The LARSIM Model of the Moselle River Basin as an Example of Flood Forecasting in a Transboundary Water System[1]

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Summary

The watershed of the Moselle with an area of about 28,000 km² is a transboundary water system covering parts of the countries France, Luxembourg and Germany. Due to frequently occurring flood events, a transboundary co-operation is necessary. The extension of forecast times is targeted as one measure of improved flood prevention. Therefore, a flood forecasting model, based on the program system LARSIM, was designed with forecast times of up to 48 hours. This model is grid-based, consisting of 154 cells with an area of 14 by 14 km for each cell, and is currently used as a real-time flood forecasting system for the Moselle. The input data include hourly values of measured discharge (at 20 gauges) and of measured precipitation (at 50 weather stations), plus the 48-hour precipitation forecasts of the German Weather Service. The measured data is automatically transmitted from France, Luxembourg, and Germany to the flood forecast center in Trier (Germany). The forecast model is currently recalibrated using a higher resolution model with a grid cell size of 1 km², which equals roughly 28,000 grid cells. Additionally, the interpolation of precipitation is being improved.

1 Introduction

The floods of 1993 and 1995 along the Rhine and the Maas River inundated entire cities and villages in France, Belgium, and Germany, and led to the evacuation of several 100,000 people in the Netherlands. Due to the enormous damage, the secretaries of the environment of the respective countries signed a resolution with which the watershed commissions along the Rhine, the Moselle, the Saar, and the Maas River were assigned to draw up integrated and internationally coordinated flood prevention measures. Within the watersheds of the Moselle and the Saar Rivers, transboundary co-operation got off to an early start. In 1985, the first international workgroup for flood prevention was founded. Two years later, an agreement was signed coordinating the notification process during a flood with the goal of assembling an automatic water level information system. In 1998, the International Commission for the Protection of the Moselle and Saar Rivers (IKSMS) put together the "Aktionsplan Hochwasser" (IKSMS 1999), a set of flood prevention measures, with the following goals:

- Short-term optimization of monitoring systems and measuring devices
- Improvement of disaster prevention plans
- Prolongation of the forecast times for the Lower Moselle River of up to twelve hours until the year 2000 and of up to 24 hours until the year 2005.

In order to prolong forecast times for the Moselle watershed (approx. 28,000 km²), the flood forecast model LARSIM has been further developped, namely to reach a forecast time of 48 hours by incorporating weather forecasts.

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The IKSMS is instructed to coordinate and document the implementation processes of the "Aktionsplan Hochwasser". The afflicted countries are in charge of the actual implementation and the financing. The European Union supports an improved flood forecasting along the Rhine and Maas Rivers by investing 136 million Euros until the end of 2001 as part the collaboral program IRMA („INTERREG-Rhein-Maas-Aktivitäten“).

2 The LARSIM Model of the Moselle river basin

A flood forecasting model, based on the program system LARSIM (Large Area Runoff Simulation Model), was established for the Moselle river basin (Fig. 2 (1)) on behalf of the Rhineland-Palatinate (Germany) water authorities.

LARSIM is based on the river basin model FGMOD (Ludwig 1982), which was developped for the systematic modelling of runoff generation and flood-routing. LARSIM can be applied both as a water balance model for continuous simulation and as an event-based flood forecast model. It is successfully used for operational flood forecasts in several German flood forecast centers.

If LARSIM is applied as a water balance model, the processes of interception, evapotranspiration and water storage in soils and aquifers are included beside runoff generation in the area and translation and retention in river channels (Bremicker 2000). It is currently tested in such a mode for the low and mean flow forecast for the Neckar River (Bremicker & Gerlinger 2000).

Snow accumulation and snow melt can be considered in both model versions as well as artificial influences (e.g. storage basins, diversions or water transfer between different basins).

In a first step, an event-based flood forecasting model was established for the Moselle River (Gerlinger & Demuth 2000). Input data for the runoff forecasts are the 48-hour precipitation forecasts which are computed by the German Weather Services (DWD) numerical weather prediction model (NWP) system for the whole Moselle basin.

The structure of the Moselle model was designed according to the horizontal resolution of the NWP-“Deutschland Modell” in order to directly include the precipitation forecasts. 154 Grid-based subareas are used with sizes of approximately 14 by 14 km.

The model is operationally used in a test mode as a real-time flood forecasting system at the flood forecast center in Trier (Germany). First applications of the LARSIM model in the Moselle river basin for a 24h-flood forecast have been successful (Fig. 1). The predicted and measured discharges correspond quite well, namely for the Lower Moselle River. Input data for the continuous adjusting of the model are hourly values of water levels of 20 gauges and the precipitation measurements of 33 rain stations transmitted automatically from France, Germany and Luxembourg to Trier (Fig. 2 (2)). Additionally, the values of 17 stations in France are currently called on via email twice a day.

Close international co-operation enables the provision and exchange of the hydrological information which is a prerequisite for the successful flood forecasting in this transboundary water system.

3 Model Improvements

Improvements in the model performance are expected from a closer meshed grid, namely a 1 by 1 km grid. This will enable better forecasts especially for small basins and the Upper Moselle River. A complete new model structure has been designed (Fig. 2 (3)) and a recalibration of the model is under way. For the forecast of precipitation, we also use a higher resolution grid ("Lokal-Modell" of the German Weather Service, 7.5 km grid). In addition, the areal precipitation is now calculated by an External-Drift-Kriging approach. A time-space adjustment of the precipitation forecasts using artificial neural networks is under investigation.

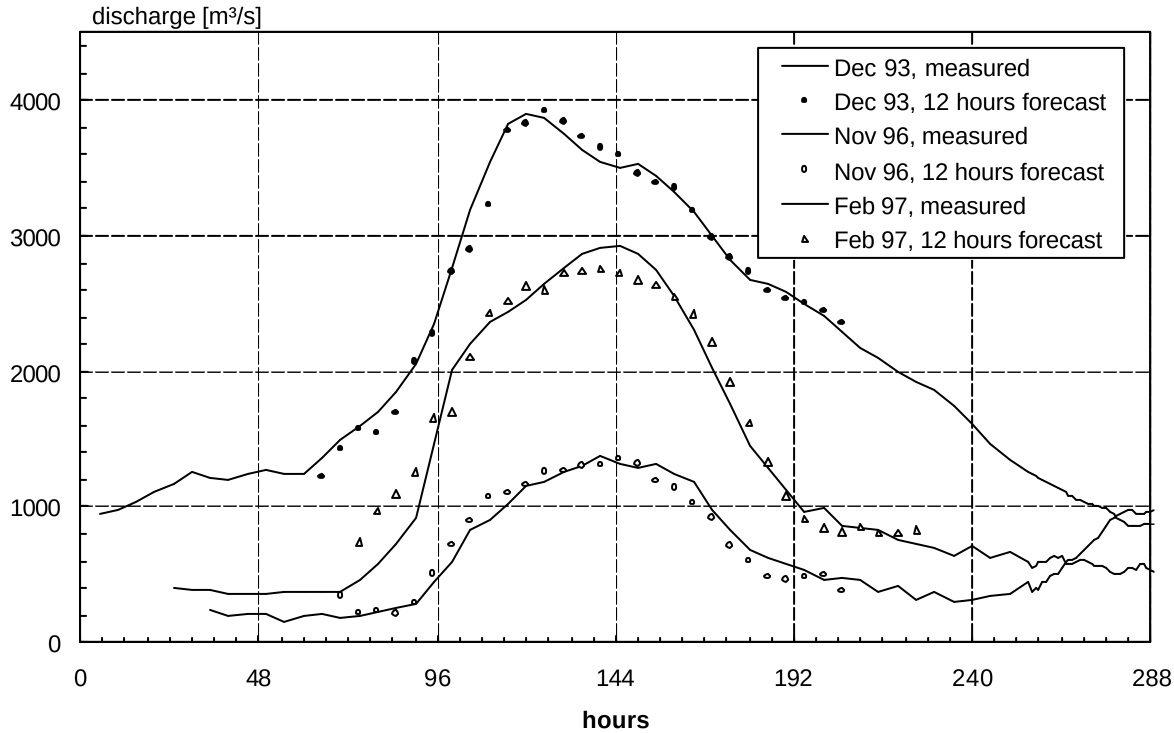

Figure 1: Comparison of measured discharges of three different floods to the 12 hours forecasts (gauge Trier/Moselle; area 23,772 km²)

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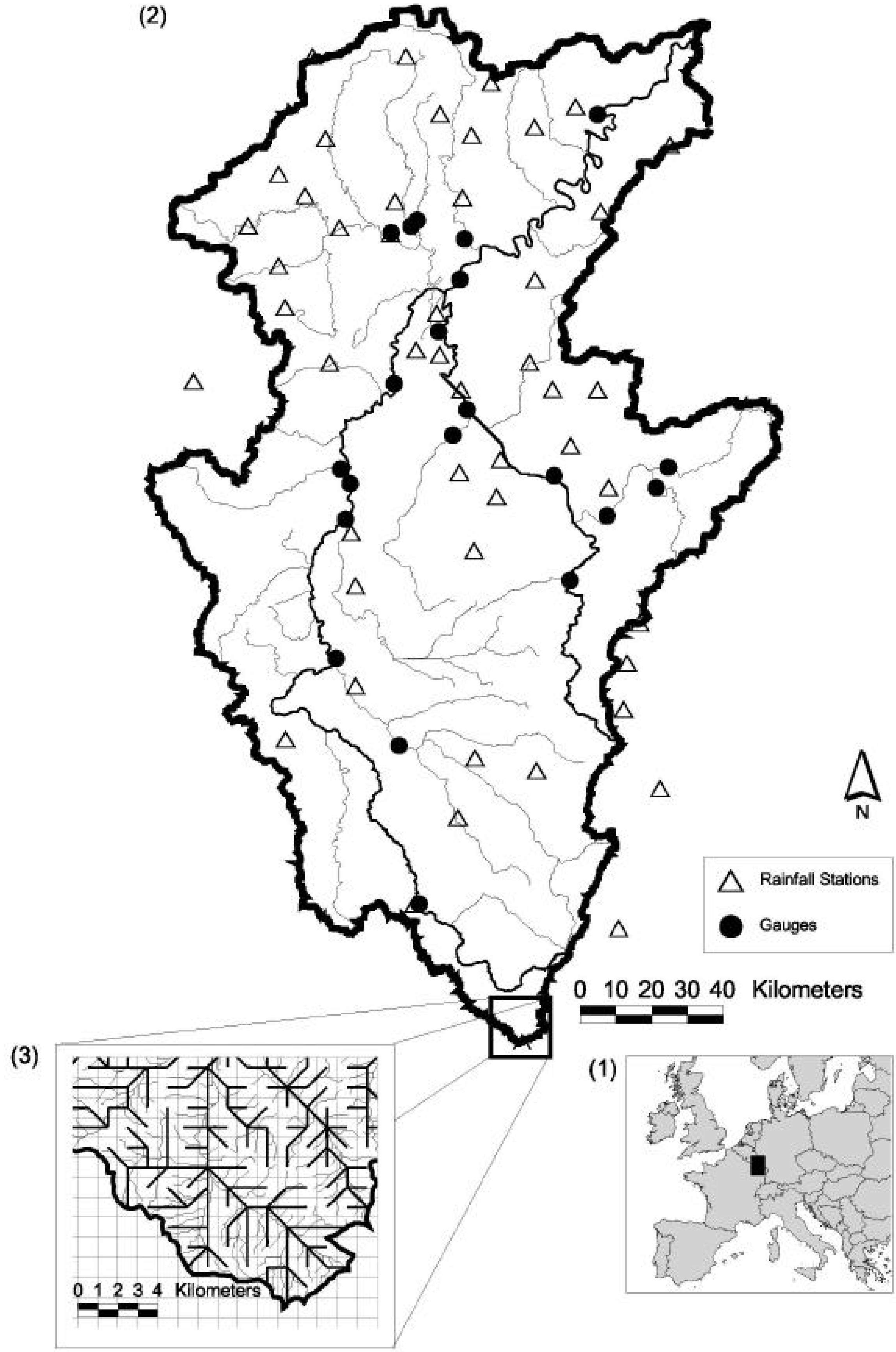

Figure 2: (1) Location of the Moselle basin in Europe (2) Moselle basin and location of rainfall stations and gauges (3) Example of model grid and river network of the improved 1 km x 1km model