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Extended Abstract

*Effectiveness and Efficiency of Early Warning
Systems for Flash Floods*



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1 Introduction

The issue addressed within the EWASE project centres on the assessment of the effectiveness and efficiency of Early Warning Systems (EWS) for medium sized river basins prone to flash floods. Two study basins are considered: the Besòs basin (1020 km²), Mediterranean climate, near Barcelona, Spain, and the Traisen basin (921 km²), alpine climate, north east Austria.

The approach pursued relates the concept of risk analysis to the evaluation of strategies for flood damage prevention by means of early warning in order to review the performance of existing structural protection schemes and to investigate how the protection schemes are improved through the use of an EWS.

For the assessment of EWS effectiveness, the reliability of forecasts will be linked to the economic benefit - both as a function of warning lead time. Forecast reliability is evaluated by the analysis of an ensemble of flood forecasts. The Flood forecast ensemble describes the uncertainty due to precipitation forecast, model parameters and model structure.

The specific challenge of the risk analysis is to produce results which are comparable between Spain and Austria. The economic benefit results from avoided damage through the EWS. A questionnaire based survey is used to estimate this potential. The results of a benefit-cost analysis (BCA) for the EWS enter a multi-criteria analysis which will take into account intangibles as well as stakeholder preferences.

2 Methods

The crucial point for the assessment of EWS effectiveness and efficiency is the link between **forecast reliability** and **economic benefit**. In this context the aspect of time is vital. Therefore, both attributes have to be quantified as a function of warning lead time.

Forecast reliability in the context of flood forecasts is understood as the probability of correctly predicting a flood event. Forecast reliability is affected by uncertainties inherent to the underlying modelling system and decreases with lead time. Main sources of model predictive uncertainty are uncertainties associated to precipitation forecasts, hydrological model parameters and the model structure. Precipitation forecast uncertainty is quantified by means of ensemble forecasts. Model structure and model parameter uncertainty are strongly interrelated and depend on the event and the location (Refsgaard et al., 2006). The comparison of the predictions of multiple simulation models is a suitable approach to characterise these uncertainty sources in a comprehensive way, e.g. (Georgakakos et al., 2004). Within EWASE three rainfall runoff models are applied to both study basins. The temporal evolution of forecast reliability is evaluated by means of a multiple step ahead method, e.g. (WMO, 1992). In this regard, the approach taken by (Berenguer et al., 2005) is enhanced to analyse the outcome of multi model ensemble forecasts.

Economic benefit

EWASE risk analysis pursues a strategy which differentiates vulnerability into exposure and susceptibility (Merz et al., 2007). Exposure can be quantified by the value of elements which are at risk. Susceptibility describes to what degree the affected elements will be damaged. Exposure is derived from analysing national accounts of the respective country and is therefore site specific. Susceptibility is expressed through relative damage functions which are assumed to be global (ICPR, 2001). This implies that they are not site specific but transferable between countries. Several sets of damage functions are used for expressing their associated uncertainty (Penning-Rowsell et al., 1994). Comparability of the results across countries necessitates comparability of input data. This is unquestionable for susceptibility, as the same damage functions are used in both countries. As regards exposure the prerequisite for comparability is information standardised at European level. This can be expected for information available from the Statistical Office of the European Communities (EUROSTAT). In this way, it is assured that the economic information elaborated in EWASE is strictly comparable for the basins.

EWS assessment

In the frame of the BCA the costs in terms of Net Present Values will be opposed to benefits in terms of mitigated Expected Annual damage for different scenarios of EWS operation and failures. The outcome of BCA supports the definition of an acceptable level of uncertainty for EWS in economic terms.

Being aware of the fact that not all aspects of flood damages can be expressed in monetary units, intangible damages are additionally considered by a multi-criterion approach. The results will be displayed in a spread sheet based decision support tool, which enables decision makers to evaluate the influence of different preferences on the outcomes (Gocht, 2004, Lotov et al., 2004, Perman, 2003).

3 Results and Discussion

- *Most important scientific results and important events*

Work is in progress and so far only intermediate steps have been accomplished within the different work packages.

Precipitation forecast uncertainty:

For the Traisen basin four days quantitative precipitation ensemble forecasts of the ZAMG (Central Institute for Meteorology and Geodynamics) in 15 minutes time steps are used. This ensemble covers the uncertainty associated to precipitation forecast in the range between +6 and +48 hours. The ensemble forecast is generated on the basis of extrapolated rainfall field observations based on rain gage measurements and radar observations (INCA) with numerical weather prediction systems (ALADIN and ECMWF).

For the Besòs basin precipitation forecasts are based on the SPROG steady state radar nowcasting technique (Seed, 2003), which extrapolates the observed motion field and filters out small scale precipitation patterns. The uncertainties associated to precipitation forecasts are quantified in terms of a probabilistic ensemble. Previously analysed uncertainty structures are used to generate perturbations via a probabilistic simulation approach. The perturbations, in turn, are imposed to the nowcasted rainfall field. The uncertainty structures are obtained from the analysis of residual fields between radar observations and interpolated rain gage observations using Fast Fourier Transformation. The perturbations are characterised by the mean, the variance and space-time correlation.

Hydrological forecast uncertainty:

Uncertainties in hydrological forecasts are comprehensively represented by means of a multi model ensemble. The ensemble of multiple model predictions includes propagated precipitation forecast ensembles in combination with model structural and parametric uncertainty. It constitutes an empirical distribution of predicted discharges and characterises hydrological forecast uncertainty. Data sets for the simulation models WBRM, COSERO, DICHITOP have been set up for both study basins. Calibration is in great parts completed. First results obtained for both the Traisen and the Besòs basin are shown in figure 1.

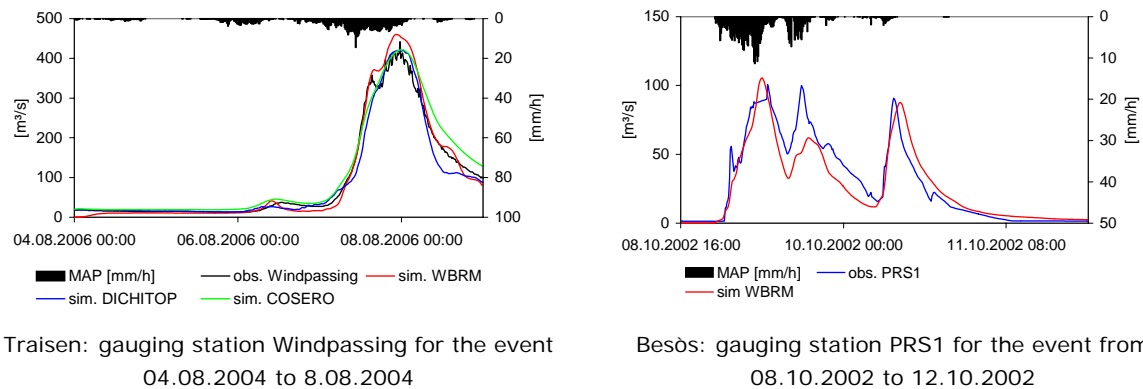


Figure 1: Observed and simulated hydrographs for the study basins

Economic benefit:

Initially it was intended to extract all necessary statistical information from EUROSTAT as a one stop shop to ensure comparability of the data. This turned out to be not feasible as detailed information on regional level is rarely available from this source. Therefore national and regional data sources had to be tapped. This increased effort provided useful results. Since the national and regional statistical bodies operate in compliance with national standards, which in turn are derived from international standards, trans-national comparability appears to be no matter of concern.

EWS Assessment:

As radars are multi-purpose instruments it states a problem to relate a radar to non structural flood protection only. The radars are operated for military and aeronautical purposes. So, meteorological applications appear to be secondary products of radar operation. It seems appropriate to associate a certain rate of allowance with precipitation forecast rather than full investment, maintenance, and operating costs.

Study visits to the basins revealed, that structural protection measures are in place in both basins. In the Besòs basin walls are often to be found in larger urbanised areas, whereas dikes protect large parts of the lower Traisen basin. As stated in the project proposal we will analyse the enhancement of structural flood protection through early warning systems. Particularly mobile protection measures and their dependence on reliable early warning will be in the focus.

- *Comparison work plan – progress*

Progress of work is in accordance with the work plan. Presumably there are no major changes necessary.

- *Prospect of success (from present point of view)*

As the overall project progress is well within the project work plan it is expected that the objectives defined in the project proposal will be reached.

- *Scientific, economic and political relevance of expected project results (from present point of view), including added value (or dissemination) to national policies*

On the European level, EWASE will deliver a preliminary version of an internationally comparable risk assessment of combined flood management strategies consisting of structural and non structural flood protection.

The consideration of uncertainties associated to precipitation forecasts and uncertainties inherent to hydrological models achieves a more comprehensive picture of uncertainties in the EWS. Analysis of failures in the warning chain supports the improvement of current systems and setting priorities for investment in future enhancements or new EWS. This is an important contribution to national flood management strategies.

The result will be presented in form of a semi-quantitative multi-criteria analysis. Costs, benefits, social impacts and intangibles will enter the analysis in a form which takes into account stakeholder preferences. Such an interactive approach facilitates acceptance and involvement on the local level and therefore is a valuable tool for creating and maintaining awareness.

EWASE results will directly provide useful information to the EWS operators in the study basins concerning the evaluation of the current system.

- *Perspectives*

The innovative approach developed in EWASE could be detailed with regard to several aspects. The current project does not analyse to what degree stakeholders in the study basins will be able to use the information provided effectively. A follow up project should develop a closer relationship to local stakeholders, particularly the population affected. New instruments like hazard and risk maps should be developed in a participative approach in accordance to

Articles 6 and 7 of the Directive of the European Parliament and of the Council on the assessment and management of flood risks. An additional spatial component to the alarm would prevent the affected population from taking unnecessary preventive measures. In this context, it is important to investigate up to which extent the efficiency of EWS could be improved by more detailed flood and inundation forecasts also including computationally fast hydraulic models. More visual approaches to multi-criteria analysis will improve communication with stakeholders as well as decision making during flood events. Furthermore, the impact of climate change could be considered in a form accessible to the stakeholders.

- *Dissemination to scientific community (published papers, conferences)*

The EWASE project has been presented as a poster presentation on the occasion of:

- EFRM 2007 - European Symposium on Flood Risk Management Research in Dresden, Germany
- General Assembly of the European Geosciences Union in Vienna, Austria
- Symposium on extreme weather of the Stiftung Umwelt und Schadenvorsorge in Rastatt, Germany

Further contributions are submitted or in preparation for the:

- WRaH208 - International Symposium Weather Radar and Hydrology, Grenoble, France
- XXIVth conference of the Danubian Countries on the Hydrological Forecasting and Hydrological Bases of Water Management 2008 , Bled, Slovenia

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