High resolution discharge simulations over Europe and the Baltic Sea catchment

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Global Water Cycle

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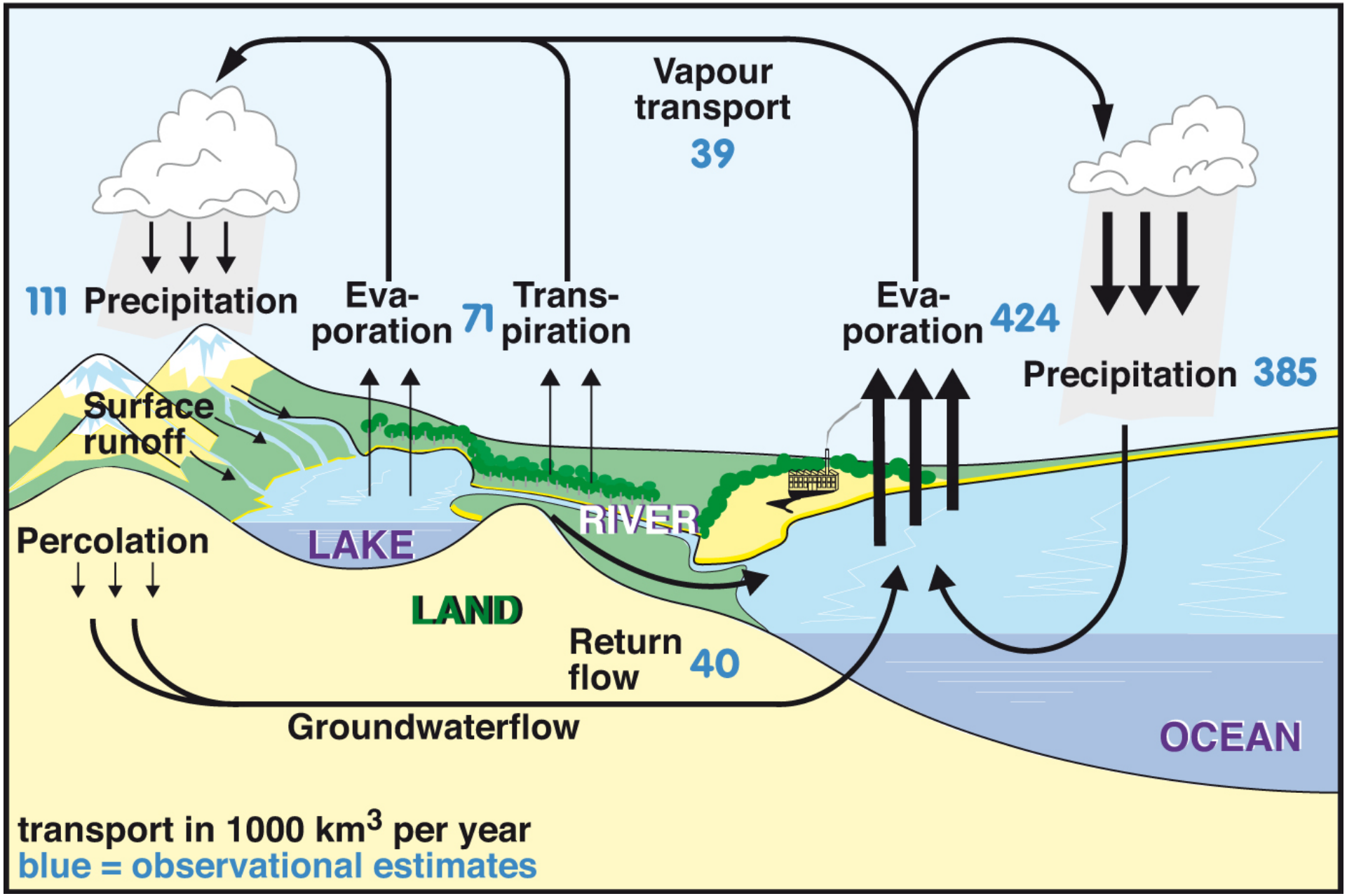

Thanks to Norbert Noreiks, MPI-M

Generating runoff in different communities

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- Hydrology: GHMs or local/regional HMs forced by CM input.
  - \+ Specific impact model focusing on hydrology
  - \+ GCM/RCM biases may be corrected
  - • Local/regional HMs are often calibrated, but for current climate.
  - – Hydrology may be inconsistent with GCM/RCM forcing
  - – No feedbacks to the atmosphere
  - – Another level of uncertainty is added

Global modelling chain in WATCH or ISIMIP

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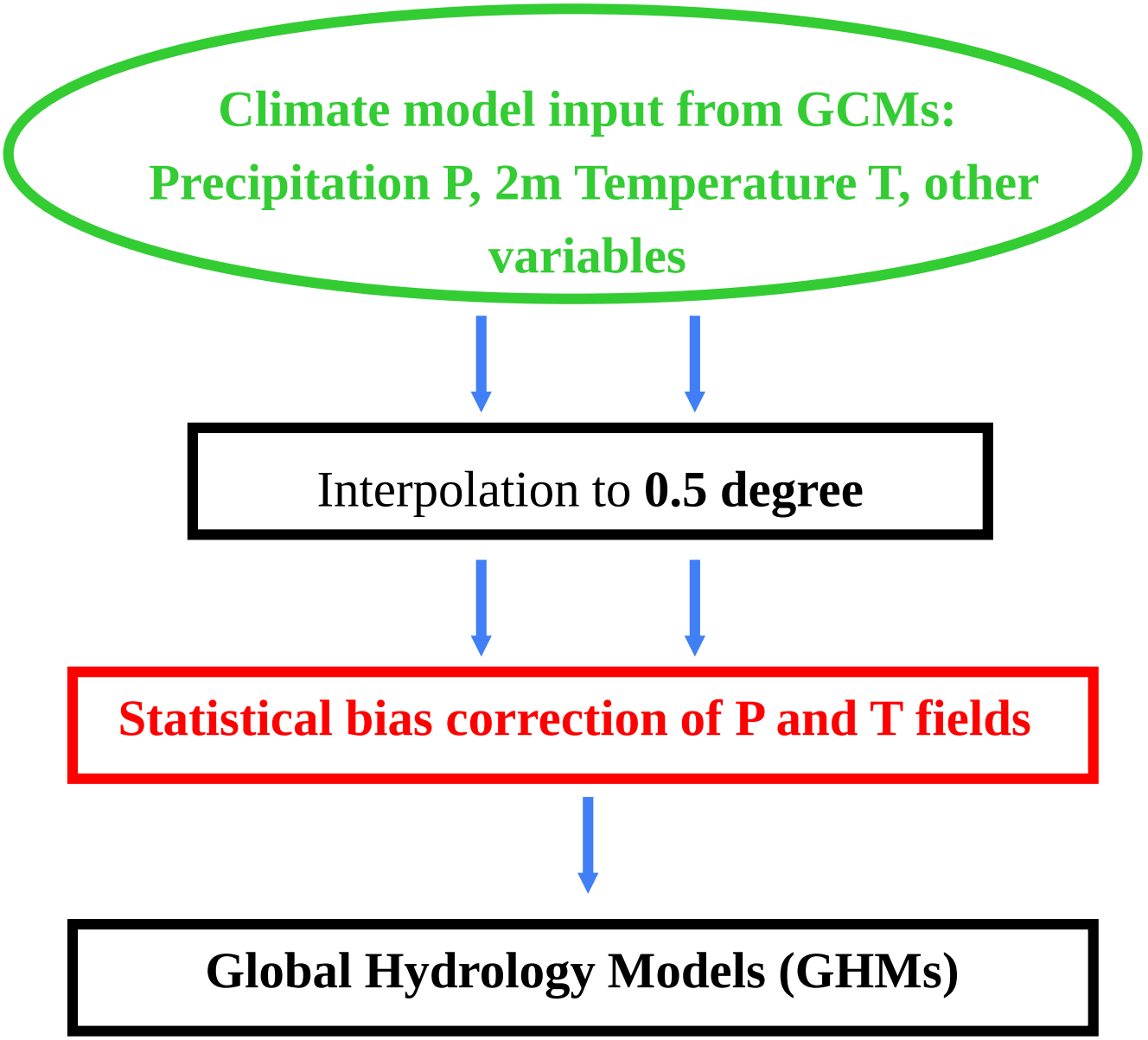

Generating runoff in different communities

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- Hydrology: GHMs or local/regional HMs forced by CM input.
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  - • Local/regional HMs are often calibrated, but for current climate.
  - – Hydrology may be inconsistent with GCM/RCM forcing
  - – No feedbacks to the atmosphere
  - – Another level of uncertainty is added
- Climate: Within LSMs of GCMs or RCMs
  - \+ Runoff/land surface variables are consistent with climate variables
  - \+ Hydrology – atmosphere feedbacks are regarded.
  - – Potentially large biases exists due to climate model biases, especially in precipitation

Regional ESM: GCOAST

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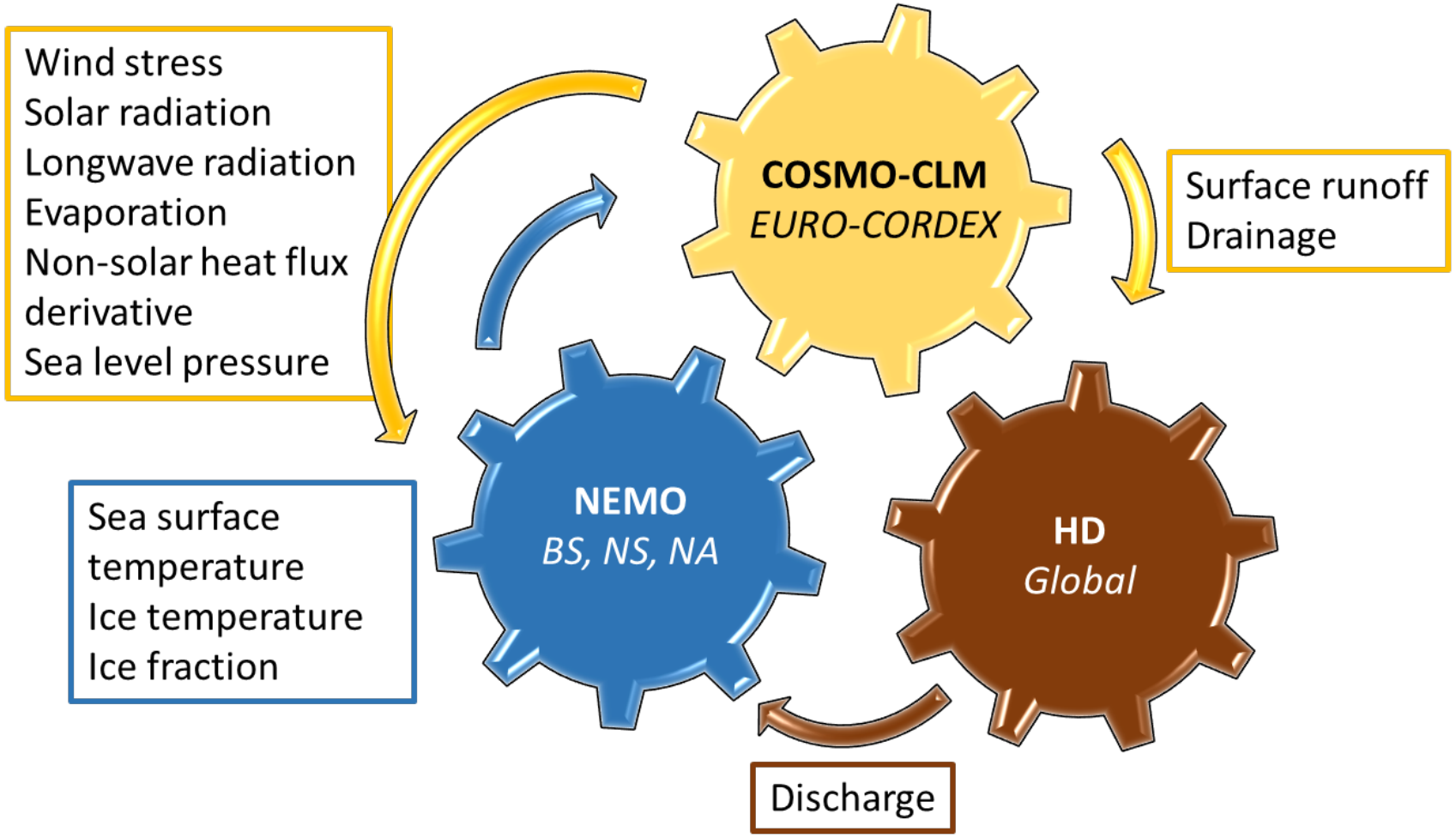

Atmosphere-ocean-river coupled model,

a subset of the GCOAST regional earth system model.

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The Hydrological Discharge (HD) model

Lateral transport of water over the land surface to simulate discharge into the oceans

Hagemann & Dümenil (1998) Clim. Dyn.
Hagemann & Dümenil Gates (2001) JGR

HD model structure

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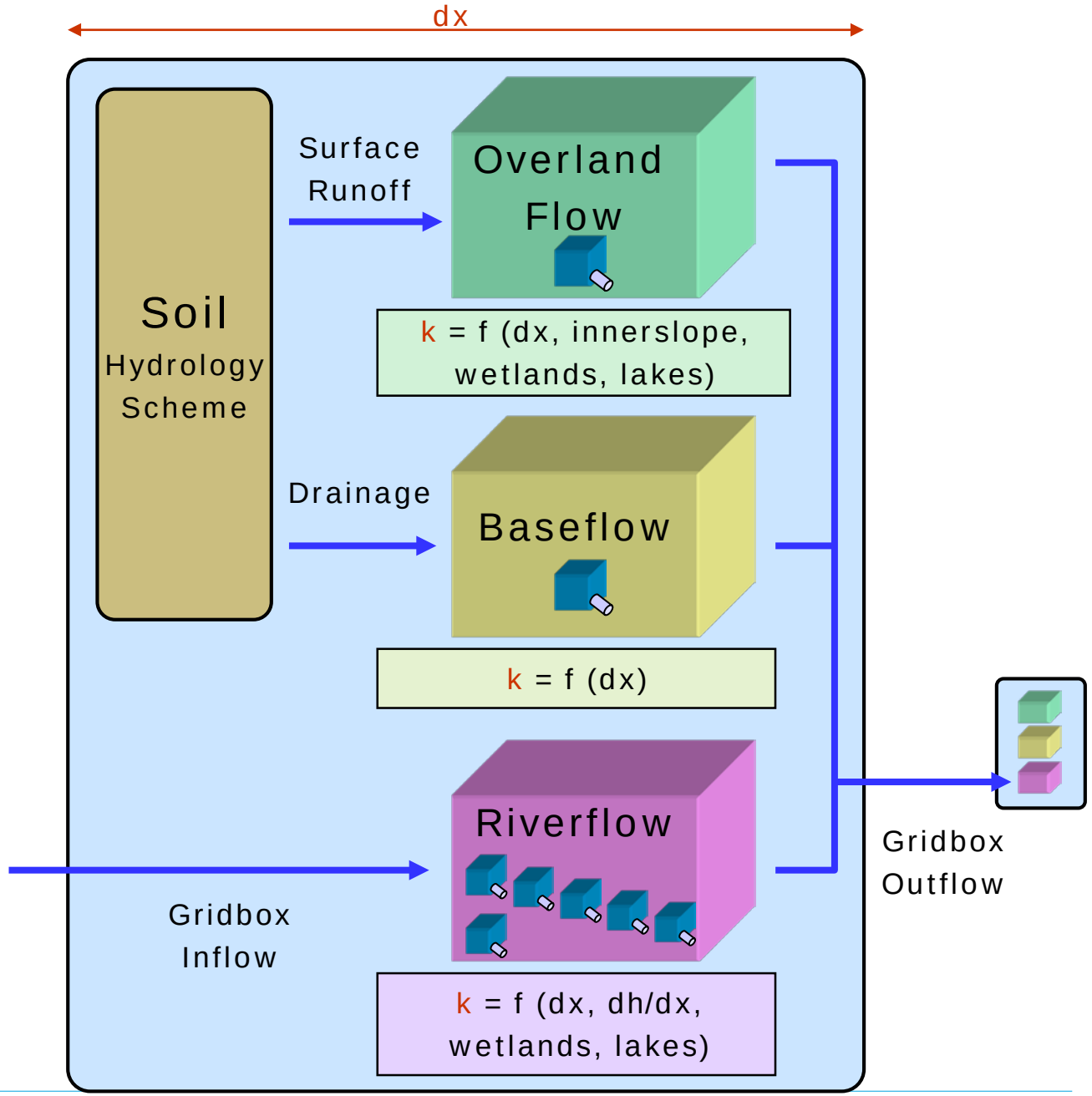
- State of the art discharge model
- Applied and validated on global scale at 1/2 deg.
- Part of MPI-ESM
- Time step: 1 day (internally 6 hours for riverflow)

<u>Coupled in regional ESMs</u>

RegCM-ES (Sitz et al. 2017)

ROM (Sein et al. 2015)

REMO-MPIOM (Elizalde et al. 2011)



HD model

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- **Increase resolution from 0.5° (50-55 km) to 5 Min. (8-9 km)**

Monthly discharges: 2000-2003

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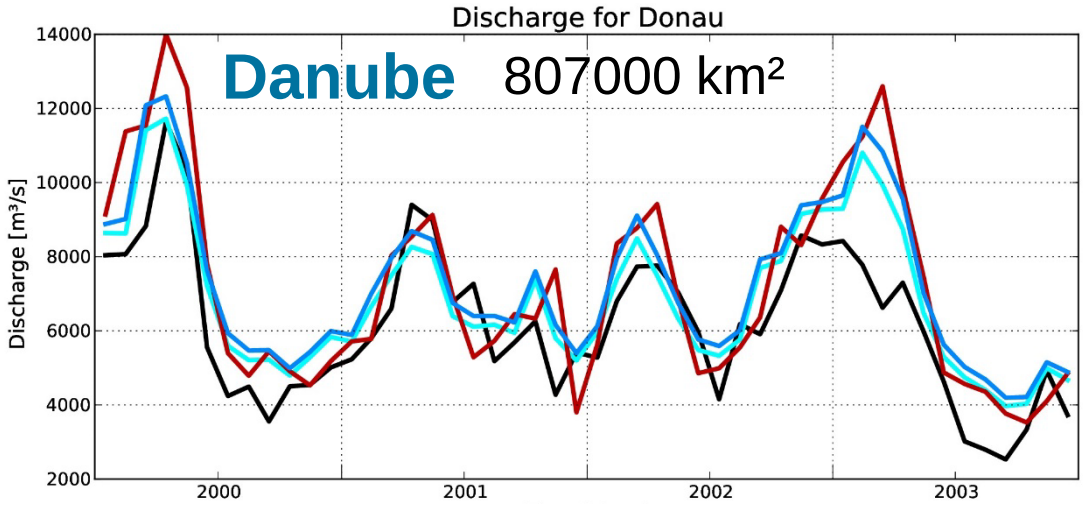
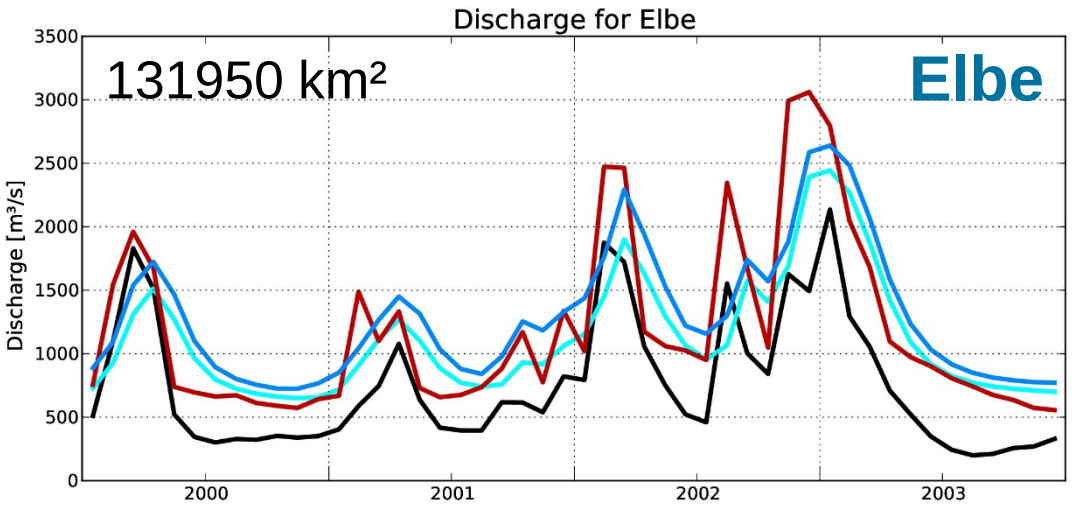
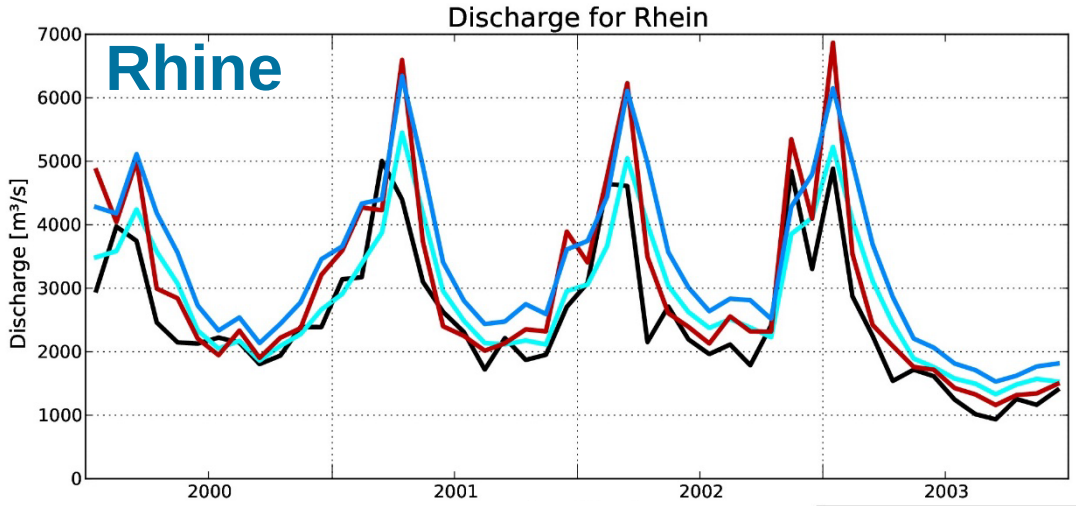
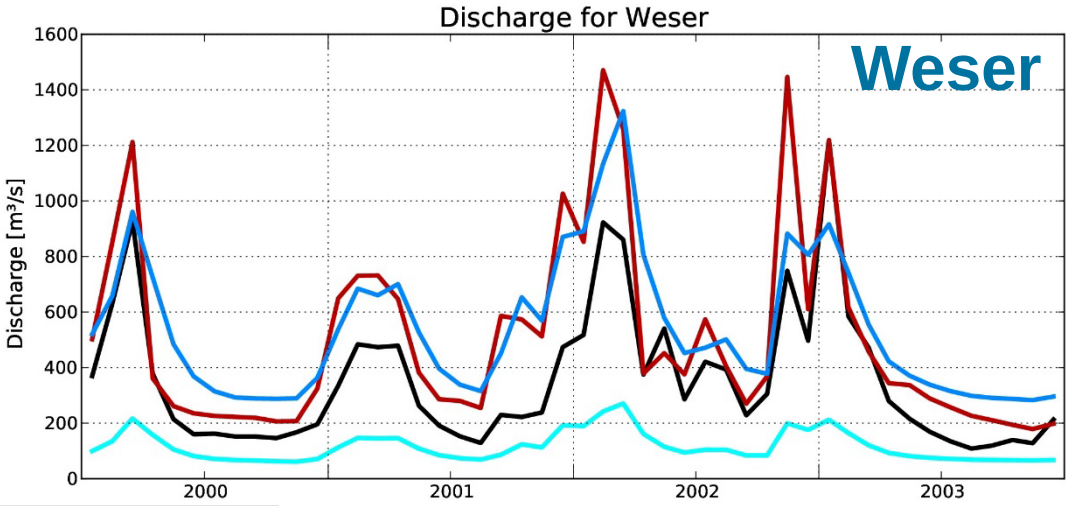


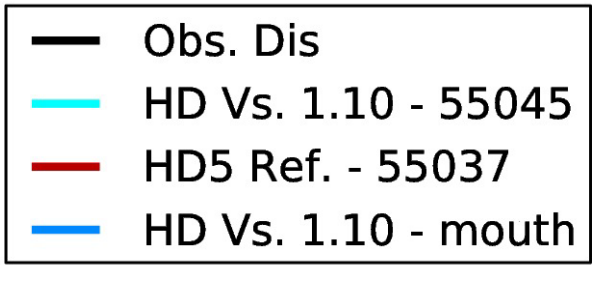




160800 km²



37720 km²



Daily discharges 2000-2003: Resolution matters

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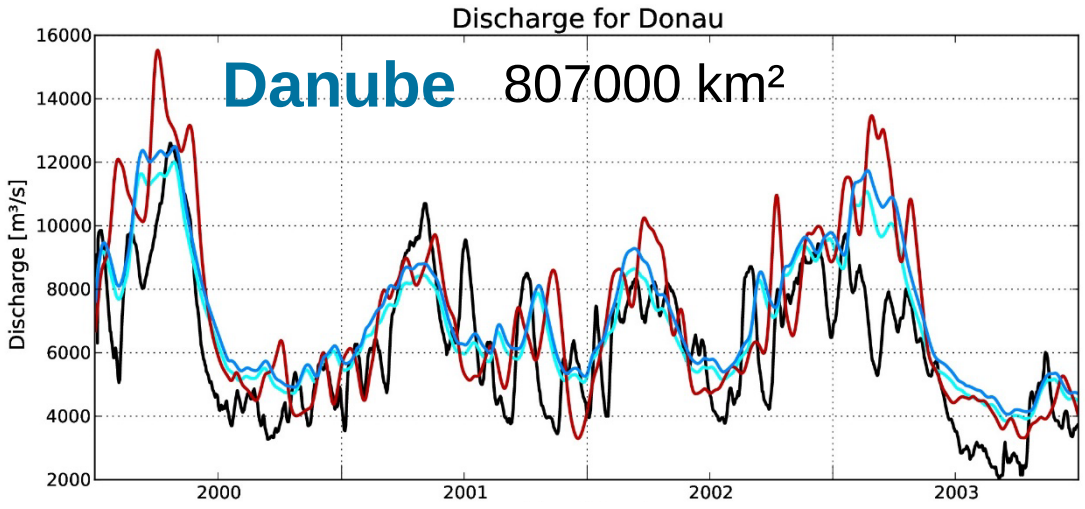
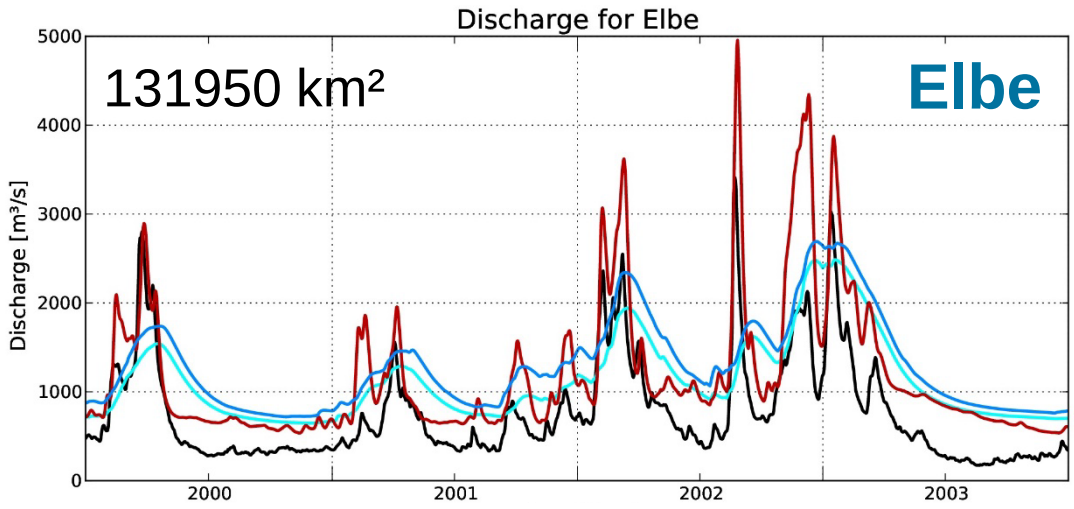
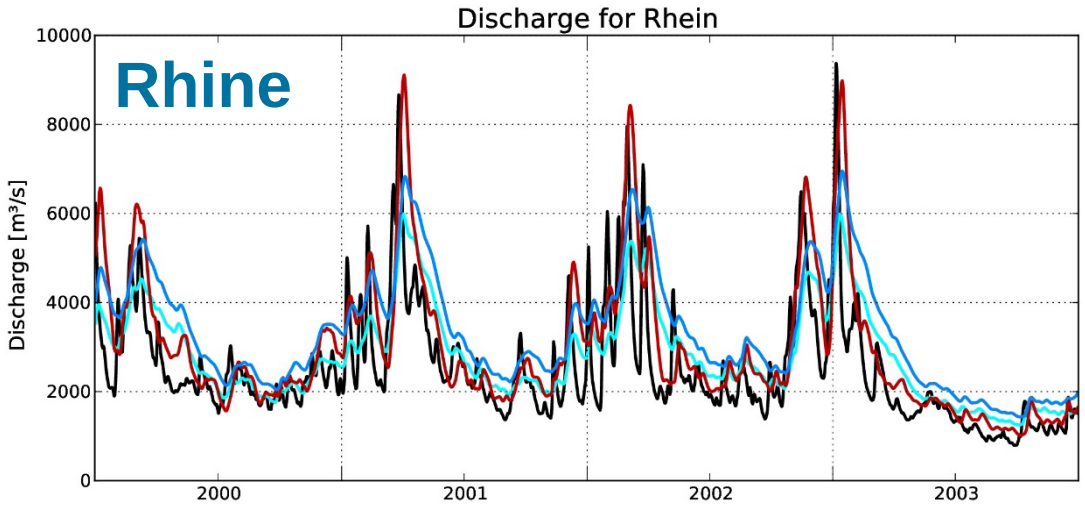
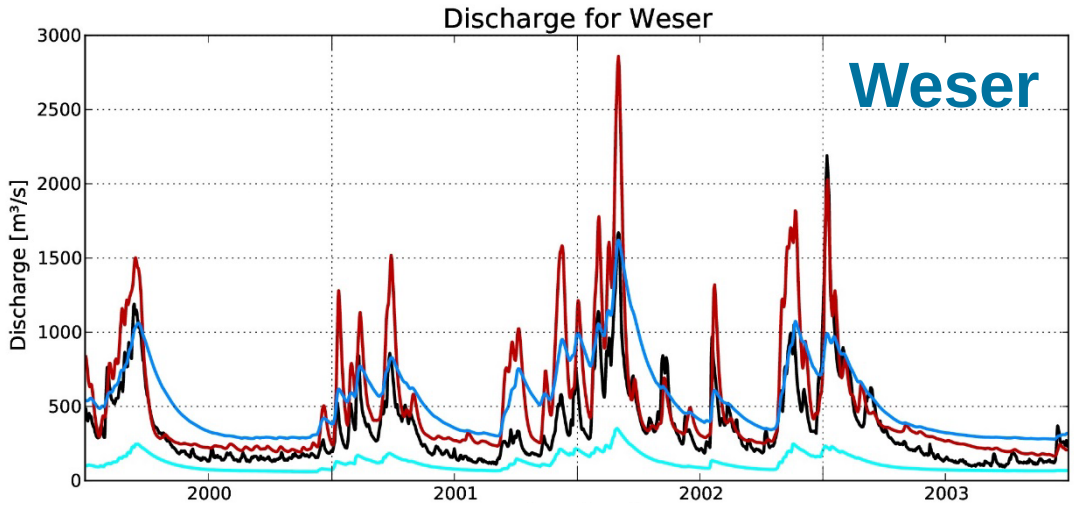


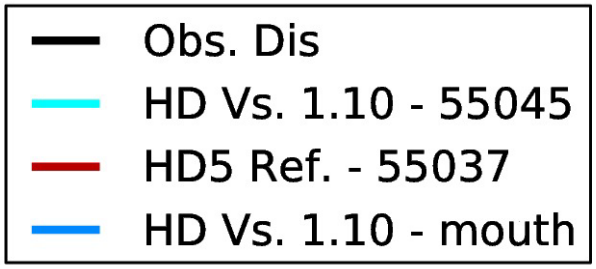




160800 km²



37720 km²



HD model

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- Increase resolution from 0.5° (50-55 km) to 5 Min. (8-9 km)
- Apply some general scaling factors to HD model parameters
- No river specific tuning or calibration!

- Reference run: 1979-2009
- Test runs: 1999-2009 using restart file of reference run
- Evaluation: 2000-2009

HD-5 Min.

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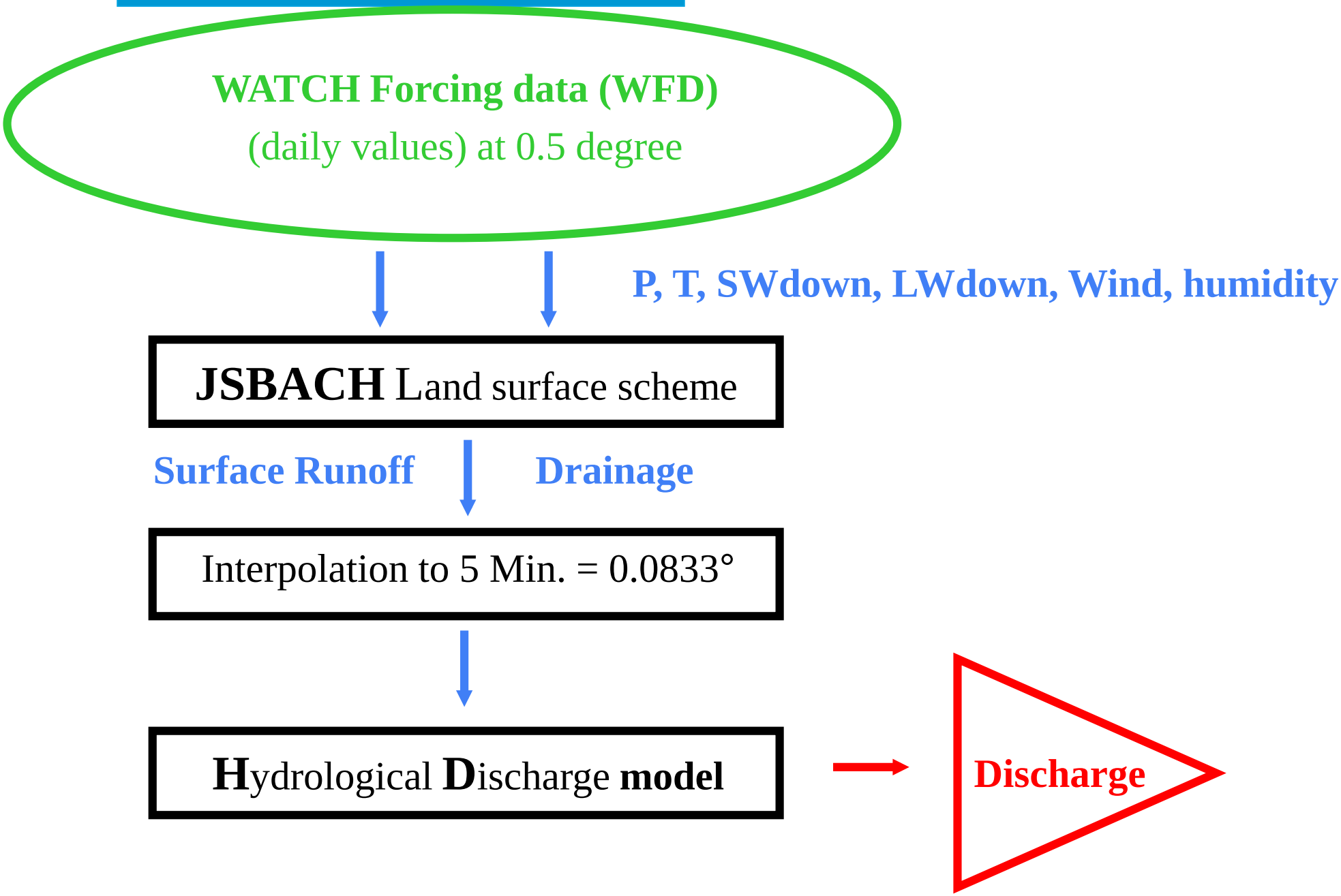

Simulated discharge: 2004-2009

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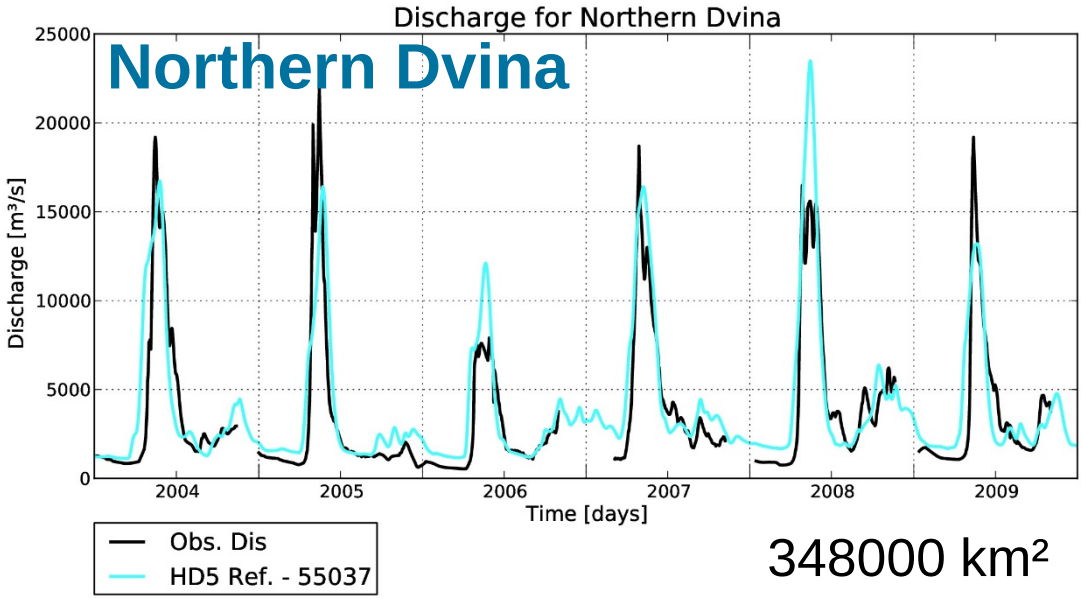
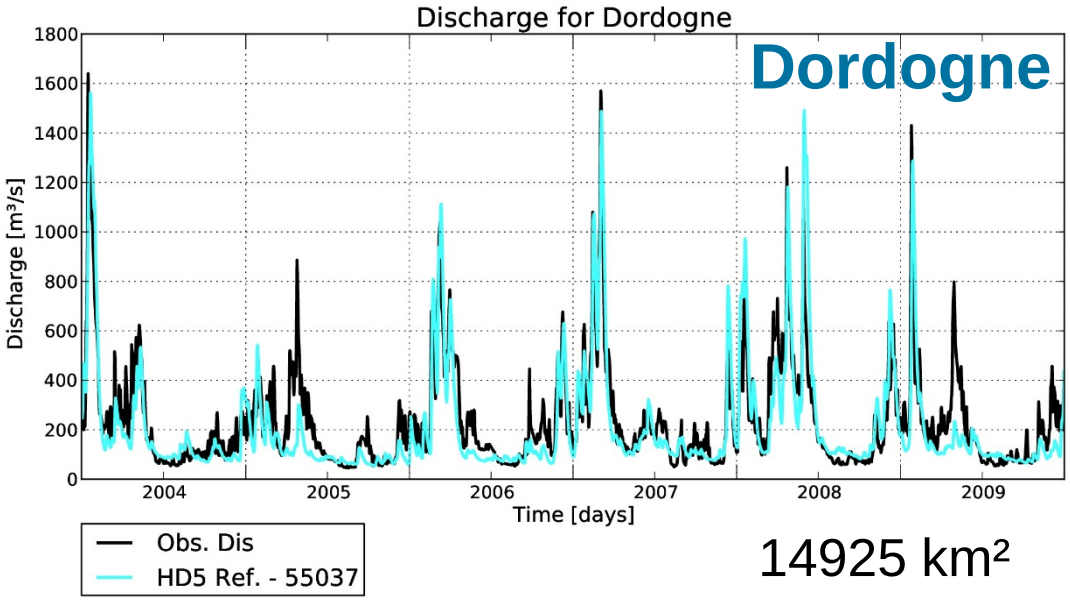
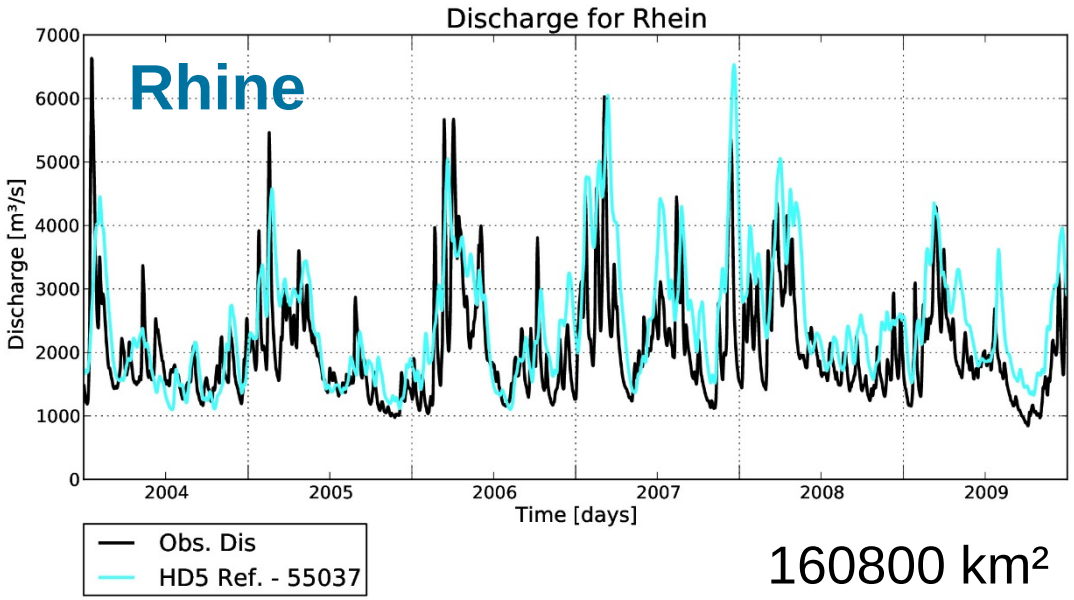


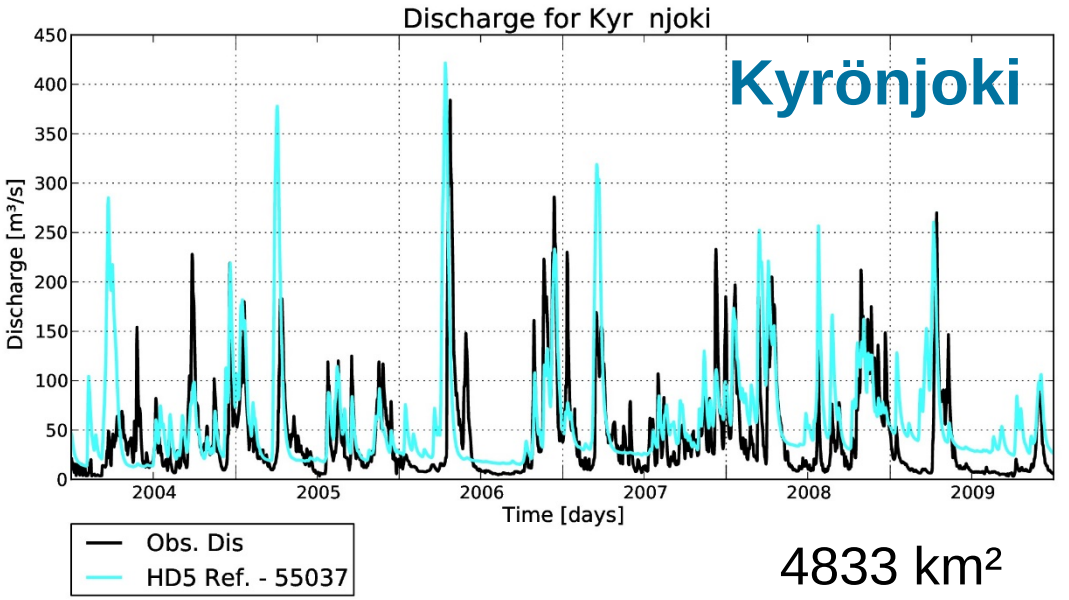
348000 km²



14925 km²



160800 km²



4833 km²

Evaluation metrics using observations

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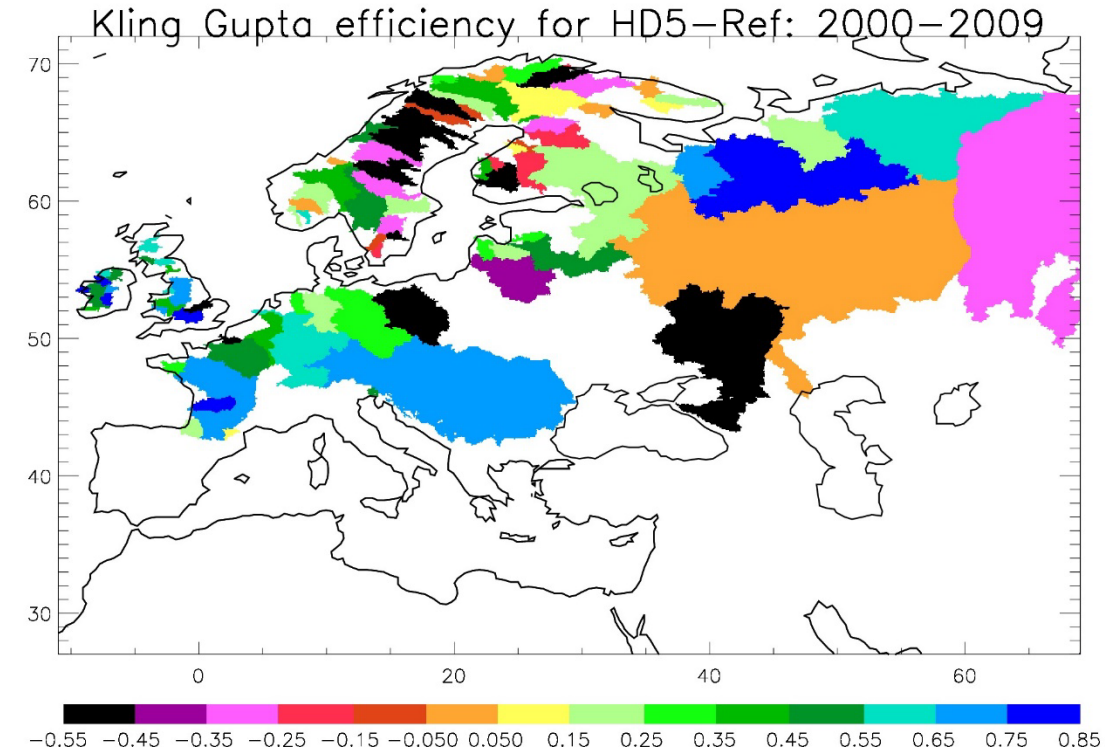
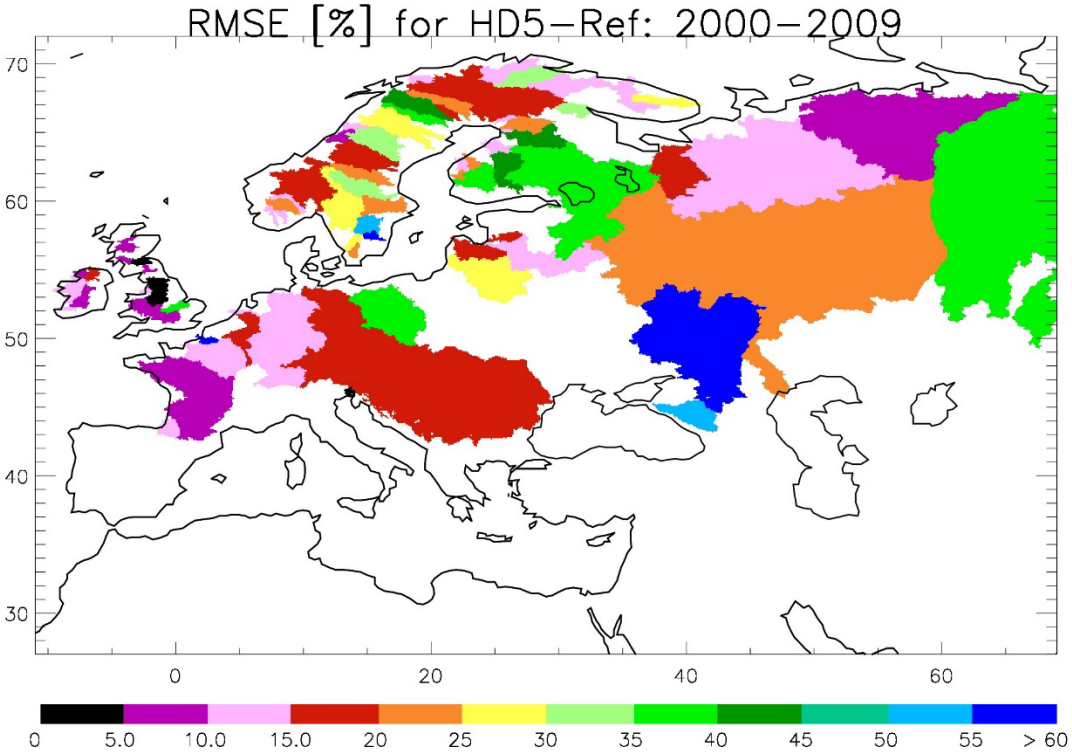
Kling-Gupta Efficiency



RMSE



Evaluation metrics using observations

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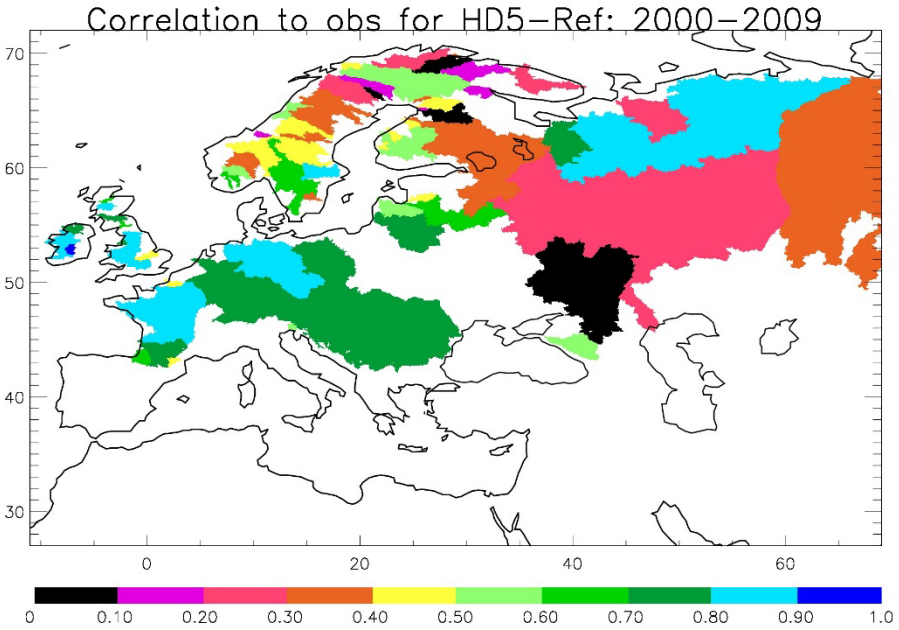
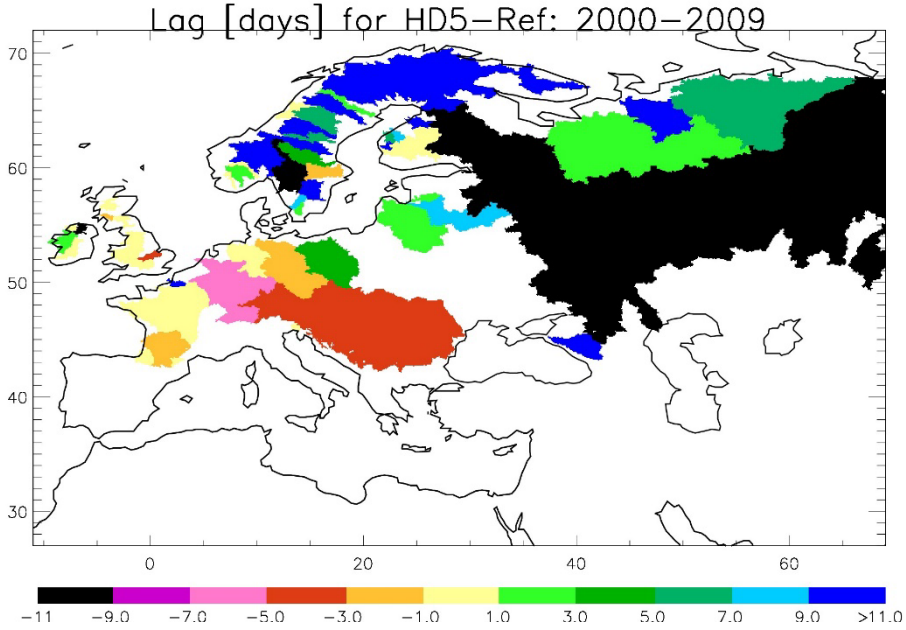
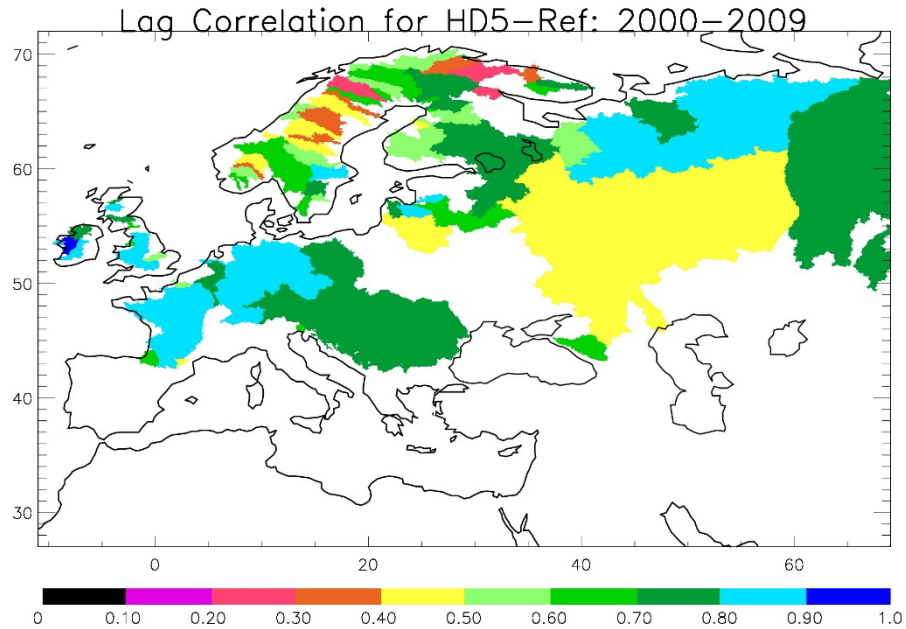
Correlation



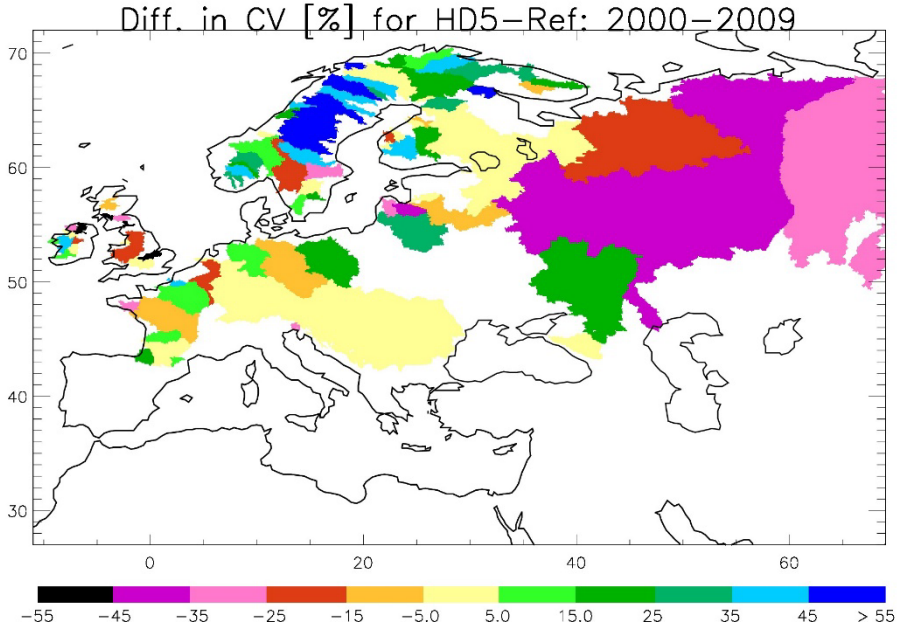
Lag



Lag Correlation



Diff. In CV



Simulated discharge: 2004-2009

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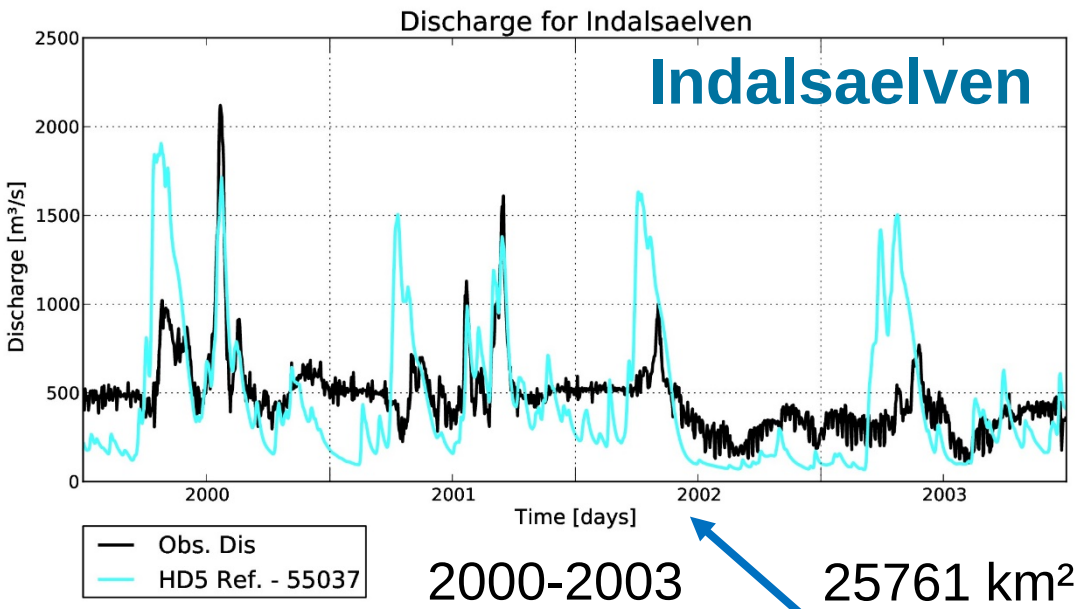
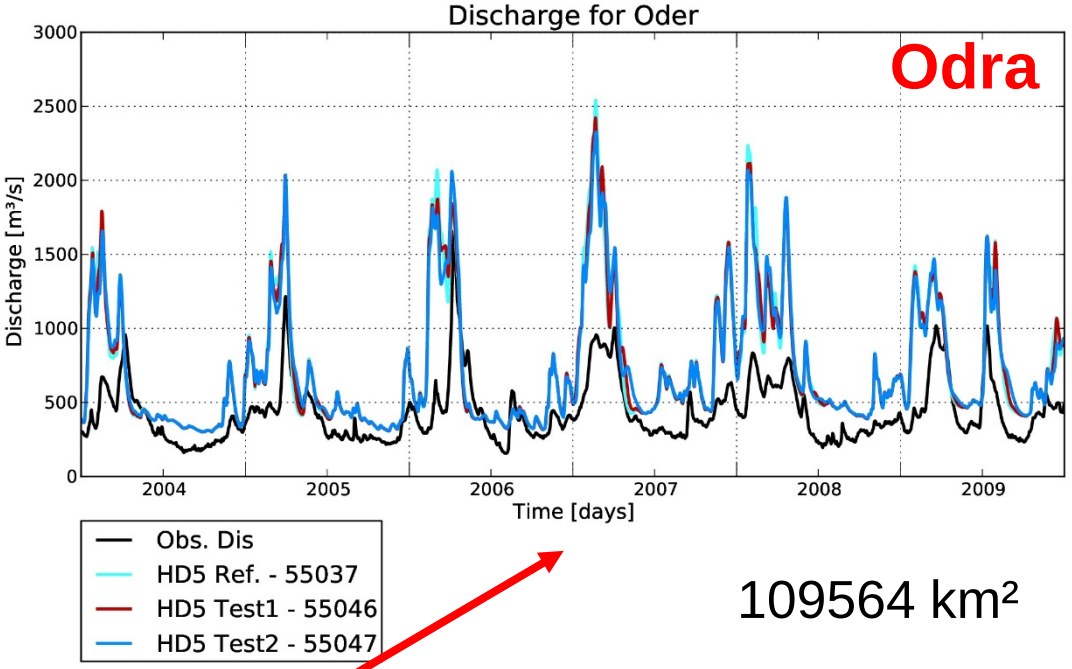
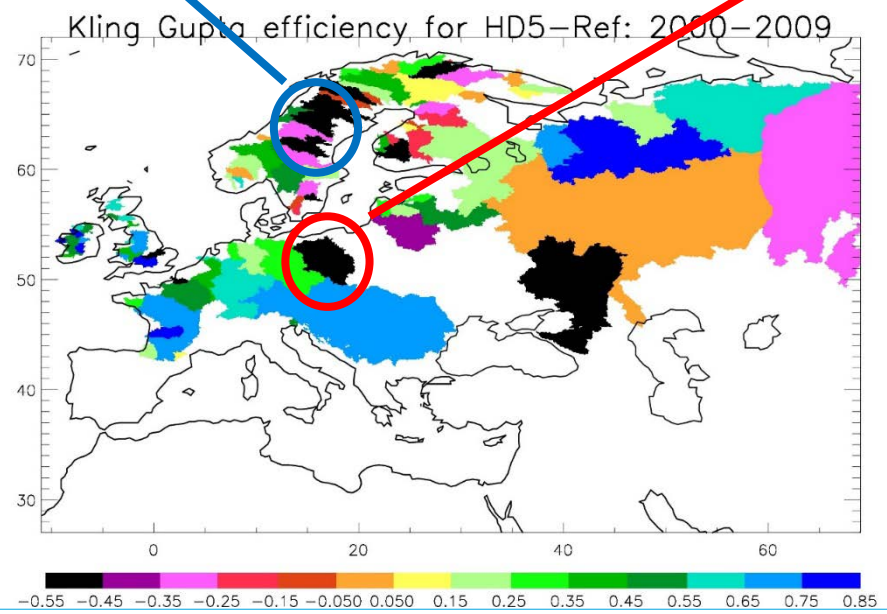


2000-2003

25761 km²



109564 km²



Differences of Test1 to HD5 REF

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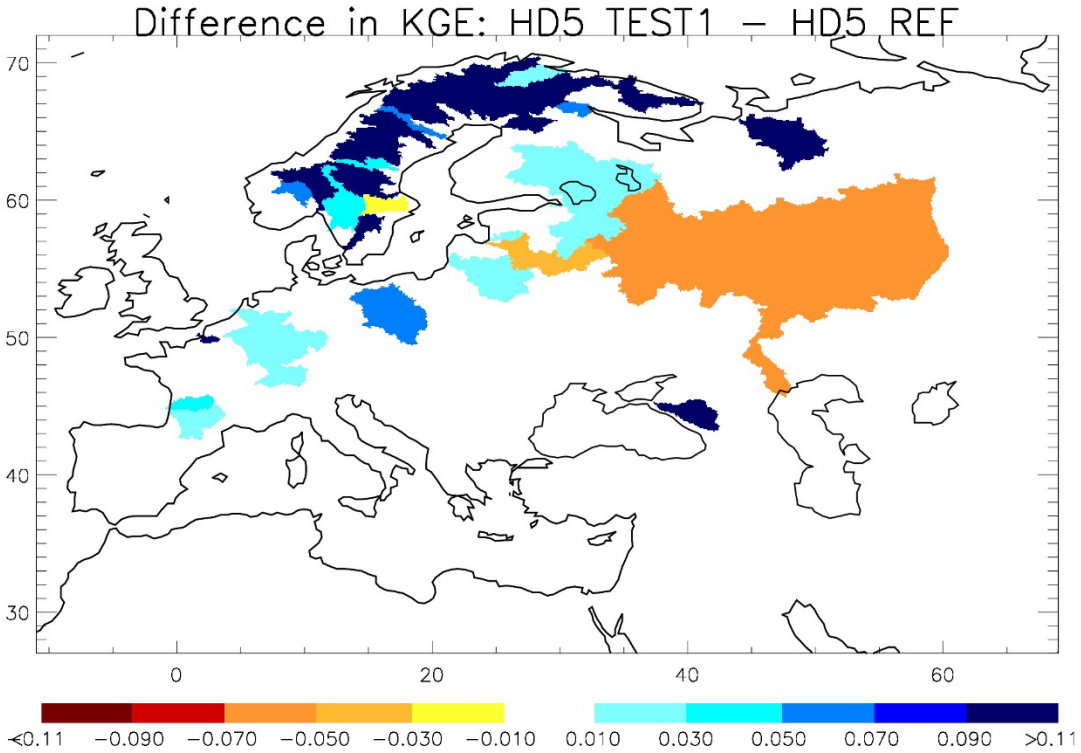
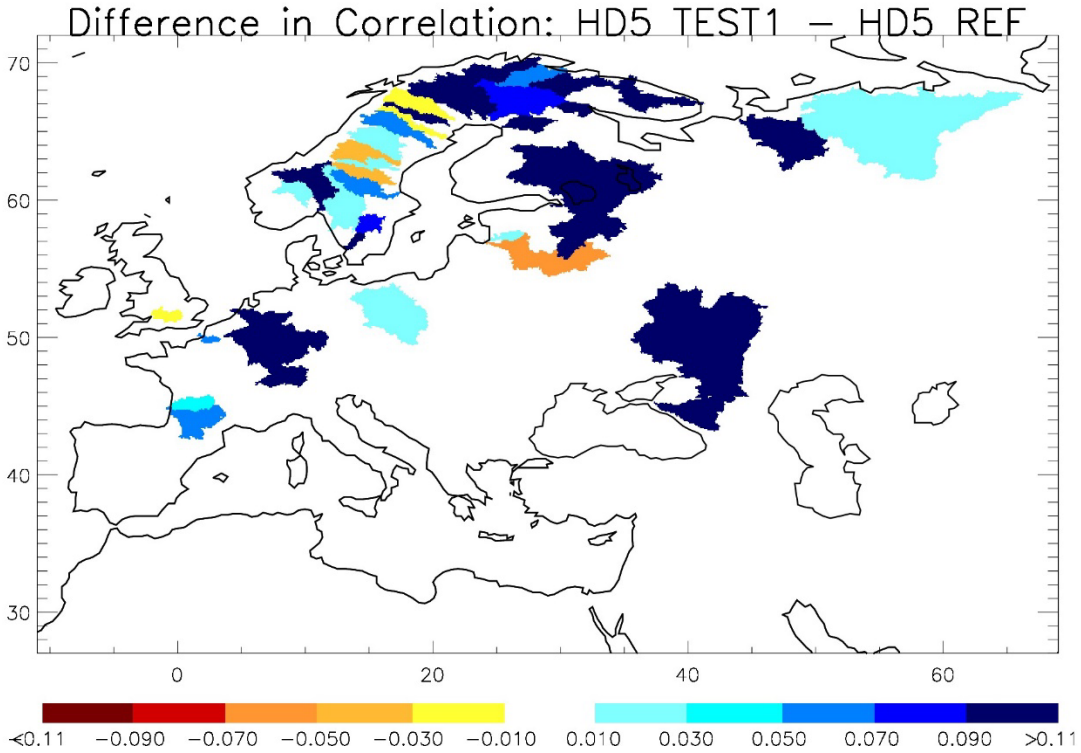
Kling-Gupta Efficiency



Correlation



- Test1: Adjusted main stream velocities to correct for lag to observations
  - Main stream = Main river path from an upstream catchment > 5000 km² until the station.
  - Main river path starts at grid box with the longest distance to the mouth

Simulated discharge: 2004-2009

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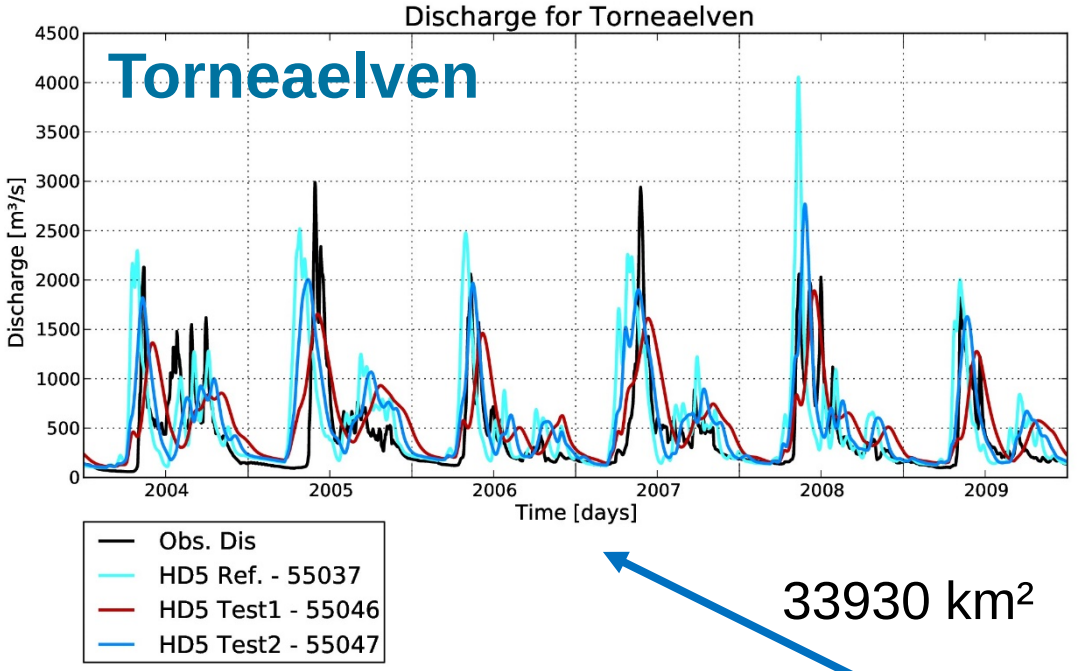
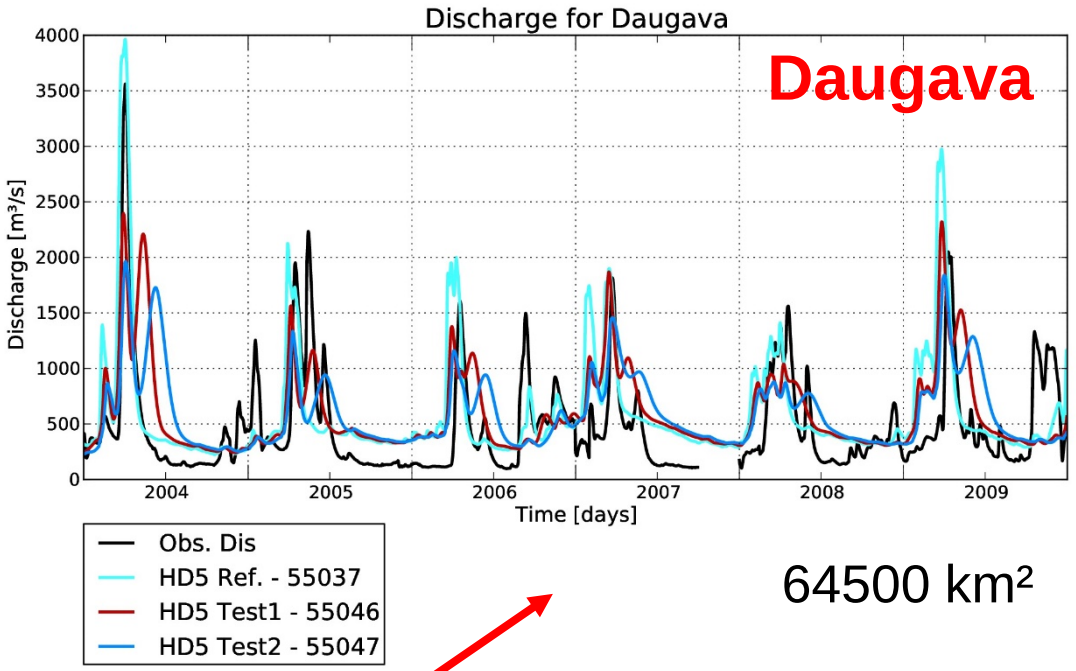
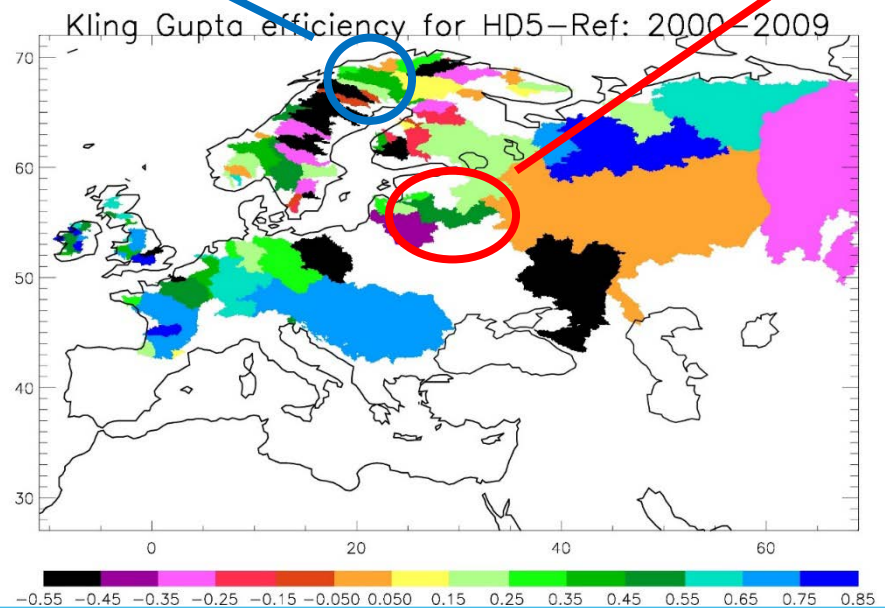


33930 km²



64500 km²



Catchments with daily data

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- Observed daily discharges are required:
  - HD model evaluation
  - Tuning of HD main stream velocities
  - Forcing for ocean and ocean BGC models

Catchments with daily observations

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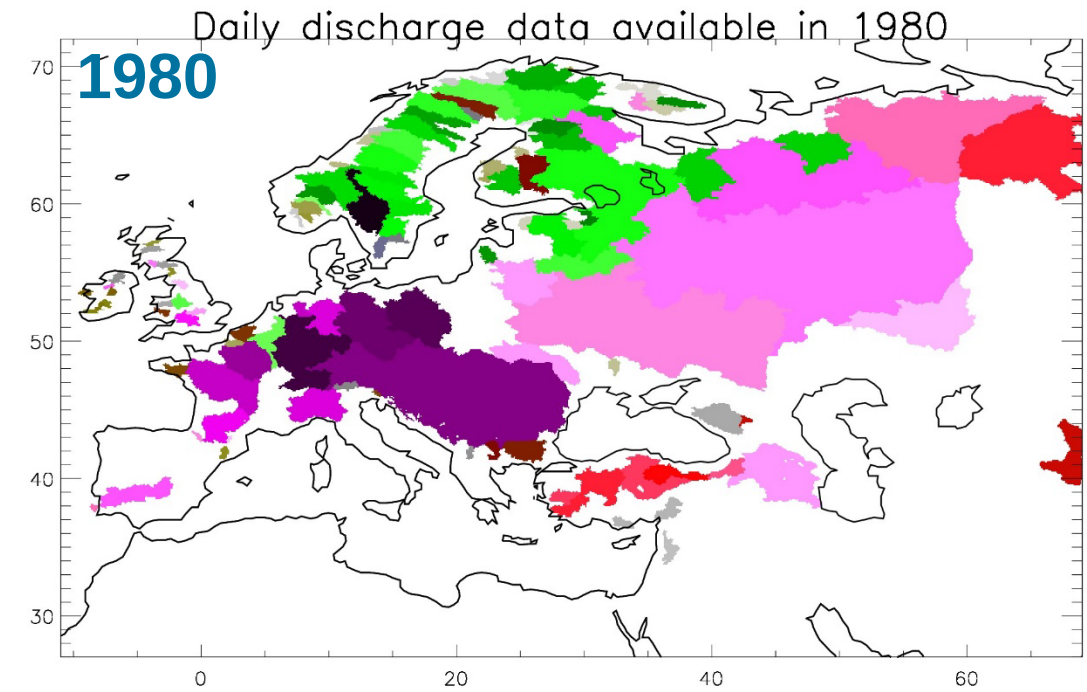

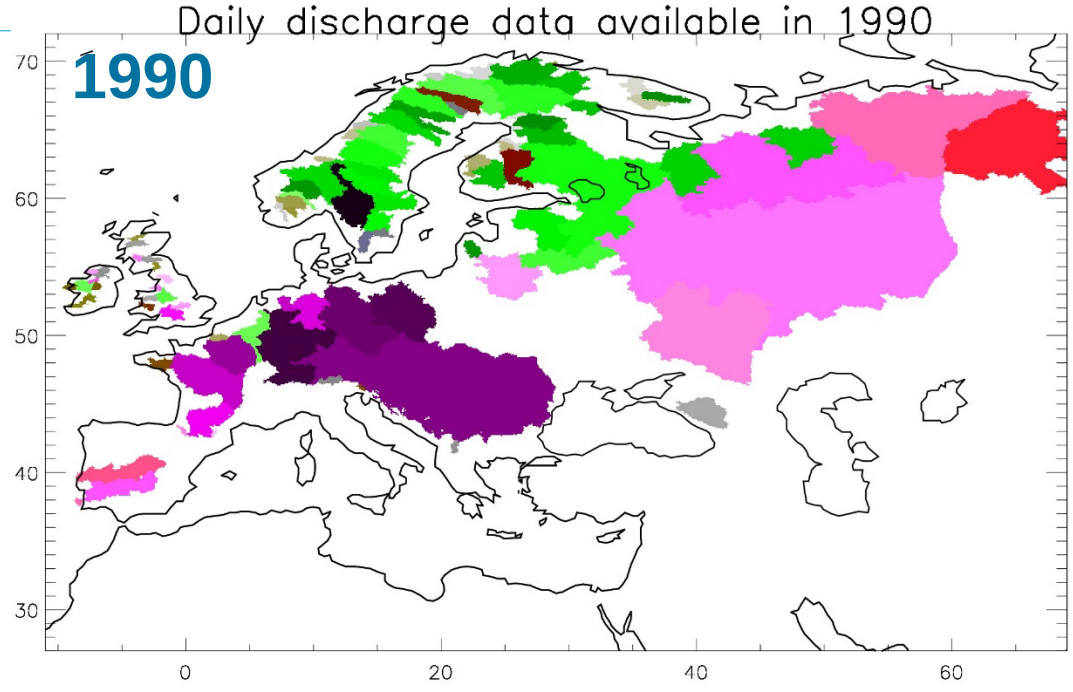

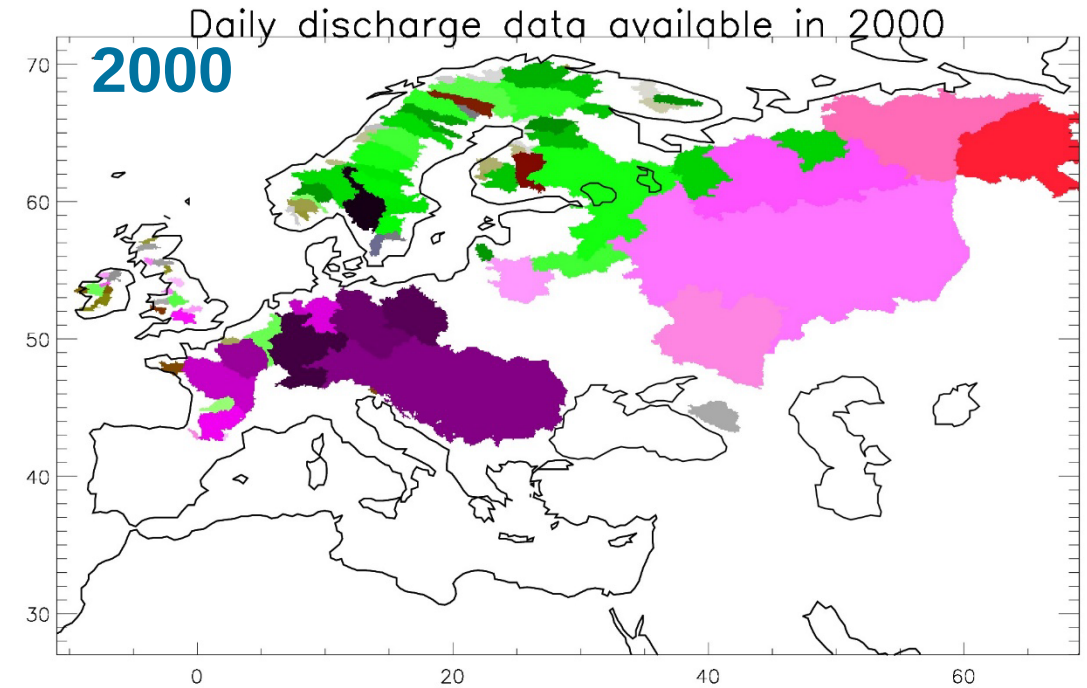

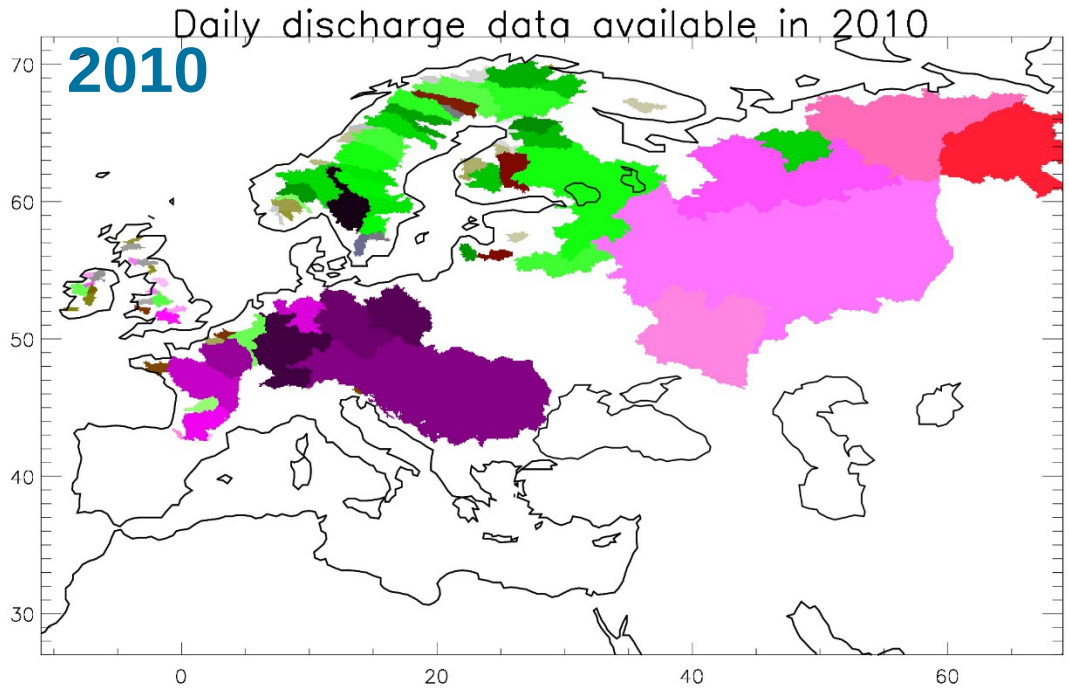

Catchments with daily data

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- Most data are from GRDC, some are from other sources
- Missing larger catchments (> 5000 km²):
  - Station currently not available
  - No available data at all
  - Time series too short
- Who has further observed daily discharges?

Summary

- Discharge model resolution of 0.5° usually sufficient if monthly river runoff from larger catchments is considered.
- For daily river runoff and smaller catchments, higher resolution is required.
- Simple transfer of HD model to 5 Min. resolution using some global scaling factors for model parameters yields good results for many European rivers
- Deficiencies occur where
  - Rivers are heavily regulated, especially in Scandinavia
  - Rivers are impacted by human water abstractions
  - 0.5 degree atmospheric forcing is too coarse
  - Forcing JSBACH has deficiencies in the timing of snow melt
- Preliminary tuning of main stream velocities leads to small improvements for some rivers → further work is needed.

Thank you for your attention!

Evaluation metrics using observations

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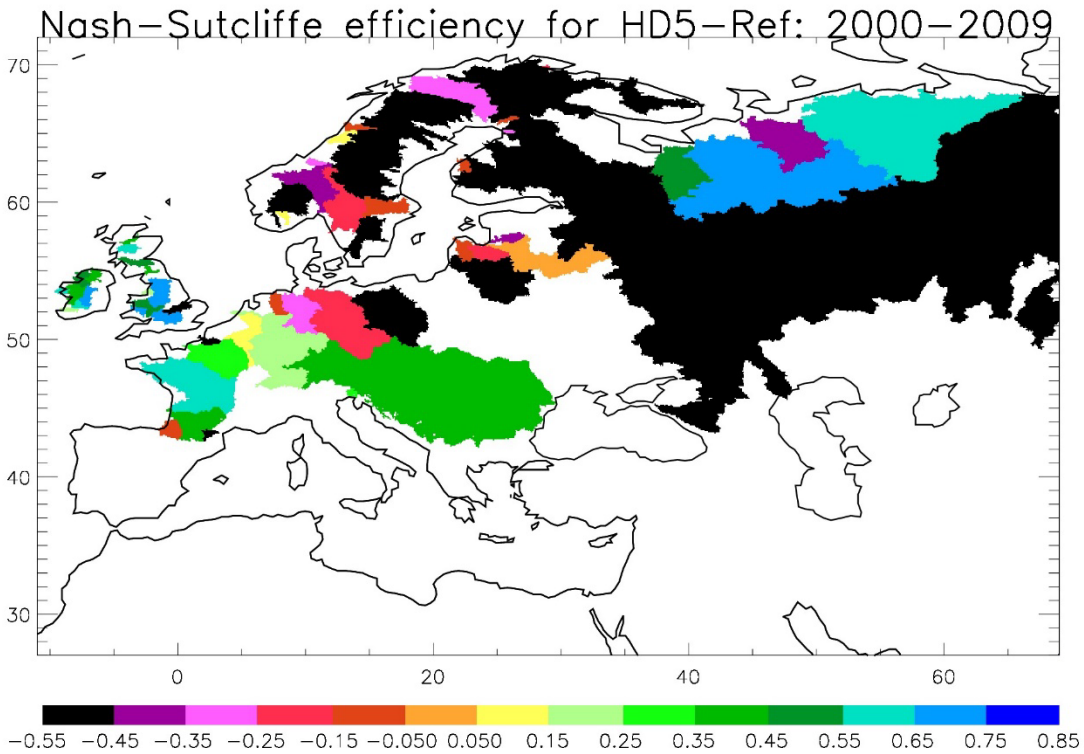
Nash-Sutcliffe Efficiency



Bias