Summary report

1st workshop on the use of ensemble prediction system in flood forecasting

(Ispra, 21-22 November 2005)

Organised jointly by the
Joint Research Centre, King's College London and Lancaster University

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Background information

Fluvial floods are a common natural hazard in Europe. Only in the 90ies, large floods have affected the Meuse and Rhine, the Oder and the Po rivers. Following the devastating floods in the Elbe and Danube river basins in 2002, the European Commission launched a project on the development of a European Flood Alert System (EFAS). Since the beginning of 2003 EFAS is being developed and tested at the Joint Research Centre of the European Commission in the Institute for Environment and Sustainability.

The aim of EFAS is to complement the Member States activities towards increased preparedness for oncoming flood events. Its specific objectives are to increase the warning time from 3 up to 10 days, to provide flood forecasting for entire river basins unrestricted by administrative boundaries and to make use of the state-of-the-art of meteorological products for flood forecasting.

In particular the use of ensemble prediction systems (EPS), produced by the meteorological services to sweep the whole range of possible weather developments, are being explored by EFAS. The principle of EPS consists of not only producing one weather forecast but of producing a suite of forecasts that start with small differences in the initial conditions. These differences in initial conditions tend to grow as the forecasting time increases. The results are different weather forecast that may cluster around similar weather developments or spread widely. The advantage is that the uncertainty in the weather forecasts can be quantified and expressed in terms of probabilities. For example, a result from EPS could be that there is 70% of probability of having rainfall exceeding 10 mm over a given area.

The two main aspects of the EFAS work related to EPS are a) how to extract meaningful information from the meteorological EPS for flood forecasting and b) how to communicate the uncertainty on flood forecasting to end users.

Since the beginning of 2005, the JRC has started to formalise the contact with the Member States' hydrological services through the means of Memoranda of Understanding (MoU). If a National service signs the MoU, the EFAS team can provide information on the possibility of flooding to the local forecasting team. The information provided by EFAS includes also information based on EPS. At present, the MoU are only established with hydrological services that are concerned with transnational river basins, with an upstream area of at least 30000 km^2.

1st EFAS Workshop on the use of EPS in flood forecasting

The first workshop on the use of EPS in flood forecasting was organised by the Joint Research Centre together with researchers from King's College in London (UK) and the Lancaster University (UK).

1. Workshop Objectives

The EFAS team organised a workshop to address two main concerns of EFAS regarding flood forecasting based on EPS:

- how to extract meaningful information from the meteorological EPS for medium-range flood forecasting?
- how to communicate the uncertainty in flood forecasting to end-users?

The specific objectives of the workshop were to explore together with flood forecasting experts from the Member States:

- the usefulness of EPS information implemented in EFAS for operational flood forecasting and decision making, and
- the perception of uncertainty in flood forecasting.

2. Workshop rationale

The workshop's concept was to have a small group of flood forecasters from different river basins working through a number of case-studies, each one representing a potential flood situation as forecasted by EFAS. On the first day, the participants worked in groups on each case-study. The second day was targeted mostly to plenary discussions on the use of meteorological EPS for ensemble flood forecasting.

Workshop participants:

11 participants were invited from 8 different countries, representing 9 different hydrological services. This allowed to have a group of forecasters with a wide range of experience, covering hydrological regimes from dry-Mediterranean to moist-continental, and with potentially different cultural backgrounds on the perception of uncertainty. Specifically, representatives from river basins in Spain

(Ebro), Italy (Po), France (Loire, Rhone, Garonne, Seine), Germany (Rhine, Elbe, Oder, Danube), Netherlands (Rhine, Meuse), Slovakia (Danube), Hungary (Danube, Drava) and Poland (Oder) were invited.

Except in one case, all participants came from a hydrological service that has signed a Memorandum of Understanding (MoU) with the JRC. The MoU implies that the EFAS partner organisation understands that EFAS products are experimental and in a testing phase, and that the receiving authorities give feedback about the EFAS information provided. It could thus be assumed that before coming to the workshop the participants had at least heard about EFAS or seen EFAS reports and/or bulletins. In addition, the participants were chosen such that about half of them had already received in real-time an EFAS information report on the possibility of a flood to happen more than 3 days in advance, and the other half had never been in contact with EFAS information reports.

In one case, the participant came from a hydrological service which had no previous contact with EFAS and is not part of the EFAS network (EDF in France). This participant had thus no background knowledge about the EFAS project and could provide an “external” view of EFAS forecasting. Also, the workshop could benefit from the experience of a participant who is used to work with both meteorological and hydrological forecasts and has experience on the communication of forecasts to end-users, since the participant came from an organization where forecasters and end-users are grouped in the same establishment.

Organisation of workshop

Entry questionnaire
Following a general introduction of the workshop, the participants were asked to fill in an anonymous entry questionnaire. This questionnaire aimed to assess their working experience and their expectations regarding the workshop.

Background information
In order to bring all participants to a similar level of knowledge about the EFAS project and its products, a general technical presentation was given. The following subjects were covered:

- the rainfall-runoff model LISFLOOD used in EFAS,
- the set-up of the EFAS system,
- rationale of Ensemble Prediction System weather forecasts,
- methodology employed in EFAS to calculate critical thresholds and define alert levels,
- EFAS interface and its way of visualising EFAS results.

Care was taken not to bias the participant's point of view on EPS and EFAS prior to the case studies. Further, the political context and the demand driven nature of EFAS and the WDNH action was briefly lined out. It was underlined in this context that the subsidiarity principle is fulfilled by EFAS.

Case studies
The 11 participants were divided into 4 groups: 2 groups of three participants and 2 groups of two participants each (two participants were working together due to language constraints). To each group one of the workshop's organizers was assigned as an "observer". The main role of the observer was to assist the groups in any technical problem. The observer was *not* supposed to interfere in the group's discussions and in the decision making process. In parallel to the technical assistance, the observer could also take notes on how the group was dealing with the information provided.

Each group had to work through three case studies, one after the other. For each case study they had a time limit, evaluated as sufficient to investigate the data and put some pressure on the decision making process, which is often the case in real-time forecasting situations. Also, more time to work was given in the first case study, since the participants were in contact with the provided information for the first time.

The case studies were selected from real flood events during the summer period of 2005 in the Elbe and Danube river basins. In each case the role of the EPS

was slightly different – sometimes supporting, sometimes contradicting the results of the deterministic forecasts.

Each case study consisted of flood forecasting information for three consecutive forecast days, which basically was:

- maps characterising the river basins, including topography, river network and localization of discharge gauging stations;
- information about meteorological conditions, such as precipitation measurements of the past days extracted from a synoptic network, as well as precipitation forecasts from the Deutsche Wetterdienst (forecast range of 7 days) and the European Centre for Medium-Range Weather Forecasting (forecast range of 10 days), including overview maps with 51 EPS members. Qualitative radar information was was at disposition if asked for, as well as synoptic meteorological charts, maps of sferics, etc.;
- observed discharges at the selected discharge gauging stations for the past days;
- 2-day flood forecasts at the selected stations from a supposed to be "local" model;
- EFAS information reports summarising the situation for the next 7-10 days, including deterministic and EPS-based flood forecasts. Under request, the groups could also see the hydrographs forecasted at the gauging stations.

On a rotating basis 1 control group was assigned to receive reduced information, which consisted of all information mentioned above, *except* the EFAS information reports and the forecasted hydrographs. So for each case study there was 1 control group with only weather forecasts and the 2-day "local" hydrological forecasts, while the other 3 groups had the complete deterministic and probabilistic information. The control group was thus *without* any hydrological information based on EPS.

The task of the groups consisted in the evaluation of the hydrological situation for each forecasting day. They had to summarise the situation and decide weather or not they would contact the civil protection authorities with a flood warning. If their advice was to initiate an emergency procedure, they also had to indicate the level of severity of the situation: low, medium or high. It was up to the participants to define what "low", "medium" and "high" severity meant.

While the participants were working through the case studies, the observers were taking notes on how the group dealt with the uncertainty in the forecasts, if EPS information was used, what additional information was requested, and the general attitude of the participants towards the exercise. In addition, and with the consent of the participants, the discussions were recorded on tapes. The tapes will be transcribed and investigated for wording on uncertainty and risk perception.

Reporting of case study results

At the end of the 1st day, in a plenary session the participants reported their experience and decisions for each case study. The focus of the discussion was mainly on the decision making process and not on hit or false alarms.

Plenary discussion on uncertainty in flood forecasting

In the morning of the 2nd day, the organisers presented the real situation for the case studies. This presentation was followed by a general discussion on a) the use of EPS in flood forecasting, and b) the most useful visual representation of multiple flood forecasts.

External presentation on communication of risk to people with special needs

Mr. Hakkinen presented the particular challenges upon communicating disaster preparation and warning to special needs populations. Mr. Hakkinen is presently working with the DAISY Consortium (DAISY denotes the Digital Accessible Information System) and the Research Institute of Japan's National Rehabilitation Center. His work focuses on the technical and human factors of disaster preparedness and warning for populations with special needs. He was an invited speaker on this subject at the World Summit on the Information Society in Tunis in November, 2005. Since 2003, he has been the coordinator of the International Open Source and Standards for the DAISY All Project, which consists in developing standards, tools and capacity building programs for the local creation and delivery of accessible information in the developing countries of Asia.

Preparation for Guidelines on the use of EPS in flood forecasting

In the afternoon of the 2nd day, possible items for guidelines on the use of EPS in flood forecasting were discussed. The JRC will prepare a draft of these guidelines and send them to the participants for revision before coming to the final version.

Exit Questionnaire

At the end of the workshop, the participants were asked to fill in an anonymous exit questionnaire. This questionnaire addressed three issues: 1) general perceptions of EPS and the best way to communicate uncertainty in flood forecasting, 2) organizational flood forecasting capacities and potential usefulness of EPS to the participants' organizations, 3) evaluation of the workshop.

3. Main results

From the discussions carried out during the workshop, some important aspects emerged concerning the practice in flood forecasting and the use of EPS.

Practices in flood forecasting

- Flood forecasters have a tendency to maintain the highest alert issued until they are sure that there is no risk of achieving the alert level anymore. In different workgroups, it was observed that when forecasters issued a high alert level in the first day of forecast, they prefer to keep it through the next days, even if the risk decreased. They would only decrease the alert level they issued if in the third day the situation showed to be no longer severe.
- Persistency of flood forecasts was taken into account from one day to the other and assisted forecasters in their decisions.
- Forecasters highlighted the difficulties of performing flood forecasting over a region where they are not used to work with. The local expert knowledge forecasters usually have of the river basin and of the prior meteorological and hydrological situations was perceived as a key element in good flood forecasting.

Results with regard to EPS

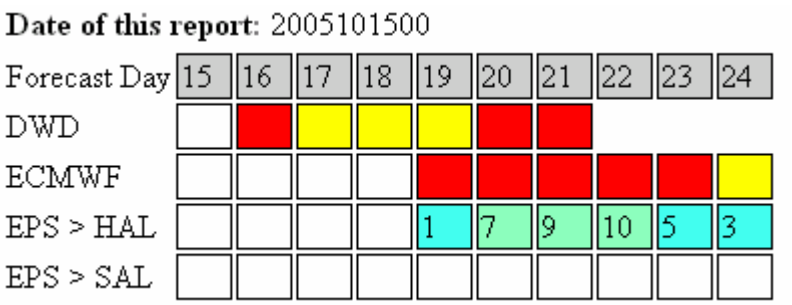
- EPS forecasts were perceived as a means to increase the confidence in a flood forecast when they were in agreement with the deterministic forecasts. When EPS forecasts were giving contradictory results to the deterministic forecasts, however, they were perceived by the majority as more confusing than helpful. One participant mentioned that in this case they were just “noise”.
- EPS was estimated to be particularly valuable when the deterministic forecasts were giving conflicting results, e.g. a critical situation is forecasted based on DWD weather forecasts, but no critical level is reached in flood forecasts based on ECMWF forecasts.
- The overall EPS result was perceived as a more stable source of information than the deterministic forecasts when these latter are intermittent (with no persistency).
- Once having been introduced to the EFAS information reports and to EPS forecasts, the groups acting as Control groups (i.e., working without EFAS reports nor EPS information) strongly missed the additional information provided in the EFAS information reports and in the flood forecasts based on EPS.
- The presence of large uncertainty in the EPS forecasts more than 3 days ahead in time tended to lead to a “wait and see” attitude and postpone action to the next day of forecast. The fact of having more than 3 days in

advance seems to give the confidence that there is enough time to respond and activate civil protection response.

- The representation of 51 EPS forecasts in a graph with multiple hydrographs was perceived by some participants as rather confusing, whereas the box representation used in EFAS to summarise the temporal evolution of alerts for the deterministic and the ensemble forecasts was found a good means to communicate essential information. During the discussion, the importance of visualization of results in a useful and concise way was stressed.
- It was generally confirmed that the understanding of using EPS increased with subsequent case studies. This illustrates a training effect that arises when using EPS on a daily basis and highlights the importance of providing training on EFAS-EPS products to end users.
- Most participants felt that after the exercise their understanding of EPS and of the potential use of EPS for flood forecasting has improved.

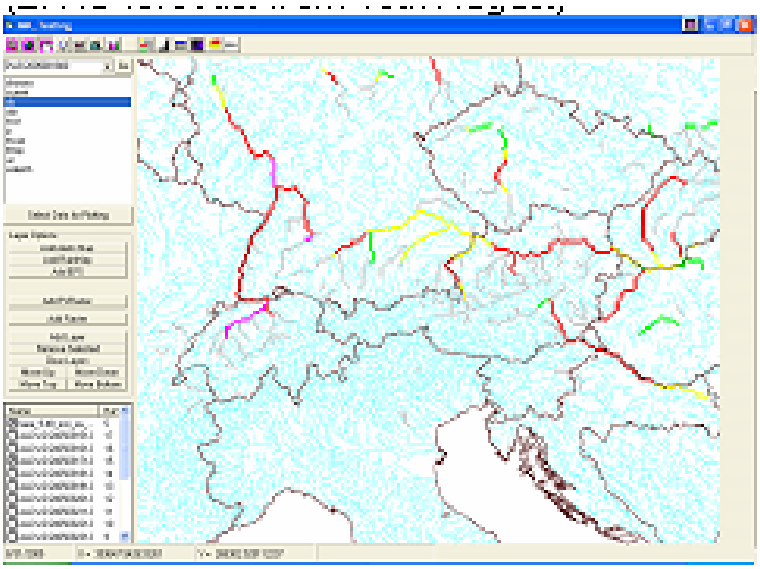
Results with regard to visualization of flood forecasts based on EPS

- Most participants agreed that showing all 51 resulting EPS hydrographs in one graph is confusing and difficult to interpret.
- 10 out of 11 participants agreed that the box representation of alert threshold exceedance developed by the JRC is a very good way of summarising multiple forecasts including those based on EPS. During the workshop exercise these diagrams were the ones mostly consulted for the medium-range information.



Example of a box representation of the temporal evolution of threshold exceedances of EFAS alert levels for a given day of forecast

- Some discussion revolved around the spatial summary maps produced and distributed by EFAS. Although the spatial overview map was perceived as very useful from a forecaster point of view, the concern was raised that this map may show too much the level of detail that EFAS can simulate – including small river basins responding within the 48-hour forecast range. The masking of all results less than a certain upstream area was considered as a possibility to partially resolve this problem.



Example of a spatial summary map produced by EFAS showing the highest EFAS threshold exceeded at any time during the forecast range

Guidelines for the use of EPS in flood forecasting

The discussion on writing guidelines for the use of EPS in EFAS flood forecasting was organised in the form of a brainstorm on several subjects, including: a) presentation of EPS probabilistic products and their interpretation, b) best way to communicate uncertainty and c) research aspects to be investigated. From the collection of ideas and based on the experience acquired using EPS weather forecasts in EFAS, guidelines will be drafted and sent to the workshop's participants for comments.

The main important ideas of the brainstorm session can be summarised along the following key aspects:

- *Training*: EPS results become meaningful and consequently more useful with experience. This experience can be provided through long-term climatologies, hit/false alarm rates assessment, post-event analysis, etc. However, even if the local forecasters receive this information from a third party, they usually wish to build up their own expertise for their local conditions. Two possibilities for increasing the experience of local forecasters on the use of EPS were discussed: i) provide training data sets that would allow the forecasters to assess the EPS performance for certain flood events observed in their local river basins, and ii) give the forecasters access to daily forecasting products for their river basins and over an extended period of time.

- *Communication*: Communication of probabilistic results and their uncertainty ranges was perceived as very important. This includes not

only uncertainty coming from the meteorological fields but also uncertainty from model parameterisation and initial conditions.

- *Research*: a very important part of the discussion revolved around research aspects on EPS products. The need of investigating more deeply ensemble flood forecasts based on EPS showed on one hand that EPS weather forecasts and their use in flood forecasting are perceived as not totally understood yet. On the other hand, suggestions such as calculation and exploration of the 51 soil moisture maps or other variables from the ensemble prediction system can be a clear sign that EPS may also provide forecasters with useful information on other hydrological variables involved in the rainfall-runoff process.

4. Summary and conclusion

The 1st workshop on the use of EPS in flood forecasting brought together a small group of flood forecasters from the EFAS network to work on the subject of Ensemble prediction flood forecasting. The workshop was organised in two parts: a practical part where case studies had to be worked through, and a discussion part where the experiences from the case studies and the home organisations were exchanged. Questionnaires and observer sheets were used to monitor the knowledge of EFAS and EPS products before and after the workshop.

The workshop was very successful in several respects. The participants expressed their interest in the subject and most of them found that the workshop brought their knowledge about ensemble predicution flood forecasting forward. The discussion about the case studies showed clearly that the use of EPS in flood forecasting has a great potential. Once introduced to the concept of probabilistic flood forecasting and being used to working with ensemble streamflows, the participants missed not having the EPS information during the case studies if they were not provided. The workshop revealed interesting patterns in the use of EPS, e.g. that they were considered positive when confirming the deterministic forecasts whereas they were considered rather disturbing when being contradictory.

An important part of the discussion revolved around the presentation of multiple forecasts and EPS in particular when dealing with medium-range flood forecasting. The form of presentation elaborated by the EFAS team found generally positive feedback and was considered very useful.

Overall the participants felt that training on specific case studies for their own river basins are necessary to properly understand the value of EPS. Providing training material or daily access to EFAS results was considered an important aspect for the successful use of EFAS results.

Annex 1: AGENDA

Workshop on the use of Ensemble Prediction System weather forecasts in hydrological forecasting

Date: 21st-22nd November 2005
Venue: JRC/IES, Ispra, Italy

DAY 1: Monday, 21st November

Morning:

a) Welcome
b) Round table: introduction of participants
c) Background information on EFAS and meteorological Ensemble Prediction Systems
d) Presentation of the workshop concept
e) Workgroup: Case study 1

LUNCH

Afternoon:

f) Workgroup: Case study 2
g) Workgroup: Case study 3
h) Groups summarise their results for each case study

DINNER

DAY 2: Tuesday, 22nd November

Morning:

i) Presentation of the real situation for each case study
j) Discussion on the forecasting exercise: using deterministic and probabilistic EPS information
k) External presentation on communication of risk to people with special needs

LUNCH

Afternoon:

l) Discussion on communicating risk and uncertainty in flood forecasting
m) Draft for EPS Guidelines: on the use of EPS in flood forecasting

END OF WORKSHOP

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1st workshop on the use of EPS in flood forecasting (21-22nd November 2005, JRC Ispra)

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