SPECIAL PROJECT INTERIM REPORT

Reporting year	2007-2008
Project Title:	Optimisation of Water Management using Ensemble Forecasts
Computer Project Account:	spdewmef
Principal Investigator(s):	Dr. Markus Pahlow, Dr. Corinna Möhrlen, Jess Jørgensen
Affiliation:	Ruhr-University Bochum, Institute of Hydrology, Water Resources Management and Environmental Engineering, 44780 Bochum, Germany
Name of ECMWF scientist(s) collaborating to the project (if applicable)	n/a
Start date of the project:	May 2006
Expected end date:	June 2010

Computer resources allocated/used for the current year and the previous one

		Previous year		**Current year**	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	2000	2000	2000	2000
Data storage capacity	(Gbytes)	3	1	3	3

Summary of project objectives

The project focuses on evaluating the applicability of ensemble data of precipitation as input for hydrological modelling. Hereby both flood forecasting and coupling of wind and hydro power are of interest.

Summary of problems encountered

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Summary of results of the current year

General Information

The project started in May 2006. During the project year July 2007 to June 2008, three persons were working on the project: M. Pahlow, C. Möhrlen and J. Jørgensen. During this phase of the project the objective was followed to set up, calibrate and validate a hydrological model that will later on be used with meteorological ensemble data as input.

1 Introduction

In previous work of this special project one main focus has been on the generation of meteorological input data for hydrological modeling. Here, in a next step, a hydrological model has been set up, calibrated and validated for a test catchment, the Schoenheide 3 catchment, in the Eastern part of Germany. First the daily time step model has been set up and consecutively the hourly time step model has been set up. The goal was in particular to provide a model that allows for suitable representation of flood events in terms of flood peak and flood dynamics.

2 Hydrological Model and Study Area

For this study the conceptual HBV model (e.g. Bergström, 1995) has been used. Figure 1 shows a schematic representation of the model structure and the 11 model parameters TT, CFMAX, FC, LP, BETA, UZL, ETF, K0, K1, K2, PERC that need to be calibrated.

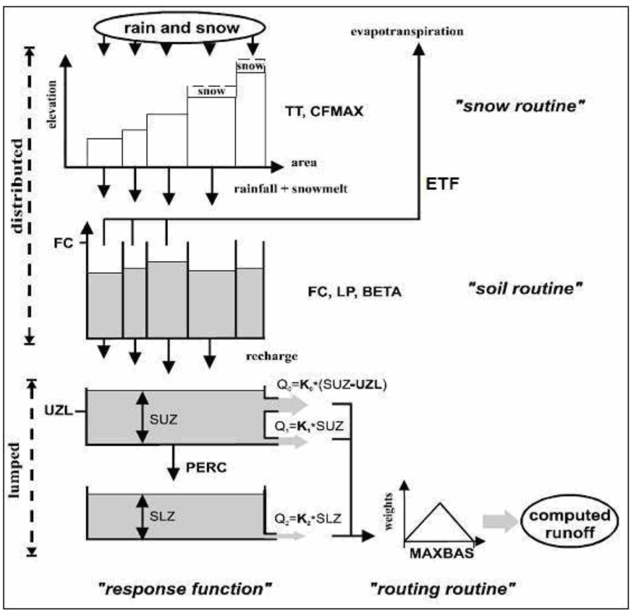

Fig. 1. The structure of the HBV-model (taken from Seibert, 1999).

Model calibration has been carried out by using simulated annealing as optimization method with subsequent manual calibration. Model performance has been assessed by means of the Nash-Sutcliffe efficiency NSE

$$NSE = 1 - \frac{\sum_{t=1}^{n} \left[Q_{obs}(t) - Q_{sim}(t) \right]^2}{\sum_{t=1}^{n} \left[Q_{obs}(t) - \tilde{Q}_{obs} \right]^2} \qquad (2.1)$$

whereby $Q_{obs}(t)$ und $Q_{sim}(t)$ are the measured and simulated discharge at time t, respectively and $\tilde{Q}_{obs}$ ist the mean of the measured discharge. A NSE-value of 1 represents a perfect match between simulated and measured values.

The study catchment Schoenheide 3 (shown in Figure 2), located in the South-West of the River Mulde catchment in the Eastern part of Germany has been subdivided into 12 zones to better account for spatial variations in soil type and land use. Data for calibration and validation were available for the time period 1990 to 2004.

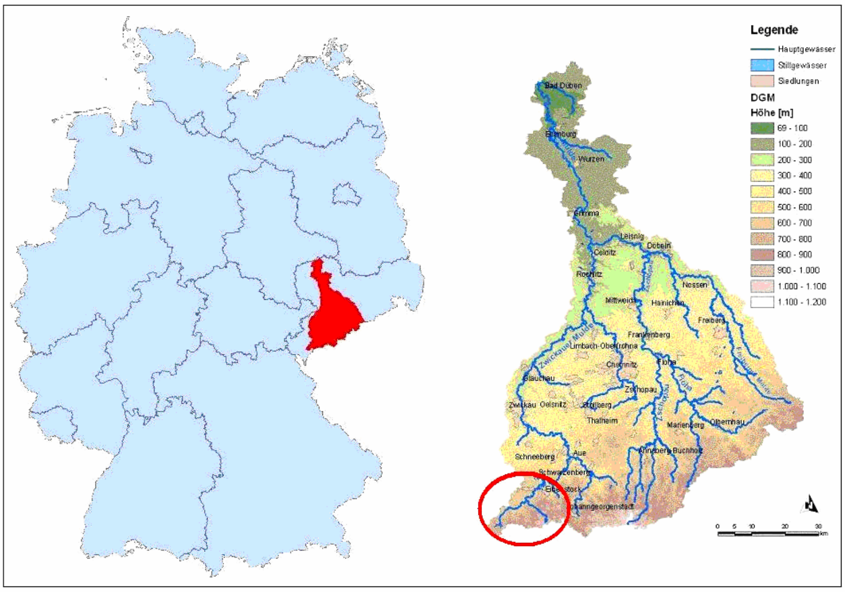

Fig. 2. The River Mulde catchment, located the Eastern part of Germany and the subcatchment Schoenheide 3 (red ellipse), which is considered here.

3 Daily Time Step Model

For calibration of the daily time step model measurements of daily temperature and precipitation at a synoptic weather station within the catchment area were used. The time period considered here starts on 1 January 1990 and ends on 31 October 2004. In addition daily discharge measurements at gauge Schoenheide 3, which is located at the inflow of the dam Eibenstock, are available. To compute the actual evapotranspiration within HBV the monthly mean temperature and monthly mean potential evapotranspiration have been computed from the data.

For calibration and validation a split sample test has been performed. Figure 3 shows the calibration result for the time period 1990 to 1996 with an NSE value of 0.77.

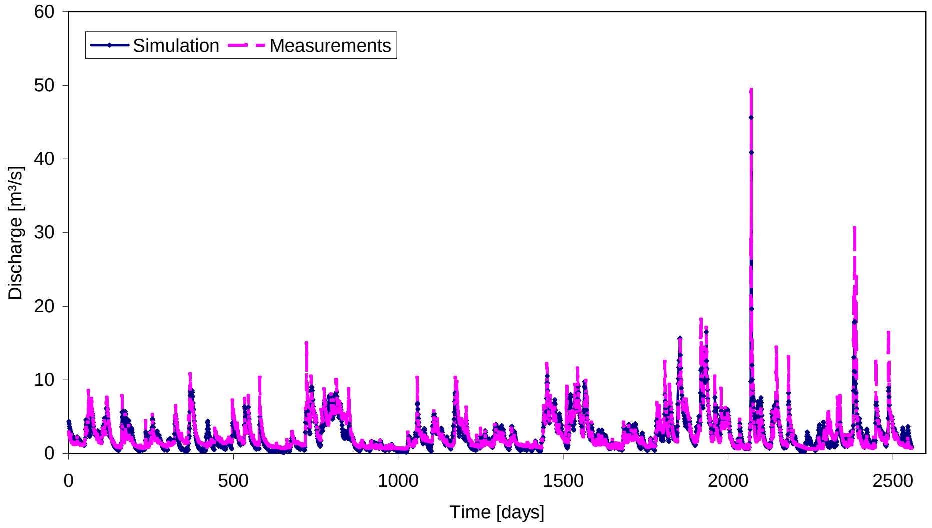

Fig. 3. Calibration time period 1990 – 1996 at gauge Schoenheide 3 (NSE=0.77).

Validation has been carried out by applying the parameter set of the first time period from 1990 to 1996 to the second time period from 1997 to 2004 with a NSE value of 0.79. This is shown in Figure 4.

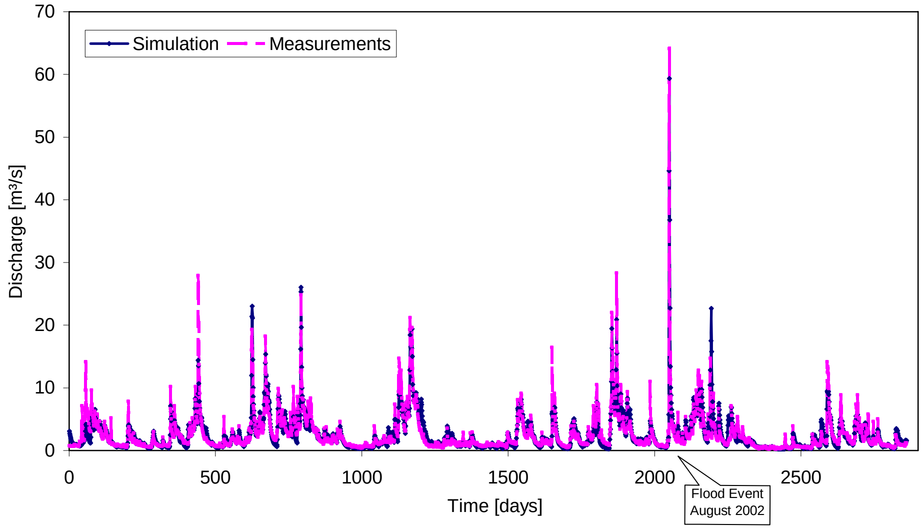

Fig. 4. Validation time period from 1997 - 2004 at gauge Schoenheide 3 (NSE=0.79).

The calibration results even improved for the validation period. The validation time period included several flood events of different intensity and among those events also the extreme flood event in August 2002 (see inset in Figure 4). In general it can be said that the calibration of the daily time step is adequate, in particular since the extreme peaks have been captured well. The dynamics of low flows could not be modeled as well as the dynamics of floods, which resulted in a NSE of 0.79.

4 Hourly Time Step Model

In order to be able to simulate flood events with the required level of detail in terms of flood peak and dynamics it is necessary to set up a hydrological model that provides discharge time series with high temporal resolution. For event-based modeling, accurate initial conditions are very important. Here we extract the initial conditions for the hourly time step model from the daily time step model. The hourly time step model has first been applied to simulate the flood event in August 2002, a record flood that devastated large regions in Europe and in particular in the state of Saxony, Germany. Figure 5 shows the resulting hydrograph in comparison to the measurements. It can be seen that even though the flood peak could be modeled well, there is still room for improvement of modeling the dynamics of the wave. The small peak preceding the main peak has not been captured. Also, the initial recession limb has been overestimated.

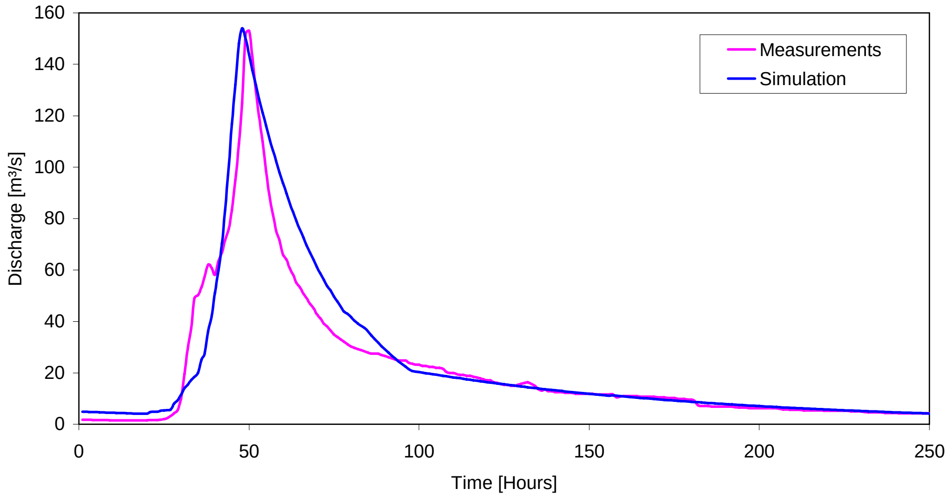

Fig. 5. Measurements and simulation results of the flood event August 2002 (NSE=0.89).

In a second test the hourly time step model has been applied to the data set of the flood event in September 1998. In Figure 6 the simulation results are compared to the measurements.

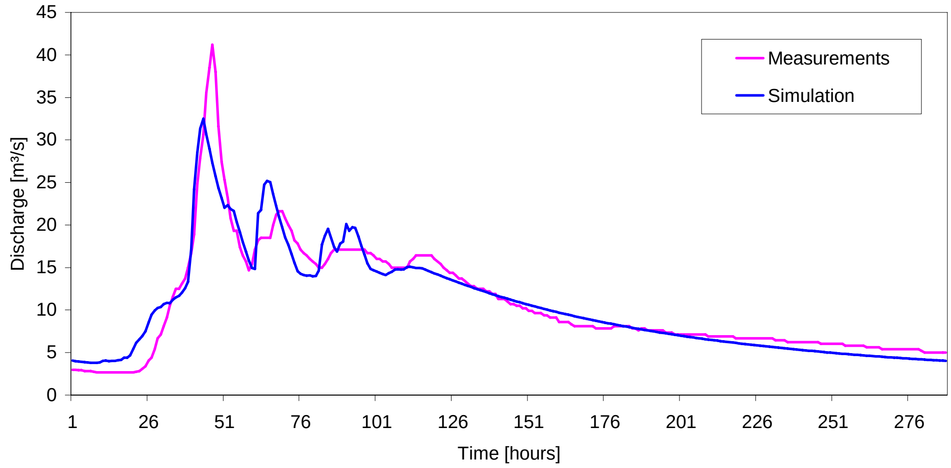

Fig. 6. Measurements and simulation results of the flood event September 1998 (NSE=0.67).

It can clearly be seen that this flood event with four peaks poses a serious challenge to the hydrological model. The peaks and the dynamics are difficult to capture, albeit the model provides the general tendency correctly. Had this hydrological simulation been a flood forecast it should be noted positively that the model had provided a forecast of four peaks, which did in fact occur.

5 Conclusions and Outlook

A hydrological model has been set up and tested to simulate flood events. Flood forecasting is a challenge, because of the requirements on accuracy and reliability of rare events. Ensemble modelling provides new opportunities to improve flood forecasting. Coupling of hydrological and meteorological modelling will be the focus of future work. The goal is to investigate the model behaviour with a high resolution ensemble in hindcast and forecast mode if the parameters from the calibration are used.

References

Bergström, S. (1995): The HBV model. In: V.P. Singh (ed.) Computer models of watershed hydrology. Water Resources Publications, Highlands Ranch, Colorado, U.S.A., 443-476.

Seibert, J. (1999): Conceptual runoff models – fiction or representation of reality? Acta University Uppsala. Comprehensive Summaries of Uppsala Dissertations from the Faculty of Science and Technology 436. 52pp. Uppsala.

List of publications/reports from the project with complete references

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Summary of plans for the continuation of the project

Next steps in this special project will be:

- further development of the hydrological model
- validation of the hydrological model
- use meteorological ensembles as input data for the hydrological model