

# Operational low flow forecasts

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Koblenz

KHR-CHR Workshop Low flows and droughts  
25 & 26 September 2007, Würzburg

# Responsibility in Germany

- Navigability of ships and maintenance of large rivers:
  - Federal Waterway and Navigation Administration (WSV)
- Flood defence, flood warning and forecasting service
  - German Federal States



# Water Level Forecasting System WAVOS

## Operational low water forecast

Bundesanstalt für  
Gewässerkunde,  
Koblenz

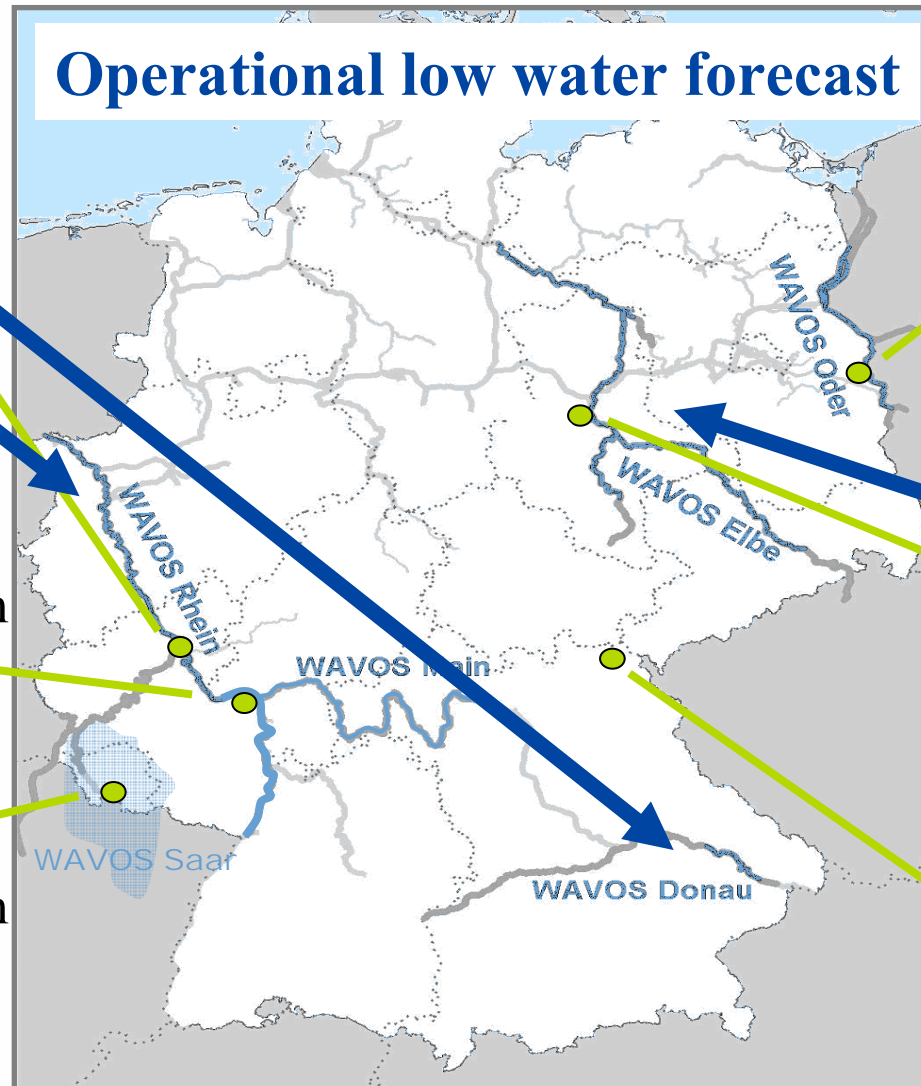
Hochwasser-  
Vorhersagezentrale  
Frankfurt (Oder)

Hochwassermeldezentrum  
Rhein, Mainz

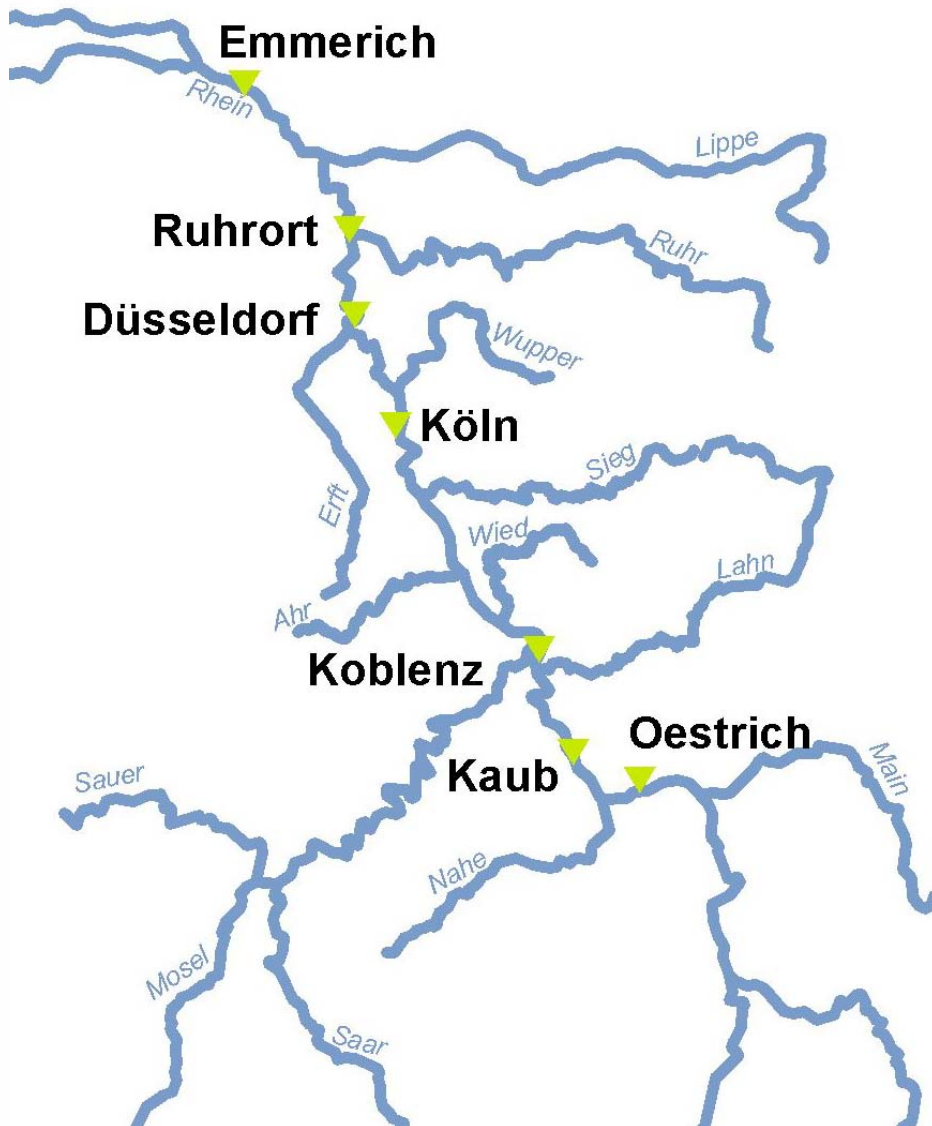
Vorhersagezentrale  
Elbe, Magdeburg

Hochwassermeldezentrum  
Saarland, Saarbrücken

Hochwasser-  
Vorhersagezentrale  
Main, Hof



# Low flow forecasting along the Rhine

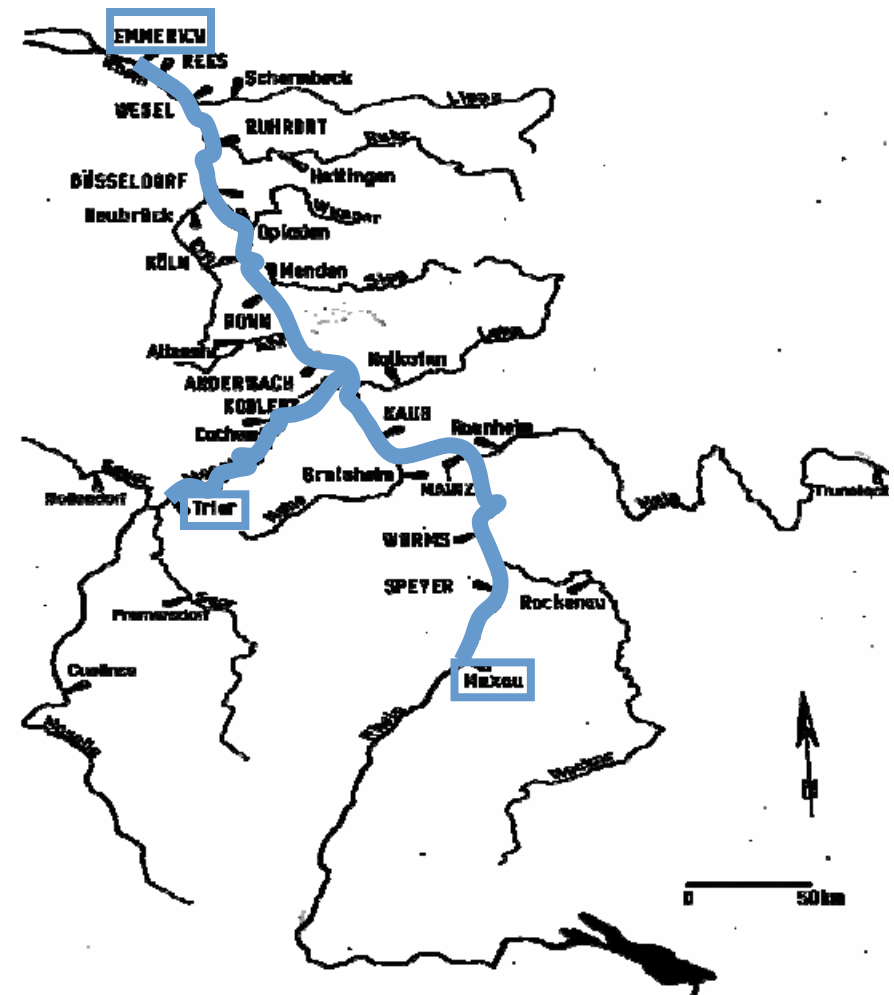


Operational low flow forecasts

- > 7 gauging stations: Oestrich, Kaub, Koblenz, Köln, Düsseldorf, Duisburg-Ruhrort, Emmerich
- > Forecasting horizon: 48 hours
- > Forecasting time: 7:00
- > Daily Forecast: Water level at gauge Ruhrort  $\leq 400\text{cm}$

# WAVOS Rhine

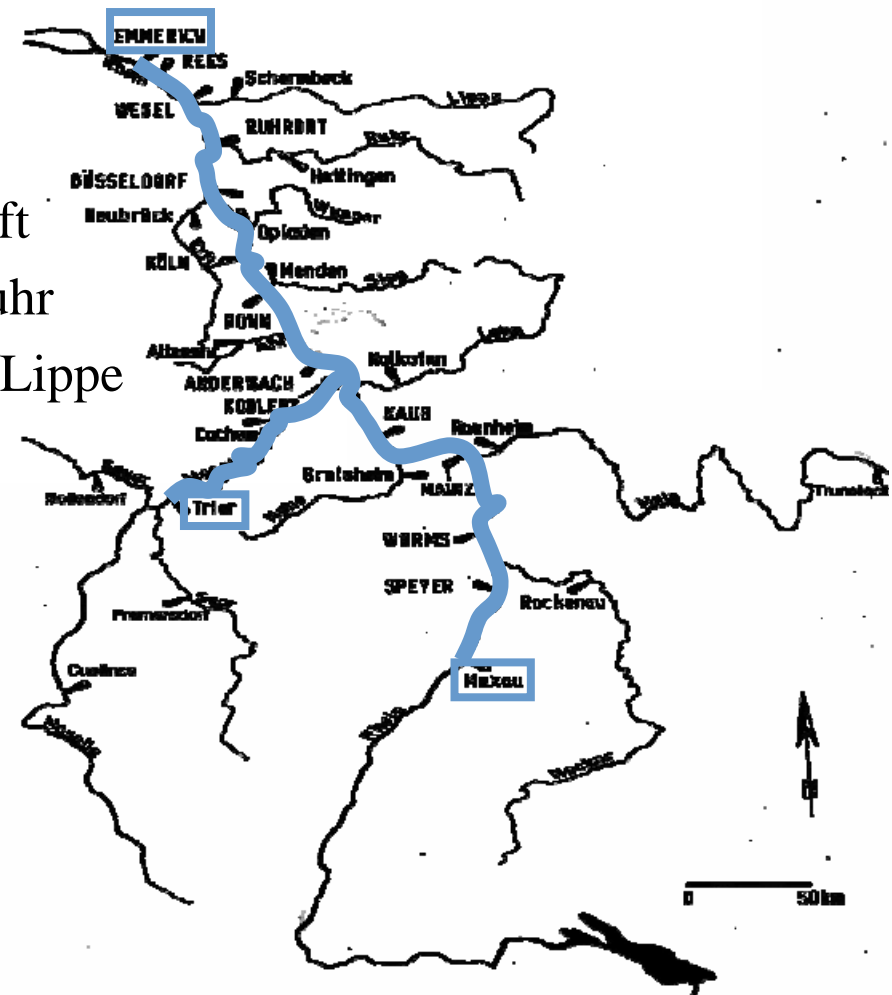
- > 1D hydrodynamic model
  - > Rhine and Moselle (685 km)



# WAVOS Rhine

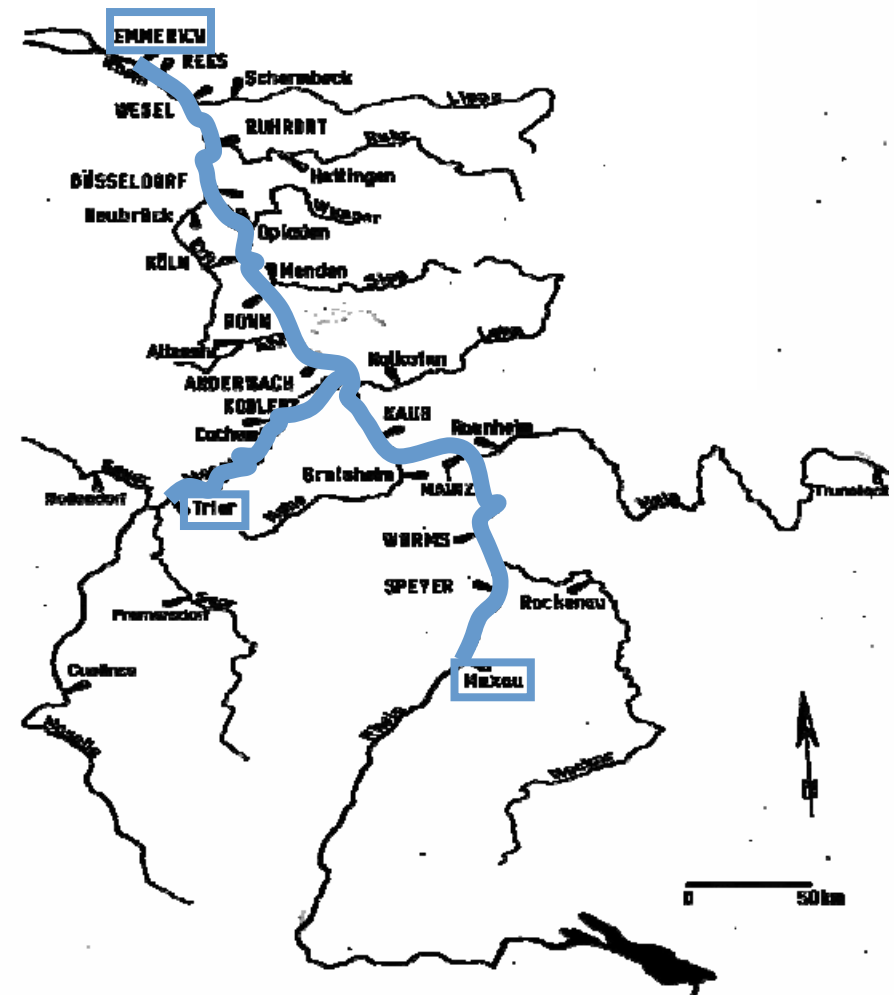
## > Tributaries Rhine model

- > Maxau/Oberrhein
- > Rockenau/Neckar
- > Raunheim/Main
- > Grolsheim/Nahe
- > Kalkofen/Lahn
- > Trier u. Cochem/Mosel
- > Friedrichstal/Wied
- > Altenahr/Ahr
- > Menden/Sieg
- > Opladen/Wupper
- > Neubrück/Erft
- > Hattingen/Ruhr
- > Schermbeck/Lippe



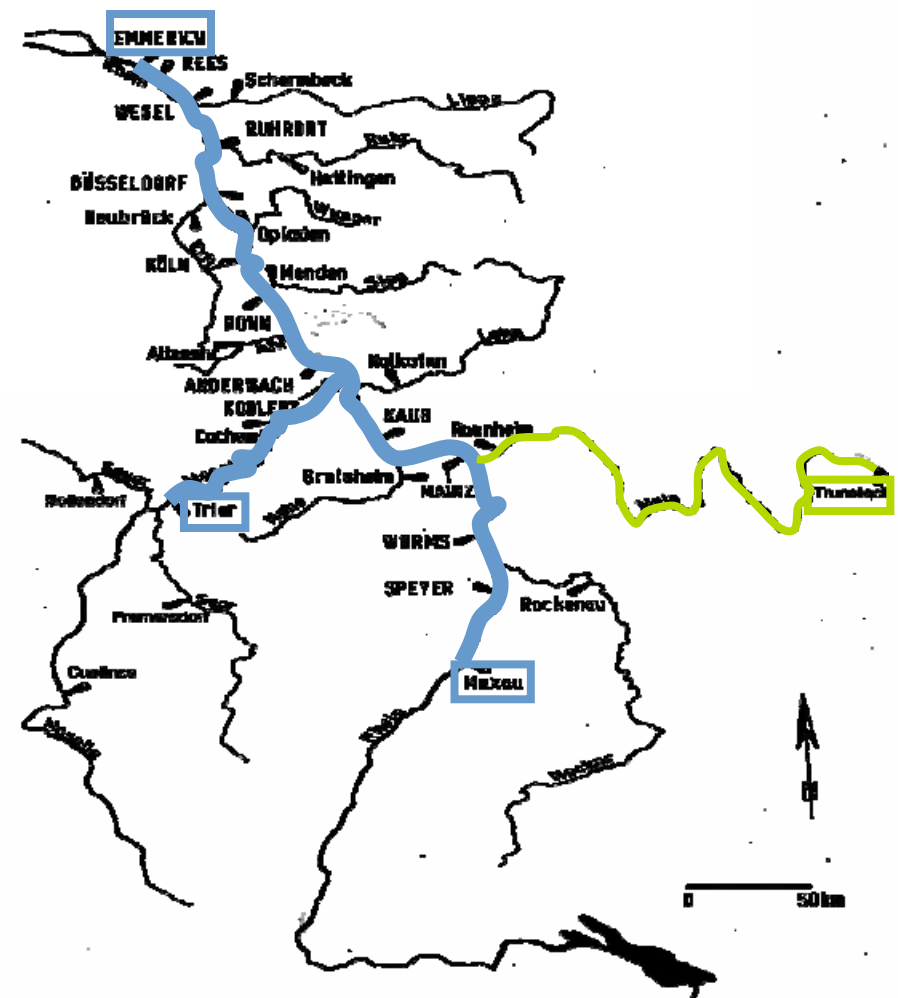
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# WAVOS Rhine

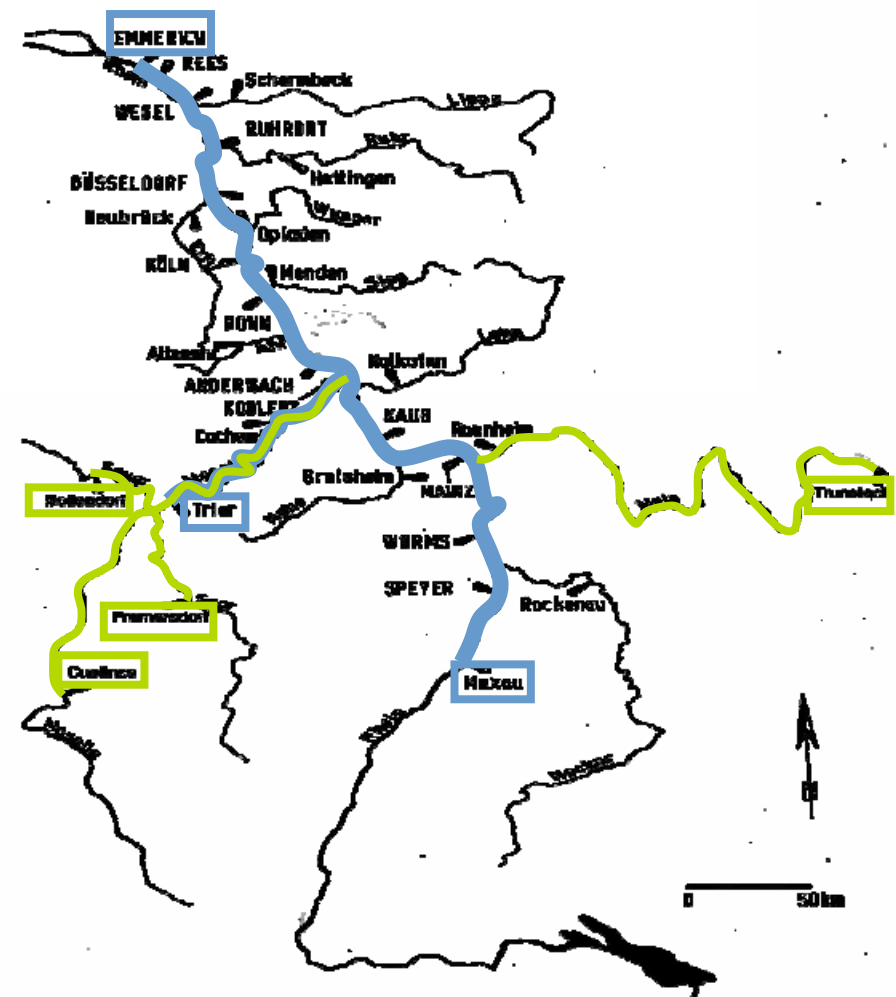
- > 1D hydrodynamic model
  - > Rhine and Moselle (685 km)
  - > Main (380 km)





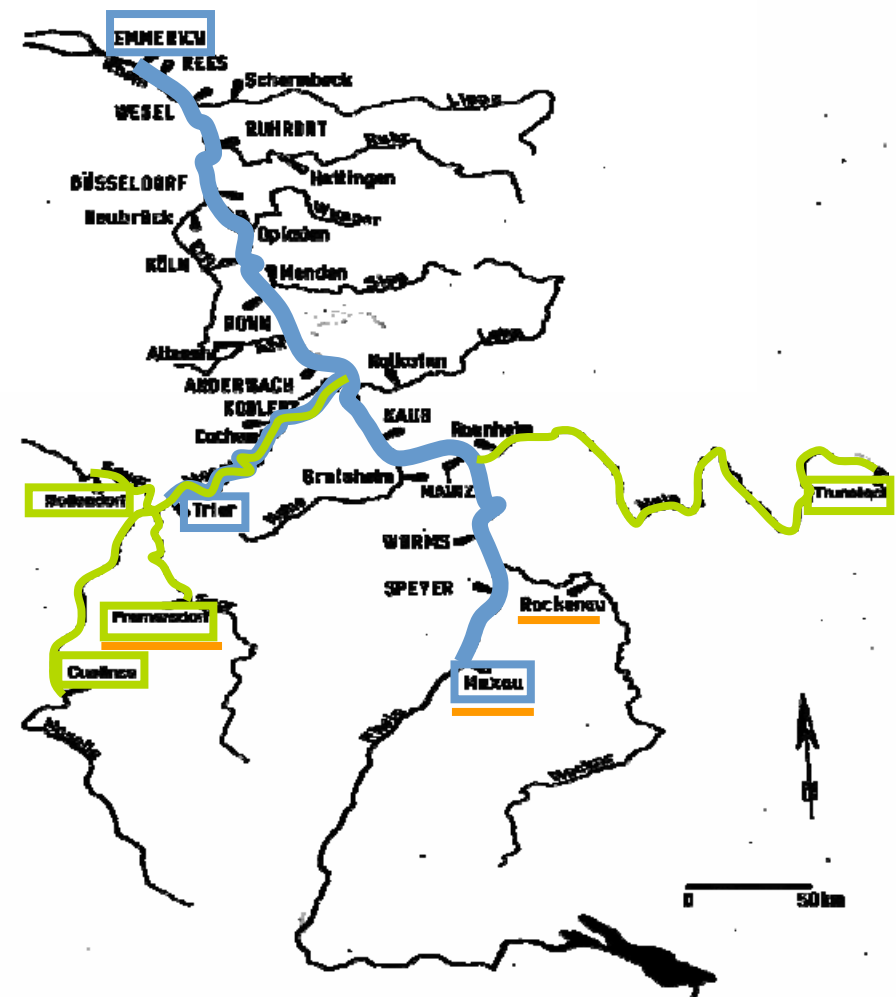
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  - > Main (380 km)
  - > Moselle-Saar-Sauer (425 km)



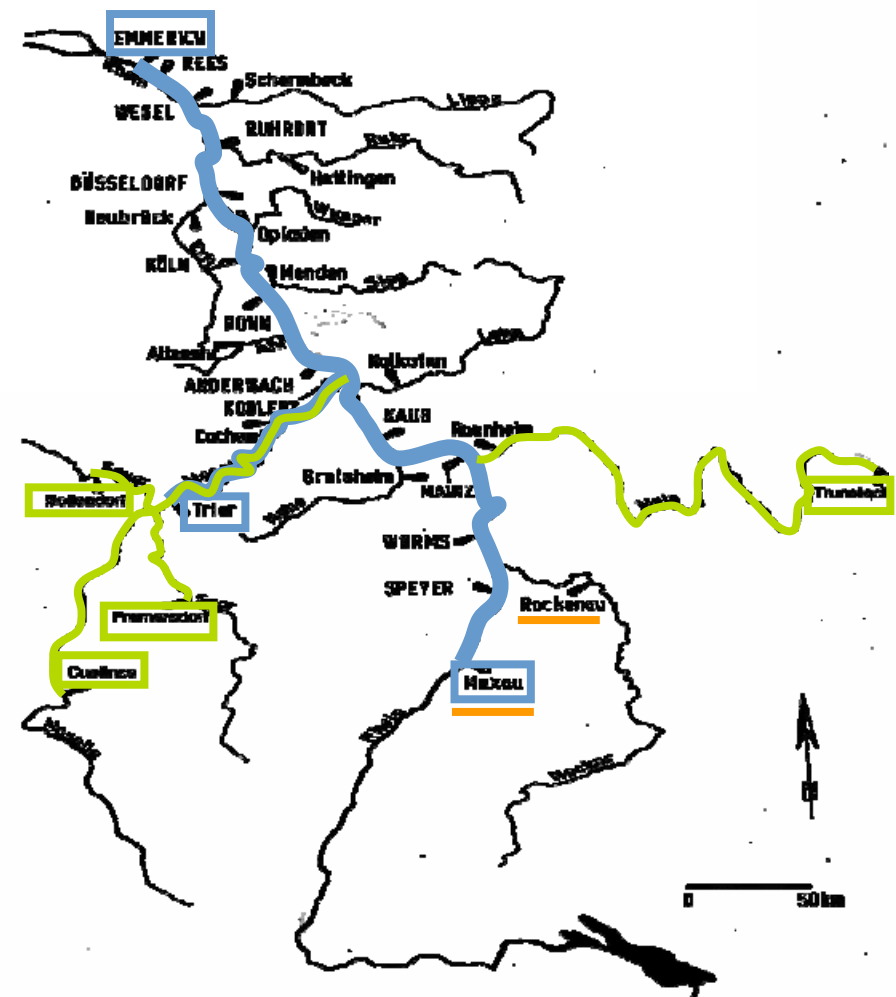
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- > Statistical model
  - > Maxau/Rhein
  - > Rockenau/Neckar
  - > Fremersdorf/Saar



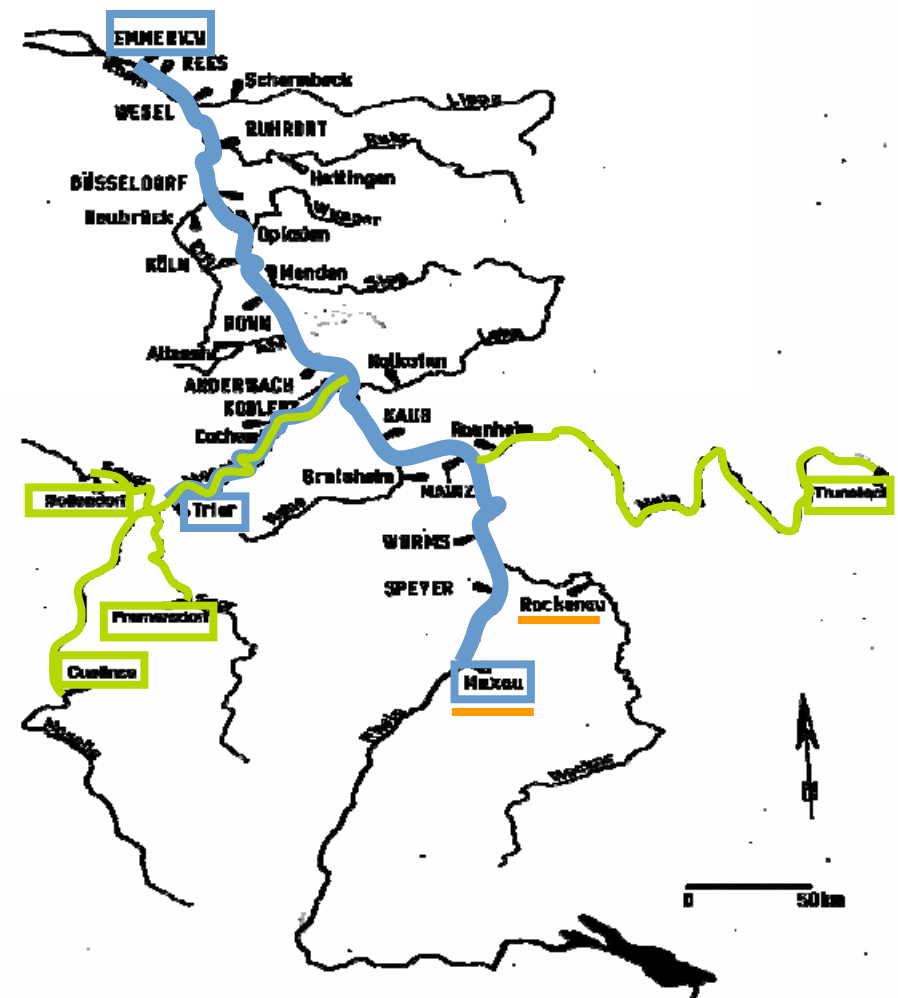
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  - > Rockenau/Neckar
  - > Fremersdorf/Saar
- > External forecasts



# WAVOS Rhine

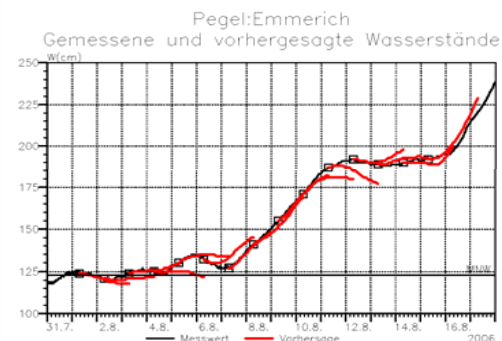
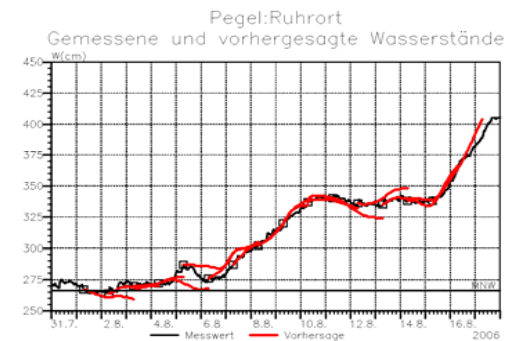
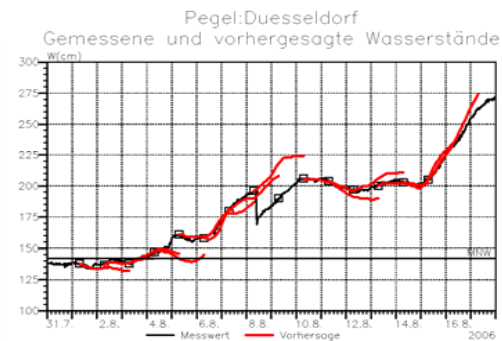
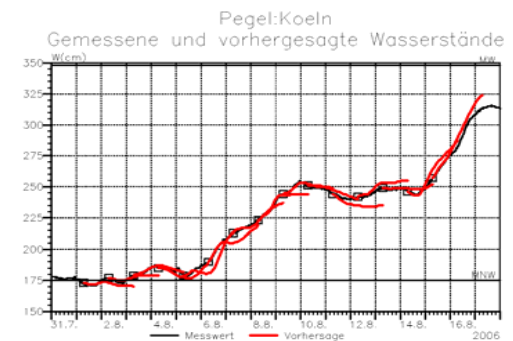
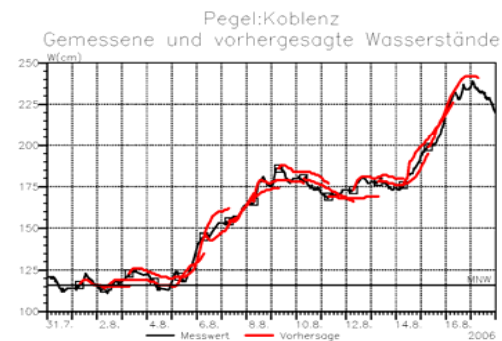
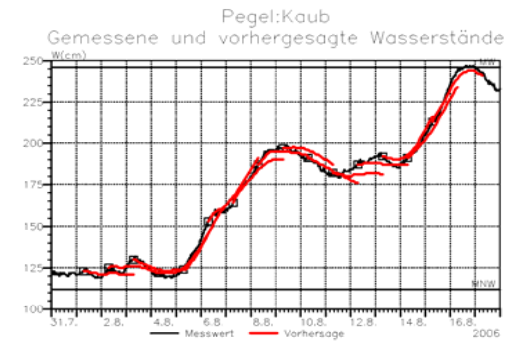
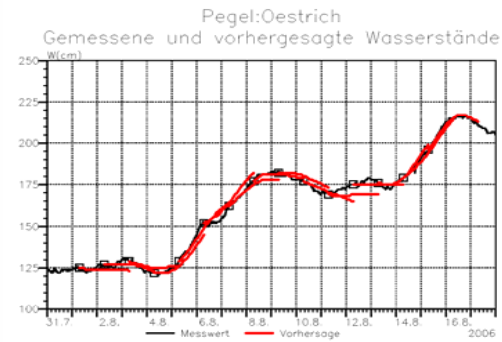
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- > External forecasts
- > Forecaster's estimate



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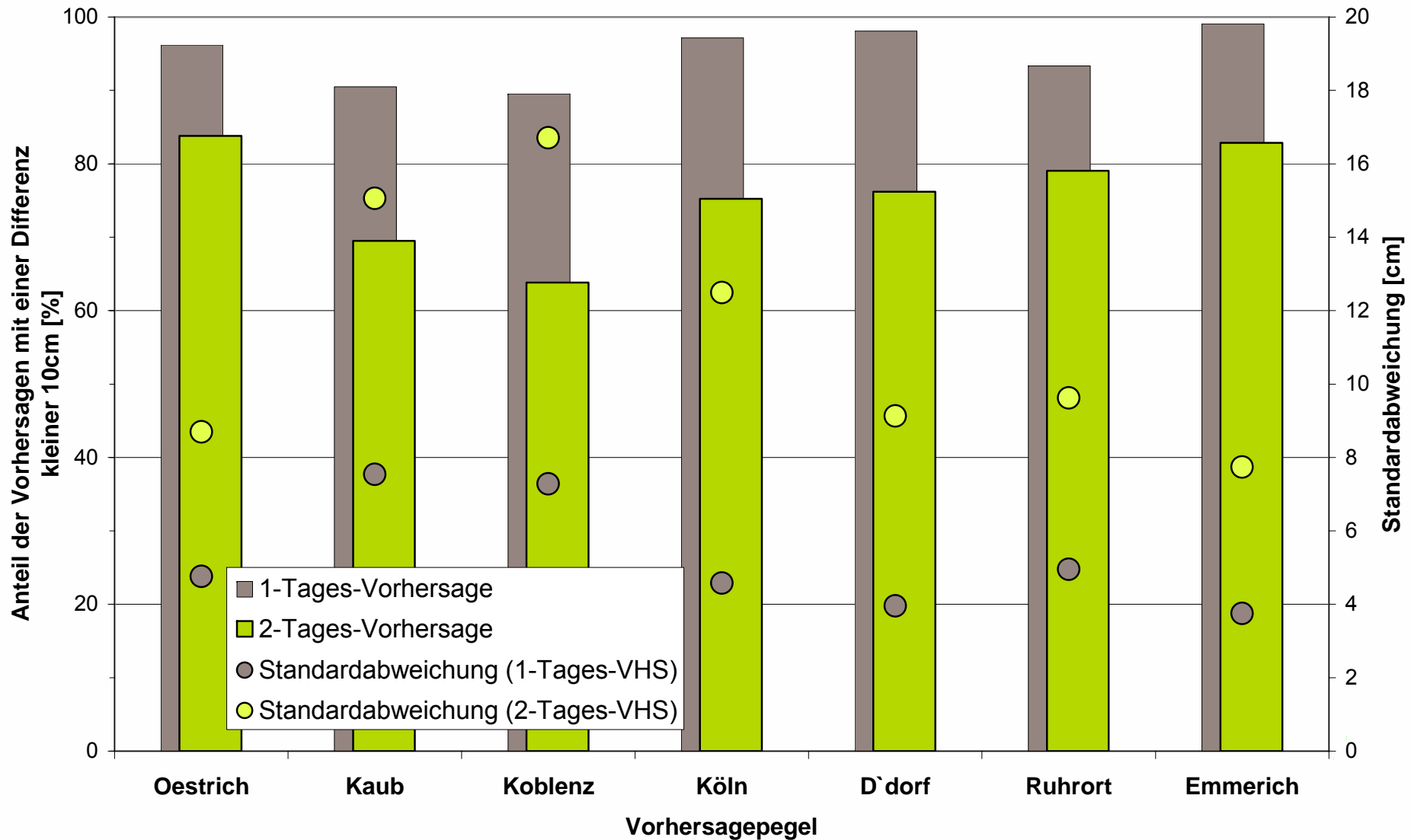
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Vorhersage Rhein 01.08.2006 – 15.08.2006 von 7 Uhr

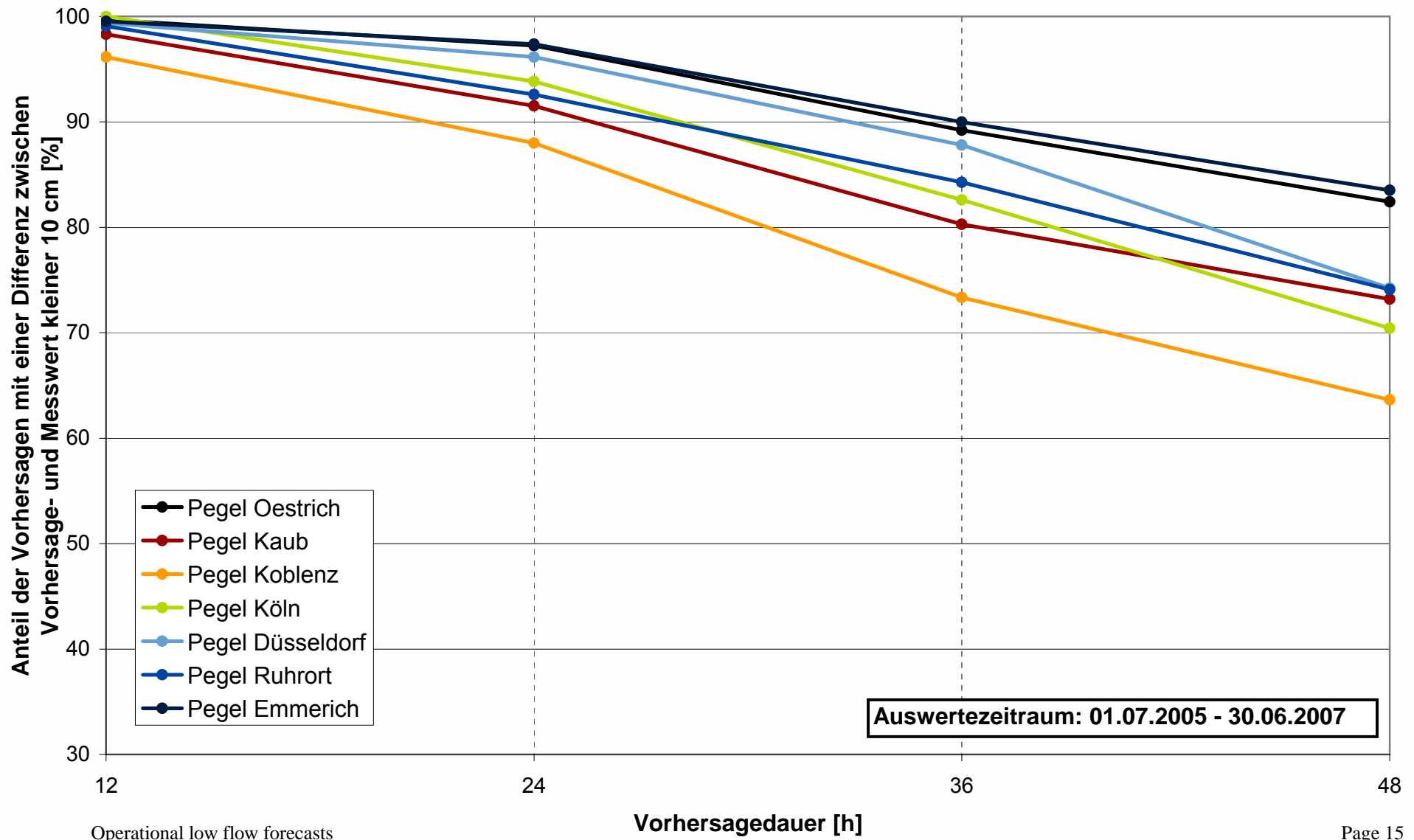


	15.08.06 07.00	16.08.06 07.00	16.08.06 19.00	17.08.06 07.00
Oestrich	196	215	217	213
Kaub	213	239	244	241
Koblenz	199	232	242	241
Koeln	257	289	310	324
Duesseldorf	205	234	254	274
Ruhrort	338	364	383	404
Emmerich	192	202	214	229

# WAVOS Rhine - Results



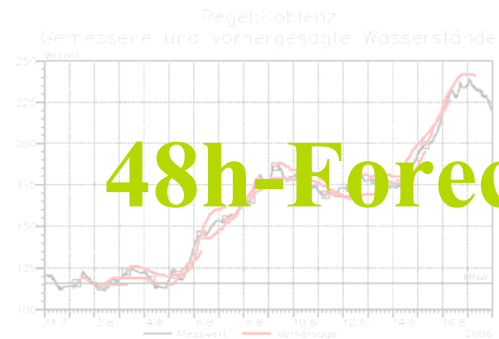
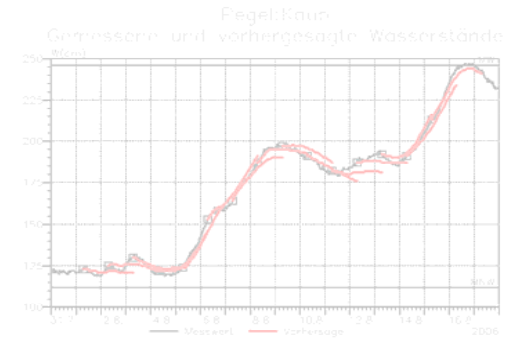
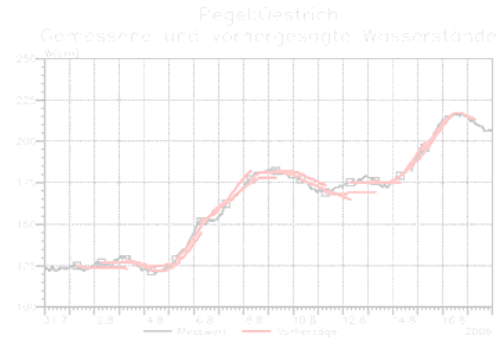
# WAVOS Rhine - Results



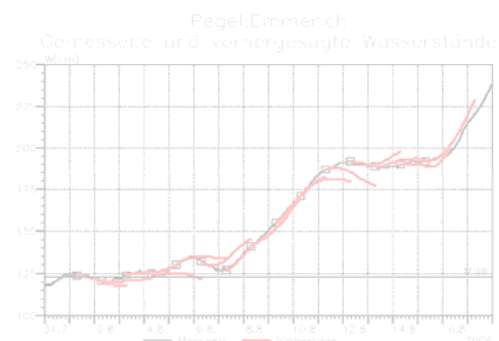
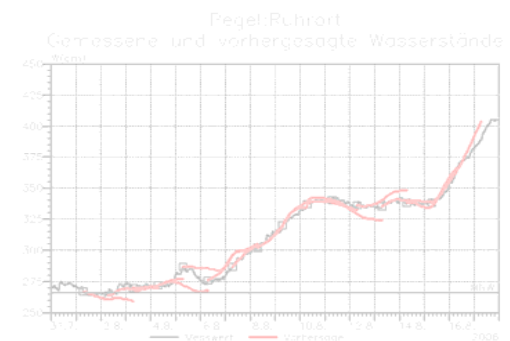
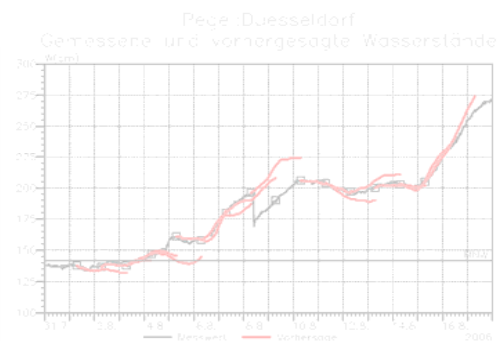
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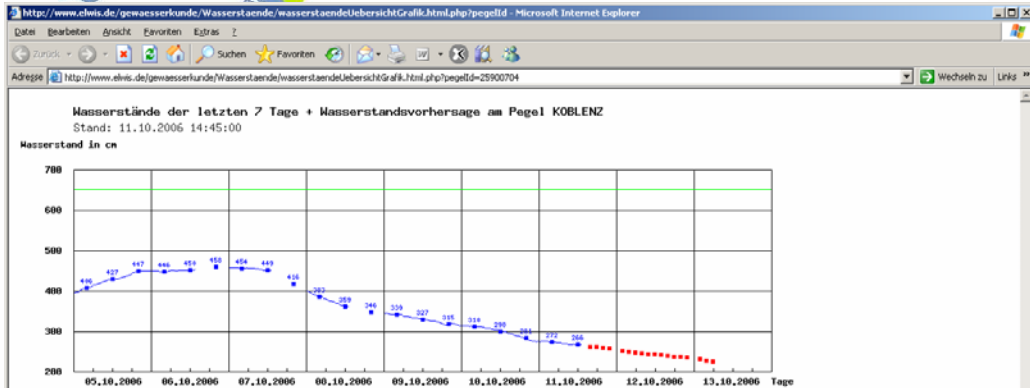
48h-Forecast



	15.08.06 07:00	16.08.06 07:00	17.08.06 07:00	18.08.06 07:00
Oestrich	196	215	217	215
Keup	213	239	244	241
Koblenz	199	222	242	241
Koeln	257	289	310	324
Duesseldorf	205	234	254	274
Ruhrort	328	364	383	404
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# Low flow forecasting along the Rhine



Elektronisches Wasserstraßen-Informationssystem (ELWIS)

Wasser- und Schifffahrtsverwaltung des Bundes

Wasserstände an schiffahrtsrelevanten Pegeln

Anzuzeigende Tage: 1, 2, 3, 5, 6 oder 7

Pegel	Uhr	Di.	Heute	Heute (V)	Do.	Fr.	Sa.	So.
KOBLENZ 550 / 80	02:00	--	--	(--)	281	250	229	--
	04:00	310	(-29)	(-38)	279	248	226	--
	06:00	--	--	(--)	278	246	224	--
	08:00	--	--	(--)	267	244	--	--
	10:00	--	(--)	(--)	266	242	--	--
	12:00	298	(-39)	(-32)	263	241	--	--
	14:00	--	(--)	(--)	262	240	--	--
	16:00	--	(--)	(--)	260	238	--	--
	18:00	--	(--)	(--)	259	236	--	--
	20:00	291	(-34)	(--)	257	235	--	--
	22:00	--	(--)	(--)	255	233	--	--

> 7 gauging stations: Oestrich, Kaub, Koblenz, Köln, Düsseldorf, Duisburg-Ruhrort, Emmerich

> Forecasting horizon: 48 hours



96 hours

> Forecasting time: 7:00

> Daily Forecast: Water level at gauge Ruhrort ≤ 400cm

> Dissemination via email to river headquarter and Internet (ELWIS)



# WAVOS Rhine

- > 1D hydrodynamic model
  - > Rhine and Moselle (685 km)
  - > Main (380 km)
  - > Moselle-Saar-Sauer (425 km)
- > Statistical model ←
  - > Maxau/Rhein
  - > Rockenau/Neckar
  - > Fremersdorf/Saar
- > External forecasts ←
- > Forecaster's estimate ←

96h-Forecast



Forecasting Range to short

Only for 2 tributaries available

....

# WAVOS Rhine

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  - > Fremersdorf/Saar
- > External forecasts
- > Precipitation runoff model



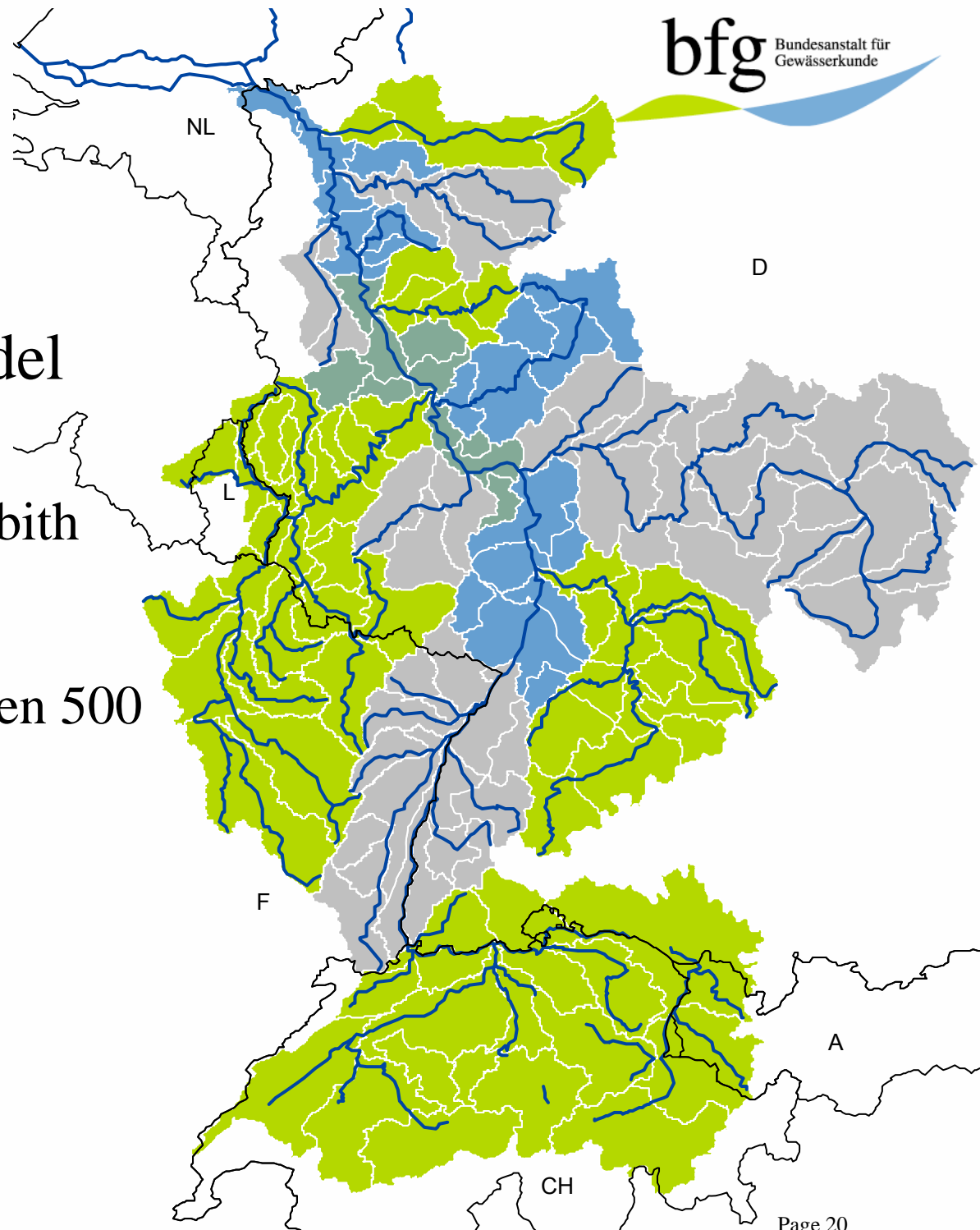
To obtain

- > a consistent forecast
- > with a adequate leadtime for all tributaries

# HBV Rhine

## Precipitation runoff model

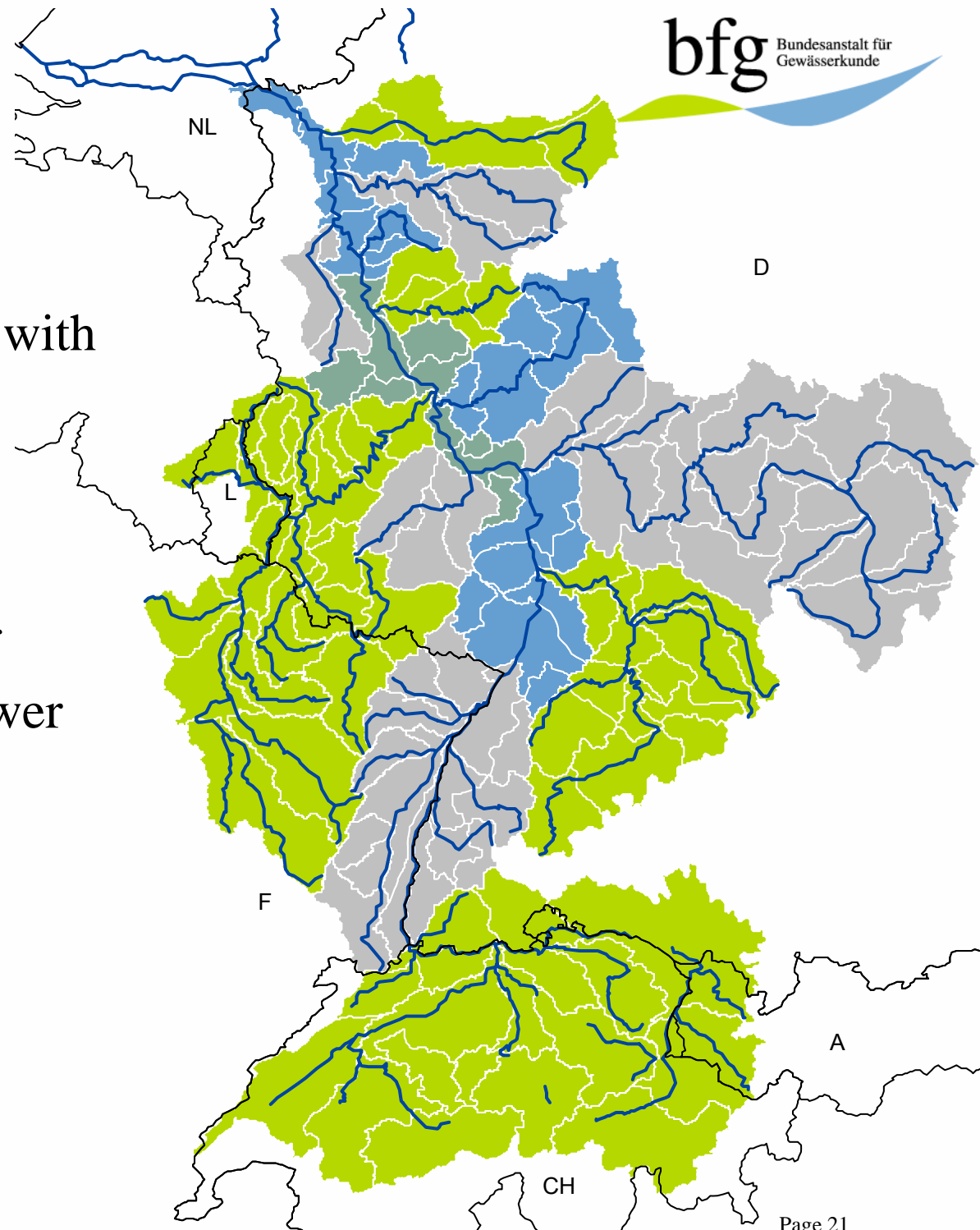
- > Catchment upstream of Lobith  
( more than 160.000 km<sup>2</sup>)
- > 134 subbasins (each between 500  
and 2.000 km<sup>2</sup>)
- > time step: 1 hour



# HBV Rhine

Development in cooperation with  
RIZA:

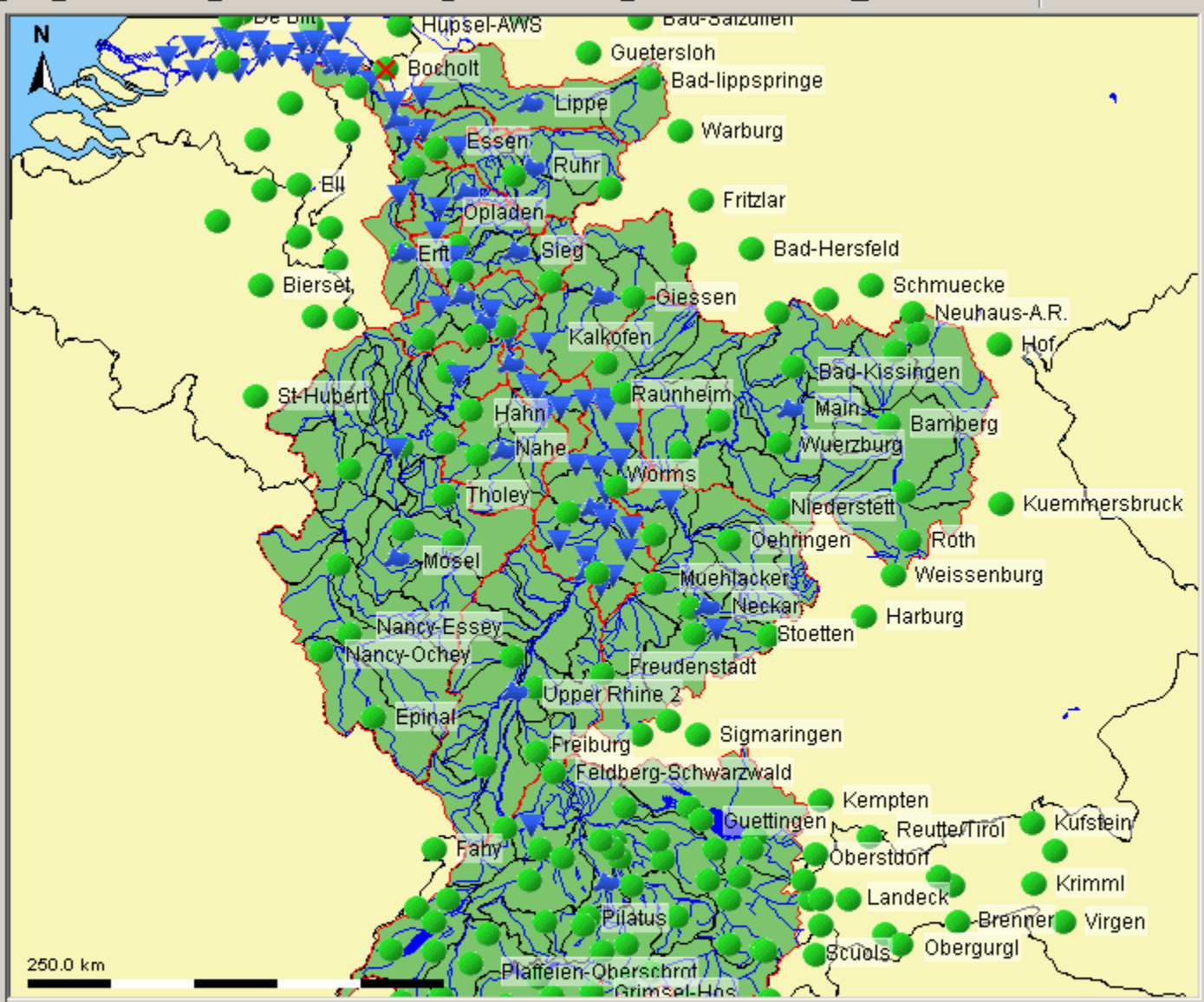
- > Flood forecast RIZA
- > case studies
  - > Transnational effects of  
extreme floods at the Lower  
Rhine
  - > Climate change



- Rhein
- Hydro measurements
- Meteo measurements
- Hydro forecasts (external)
- Meteo measurements interpolations
- Hydro updates (HBV)
- Hydro updates (SBK)
- Forecast (DWD-LM)
  - Meteo forecasts (DWD-LM)
  - Hydro forecasts - HBV (DWD-LM)
  - Hydro forecasts - SBK (DWD-LM)
- Forecast (DWD-GME)
  - Meteo forecasts (DWD-GME)
  - Hydro forecasts - HBV (DWD-GME)
  - Hydro forecasts - SBK (DWD-GME)

- Aachen
- Adelboden
- Aigle
- Altdorf
- Altenahr
- Amerongenbeneden
- Amerongenboven
- Andernach
- Arcen-AWS
- Arnhem
- Bad-Hersfeld
- Bad-Kissingen
- Bad-Marienberg
- Bad-Salzuflen
- Bad-Salzuflen

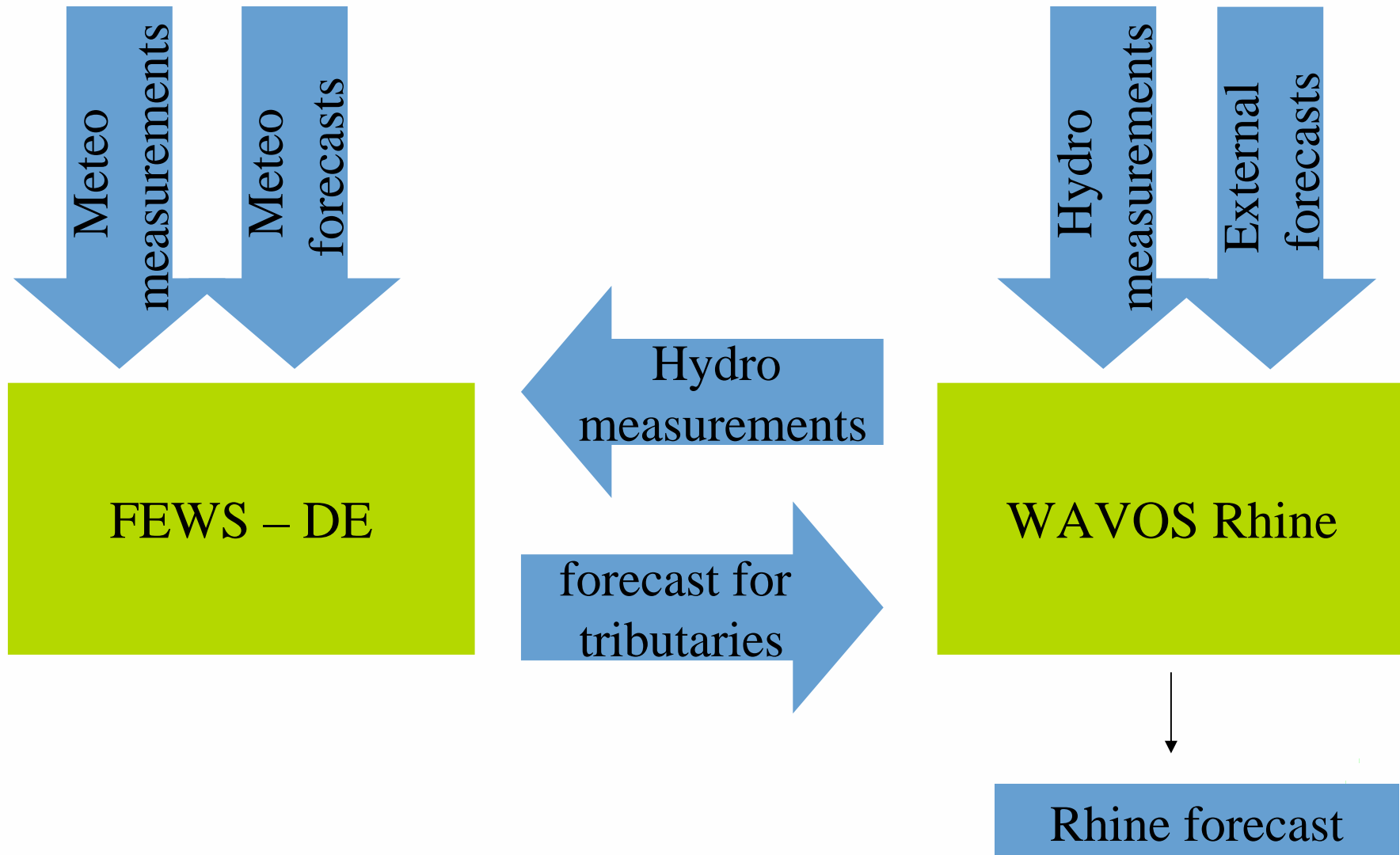
- Discharge Updated (Q.fah)
- Discharge (Q.fh)
- Discharge (Q.m)
- Discharge Updated (Q.uah)
- Discharge (Q.uh)
- Discharge (Q.us)
- Discharge (Q.fs)
- Discharge (Q.fx)
- Water level (H.m)
- Water level (H.us)



```

13.10.2006 13:30:27 INFO - Synchronisation of activity Activity.In.LogEntries finished.
13.10.2006 13:30:27 INFO - Synchronisation of activity Activity.In.LogEntries for taskRunId null
13.10.2006 13:30:27 INFO - Synchronisation of activity Activity.In.LiveSystemStatus finished.
13.10.2006 13:30:27 INFO - Synchronisation of activity Activity.In.LiveSystemStatus for taskRunI
13.10.2006 13:30:27 INFO - Synchronisation of activity Activity.In.ImportGrids finished
    
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# WAVOS Rhine – FEWS DE



# FEWS DE

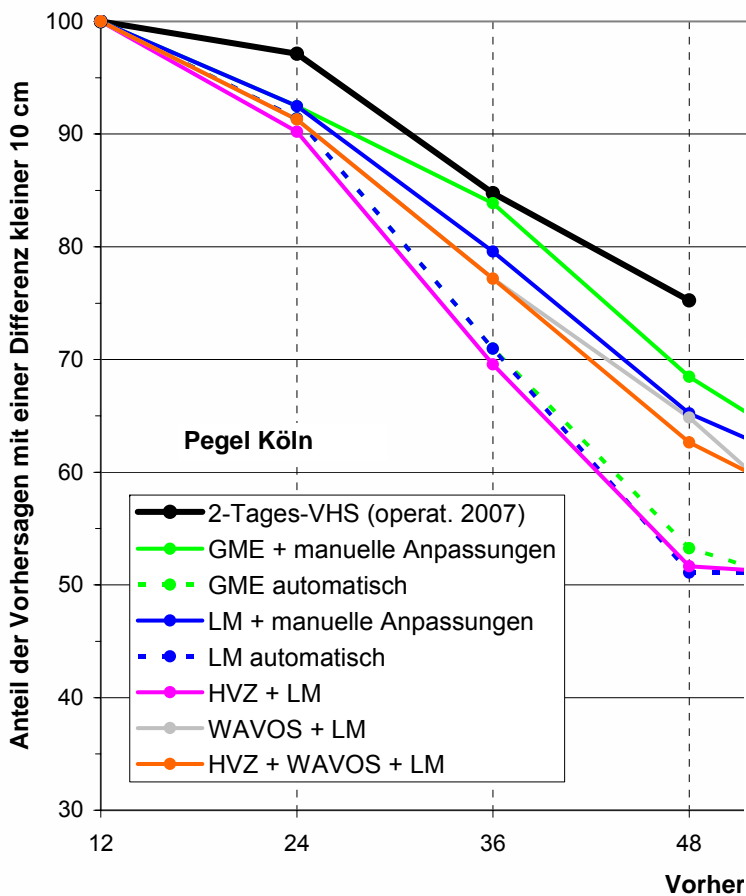
## Precipitation runoff model - input data

Phase	Data	Parameter	Spatial Resolution	Timestep	Leadtime
Initialisation	Measured TTRR station data	P, T	45 stations	1 h	
	Measured synop station data	P, T	204 stations	6 h / 12 h	
	Measured water level	W	47 gauges	≤ 1 h	
Forecast	DWD weather forecast Local Model (LM)	P, T	~ 7 km	1 h	78 h
	DWD weather forecast Global Model (GME)	P, T	~ 40 km	3 h	174 h
	BAFU external forecast	W	gauge Rheinfelden	1 h	67 h



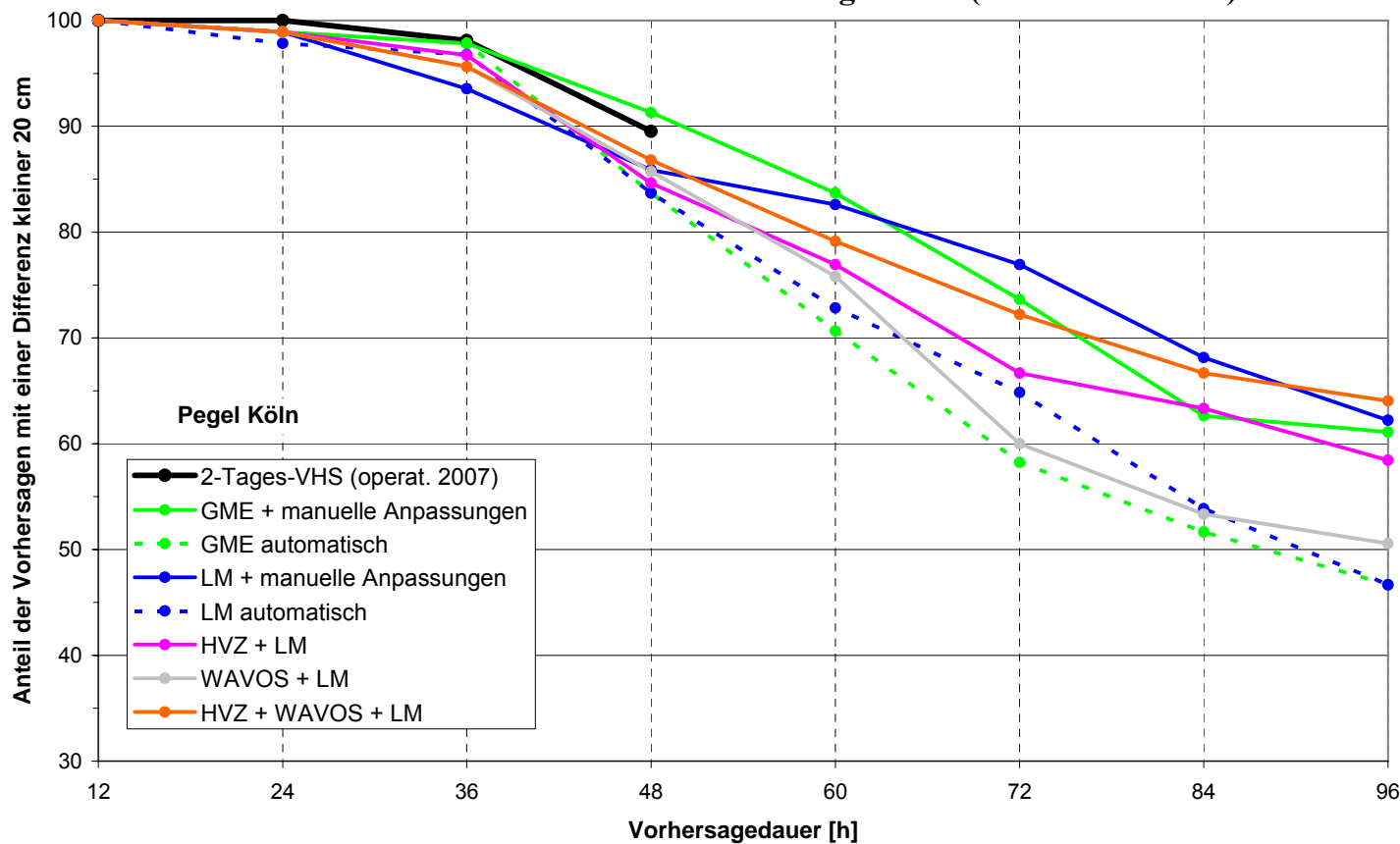
# WAVOS Rhine – FEWS DE Results

Pegel Köln (10 cm – Schwelle)



Operational low flow forecasts

Pegel Köln (20 cm – Schwelle)



Vorhersagedauer [h]

# FEWS DE

One of the main sources for the increasing of uncertainty is the uncertainty in the weather forecast

⇒ Ensemble weather predictions

⇒ Project

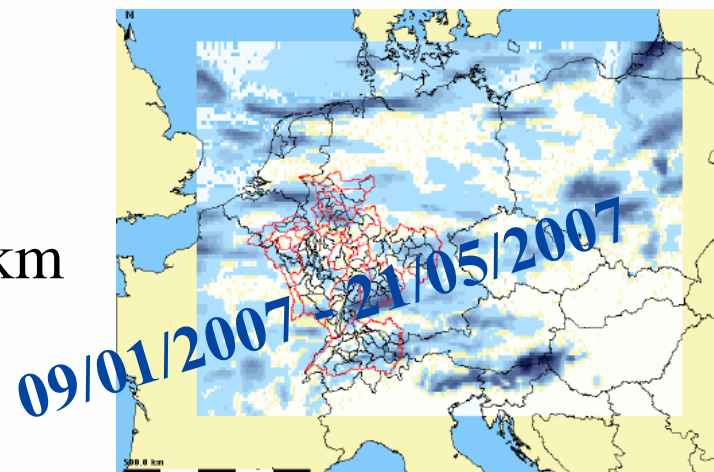
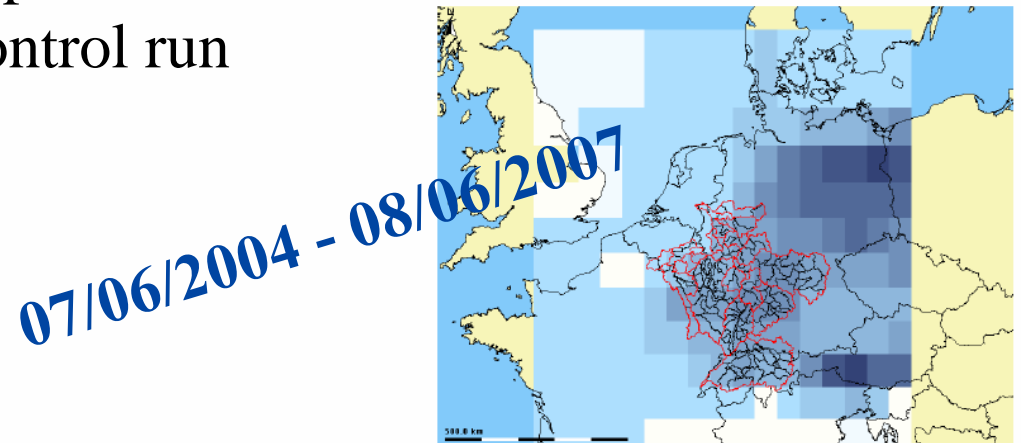
“Verification of Ensemble forecasting in the Rhine basin”

⇒ RIZA – BfG Cooperation /CHR -Project

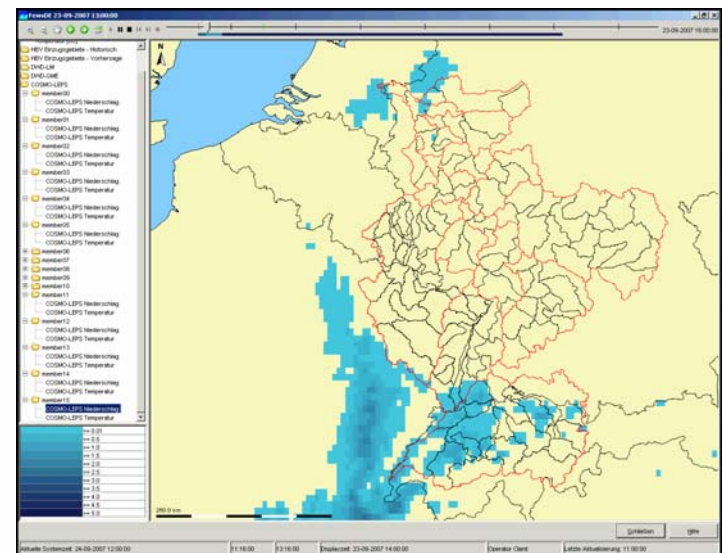
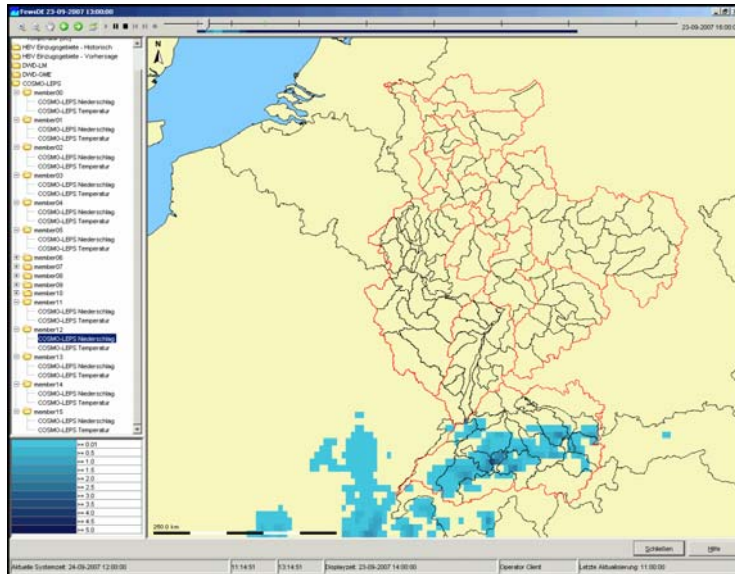
⇒ WL | Delft hydraulics

# Verification of Ensemble forecasting in the Rhine basin

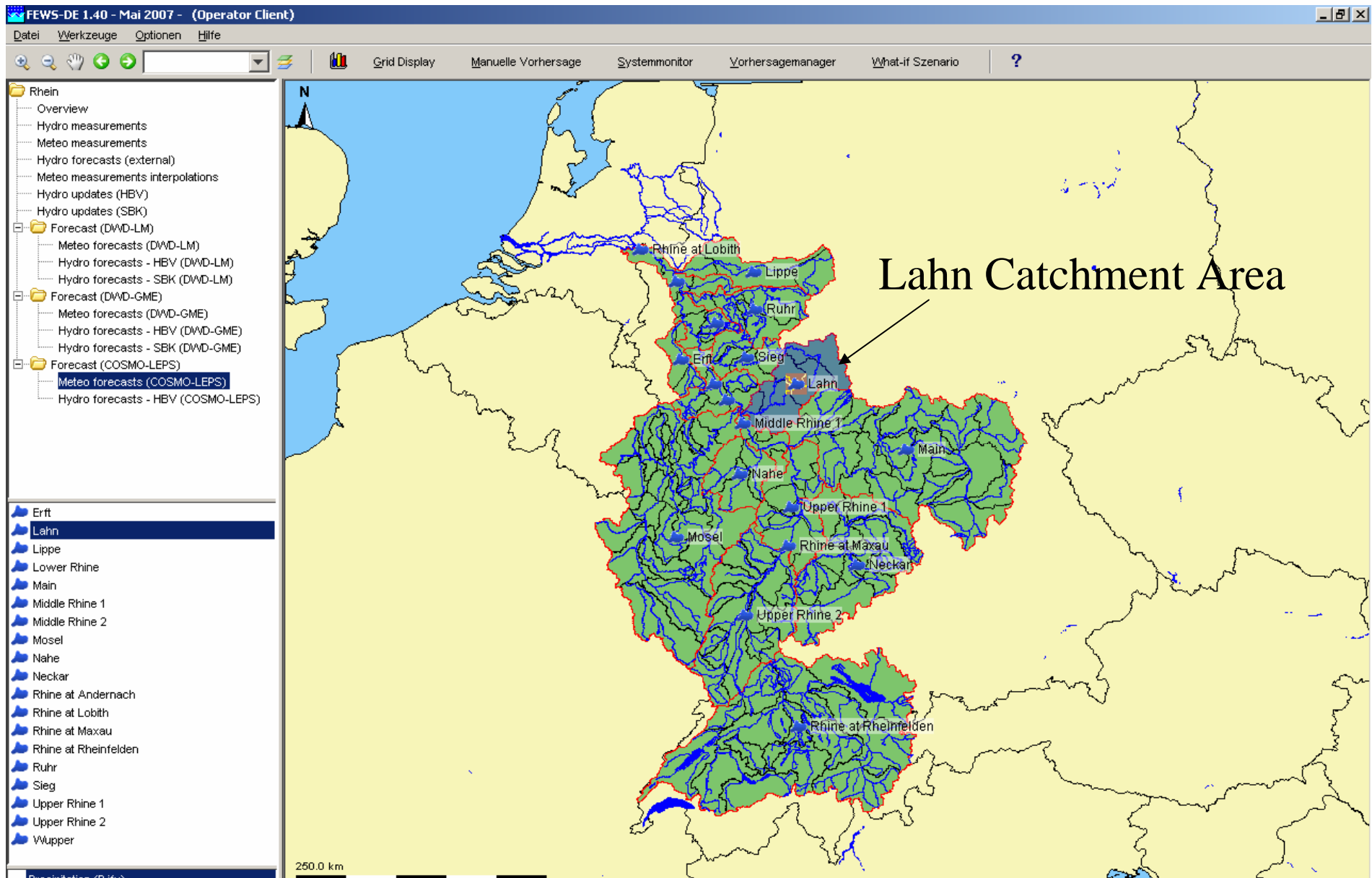
- ECMWF-EPS ensemble (re-sampled as used in FEWS-NL)
  - 50 ensemble members + 1 control run
  - timestep 12h
  - leadtime 240h
  - Spatial resolution ~ 80km
- COSMO-LEPS ensemble
  - 16 ensemble members
  - timestep 3h
  - leadtime 5 1/2d
  - Spatial resolution ~ 10km

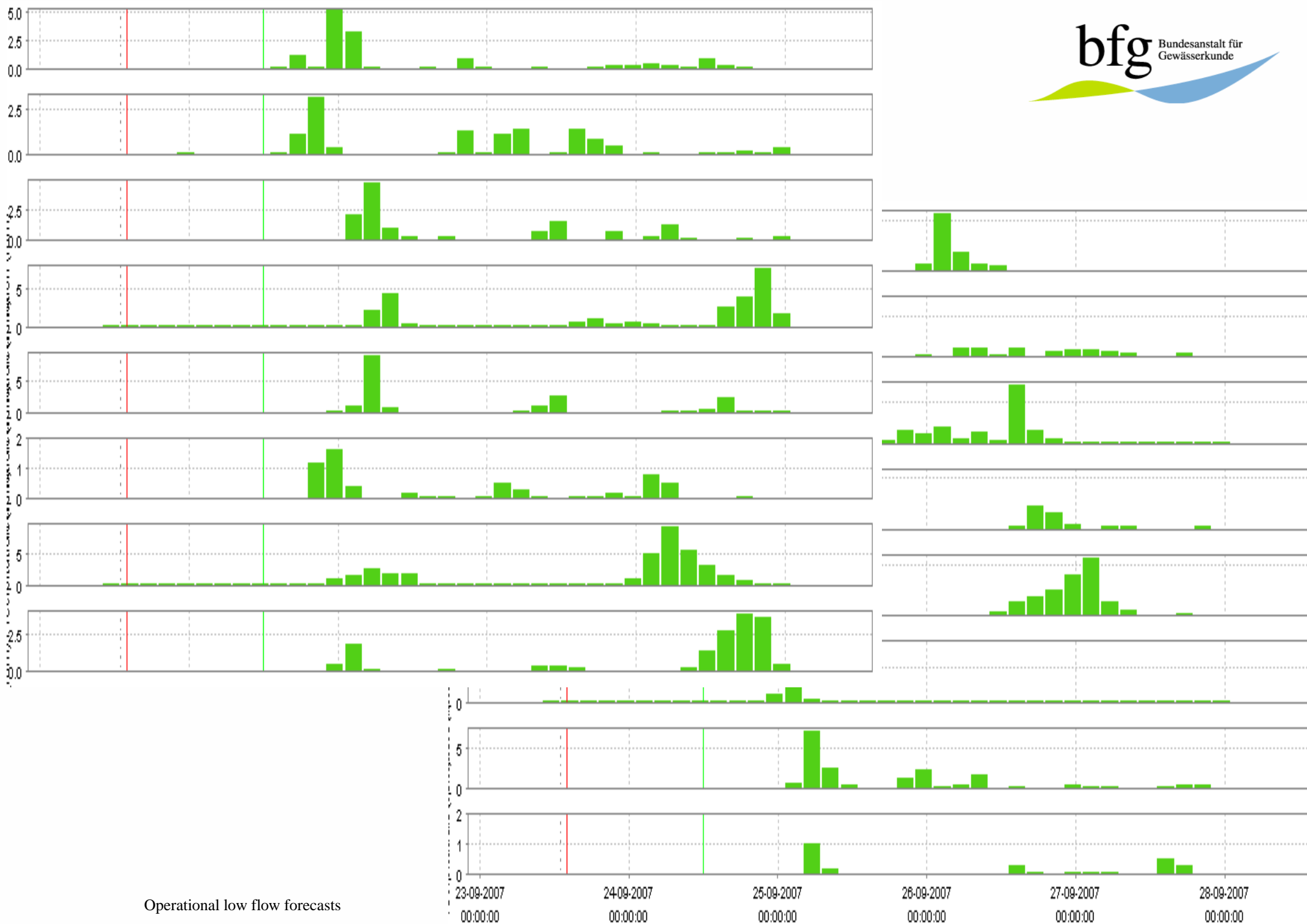


# FEWS DE – Ensemble

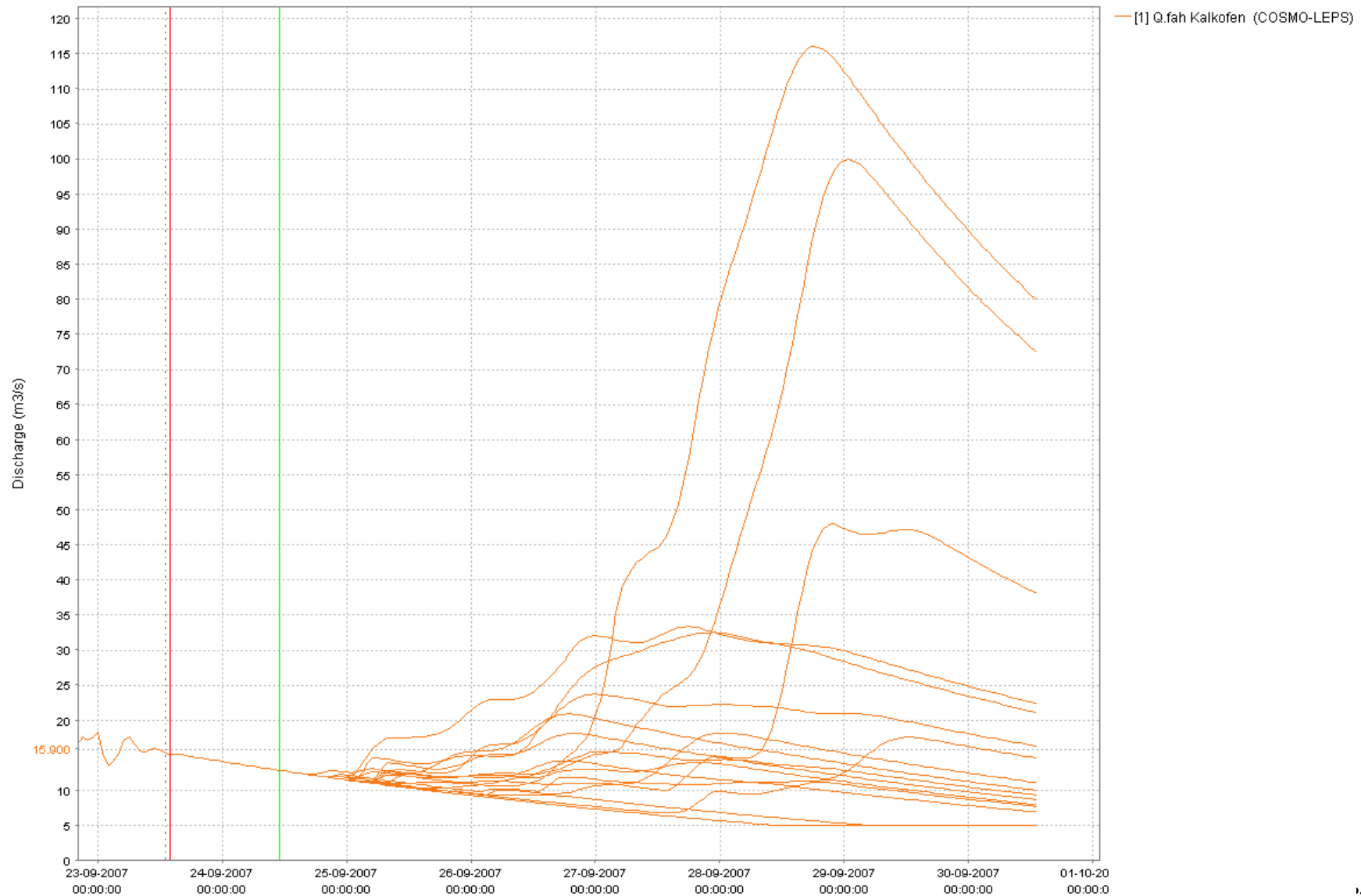


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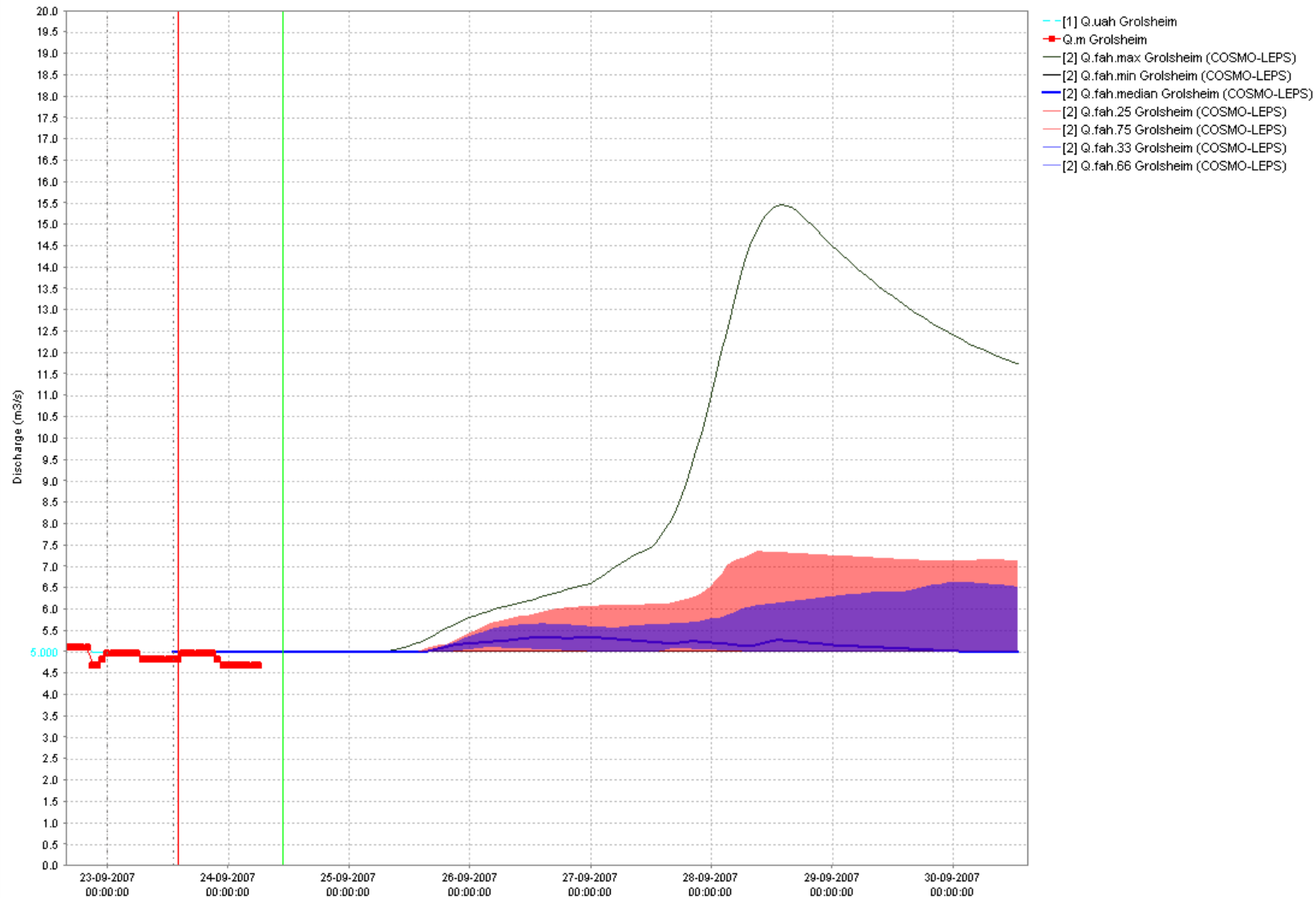


# FEWS DE - Ensemble



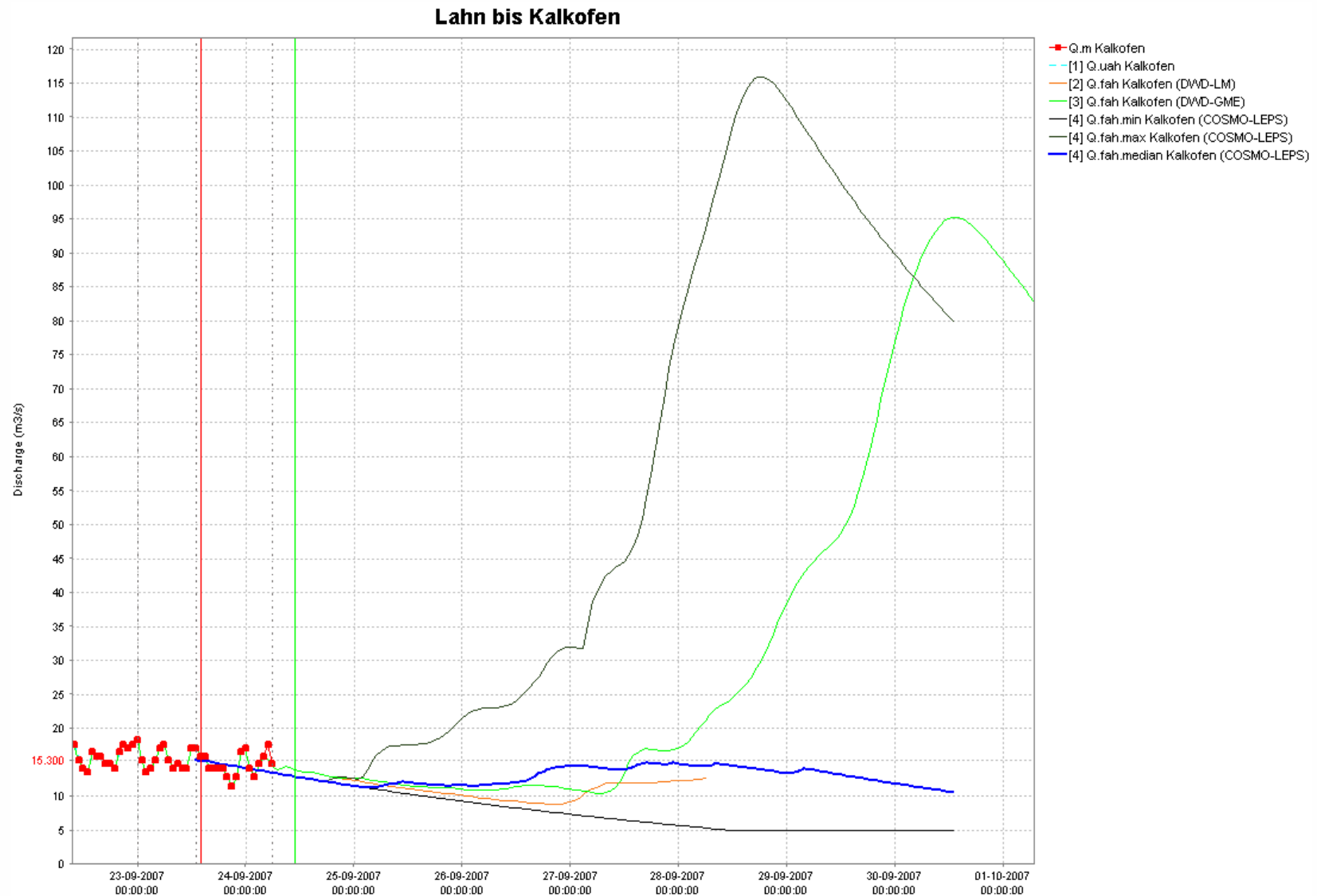
# FEWS DE - Ensemble

Nahe bis Grolsheim





# FEWS DE - Ensemble



# Verification of Ensemble forecasting in the Rhine basin

- What is the skill, reliability and potential utility of the ensemble in predicting events at different lead times?
- What are the effects of scale on the skill of the ensemble predictions?
- Do the high resolution ensembles available through COSMO-LEPS indicate a higher skill than the low resolution ECMWF-EPS ensemble where the scale issue becomes apparent?

# Verification of Ensemble forecasting in the Rhine basin

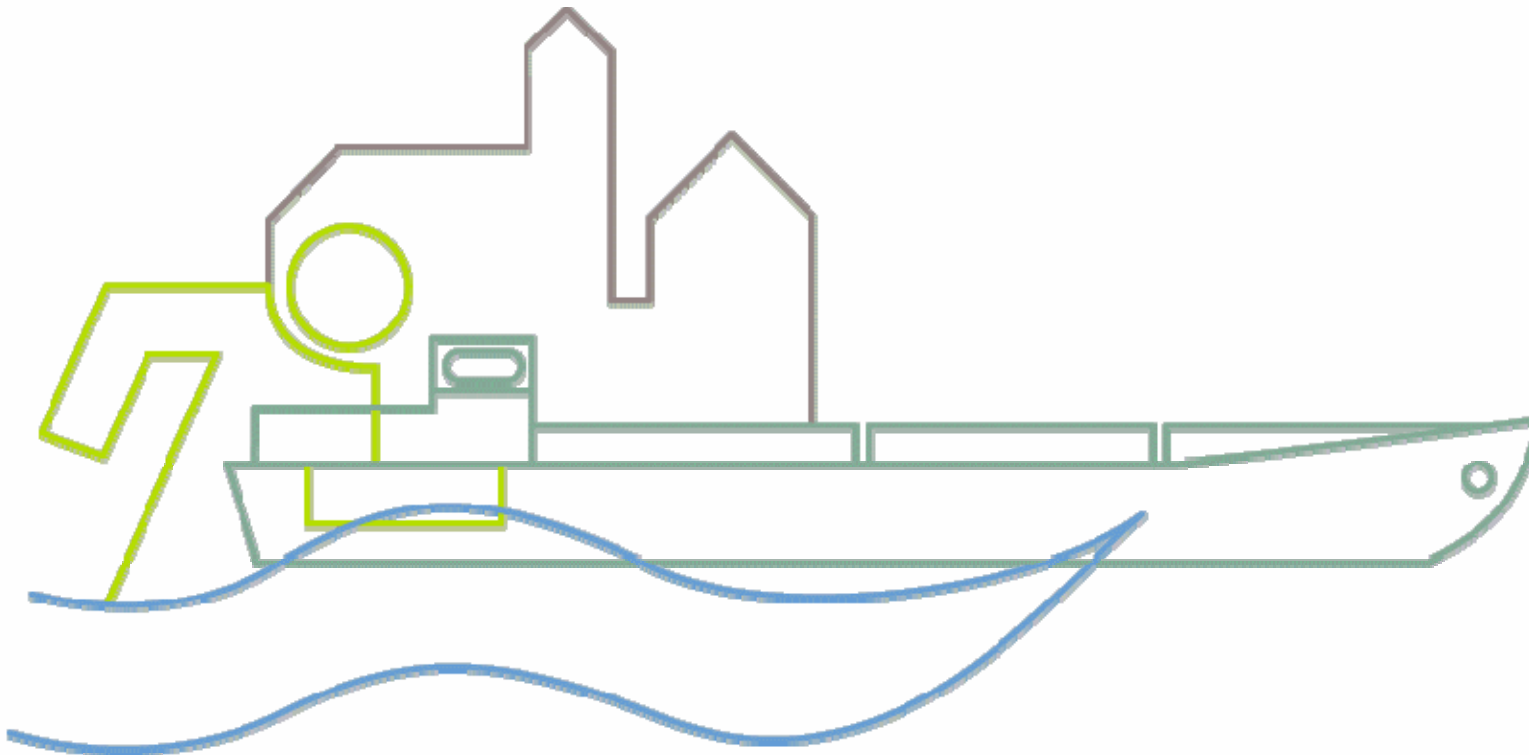
- Several statistics commonly applied in verification of probabilistic forecasts were used
  - the Brier (Skill) Score,
  - the Ranked Probability
  - (Skill) Score
  - verification diagrams
    - Relative Operating Characteristic
    - Attributes diagram.

# Verification of Ensemble forecasting in the Rhine basin - Results

- At low flows it is shown that the ensemble forecasts are a reliable indicator, with a high forecast skill for long lead times.
- For the smaller catchments the skill of the ensemble forecast was clearly shown to deteriorate faster than in the larger catchments.
- In all cases the ensemble forecast were demonstrated to have positive skill, meaning that there is utility in using ensemble in forecasting for the Rhine basin.

# Verification of Ensemble forecasting in the Rhine basin - Results

- The period over which the ensembles have been verified is limited, with few events of significance occurring in the Rhine basin. As a result the skill in predicting rare events for which the forecasting system has been constructed has not been assessed, but can only be inferred on the results found for the evaluation period.
  - Relatively short period for which the COSMO-LEPS ensemble is currently available
- => Repeat the analysis in 1 to 1½ years when a more substantial set of ensembles is available, and if available a larger number of (extreme) events



# Thank you for your attention !

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E-Mail: [rademacher@bafg.de](mailto:rademacher@bafg.de)  
[www.bafg.de](http://www.bafg.de)