The European Flood Forecasting system

HEPEX Workshop, 08-10 March 2004

The EFFS: the facts

- **Project EFFS was sponsored by the 5th Framework Programme of the European Commission.**
- **Duration 01/03/2000 – 31/09/2003 (42 months).**
- **EC financial contribution: 1.8 M€ over 3,5 years.**
- **11 institues + 8 NAS institutes= 19 partners in total.**

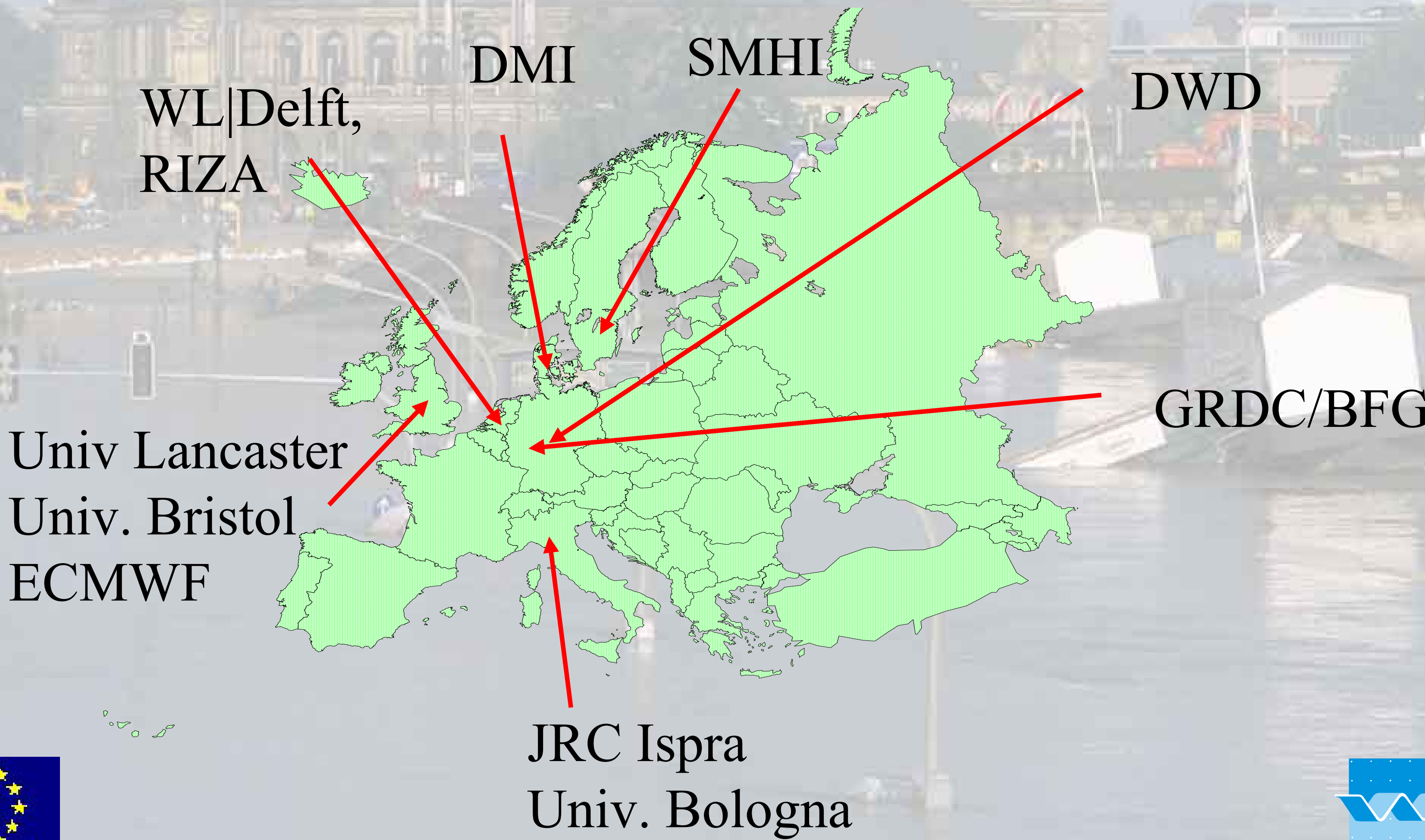
EFFS Project Objectives

- **EFFS aims at developing a prototype of a flood forecasting system for the European countries for up to 10 days ahead.**
- **The main emphasis is on the medium-range lead time, i.e 4 to 10 days.**
- **The prototype is designed at providing pre-warning to local water and flood forecasting authorities across Europe.**
- **The system should permit encapsulation of pre-existing hydrological and river routing models already tested and used by local authorities.**

EFFS "Mother" Consortium

- Original Consortium: 11 institutes
- 3 Weather services (DWD, DMI, ECMWF)
- 3 Universities (Lancaster, Bristol, Bologna)
- 2 Research Centres (Delft Hydraulics, JRC)
- 2 National Hydro-meteorological Services (SHMI, BAFG)
- 1 National Water Management Authority (RIZA)

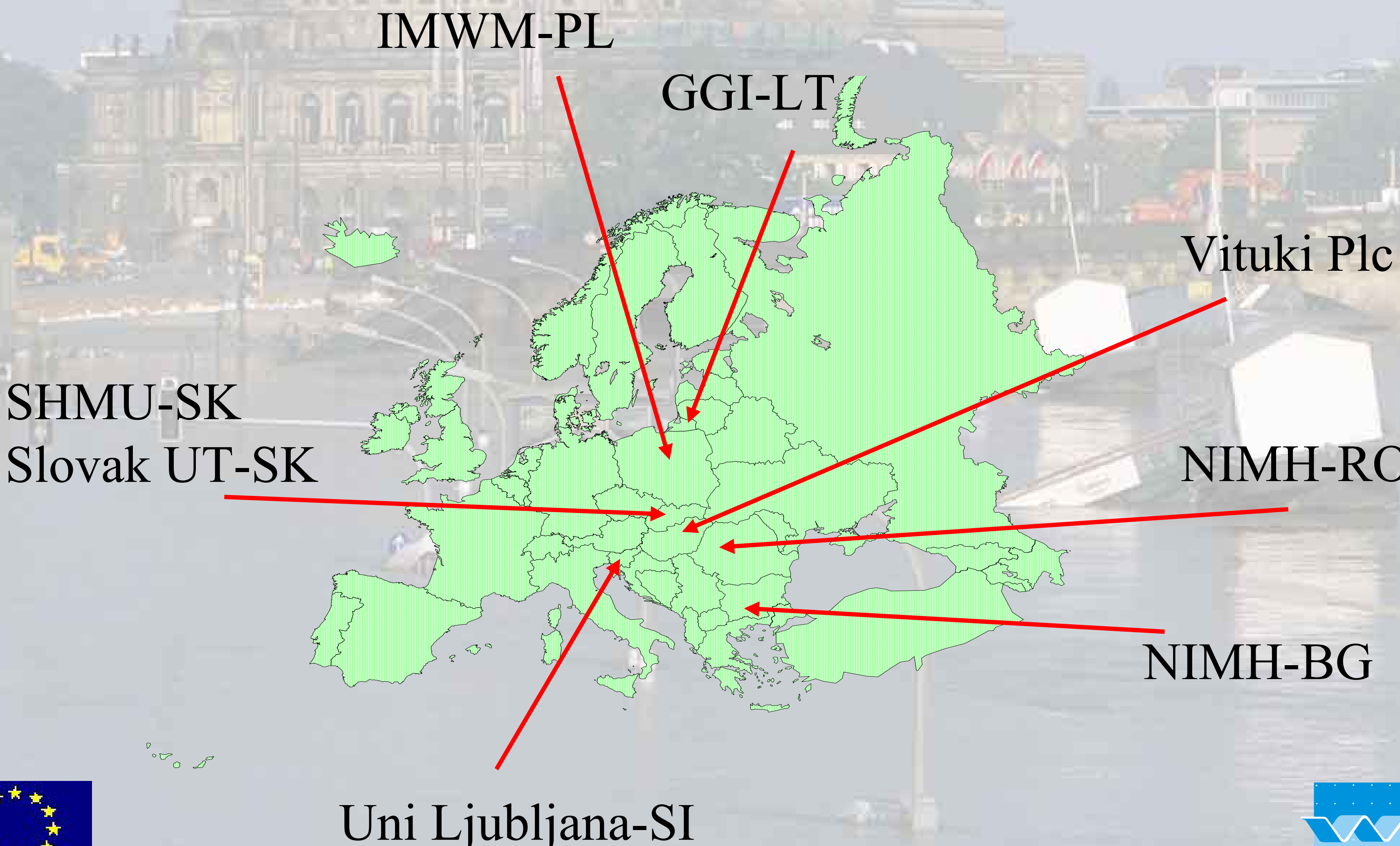
EFFS "Mother" Consortium



EFFS NAS-1 amendment

- **In June 2002 an EFFS amendment is approved to include 8 additional institutes from the Newly Associated States (NAS) in view of the enlargement of the EU.**
- **Amendment financed with ~ 4 k€ over 1 year**
- **New opportunities: Data from river systems in Eastern Europe are made available for sharing within the consortium.**
- **Results of hydrological and river routing models can be compared.**

EFFS NAS-1 Partners



EFFS Project Organigramm

WP 1 Co-ordinator & interface with EC
WL-Delft Hydraulics

WP 2 Meteorological data collection & supply
DWD

WP 3 Hydrological data collection
GRDC

WP 4: Building a geographical DB
UNI Bristol

WP 5 Parameter and forecast uncertainty estimation
Lancaster

WP 6 Downscaling and validating meteorological forecasts
DMI

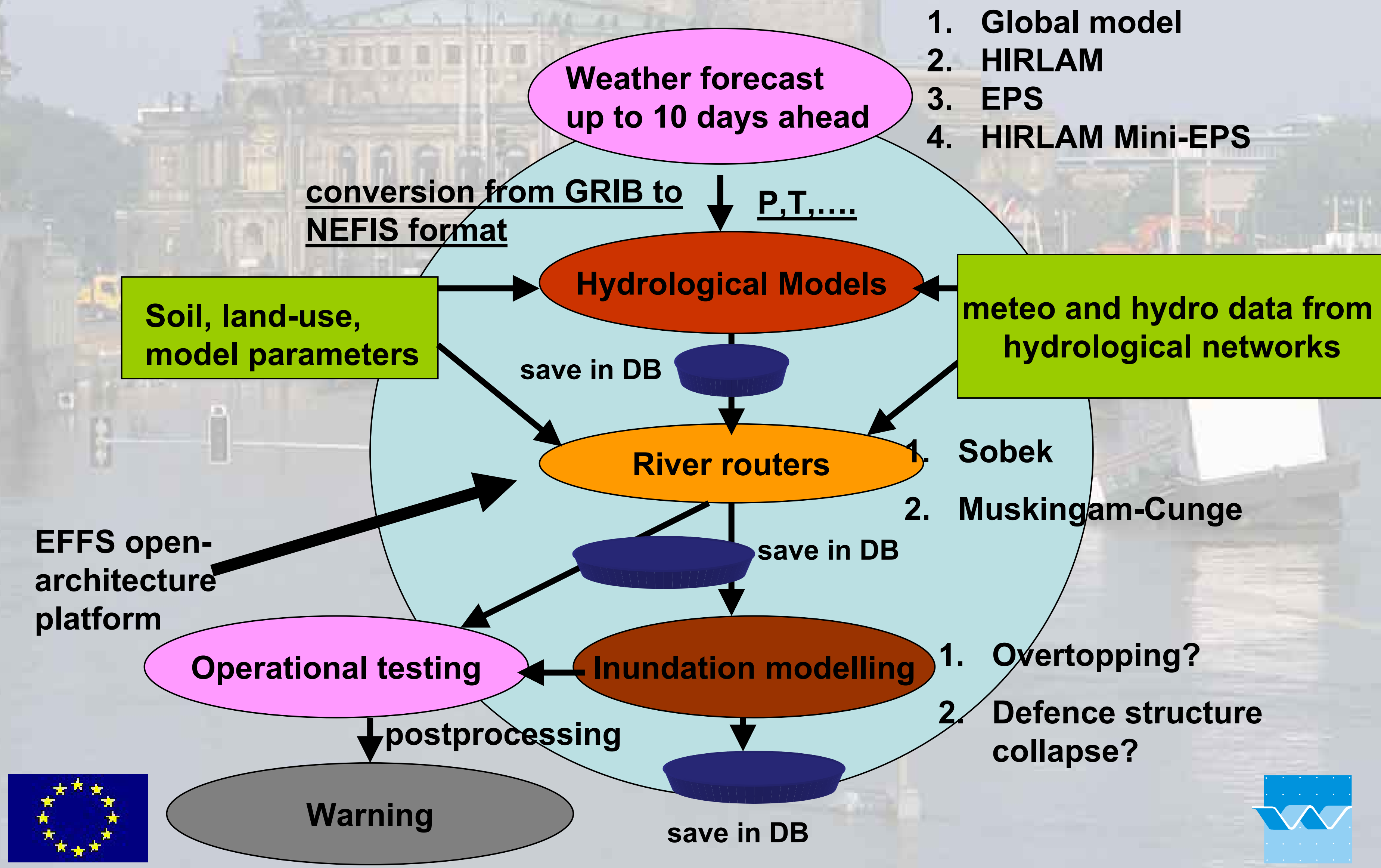
WP 7 Development of the European-scale FF system
JRC

WP 8 Application, validation & comparison of watershed models
Uni Bologna

WP 9 Set-up & testing of prototype system
RIZA

WP 10 Dissemination of forecasts & warnings
SHMI

EFFS structure



Numerical Weather forecasts

- **ECMWF supplies medium range meteorological data from their deterministic model and from their Ensemble Prediction System (EPS).**

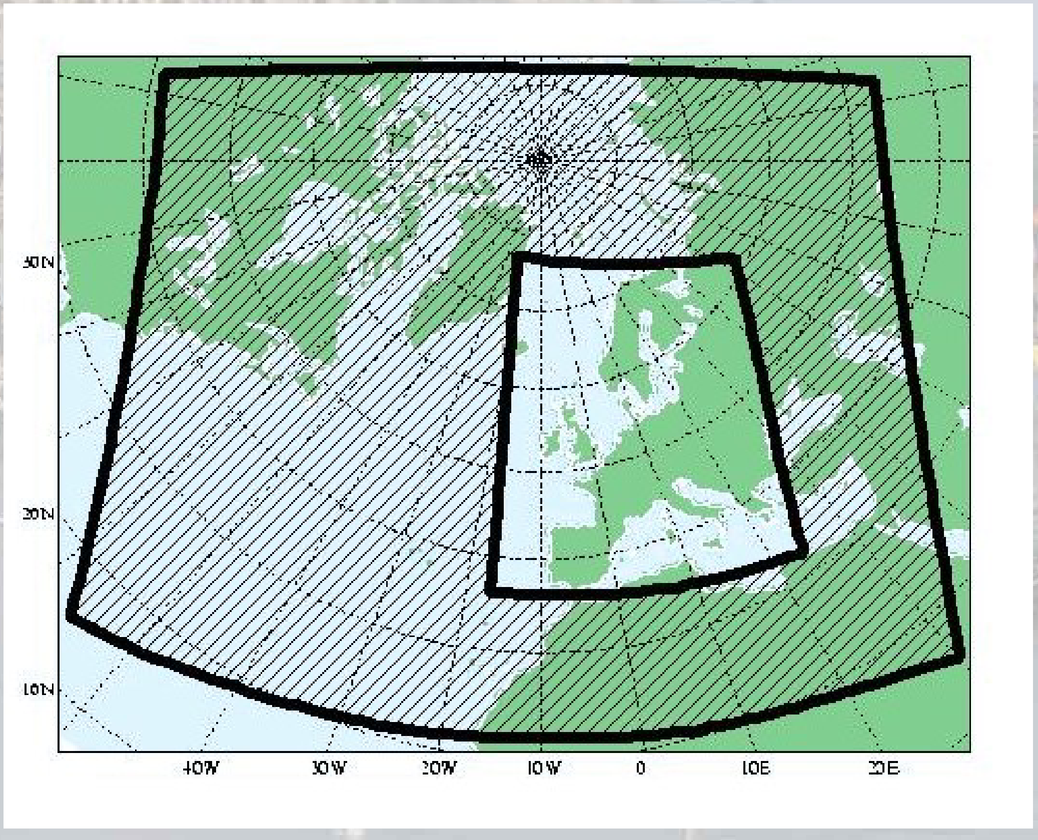
- **DWD and DMI supply deterministic high resolution short range forecasts from their High *R*esolution Local Area Model (HIRLAM).**

- **HIRLAM is initialised through Global ECMWF model output**

- **The high-resolutions forecasts make it possible to estimate the impact of horizontal resolution of the atmospheric predictions on water level forecasts.**

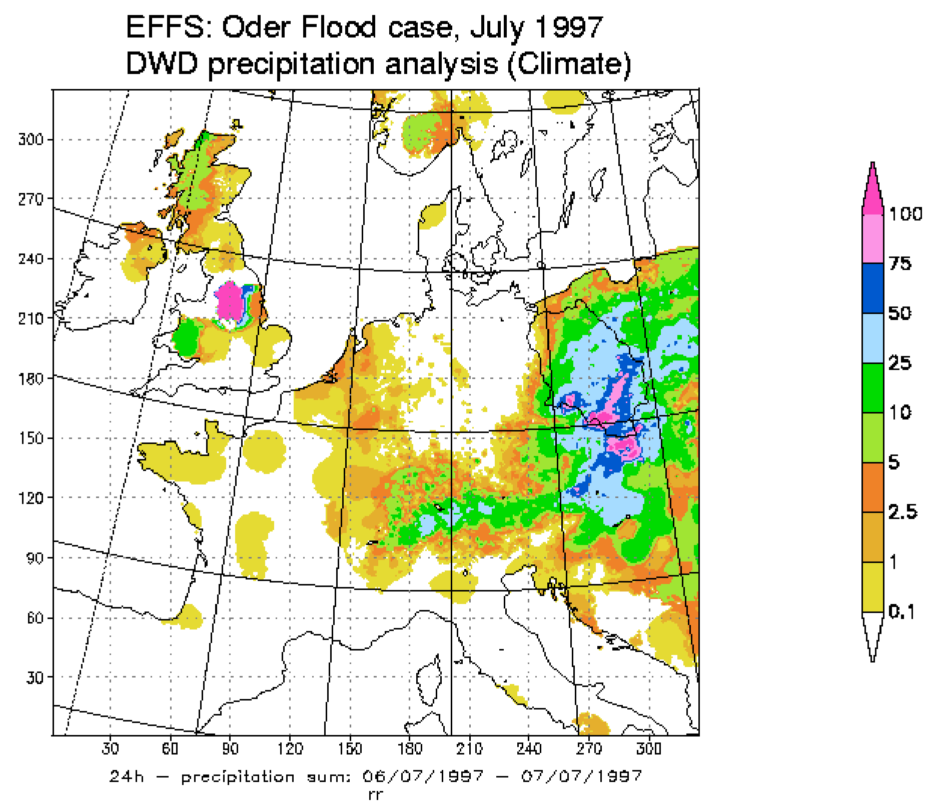
- **In addition, DMI is experimenting with mini ensembles with the aim to investigate uncertainties in the precipitation forecasts.**

High Resolution Local Area Model nested domains



Courtesy Danish Meteorological Institute

Precipitation hindcast



Courtesy Deutscher Wetterdienst

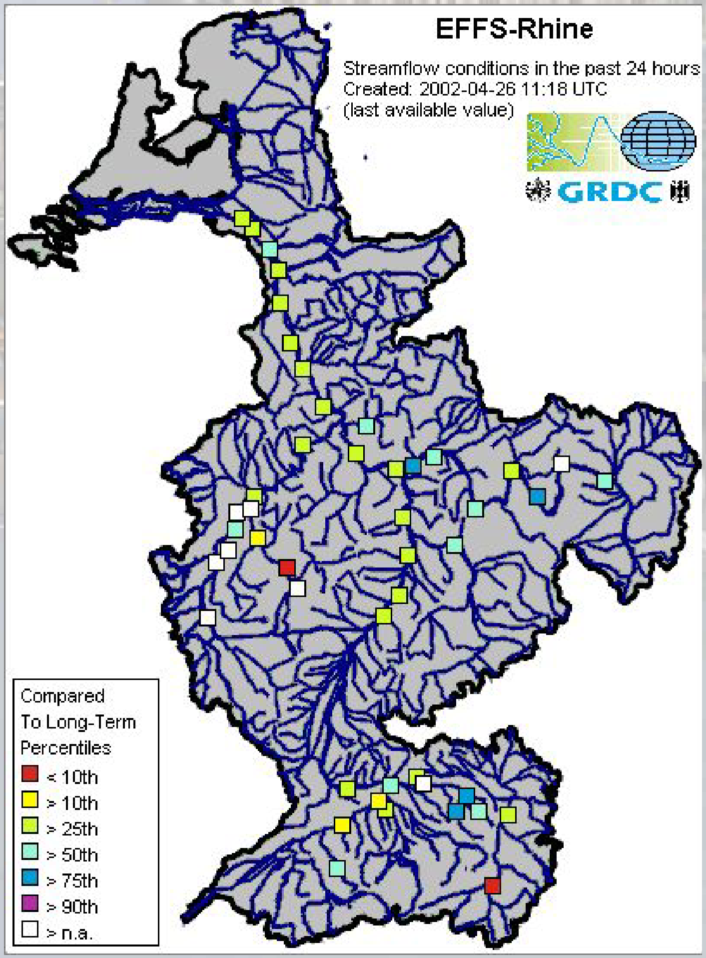
Hydrological measuring networks in flood forecasting

- **The operation of a river basin-scale flood forecasting system, and in particular of a continental-scale system, as EFFS, requires regular update through measured data.**

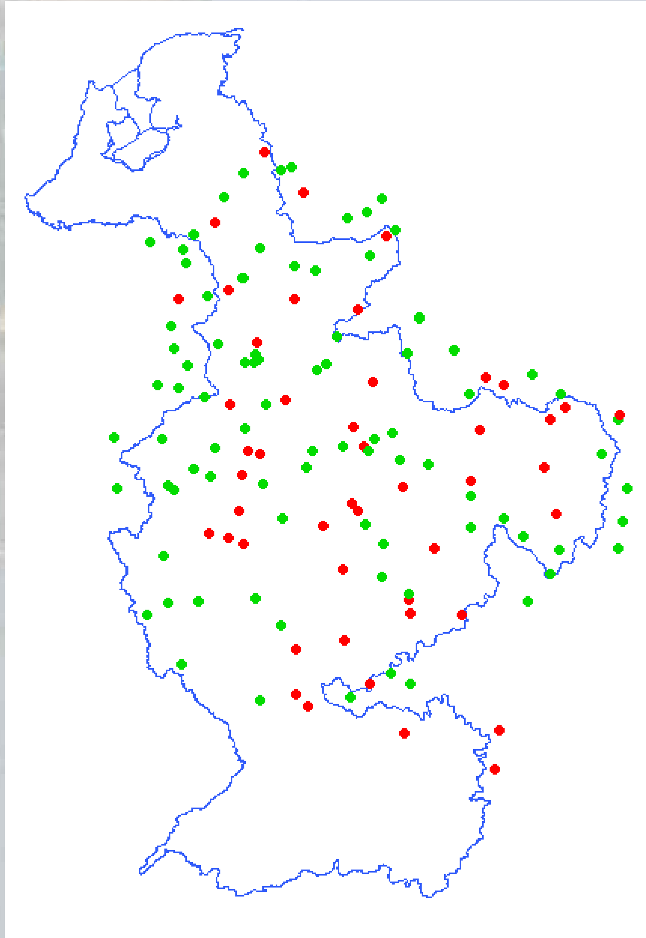
- **Which data are required?**

1. **Precipitation**
2. **Temperature**
3. **Synoptic weather data**
4. **Discharge data at critical locations**
5. **Water level data at critical locations**

Measurement network for the Rhine Basin



Stream flow gauges

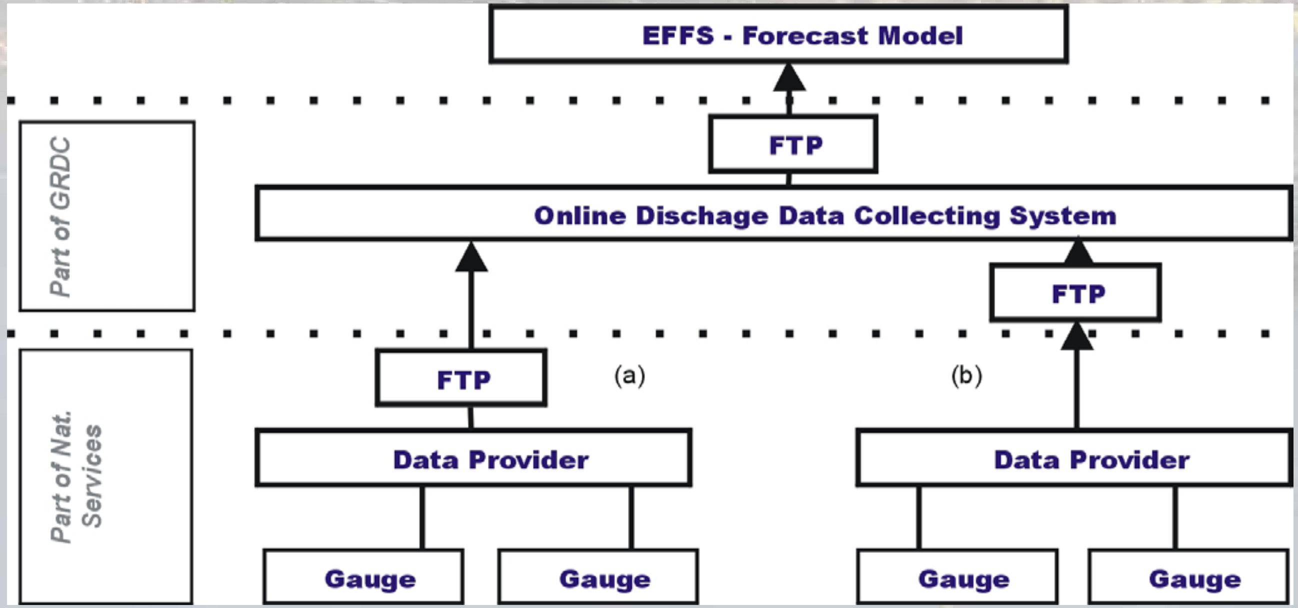


DWD meteorological stations

Data acquisition in EFFS

•The following scheme shows the data-stream from measuring networks to the EFFS is performed.

•The data acquisition was led by the GRDC in Work-Package 3.

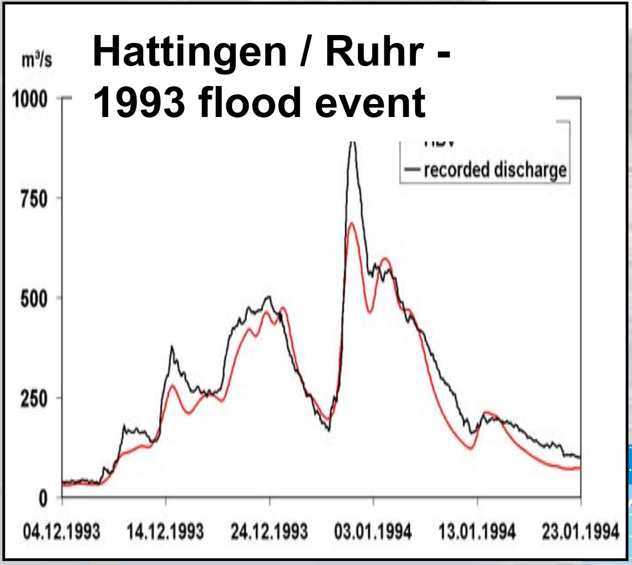


Courtesy GRDC

Utilisation of measured data in the flood forecasting system

- The regularly update measurement form the hydrological networks are used for the following purpose:
- In now-casting (extremely short lead-time, max 24 hrs) directly measured precipitation data form gauges and radar are used to drive models.
- in EFFS (mdium-range lead-time) hydrological and hydraulic models are updated (data assimilation) through data measured over the 2 weeks precedent the begin of the forecast.

- The data are transferred from the loggers over FTP into the data-base of the flood forecasting system.



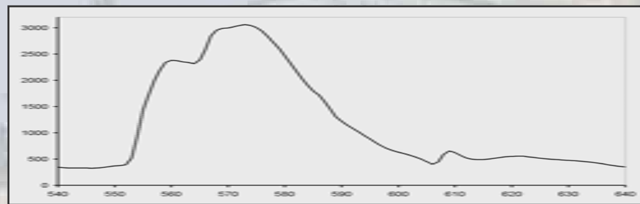
Hydrological modelling

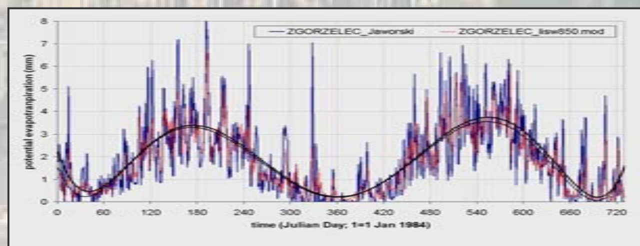
- Different hydrological models are used within the EFFS system:

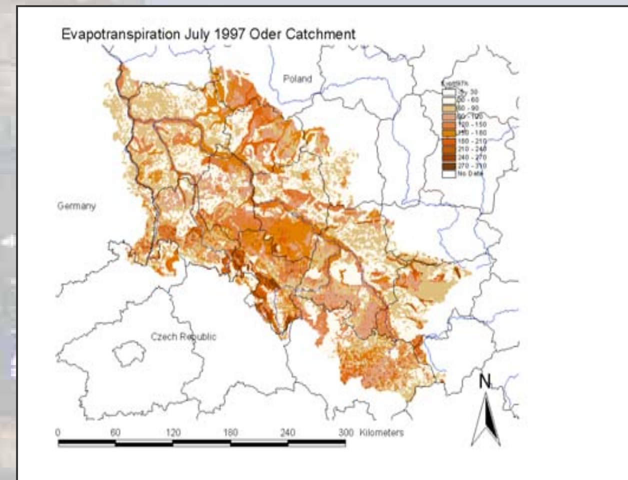
1. HBV (SHMI) semi-distributed model the entire Rhine Basin (calibrated at the BFG, Koblenz) representing the Rhine Basin up to Switzerland through 134 sub-basins.
2. LISFLOOD (JRC) raster-based model for simulation of continental river basins at 5 sqkm resolution. Used in particular for Rhine, Odra, Danube.
3. TopKapi (Uni Bologna) for simulation of the Po river basin

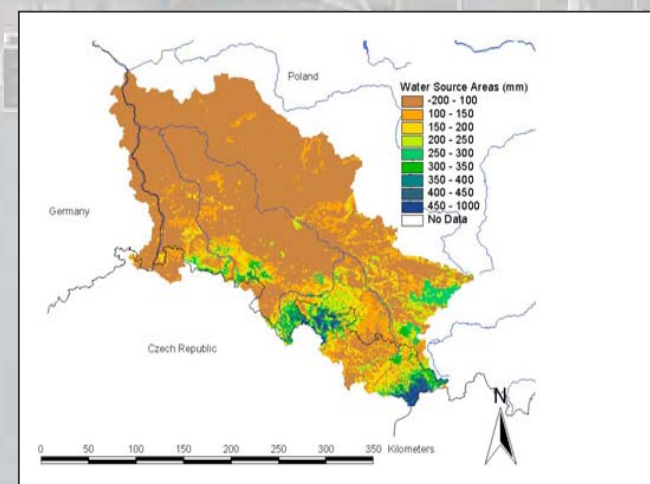
N.B.: The system is however conceived as "<u>open</u> " allowing any other model to be incorporated through an appropriate <u>model-adapter.</u>

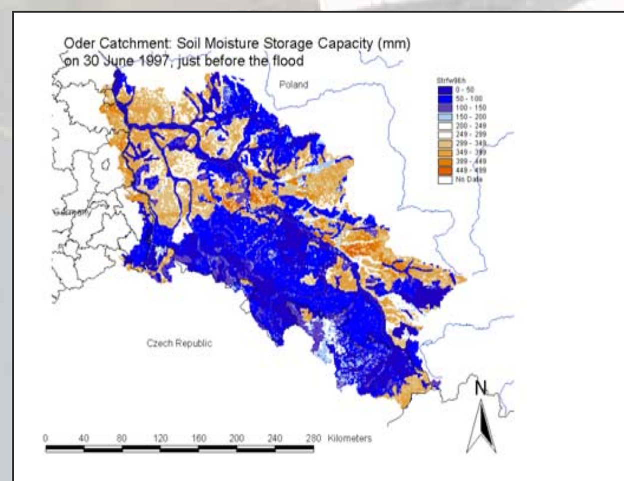
LISFLOOD model









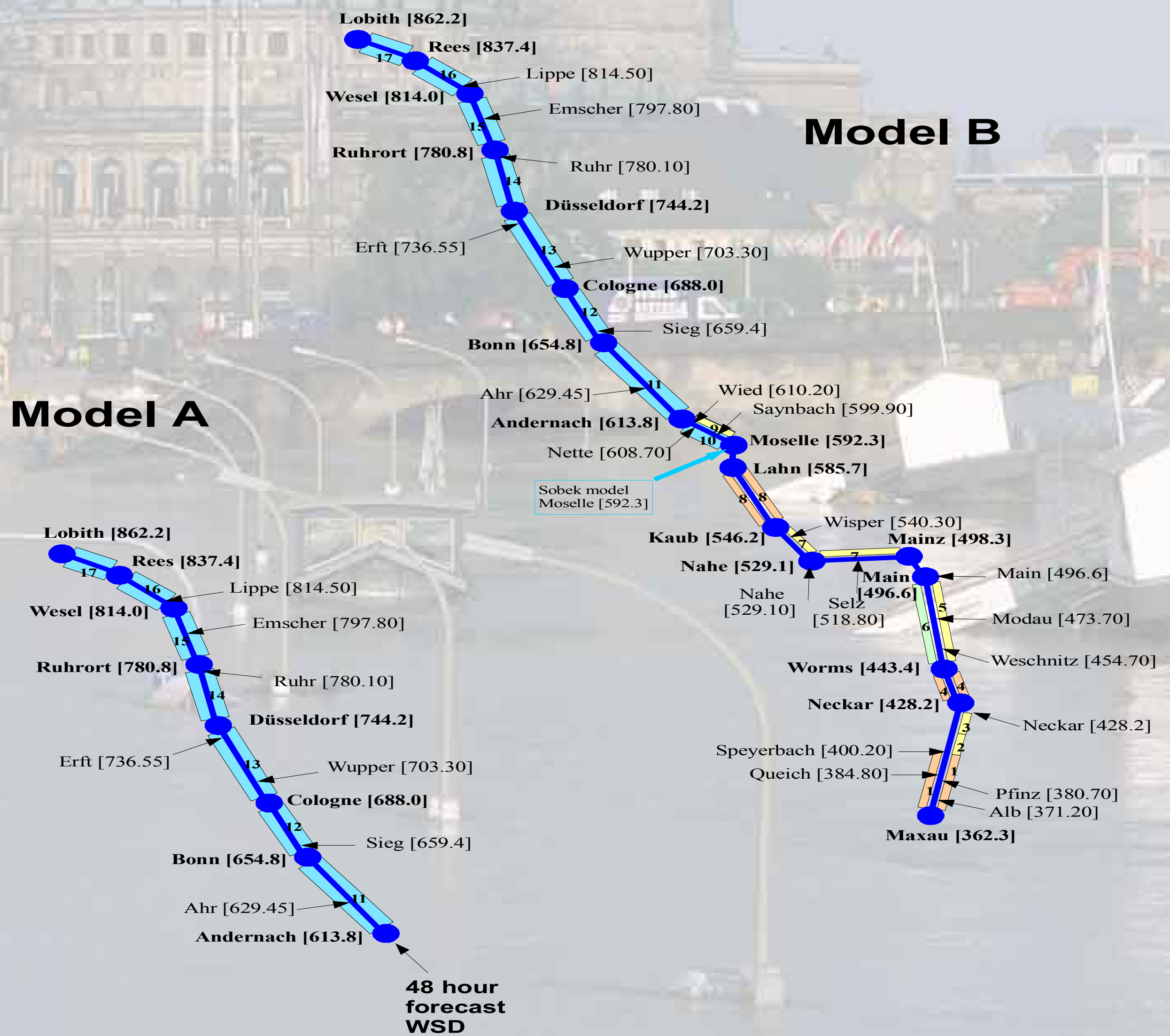


Courtesy Joint Research Centre

River routing

- Lateral inflows into the main river system are calculated by the hydrological model (e.g. HBV).
- The water is subsequently routed along the main river system (e.g. Rhine).
- Within the EFFS river routing is performed with the WL | Delft Hydraulics Saint-Venant model SOBEK.
- Discharge Q and water level height H at critical sections are calculated.
- Effects of engineering structures such as weirs, locks and bridges are included in the schematisation.

River routing



Floodplain inundation modelling

- Once water overtops a dyke and invades lowlands (e.g. polders), 2-D flood-wave propagation modelling is needed to forecast the extent of the inundation.

- Inundation modelling within EFFS can be performed by two different models:

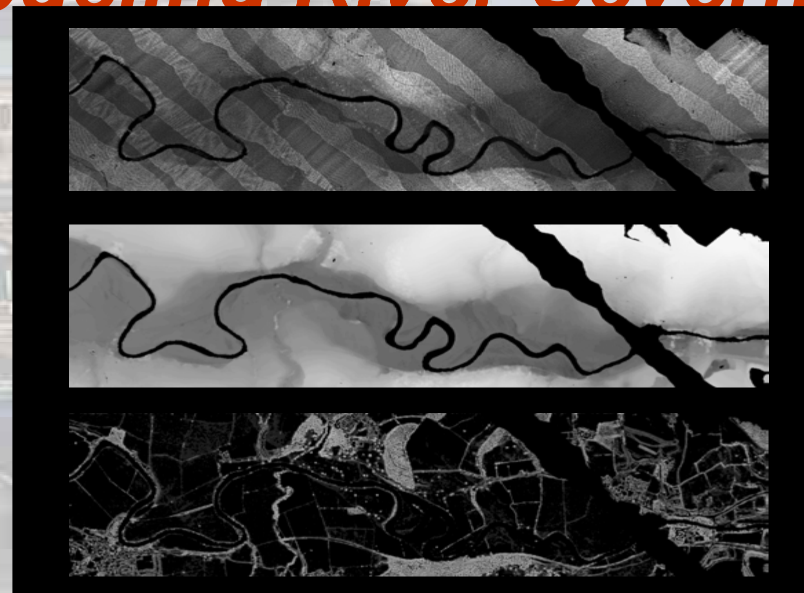
1. The 2D inundation of the University of Bristol and JRC (LISFLOOD-FP.
2. The Delft 2D inundation model.

Inundation Modeling River Severn (UK)

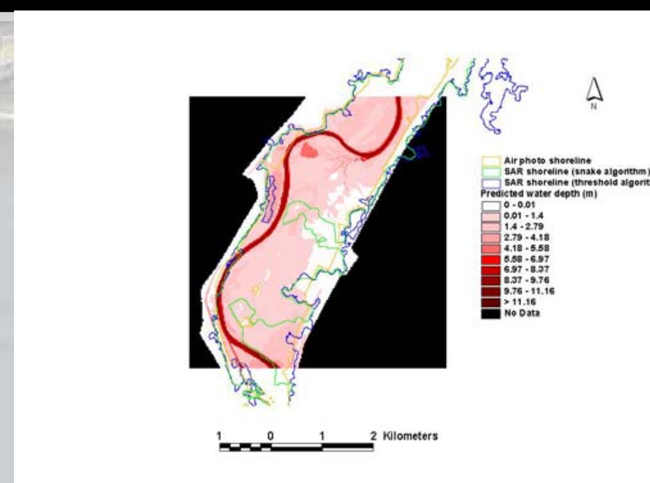
Raw LiDAR data
(6 x 3 km domain)

Topography map

Vegetation height
map



Inundation modelling
results



Courtesy University of Bristol

Uncertainty

- **Flood forecasting cannot be separated form the problem of the uncertainty inherent to the input, model structure and parameter values.**
- **Any flood forecasting system is made up by a cascade of models, usually :**

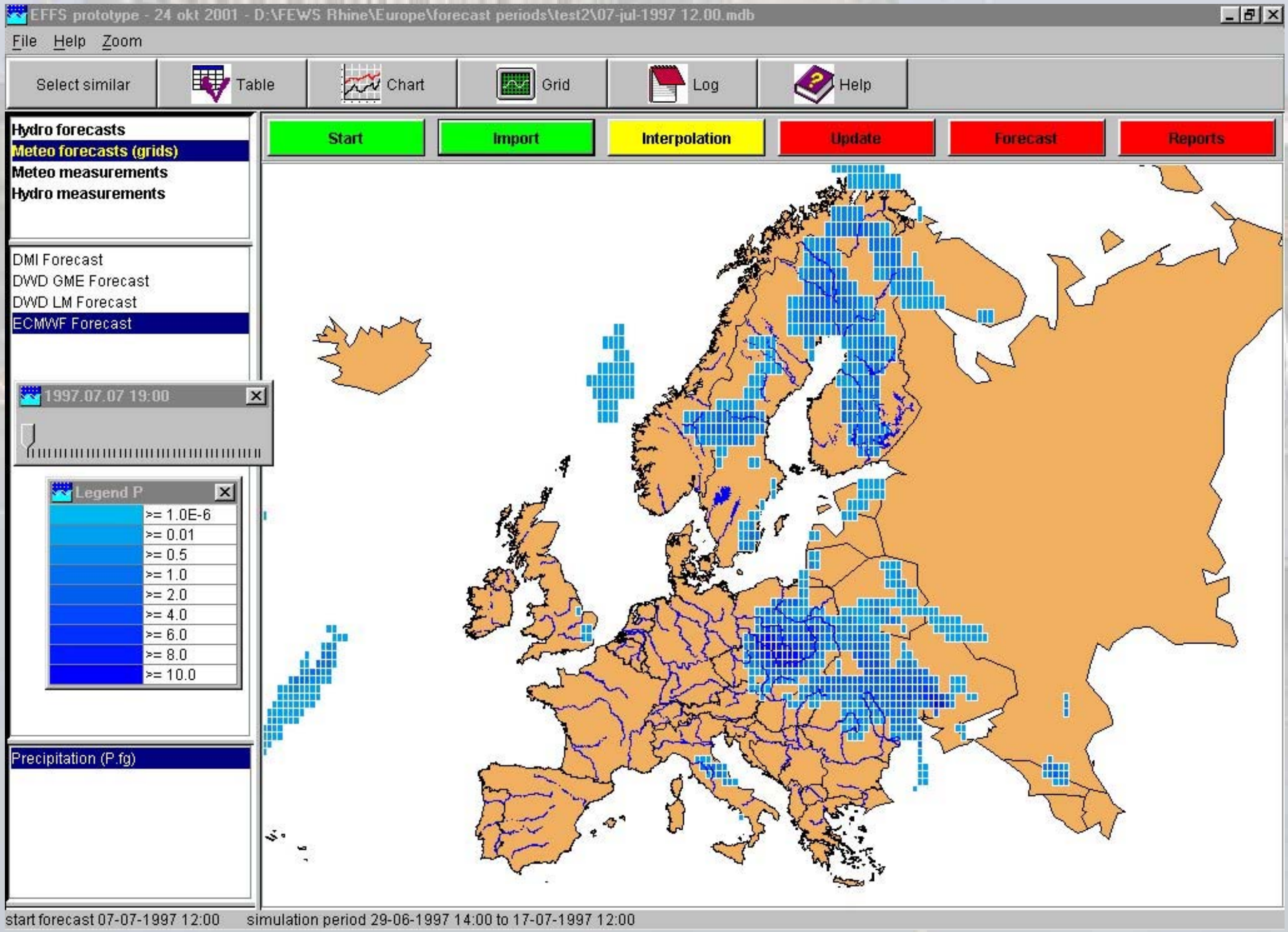
Meteo → Hydrology → Routing → Inundation

- **Each model contains parameters which lie within a range, i.e. their exact value is not known.**
- **In addition the inputs (e.g. rainfall) as well as the initial conditions are affected by uncertainty.**
- **Subsequently the predictions lead to a bandwidth of forecasted values, which may over- or underestimate the actual water levels.**

Model integration: prototype FEWS

- **The modeling steps needed in a flood forecasting system are integrated through an integration platform (shell-tool).**
- **The shell-tool is designed as open and re-usable software system.**
- **The system is adaptable to different hydrological and hydraulic models through model-adapters.**
- **The platform is linked to a data-base system.**
- **Results of various model runs are saved and retrieved subsequently from the DB.**
- **Within the shell-tool model runs, analysis of results and postprocessing are facilitated.**

The Open-Architecture Platform



Testing of the prototype

- The EFFS is being tested within the frame of the project in a semi-operational fashion by the Dutch institute RIZA on the river Rhine.
- Several hundreds of forecasts have been carried out though direct access to DWD weather forecast data and subsequent running of the model cascades.
- The predicted water levels are compared directly with the ones measured at the German-Dutch border flow measuring station.
- Results of these test-runs will be presented later on in the conference.

Flood Warning & dissemination

- Once a high water is forecast by the system, decision need to be made if evacuation is necessary.
- False alarms can be as damaging as not issuing a warning at the right moment.
- Decisions stay ultimately with the forecaster and need use of historical records for verification and uncertainty reduction.
- A systematic approach to address this issue is matter of ongoing research.

Summary

- The outlined system components will be addressed by the project partners through dedicated sessions during this conference.
- Results and applications of various project applications will be presented.
- Systematic quantification and handling of the inherent uncertainties on forecast results are a complex issue which needs particular attention from a research point of view.

Contributions

To this presentation have contributed the following people :

- Keith Beven
- Paul Bates
- Erdmann Heise
- Tony Hollingsworth
- Bo Holst
- Michael Hils
- Jaap Kwadijk
- Ad de Roo
- Kai Sattler
- Eric Sprokkereef
- Ezio Todini

The conference organisation would like to wish you a pleasant stay and is looking forward to fruitful discussion!

Thank you very much for your attention.