when coupled with seasonal forecasts and climate change model output. Furthermore, through the trans-boundary nature of the EFAS simulations it is anticipated that exchange of flood forecasting experiences, data, and research results would be favoured.

The work on EFAS started in January 2003 based on experience gained during the competitive EFFF project (European Flood Forecasting System, 2000-2003) (Gouweleeuw et al., 2004) financed by DG Research. The system is to be built together with meteorological services and Water Authorities of the Member States. The Elbe and the Danube catchments have been selected as pilot catchments representative of typical trans-national catchments.

Text.....

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The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

