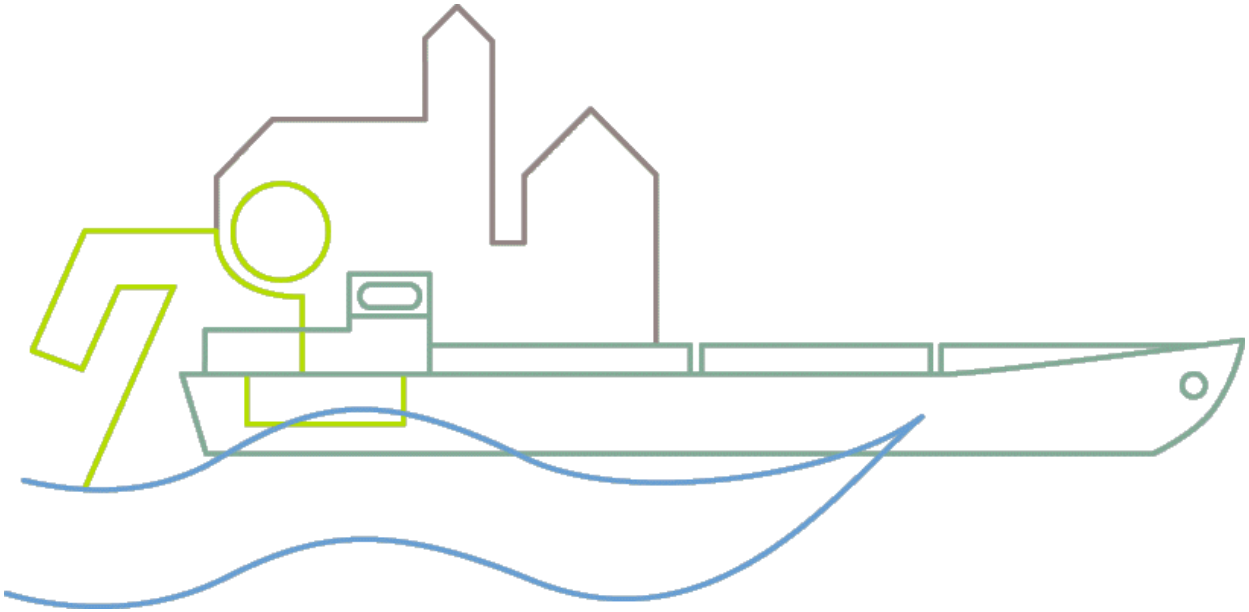

Towards a seasonal forecasting service for the German waterways

– requirements, approaches, potential products –

Dennis Meißner[1], Bastian Klein[1] and Monica Ionita[2,3]

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Seasonal Hydrological Forecasting Workshop, 21-23 September 2015, Norrköping, Sweden

Outline

- Which features of a seasonal forecast are relevant to be useful for inland waterway transport (IWT)?
- Which forecast methods do we investigate and how do our preliminary results look like?
- How do we intend to evaluate the usefulness of our seasonal forecast products for IWT?

The German Waterways – Overview

(German Federal Ministry of Transport and Digital Infrastructure, Fachstelle für Geoinformation Süd)

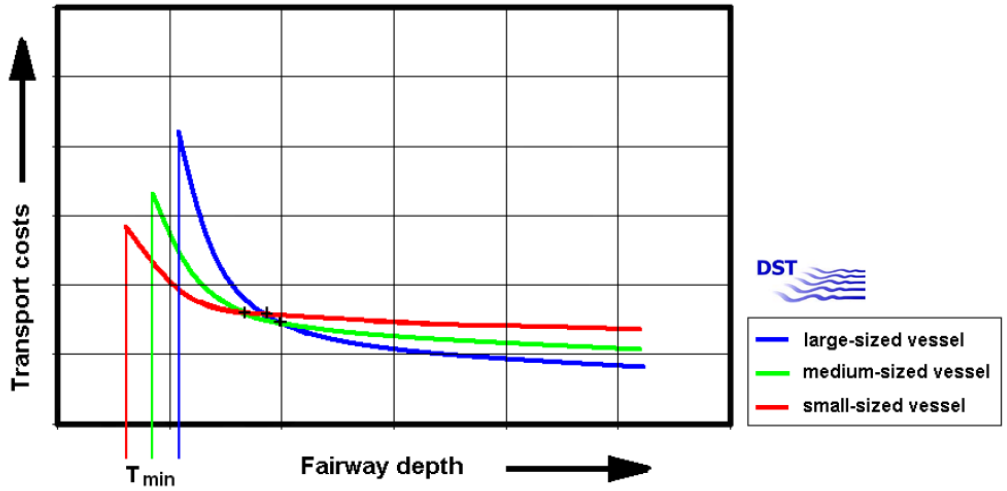
(German Federal Ministry of Transport and Digital Infrastructure, Fachstelle für Geoinformation Süd)

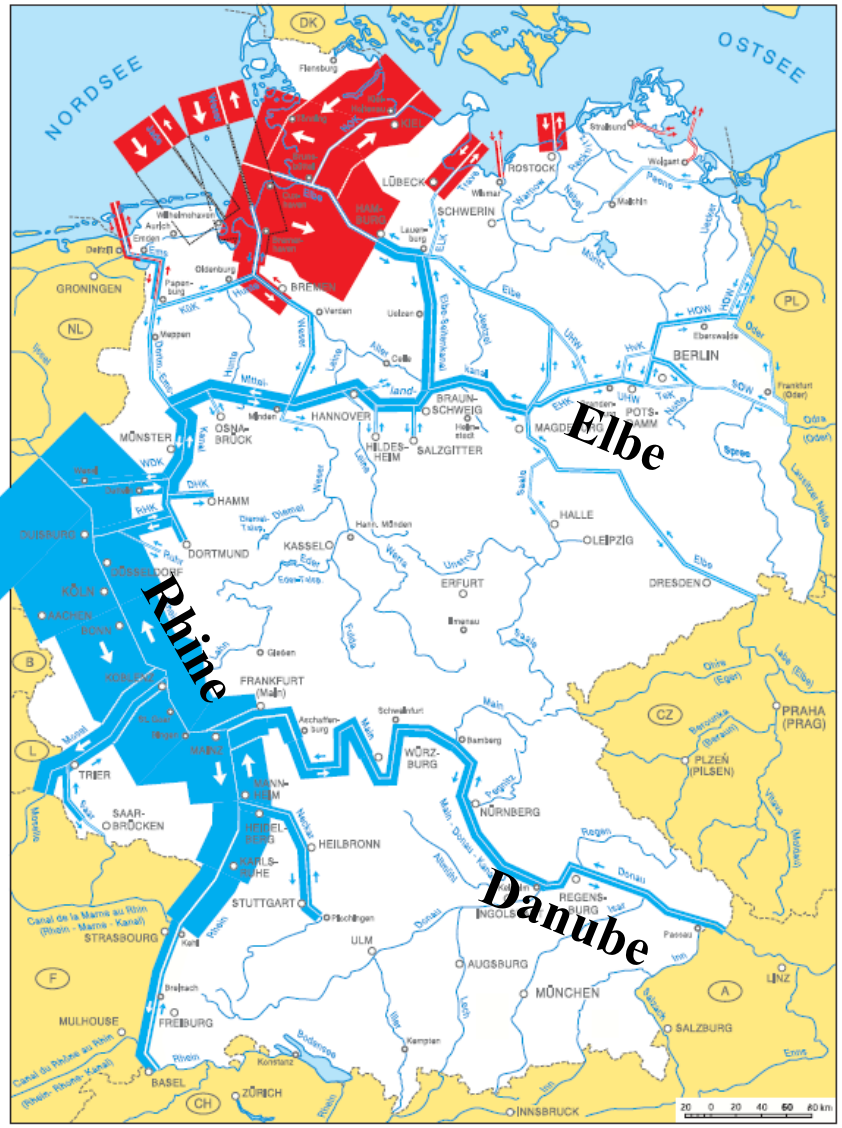
7.300 km inland waterways
(30 % free-flowing)

17.800 km² seaways

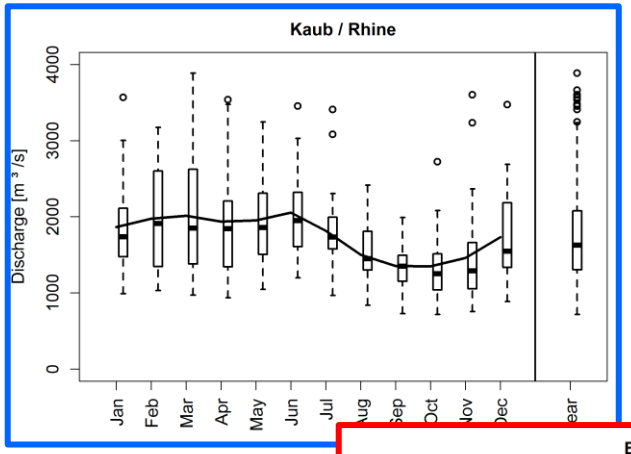
The German Waterways – Transport

- 70 % of the German waterways are of international relevance.
- River Rhine is one of the most frequented inland waterways in the world.
- 240 million tons per year are carried by IWT.
- Strengthening of IWT is necessary to handle the continuing transport growth economically and ecological sustainably.
- Low flows are the main hydrological impact on the reliability of IWT





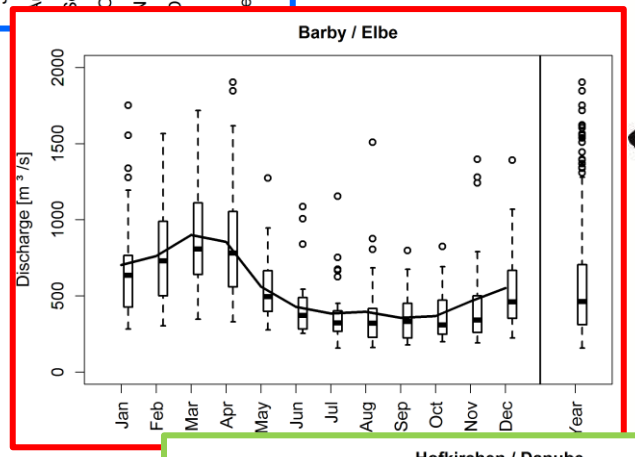
The German Waterways – Hydrology



Mixed runoff regime (still Alpine influence)

Moderate marine climate

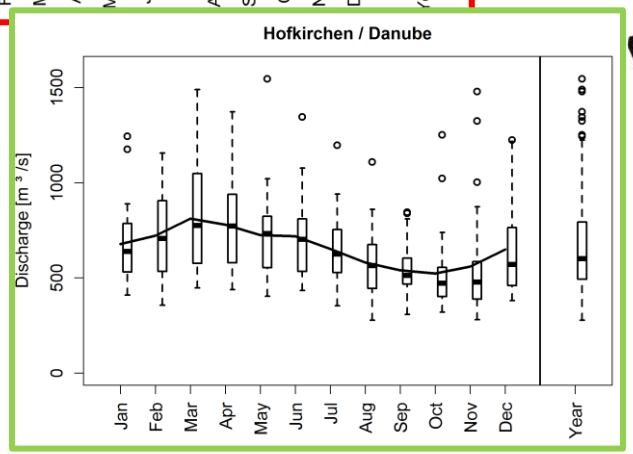
Lower Rhine: rainfall influence dominates



Continental climate

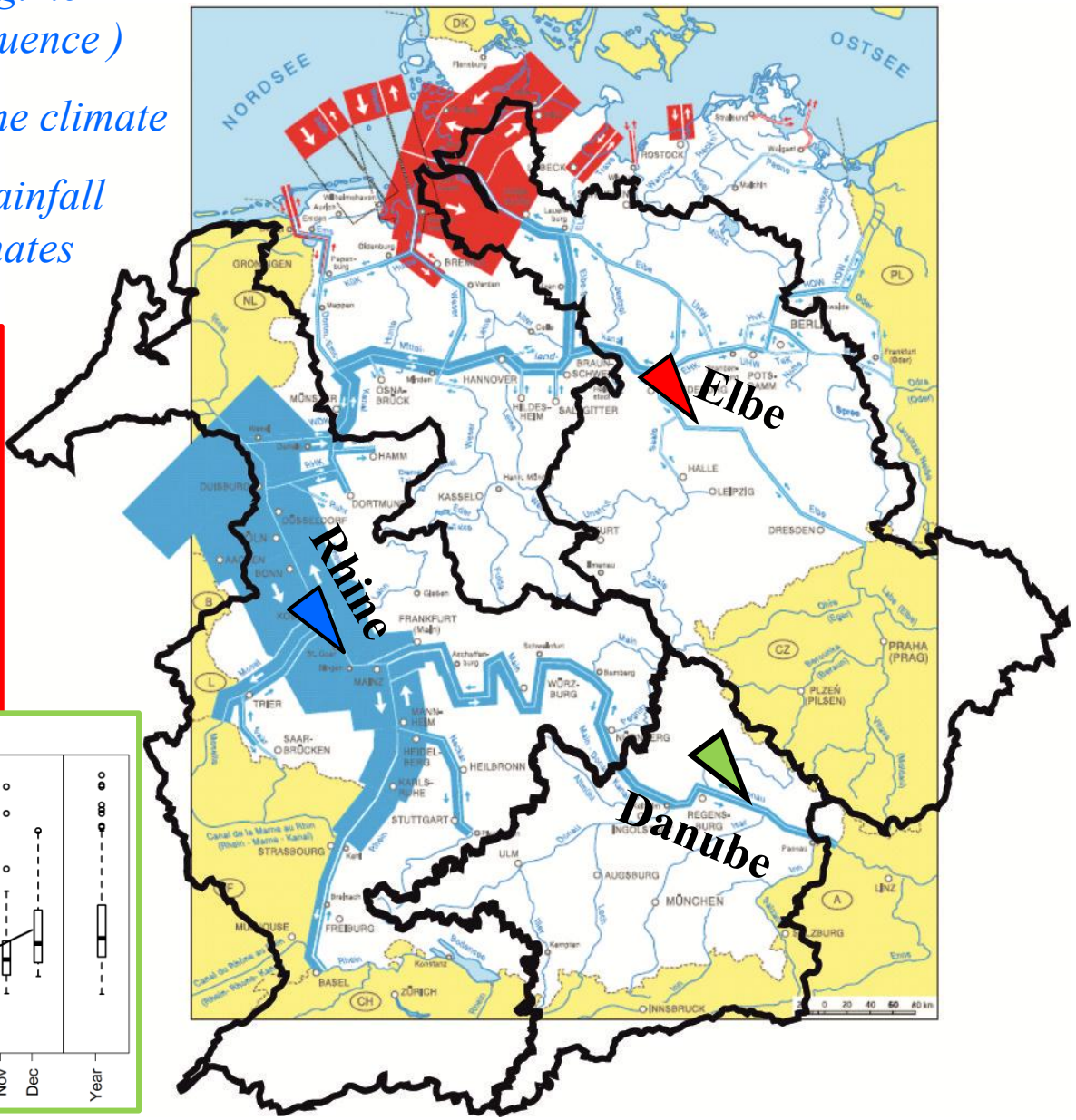
Mixed runoff regime (nival and pluvial)

Groundwater interaction



Mixed runoff regime (nival and pluvial)

Meltwater input from the Alps more downstream significant



Navigation-related seasonal forecasts

Objectives:

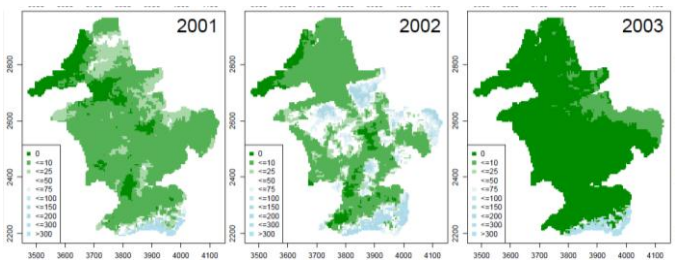
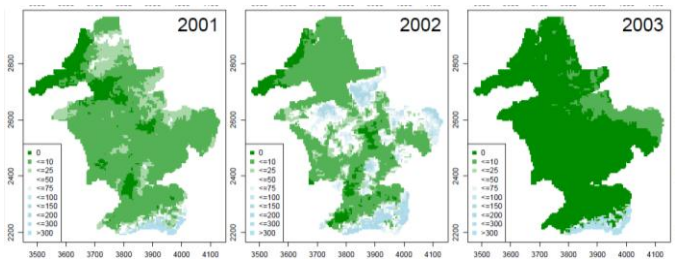
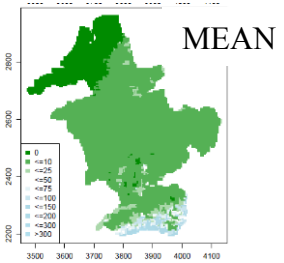
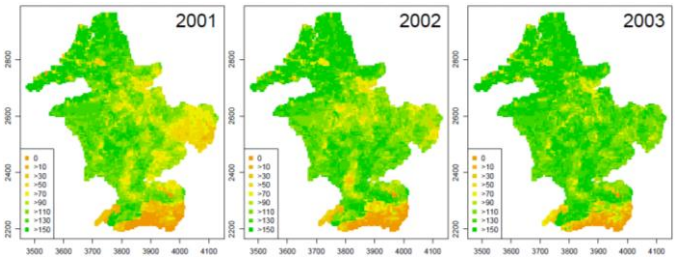
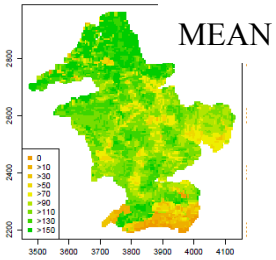
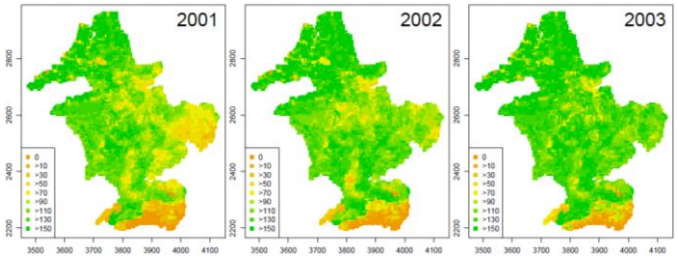
- short-term: optimization of load capacity (avoid lighterage)
- **seasonal:** optimization of timing of trips, warehousing, fleet structure, modal split

Requirements:

- predictand of particular interest: water level (= discharge + riverbed morphology)
- variables (not primarily threshold-oriented):
  - aggregation to (mean) monthly values (instead of instantaneous values)
  - focus: mean discharge (MQ), lowest 7-day mean discharge (MN7Q), also HSQ
- forecast locations: specific gauges representing navigational conditions of different waterway sections (focus on „bottlenecks“)
- all-the-year forecast service (focus on months prior to typical low flow periods)

Impact on seasonal forecast skill

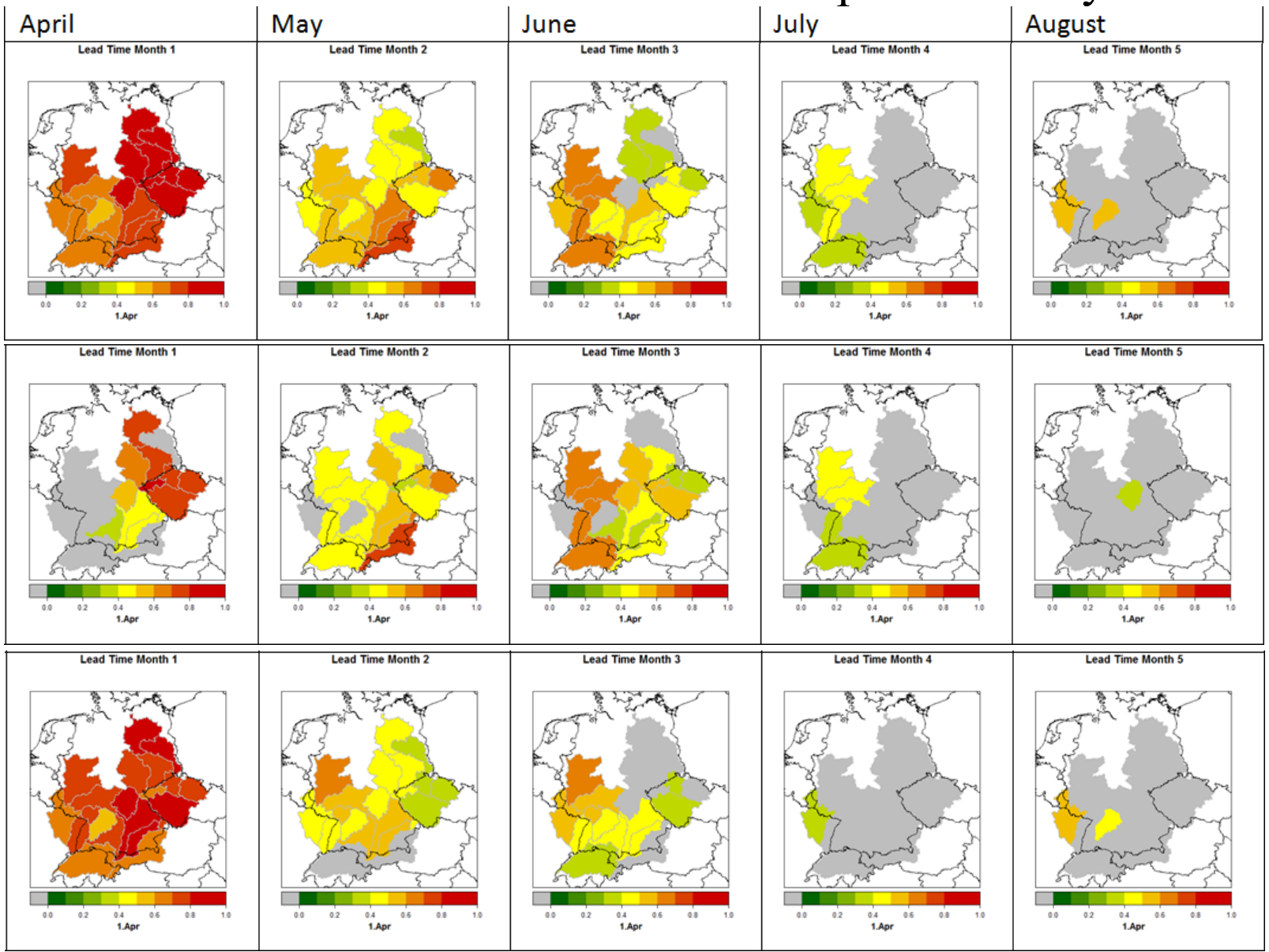
Relative contribution of snow and soil water using ESP modifications

	original ESP („perfect“ initial conditions)	**ESP** („perfect“ snow, soil norm)	**ESP** („perfect“ soil, snow norm)
SNOW			
SOIL			

1080 ensemble hindcasts (30 years x 12 initialisation points x 3 ESP-variants)
(period: 1976 – 2005)

Impact on seasonal forecast skill

Relative contribution of snow and soil water to predictability



ESP

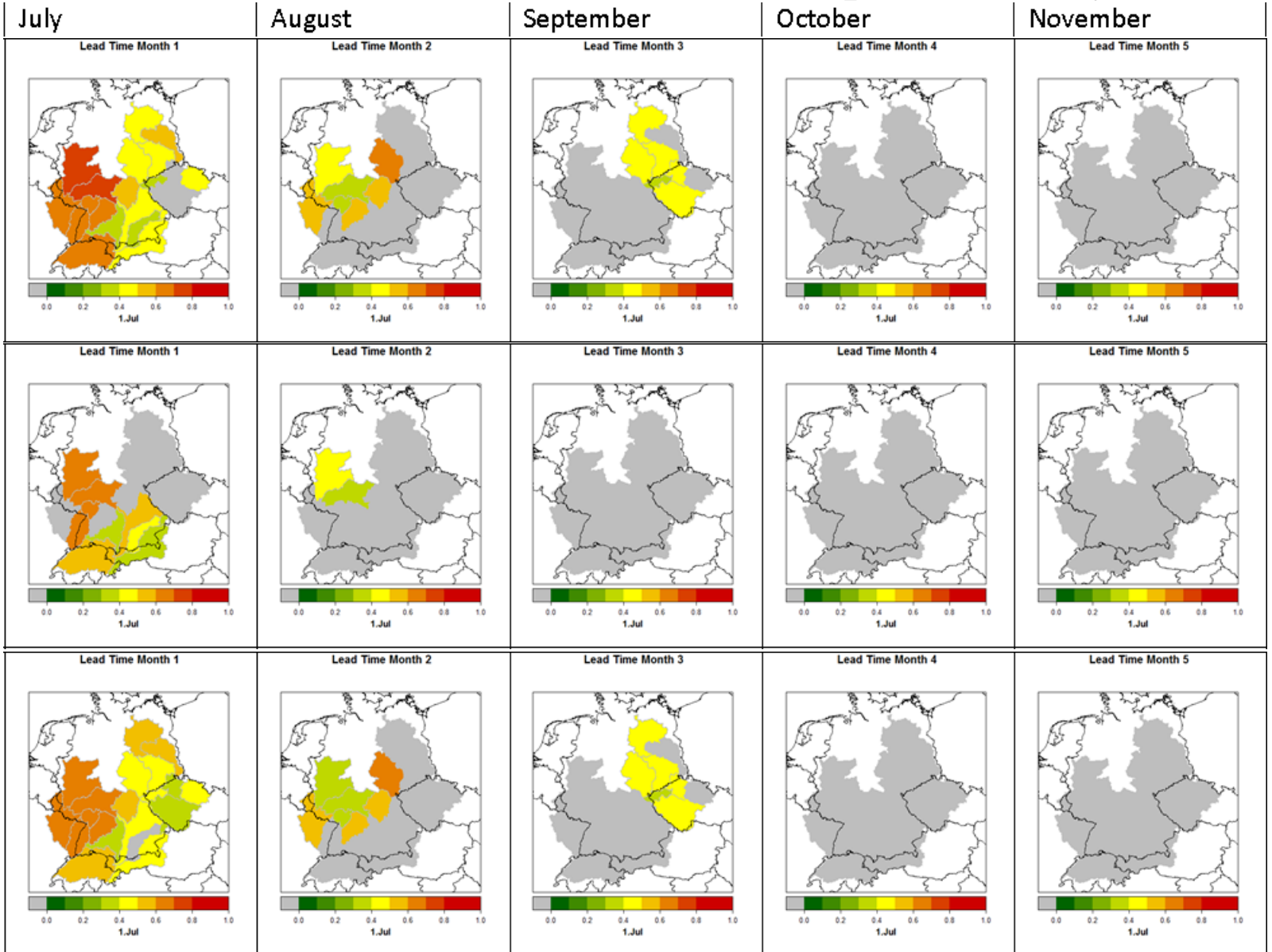
ESP (soil norm)

ESP (snow norm)

Initialization: 01st April

Impact on seasonal forecast skill

Relative contribution of snow and soil water to predictability



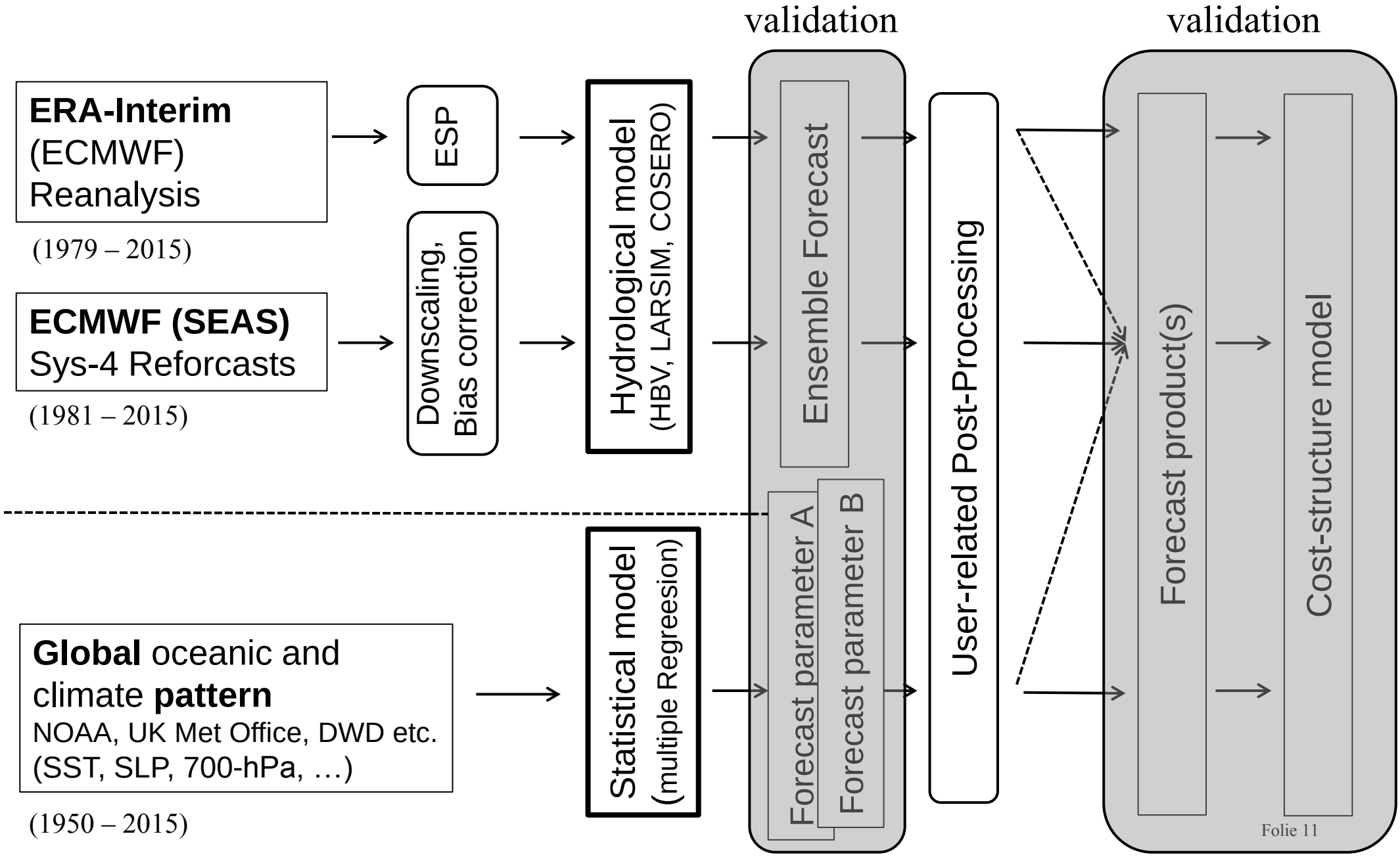
ESP

ESP (soil norm)

ESP (snow norm)

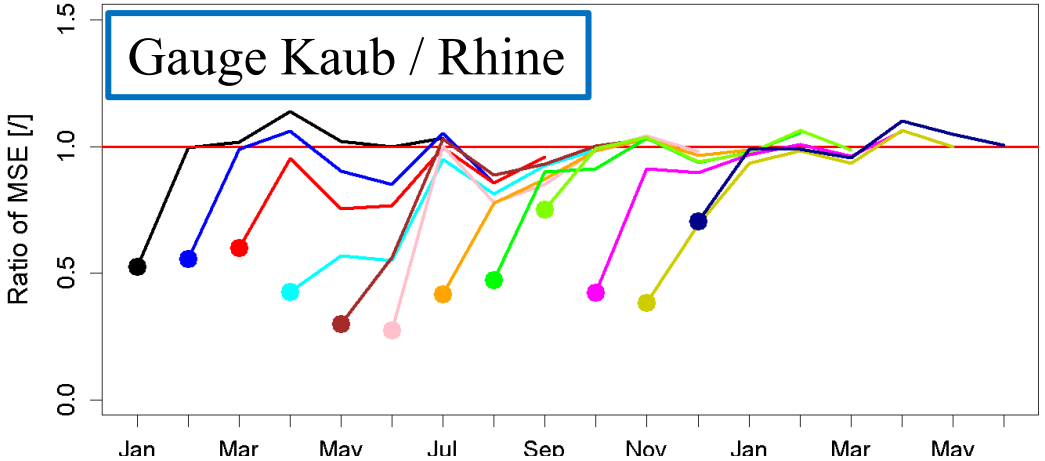
Initialization: 01st July

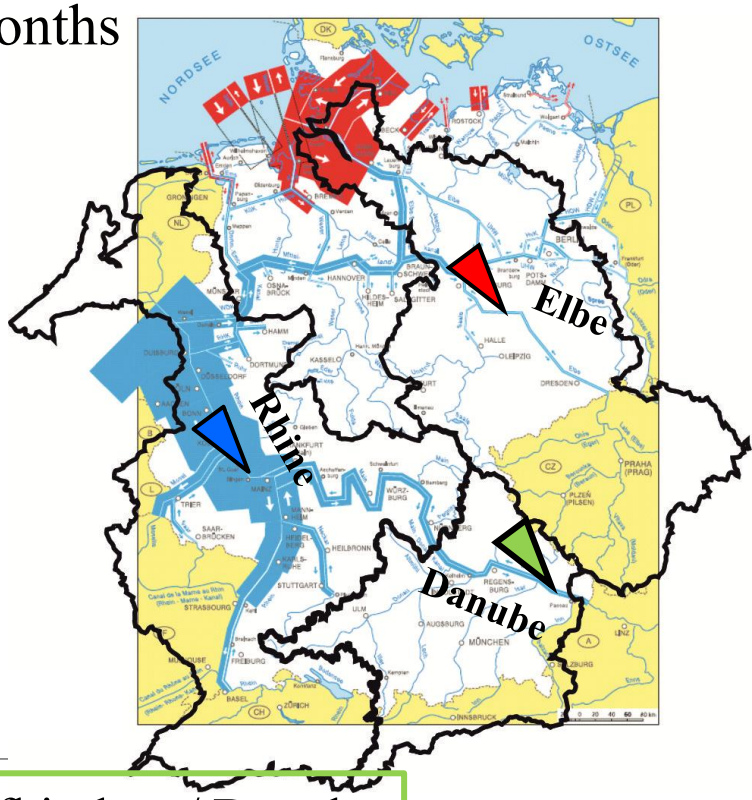
Forecast approaches

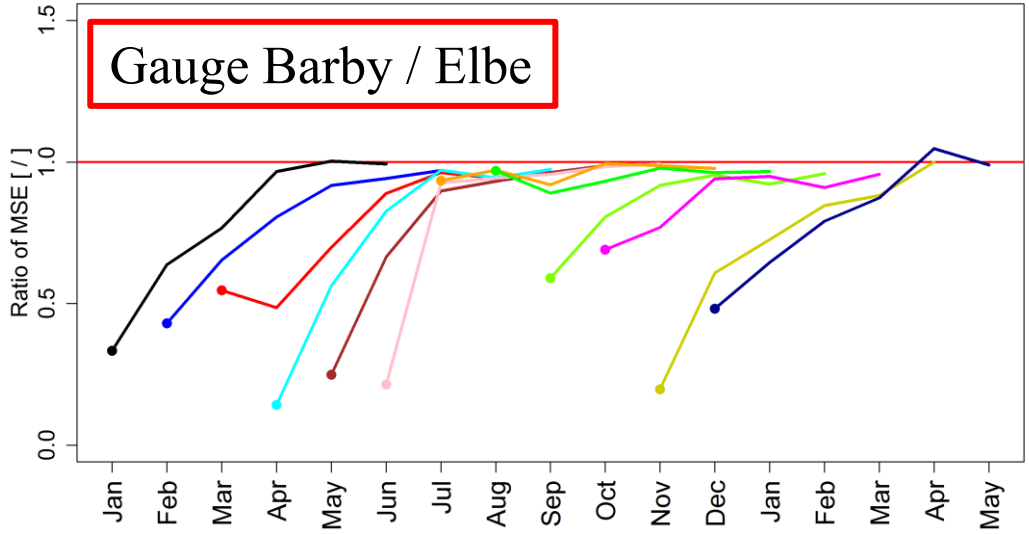


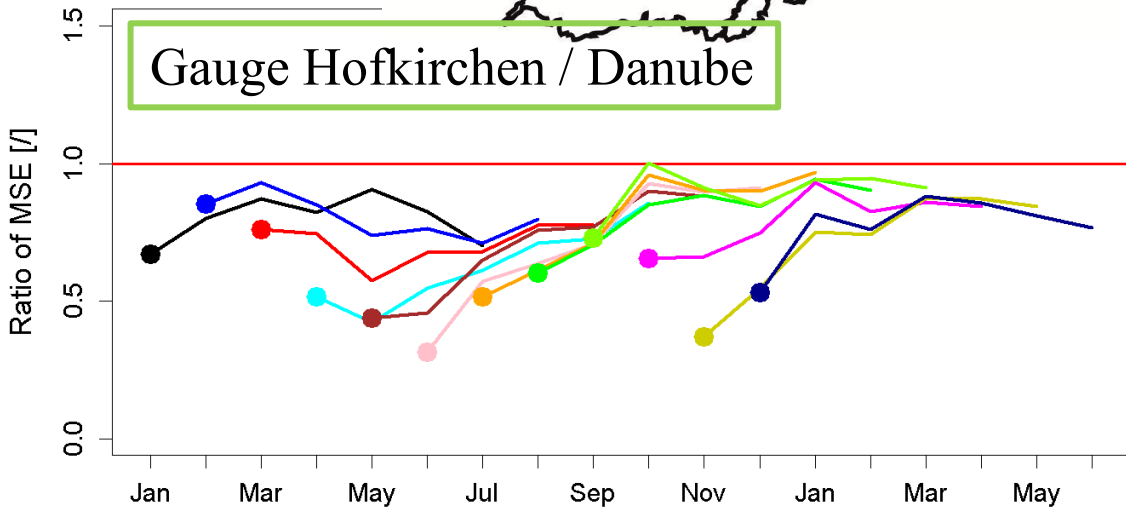
Preliminary results

- ESP-approach (resampling of ERA-Interim), lead: 6 months
- reference: climatological discharges
  (current information applied by navigational users)



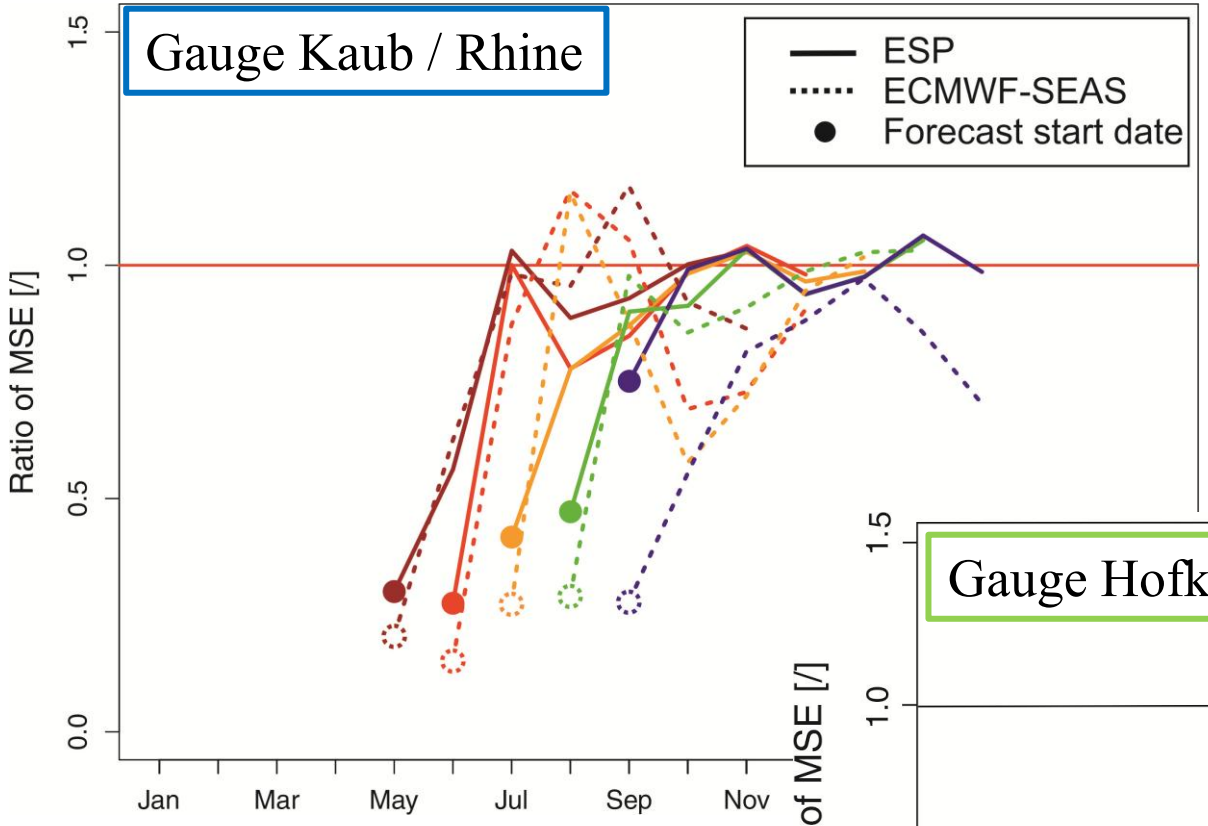


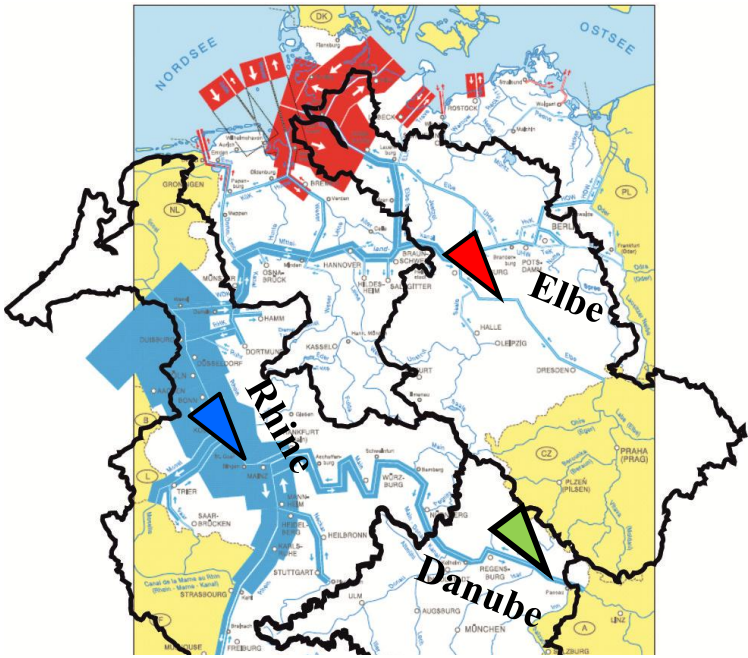


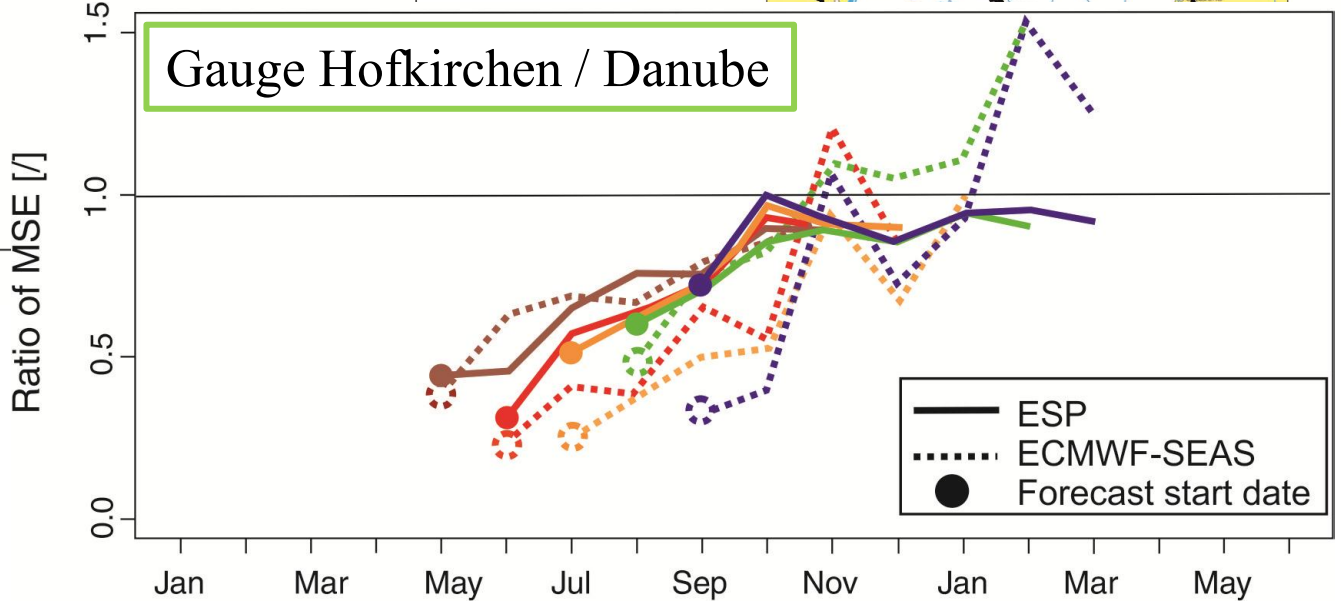


Preliminary results

- added value of ECMWF`s seasonal meteo-forecasts for the typical low flow seasons







Current low flow situation

- since beginning of July the German waterways are affected by low flows

Montag
14.09.2015

Kölner Stadt-Anzeiger

HOME | KÖLN | REGION | FREIZEIT | ABO | SERVICE | ANZEIGEN

Rhein-Berg/Oberberg | Rhein-Sieg/Bonn | Rhein-Erft | Euskirchen-Eifel | Leverku

Themen: City Outlet Bad Münstereifel | Die marode Leverkusener Brücke |

NRW

Aktuelle Nachrichten aus NRW und der Landeshauptstadt Düsseldorf

Vorlesen

KEINE GROSSEN LADUNGEN MEHR MÖGLICH

Rhein-Schifffahrt ist wegen Niedrigwasser eingeschränkt

ERSTELLT 28.07.2015

Der Rhein in Köln führt zurzeit sehr wenig Wasser. Foto: dpa

Die Schifffahrt auf dem Rhein hat derzeit mit niedrigen Pegelständen zu kämpfen. Weil die Fahrrinne nicht tief genug ist, müssen große Containerschiffe weniger Ladung aufnehmen.

Bild

1. MONAT 0,99 €

WETTER 19°C DRESDEN

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BILDplus NEWS POLITIK GELD UNTERHALTUNG SPORT BUNDESLIGA LIFESTYLE RATGEBER REISE A

11.09.2015 - 14:15 UHR HOME › REGIONAL › DRESDEN AKTUELL › DRESDEN › PEGEL DER ELBE BEI DRESDEN BEI DRAMATISCHEN 67 ZE

PEGEL BEI DRAMATISCHEN 67 ZENTIMETERN

Wer hat der Elbe blo… den Stöpsel gezogen

Wo ist nur das Wasser hin? Statt des kühlen Nass sieht man in der Elbe bei Dresden nur trockenes Geröll

Foto: Dirk Sukow

Bild

1. MONAT 0,99 €

WETTER 19°C HAMBURG

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BILDplus NEWS POLITIK GELD UNTERHALTUNG SPORT BUNDESLIGA LIFESTYLE RATGEBER REISE AUTO DIGITAL

11.09.2015 - 14:14 UHR HOME › REGIONAL › DRESDEN AKTUELL › DRESDEN › HISTORISCHER NIEDRIG-PEGEL: TROCKNET DIE ELBE AUS?

HISTORISCHER NIEDRIG-PEGEL

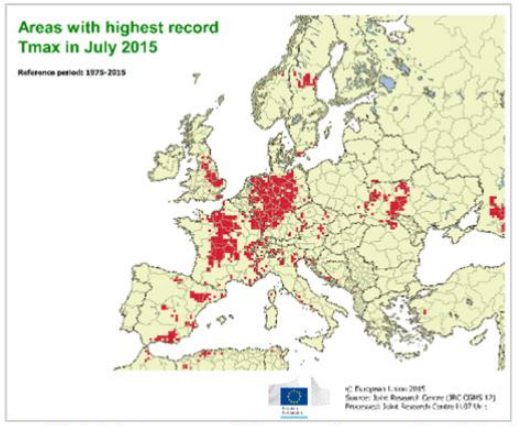
Trocknet die Elbe aus?

Eine Katastrophe für die Schifffahrt: In Loschwitz hat sich die Elbe bereits völlig in die Fahrrinne zurückgezogen

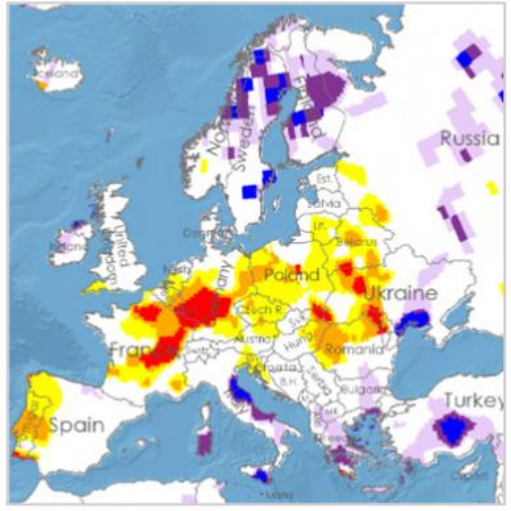
Foto: Stefan Hässler

Current low flow situation

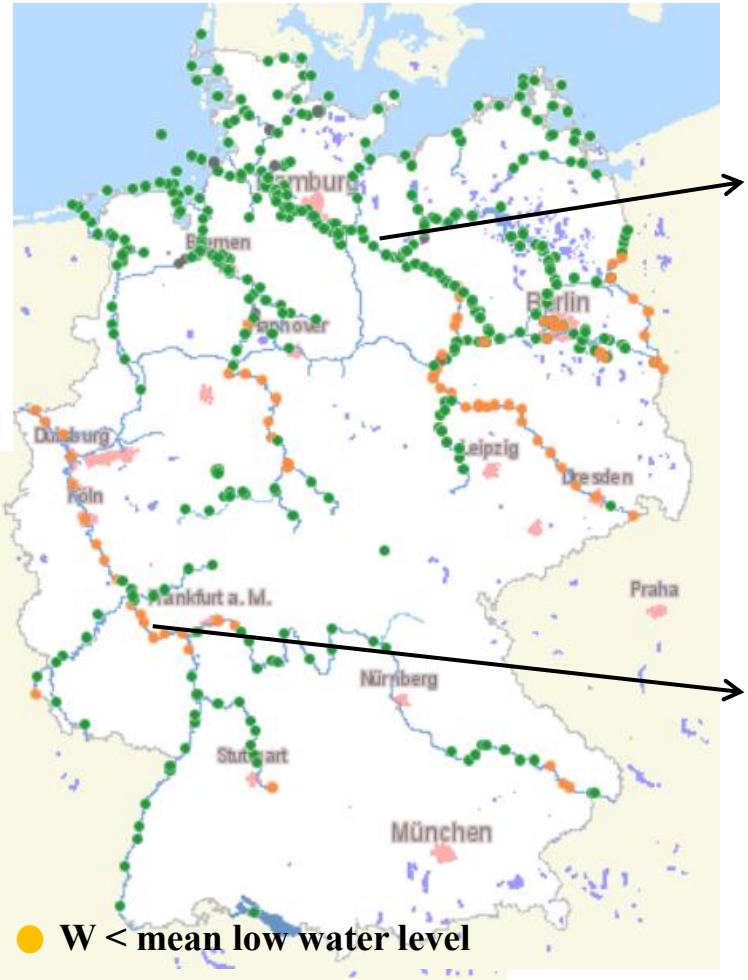
- since beginning of July the German waterways are affected by low flows
- cause: prolonged rain shortage since March / April and very high temperatures

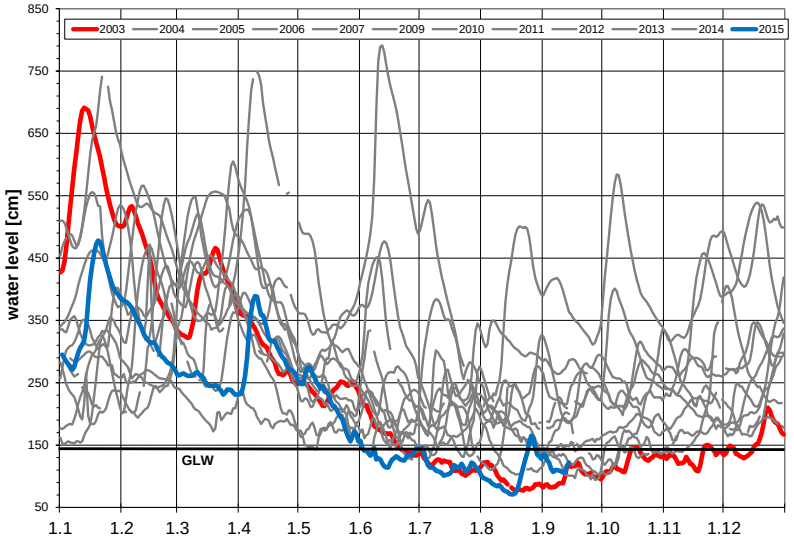


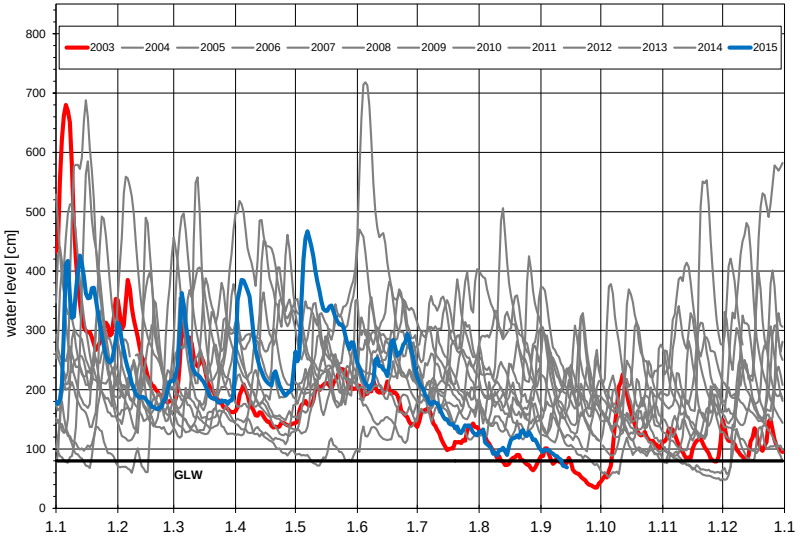
Areas with highest record Tmax observed in July 2015



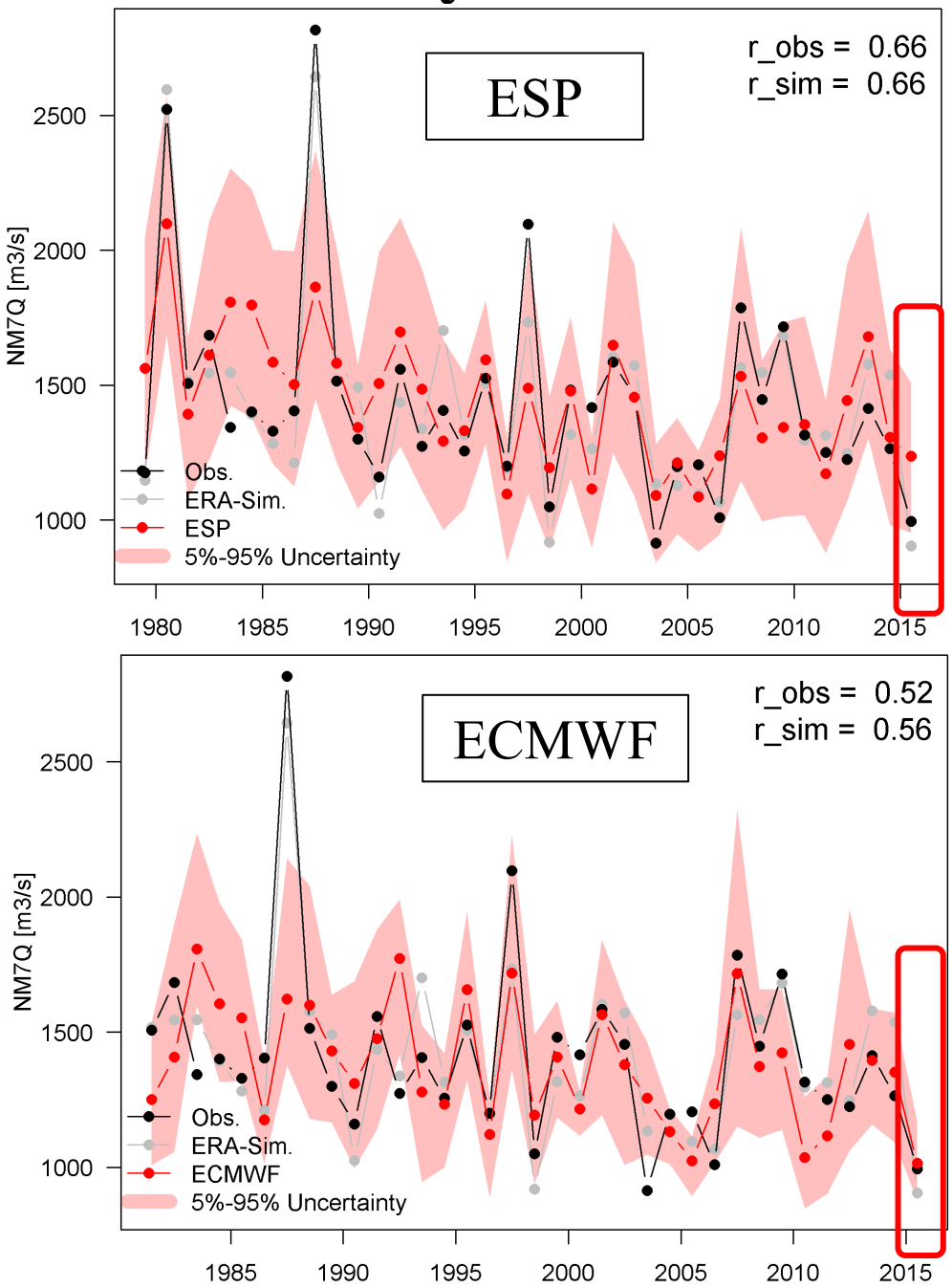
SPI-6 (February-July)







Preliminary results low flow 2015

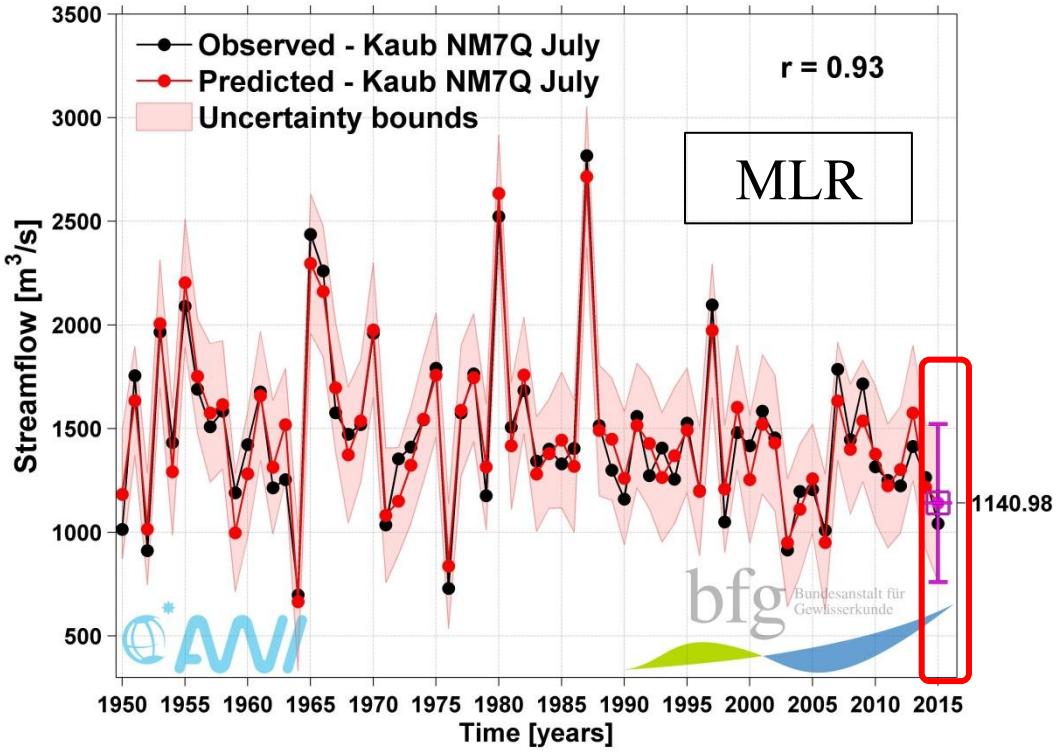


NM7Q July (lead: 1 month)

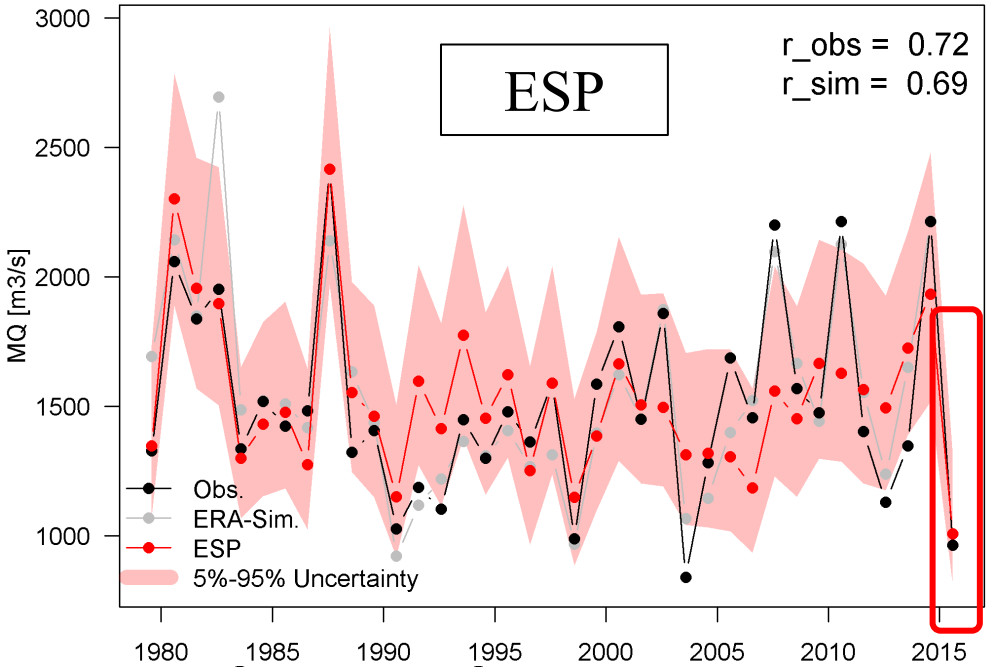
measurement: 994 m³/s

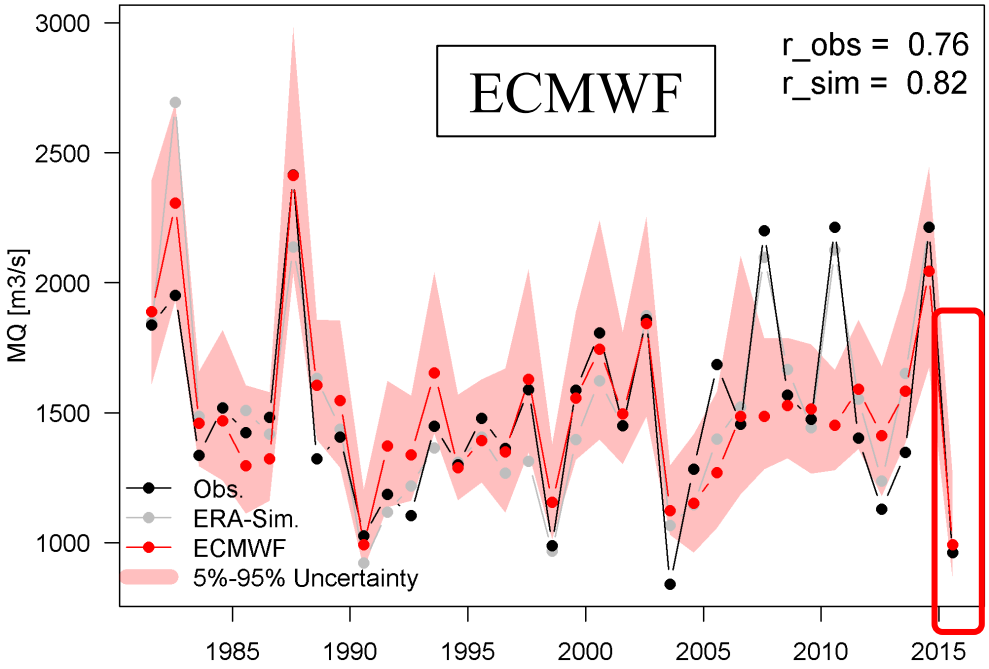
long-term mean: 1414 m³/s (MNM7Q $_{1981\text{-}2015}$)

⇨ ECMWF-SEAS already show very good forecast
(ECMWF-ENS extended to be tested for lead 1)



Preliminary results low flow 2015

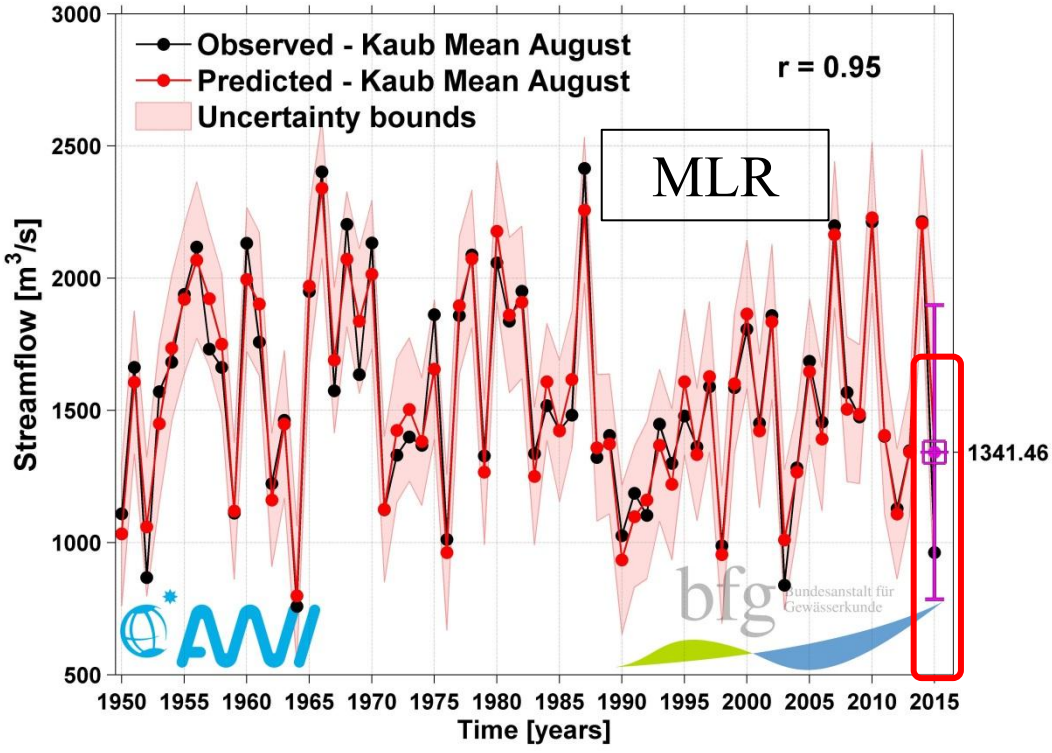




MQ August (lead: 1 month)

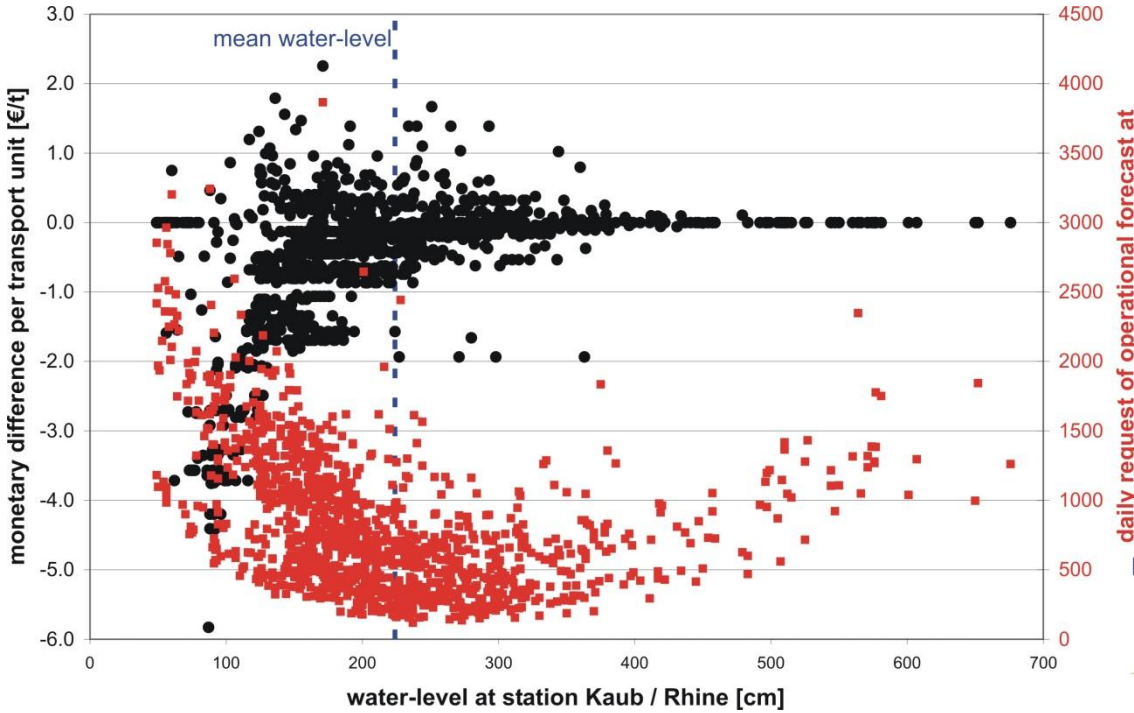
measurement: 962 m³/s

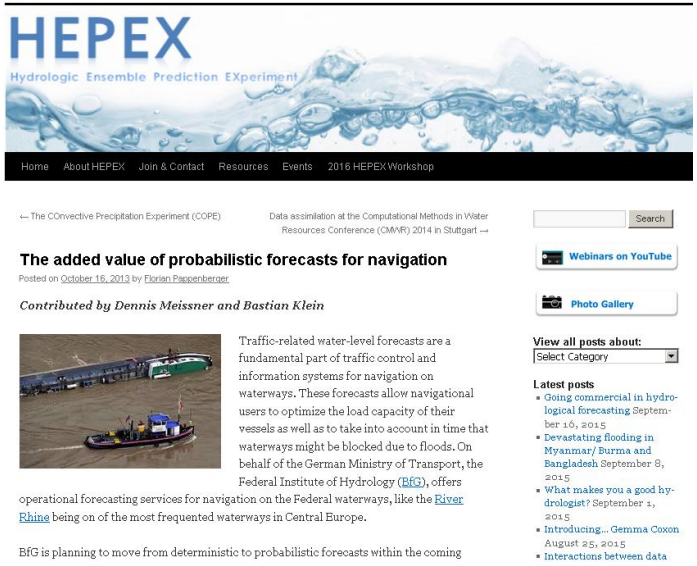
long-term mean: 1504 m³/s ($MoMQ_{1981-2015}$)



User-related validation

- transformation of forecasted discharges/water levels into transport costs (€/ton)
- coupling of hydrological forecasts to a cost-structure model developed by the Development Centre for Ship Technology and Transport Systems (DST)
- modelling different cost components (for 7 representative vessel types):
  - fixed costs (investment, insurance, labour costs)
  - variable costs (fuel, lubrication)
  - forecast induced costs (lighterage, standby-time, further transport by truck, ...)





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  - fixed costs (investment, insurance, labour costs)
  - variable costs (fuel, lubrication)
  - forecast induced costs (lighterage, standby-time, further transport by truck, ...)
- To-Do: extend model for seasonal influencing factors (e.g. flexible fleet structure)
- advantages:
  - offering objective evidence of forecast value for IWT (in addition to direct stakeholder interaction)
  - serves as eye-catcher for potential user (even if they critize some assumptions)
  - compared to hydrological forecast computationally cheap
  - expendable to additional cost components

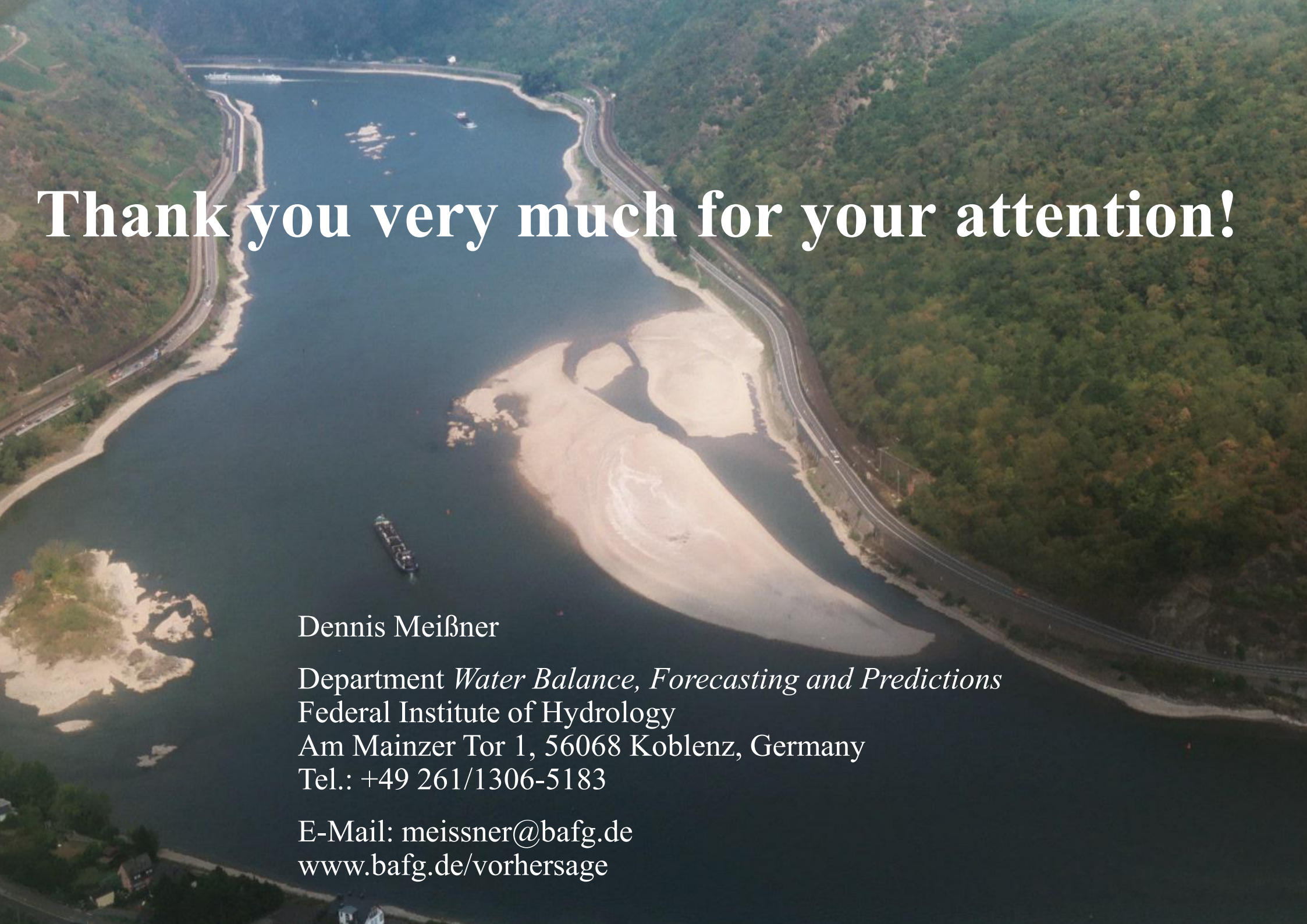
Summary

- IWT is an often negleted user of hydrological forecasts requiring seasonal forecasting services for the navigation-related gauging stations.
- Therefore BfG set-up different pre-operational prototypes for the German waterways using different methods (internal use in current drought situation).
- Despite all uncertainties using ECMWF-SEAS shows relevant improvements compared to ESP and climatology for the navigation relevant forecast moths
- Statistical approach currently developed by AWI gives promising results, careful evaluation of predictors and intercomparison within the coming months
- Next steps: Investigation of potential methods to combine the methods and design of final forecast products suitable for IWT
- Participation in 2 European projects related to seasonal forecasting:

  EUPORIAS (stakeholder, case-study)  (projectpartner, WP „transport“)
- Final aim: offering the first operational seasonal forecasting service for the German waterways (end of 2016 / beginning of 2017)

References

- *Ionita, M., Lohmann, G., Rimbu, N. 2008. Prediction of Elbe discharge based on stable teleconnections with winter global temperature and precipitation. Journal of Climate, 21, 6215-6226.*
- *Ionita, M., Lohmann, G., Rimbu, N., Chelcea, S. 2012. Interannual Variability of Rhine River Streamflow and Its Relationship with Large-Scale Anomaly Patterns in Spring and Autumn. Journal of Hydrometeorology 13(1): 172-188.*
- *Ionita, M., Dima, M., Lohmann, G., Scholz, P., Rimbu, N. 2014. Predicting the June 2013 European Flooding based on Precipitation, Soil Moisture and Sea Level Pressure. Journal of Hydrometeorology, in press, doi: http://dx.doi.org/10.1175/JHM-D-14-0156.1*
- *Mahanama, S., Livneh, B., Koster, R., Lettenmaier, D., Reichle, R. 2012. Soil moisture, snow, and seasonal streamflow forecasts in the United States. Journal of Hydrometeorology, 13:189–203.*
- *Moser, H., Cullmann, J., Kofalk, S., Mai, S., Nilson, E., Rösner, S., Becker, P., Gratzki, A., Schreiber. K.J. 2012. An integrated climate service for the transboundary river basin and coastal management of Germany. In: WMO (ed): Climate ExChange. ISBN 978-0-9568561-4-2*
- *Wood, A. W., Schaake, J. C. 2008. Correcting Errors in Streamflow Forecast Ensemble Mean and Spread. J. Hydrometeor, 9, 132–148.*
- *Wood, A.W., Lettenmaier, D.P. 2008. An ensemble approach for attribution of hydrologic prediction uncertainty. Geophysical Reseach Letters, 35, L14401*



Thank you very much for your attention!

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