imprex

Learn from today to anticipate tomorrow

Improving hydrological modelling/predictions for the Rhine river

Albrecht Weerts[1,2], Bart van Osnabrugge[1,2], Willem van Verseveld[1]
[1]Deltares, [2]WUR

@imprex_eu

Flood risk in the Netherlands

Introduction

- 60% of the Netherlands is flood prone caused by both riverine flooding and storms surge or a combination of the two
- Policy / Climate Change Delta commission
  - major flood/drought policy works if needed (1 billion euros is set aside)
  - GRADE: **G**enerator of **RA**infall and **D**ischarge **E**xtremes to calculate 1/10000 flood discharge and shape flood wave
- Clustered multi-hazard EWS
  - **RWsOS Rivers for daily water level and flood forecasting**
    - feeds forecasts/simulations into:
      - **RWsOS Water Resources**
      - **RWsOS Lakes (wind driven flood hazard)**
      - **RWsOS NDB (shipping/port of Rotterdam/Maeslant barrier)**

Current=>IMPREX=> and beyond

	Current	IMPREX	and beyond
Flood Forecasting	Lumped HBV96 -hourly -height zones linked to station certain height -fixed PET profiles -fixed interception (g/f) -big calibration effort (last time 2008) -many correction factors, WB fiddling -closed source	wflow_hbv -hourly -distributed P, T -ensemble DA -downscaling ECMWF T -open source Open question: -Makkink Eref/PET derived from Landsaf Rg (or need for recalibration)? -Forecasted Makkink Eref?	wflow_sbm -improve fidelity process formulations -hourly -distributed P, T, Makkink Eref (Landsaf) -LAI from MODIS/Landsaf -PTF <-> parameters (as little calibration as possible) -ensemble DA -forecasted P, Eref, T (downscaled) -open source, FAIR?
Policy	HBV96 -daily -big calibration effort (completed 2014) -multiple parameter sets -lumped P&T generator	wflow_hbv -daily or subhourly -Makkink PET derived from Landsaf (or need for recalibration)? -multiple parameter sets	wflow_sbm -daily or subhourly -landuse scenarios -multiple parameter sets?

Research question

- Can we develop a methodology (for real-time application) to derive gridded hourly forcing for the Rhine catchment statistical similar to calibration data set (best estimate)?
- What is the skill of the current EPS against the observed gridded forcing datasets?
- Can we transfer parameters from a lumped to a distributed model version (testing findings Melsen et al. 2016)?
- Can we develop a model with improved fidelity of physical processes with no/less calibration

real-time gridded forcing datase

Rainfall: Osnabrugge et al., 2017 WRR

- Calculate daily or hourly anomaly
- Inverse distance interpolation

of rainfall anomaly

- Multiply with monthly background grid

Temperature:

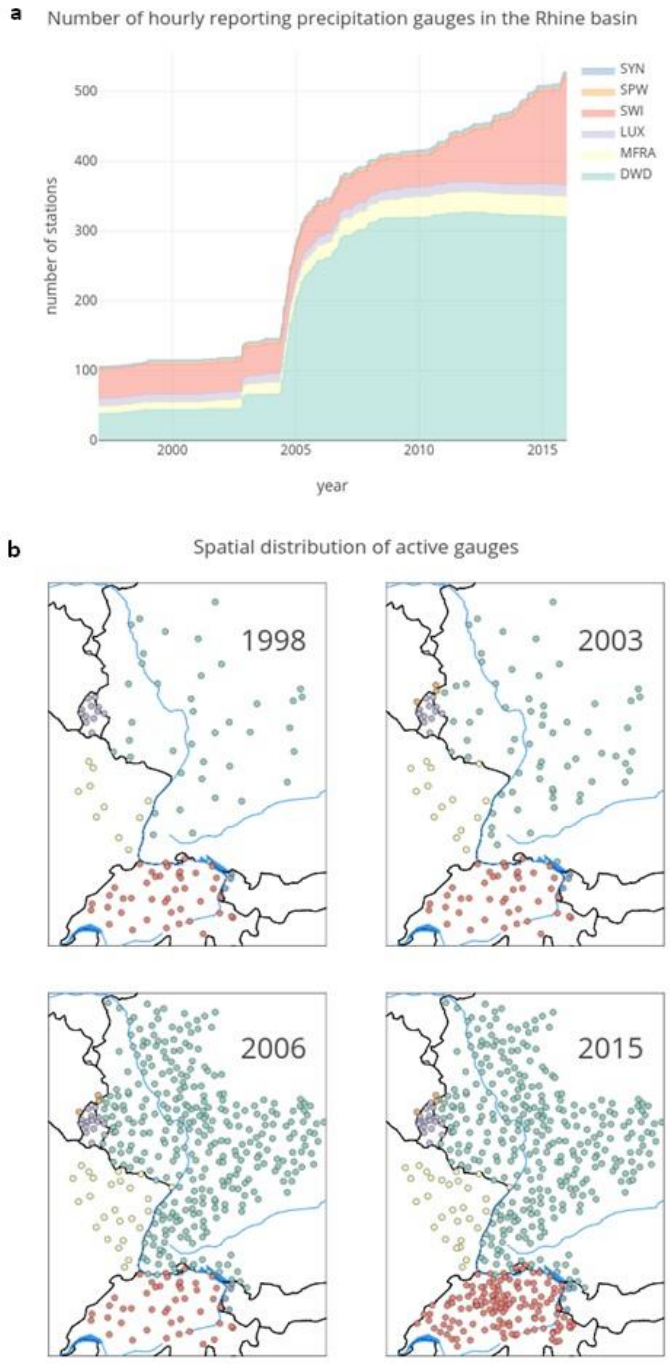
-use DEM/lapse rate to bring station values to same height

- interpolate IDW, use lapse rate+DEM to bring to height DEM

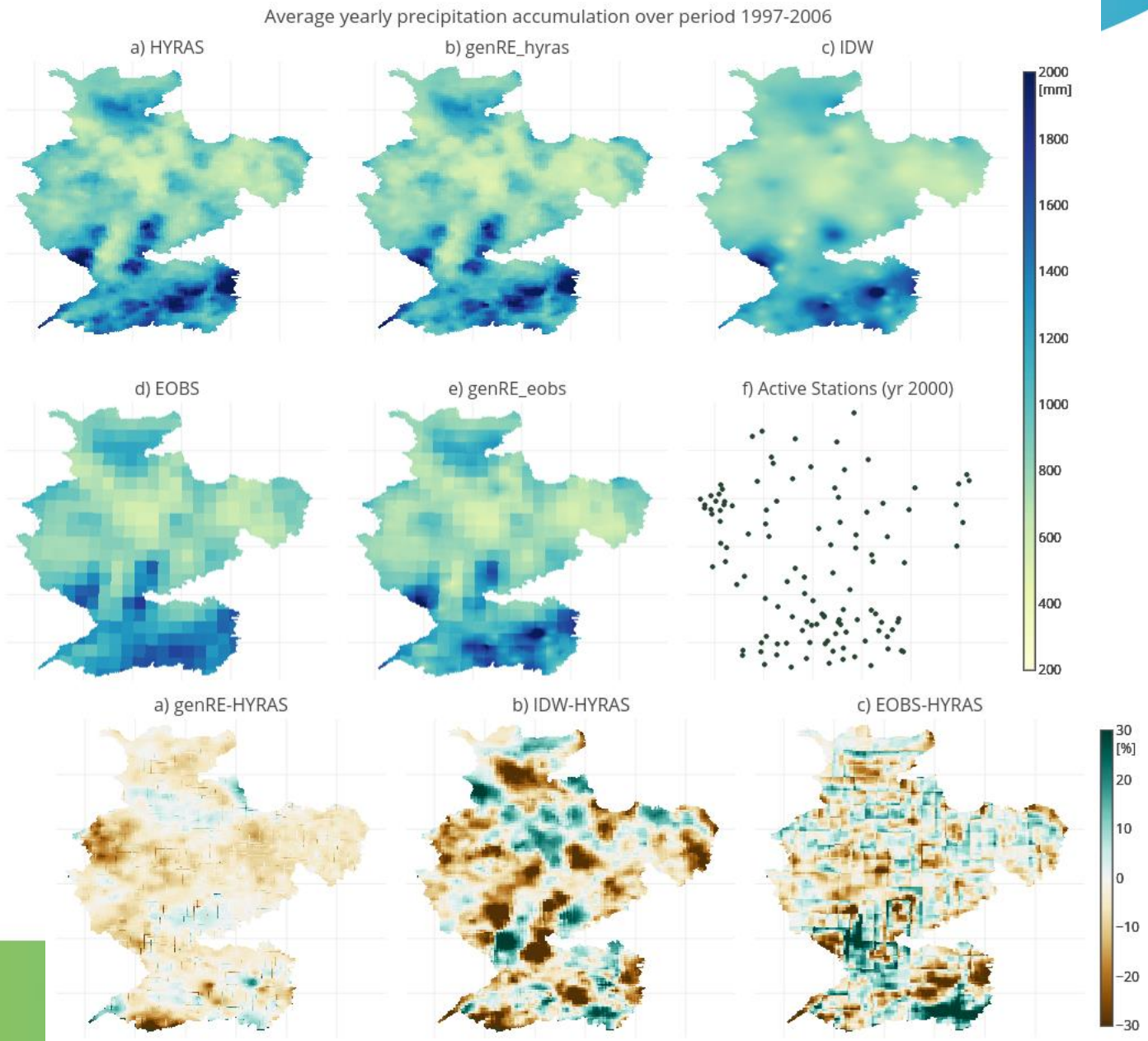
Radiation/Eref:

-downscaled from CMSAF+LSA SAF + gaps filled with ERA5

van Osnabrugge et al., 2018 (to be submitted)

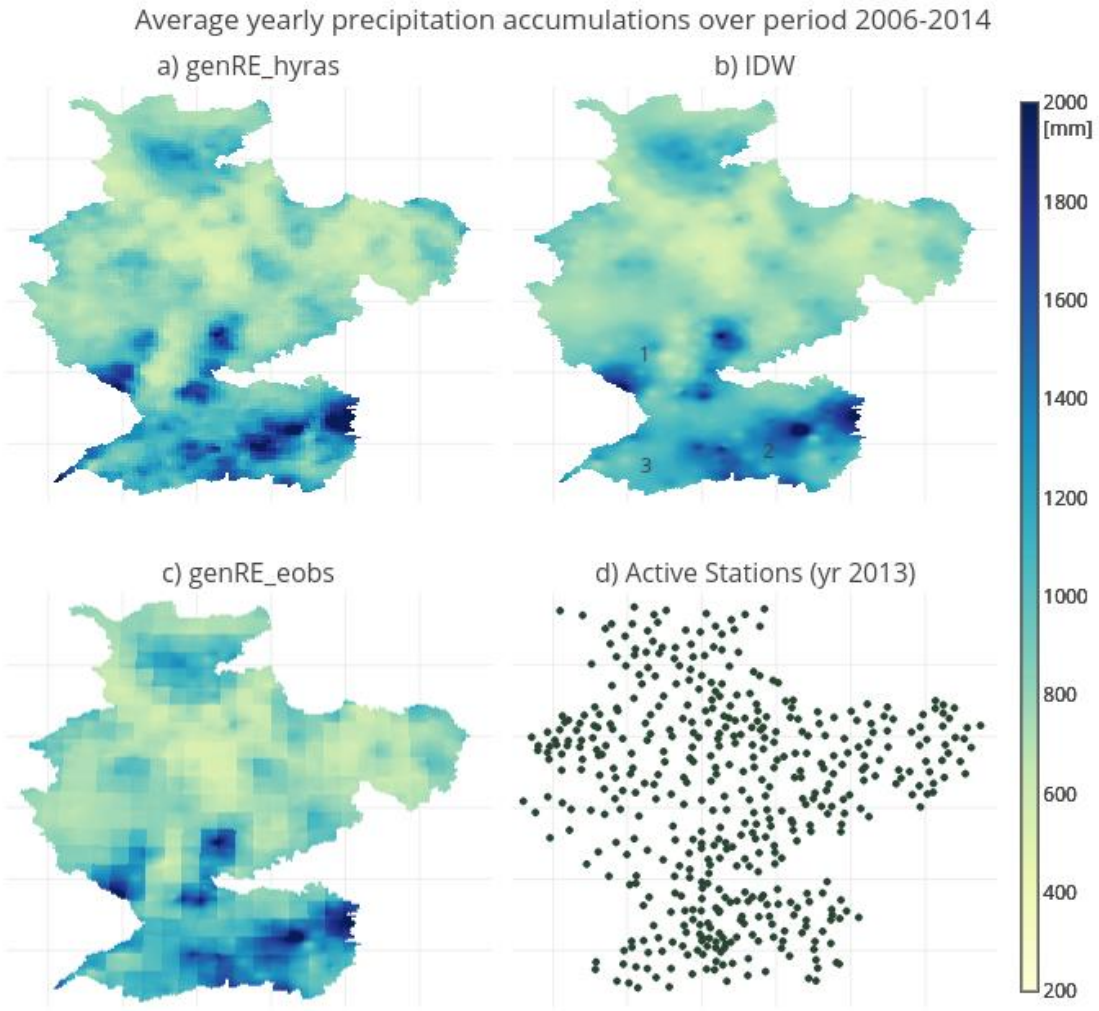


Gridded precipitation

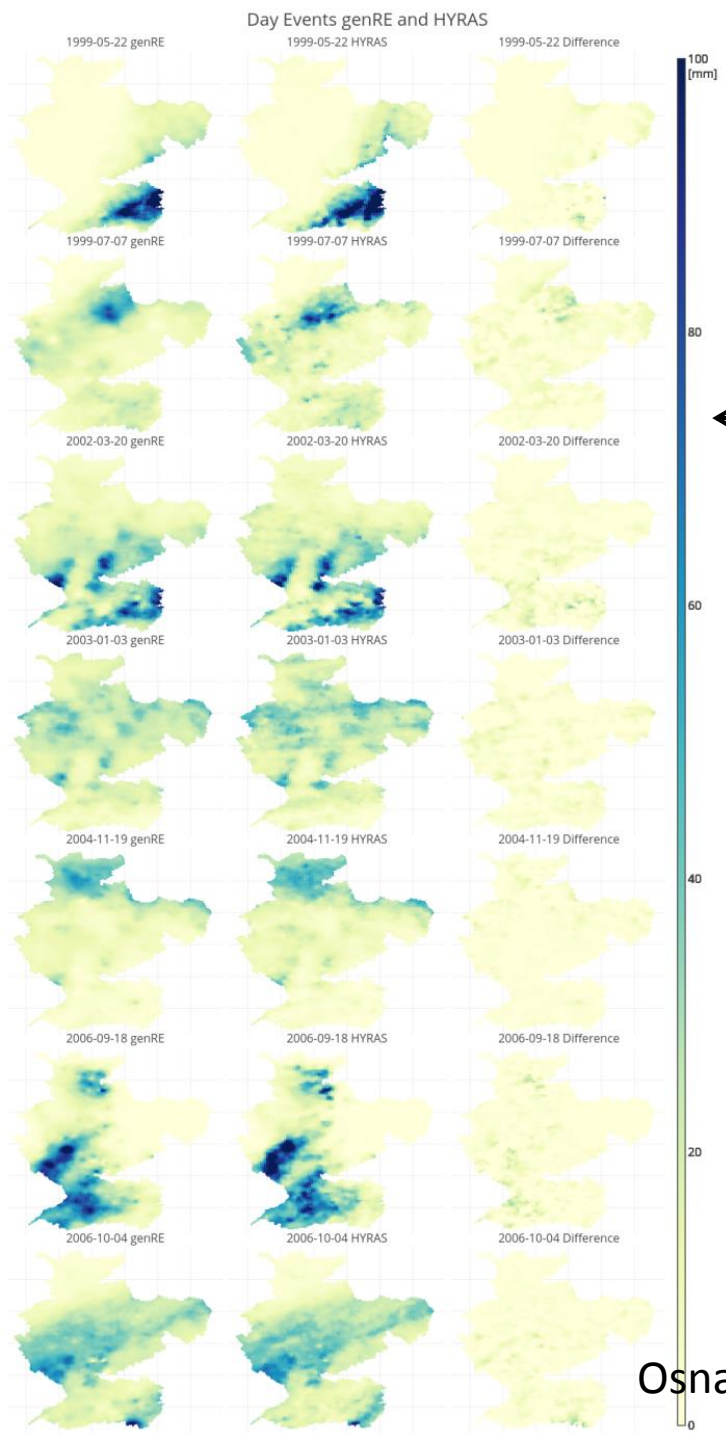


Osnabrugge et al., 2017 WRR

Gridded precipitation

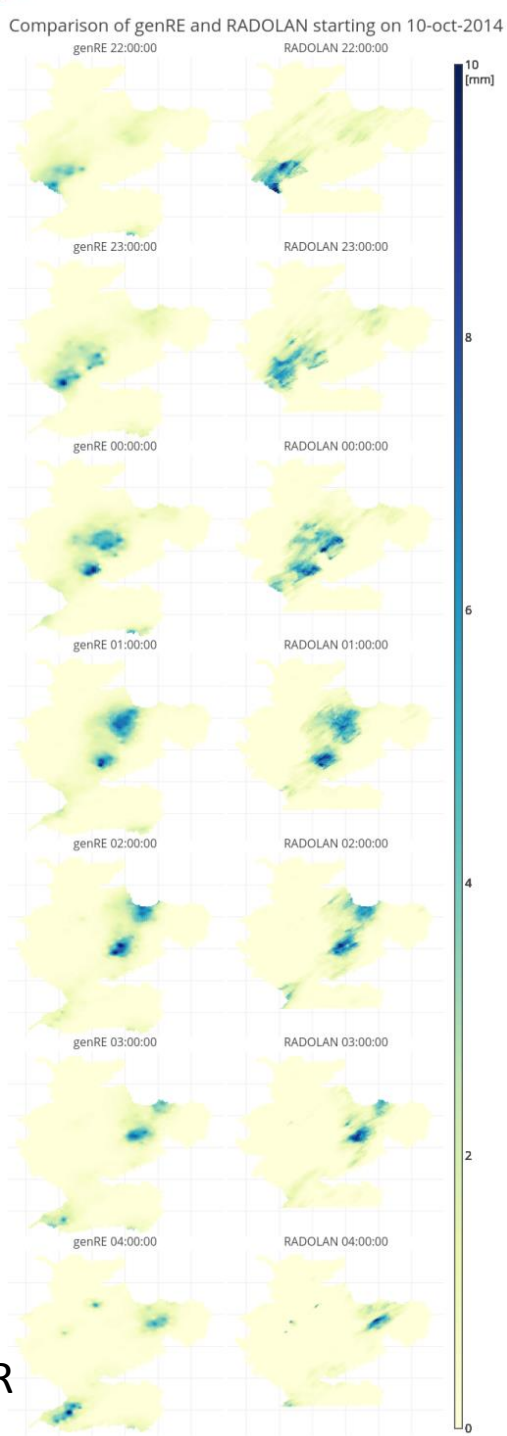


Osnabrugge et al., 2017 WRR



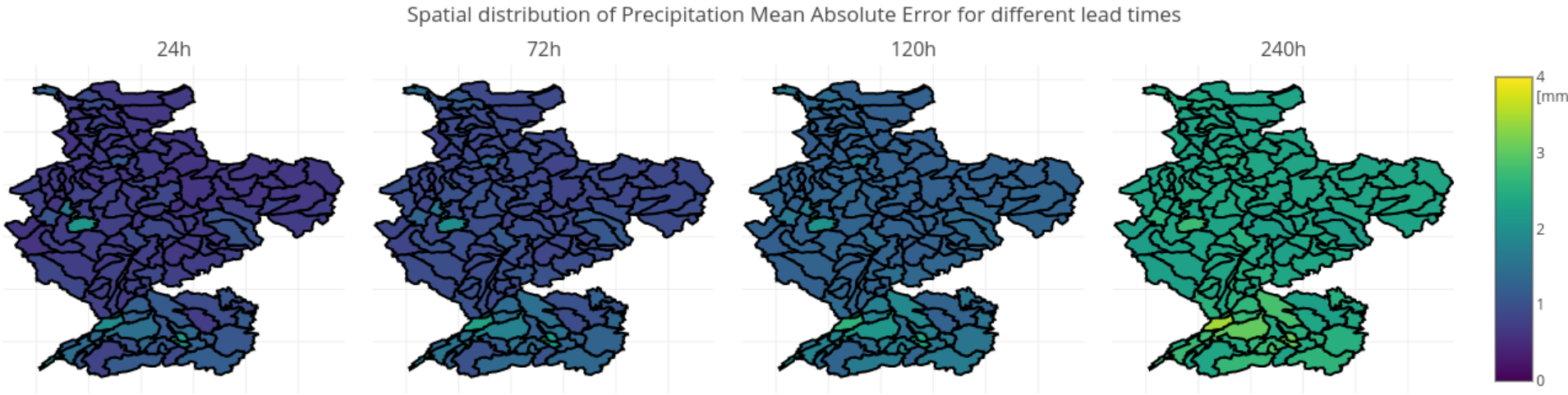
daily

hourly
(one event)



Osnabrugge et al., 2017 WRR

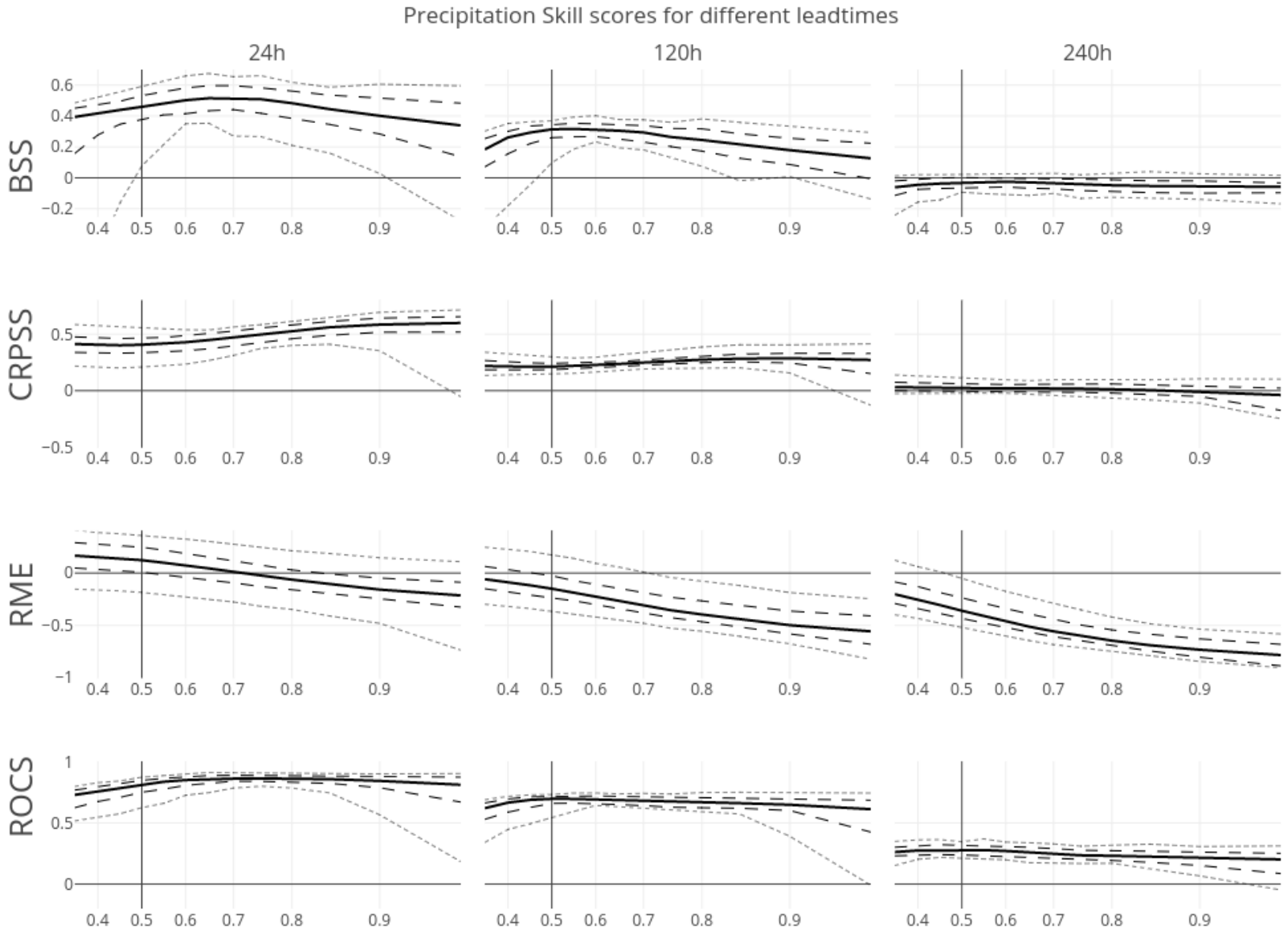
Precipitation verification reforecast dataset (1997-2016)



van Osnabrugge et al., 2018 (to be submitted)

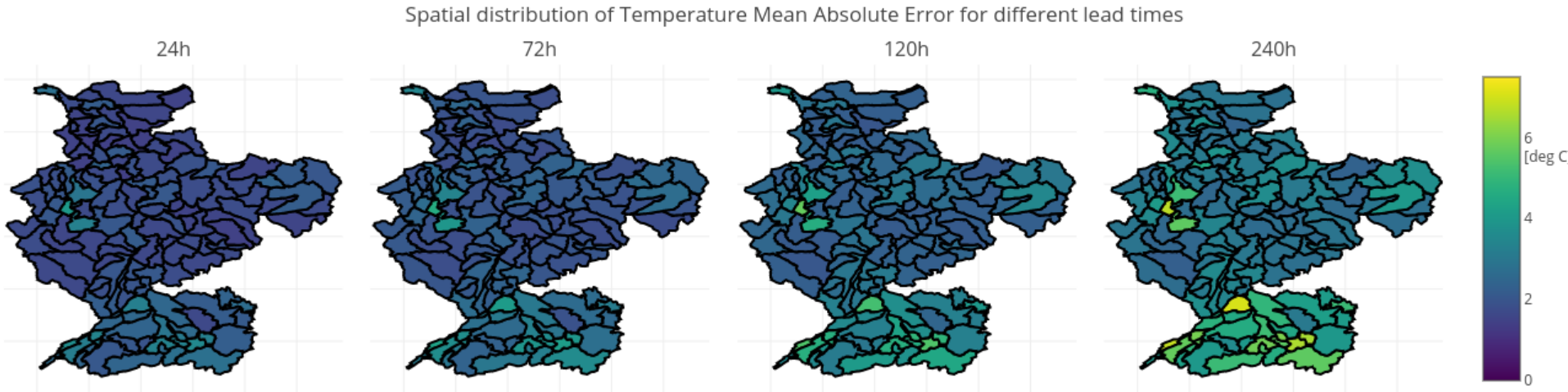
van Osnabrugge et al., 2018 (to be submitted)

Skill Precipitation ECMWF-EPS over Rhine basin

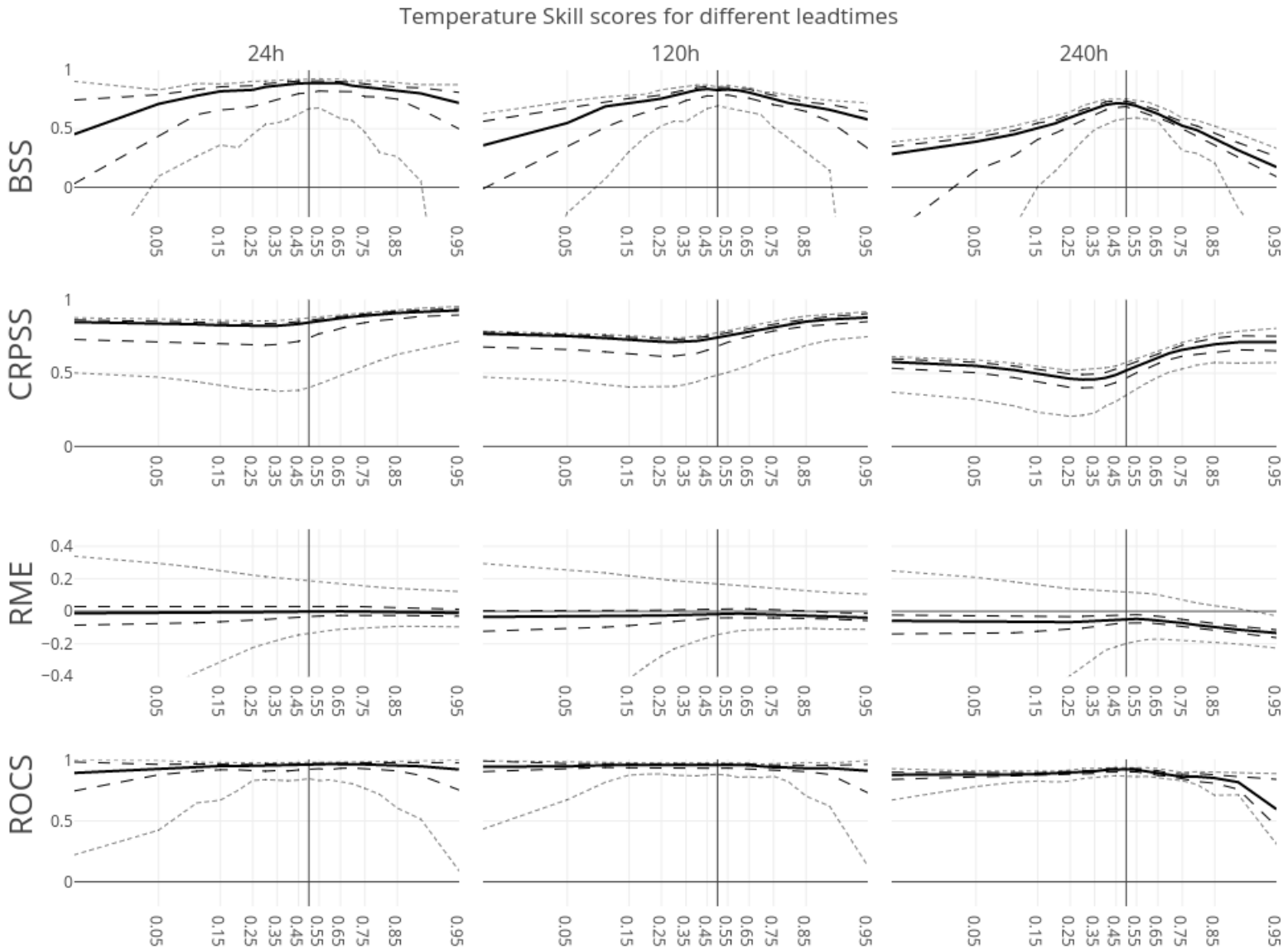


van Osnabrugge et al., 2018 (to be submitted)

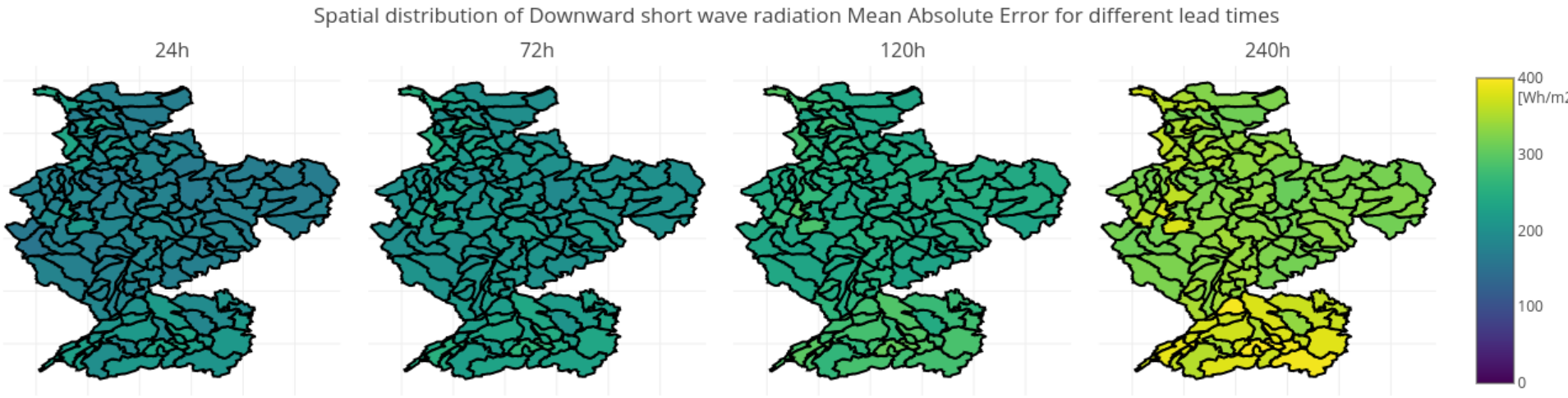
2m Temperature verification reforecast dataset (1997-2016)

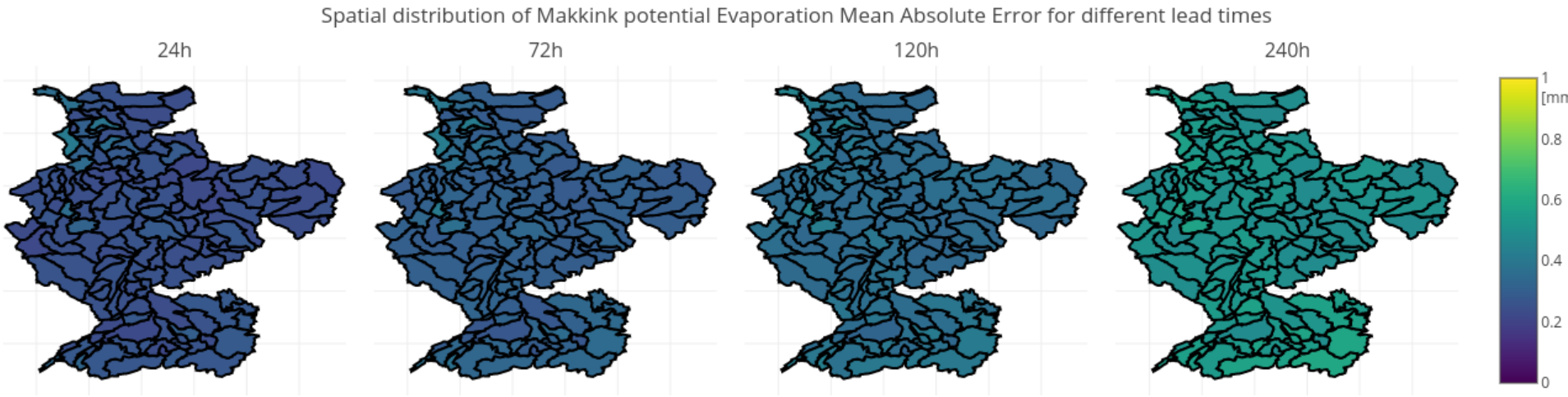


Skill Temperature ECMWF-EPS over Rhine basin

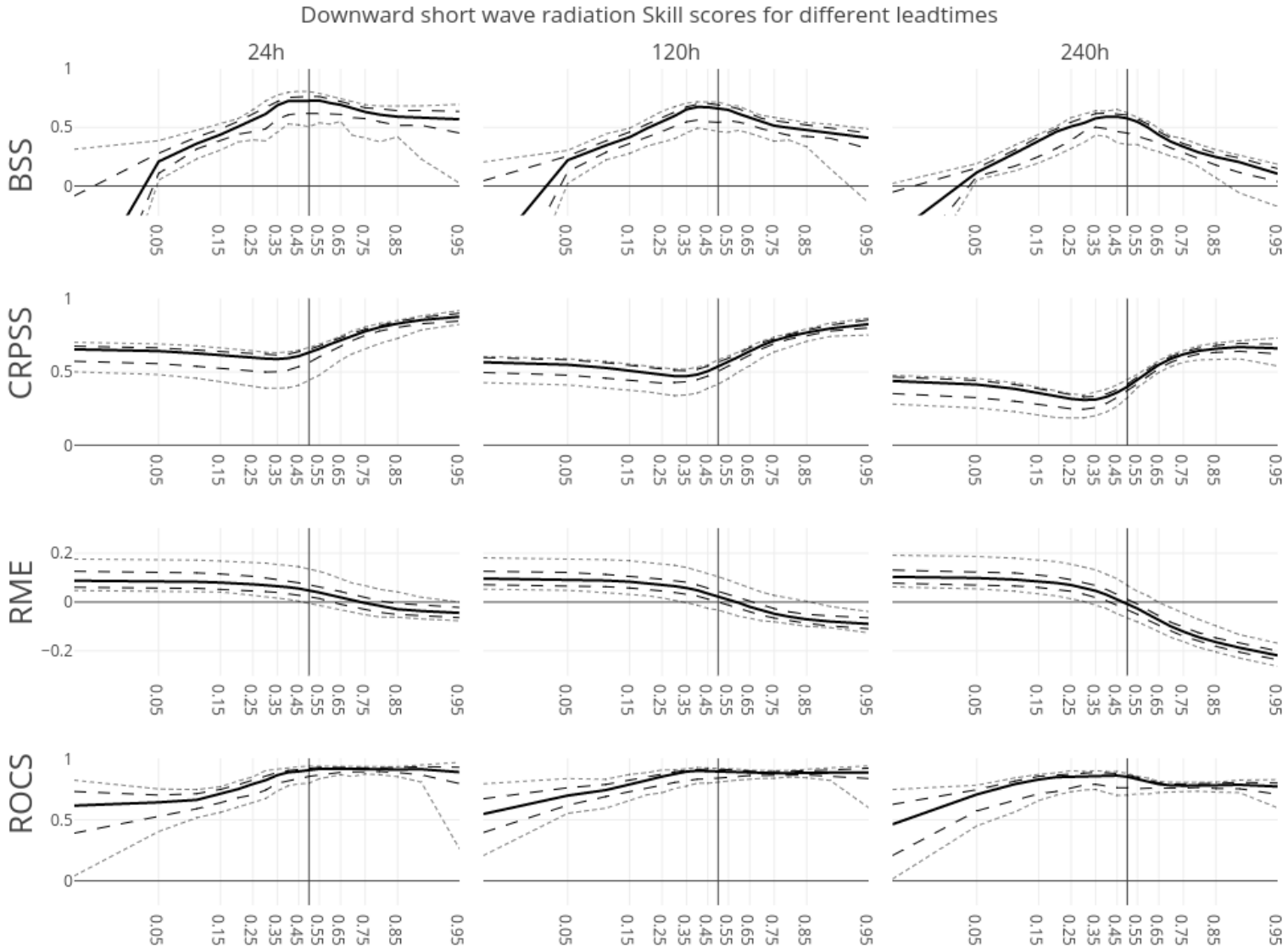


Global (shortwave downward) radiation and Eref verification reforecast dataset (1997-2016)

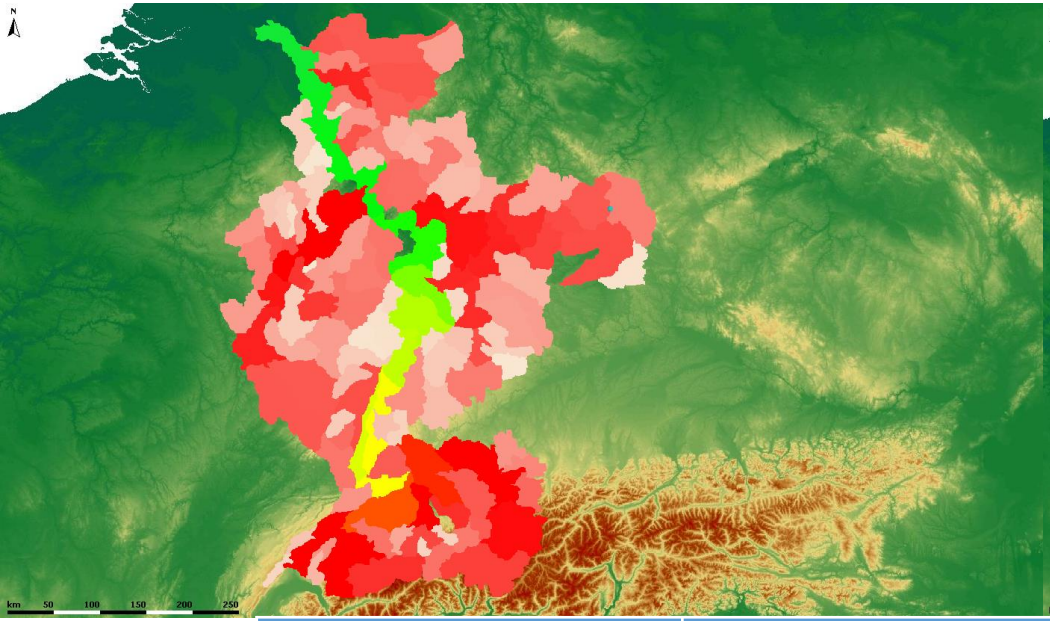


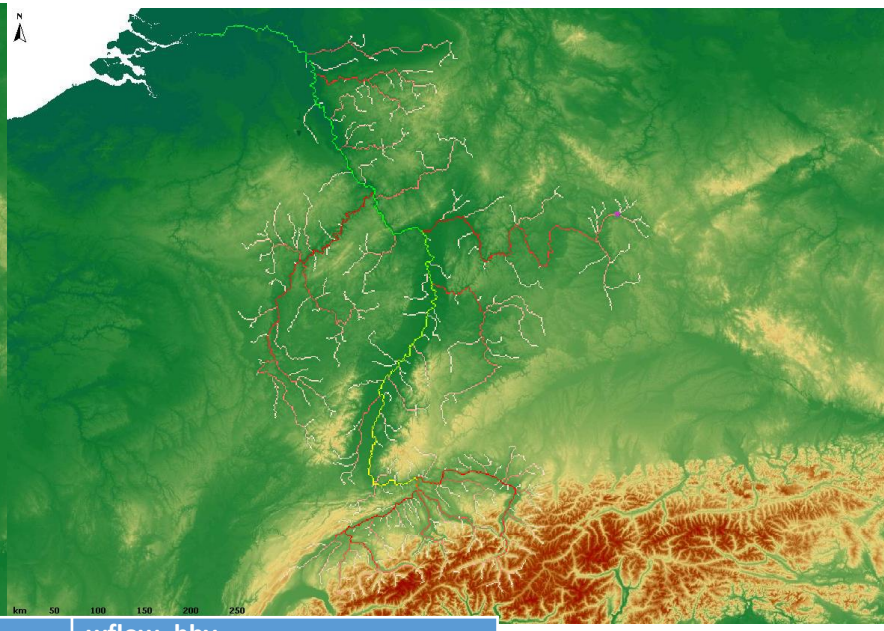


Skill global radiation ECMWF-EPS over Rhine



Transfer parameters from lumped to gridded model

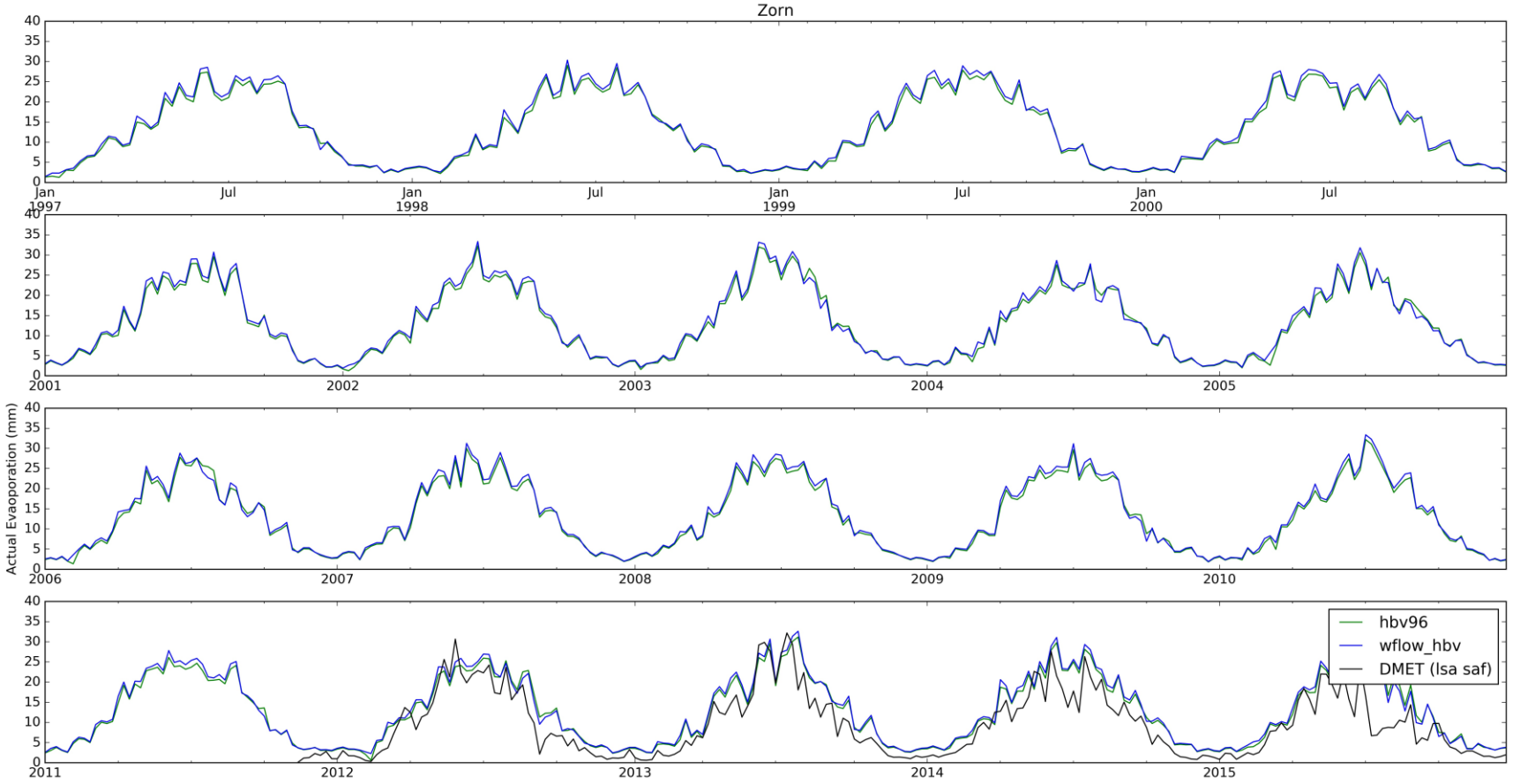




	HBV96	wflow_hbv
Upper/Lower zone	Polygon averaged	Varying per pixel
Routing	Muskingum (calibrated)	Kinematic wave (uncalibrated)
Vertical discretisation	Heightzones (area)	Varying per pixel
Vegetation	Forest/grass (heightzones , area)	Forest/grass (Varying per pixel)
Temperature	area averaged + lapse rate	downscaled via DEM +lapse rate
Coding/Numerical solution	Closed - Recstep used for upper zone	Open -lakes -upper zone
Glaciers	Glaciers included	No Glaciers (yet)

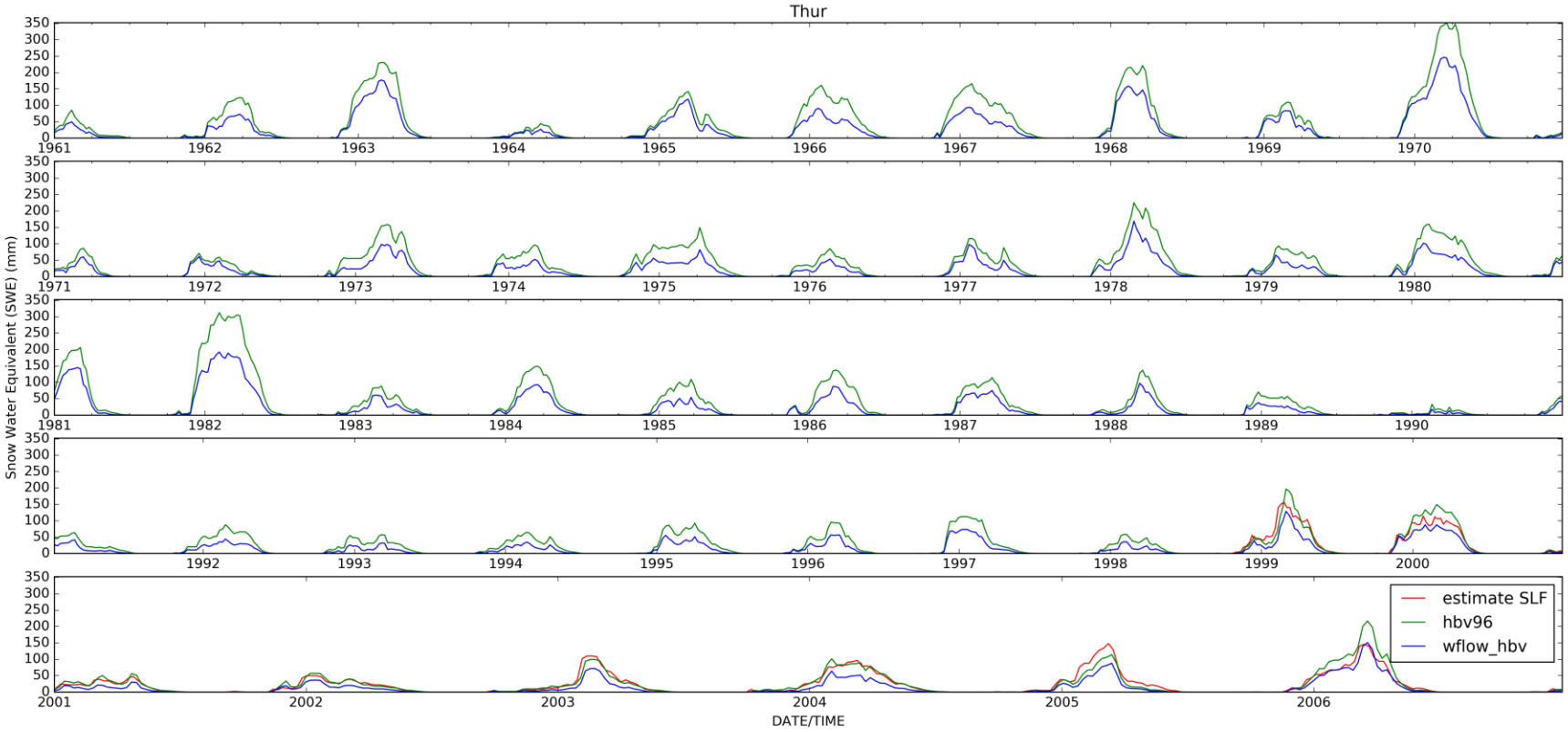
Actual Evaporation

wflow_hbv vs HBV96



Snow Water Equivalent (SWE)

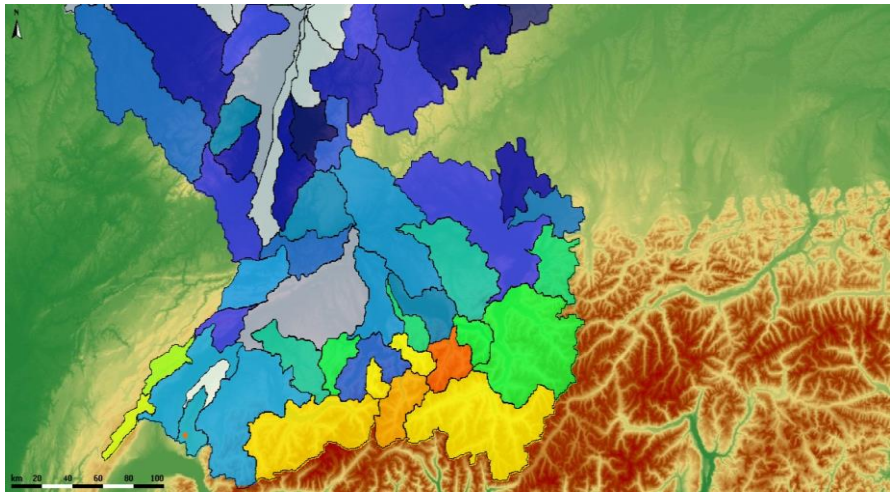
wflow_hbv vs HBV96

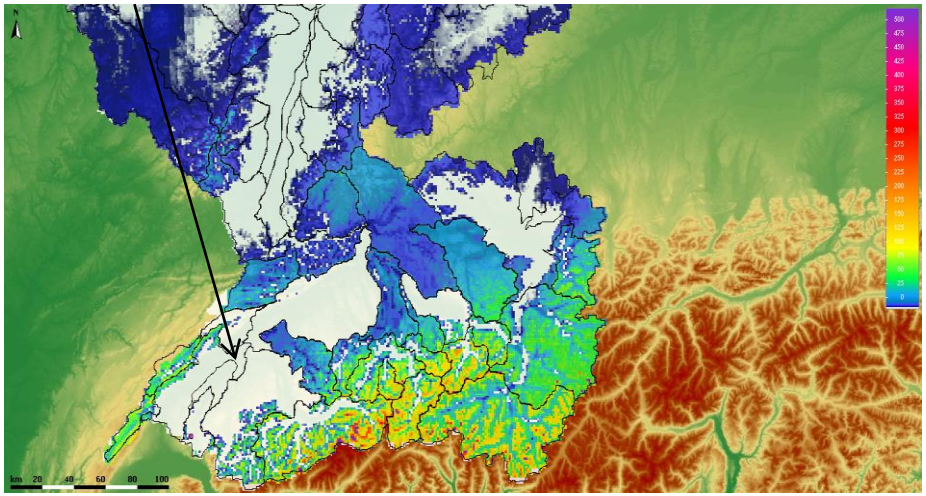


Snow Water Equivalent (SWE)

wflow_hbv vs HBV96

Unrealistic pattern (Emme vs Aare 1 and 2)



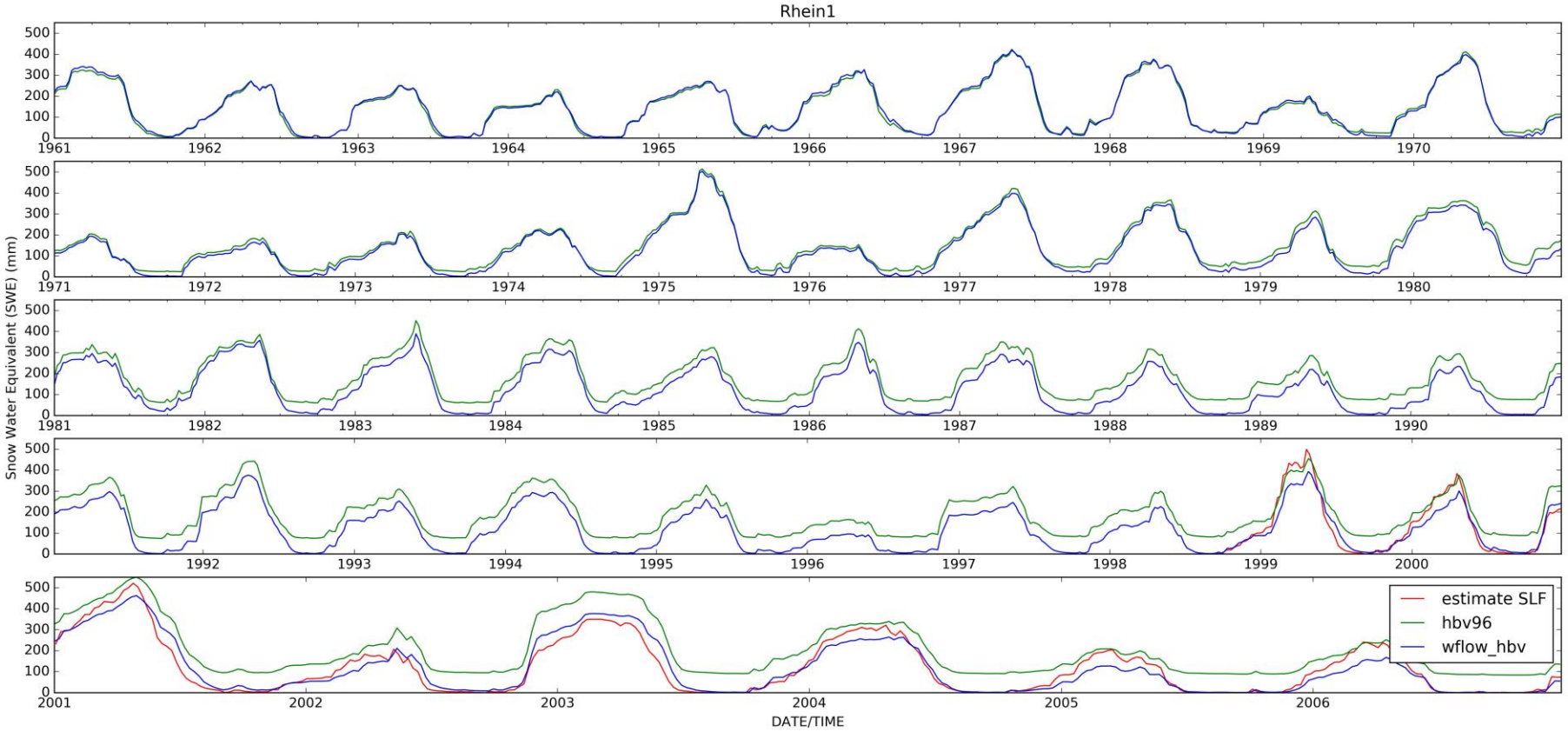


SWE in wflow_hbv in higher Alps much lower than in HBV96
especially in basins with negative TT values (strange anyway)
also resulting in unrealistic patterns (see above)

Solution: negative TT value set to same value as for Emme subbasins
Enabled avalanches/mass transport via DEM downwards

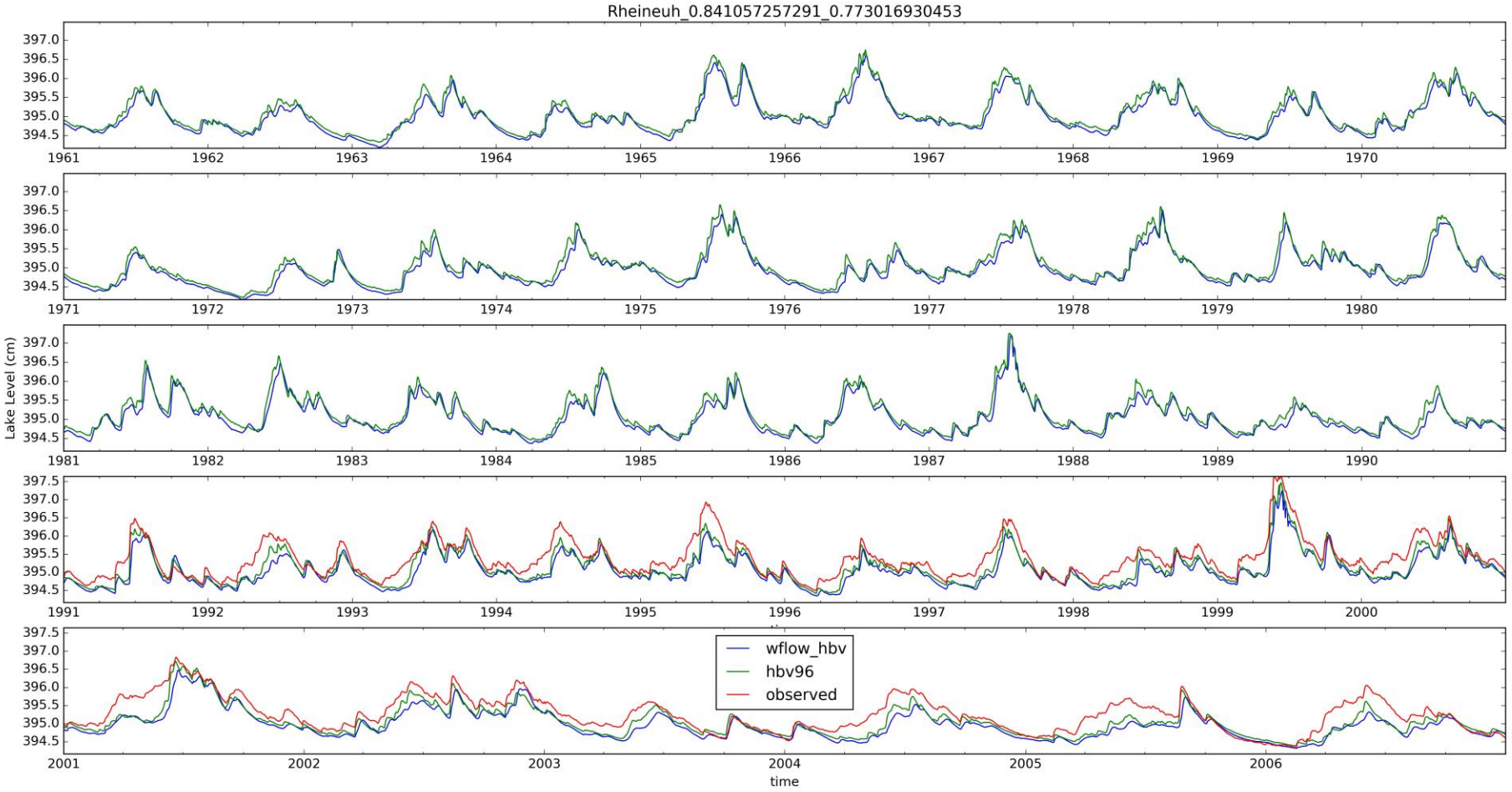
Snow Water Equivalent (SWE)

wflow_hbv vs HBV96



Lake Level

wflow_hbv vs HBV96



Lake Level

wflow_hbv vs HBV96

Table 2. KGE lake levels (period 1/1/1990-31/12/2006)

Lake	HBV96	wflow_hbv
Bodensee (upper)	**0.84**	**0.77**
Bodensee (lower)	**0.86**	**0.80**
Lac Neuchatel	**0.84**	**0.63**
Bielersee	**0.83**	**0.82**
Murtensee	**0.35**	**0.38**
Zurichsee	**0.94**	**0.84**
Vierwaldstattersee	**0.22**	**0.35**

Discharge

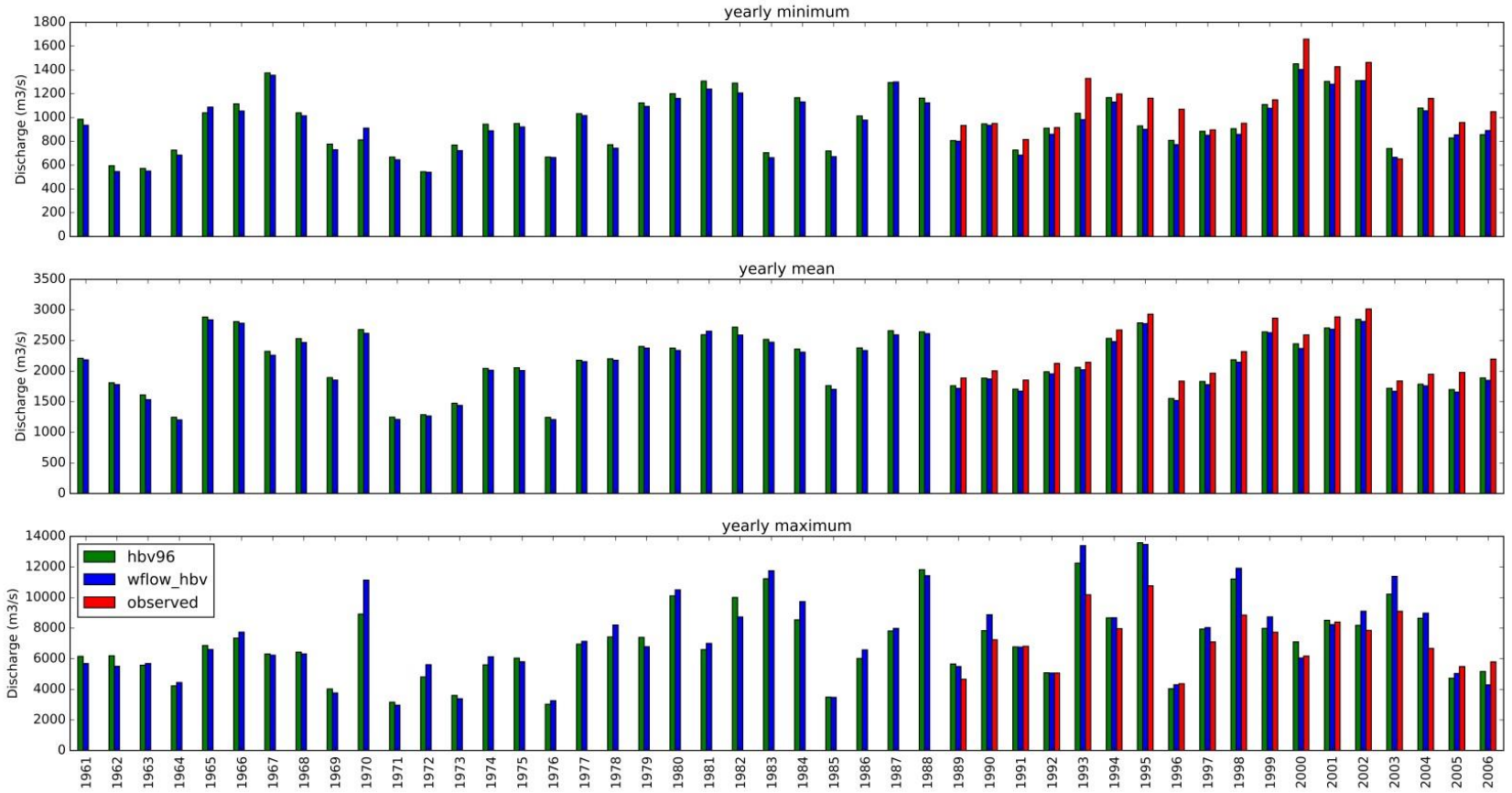
wflow_hbv vs HBV96

Table 3. KGE lake levels (period 1/1/1990-31/12/2006)

Location	HBV96	wflow_hbv
Aare 1	0.71	0.44
Thur	0.84	0.81
Maxau	0.79	0.70
Rockenau	-	-
Raunheim	0.87	0.82
Cochem	0.91	0.89
Kalkhofen	0.66	0.67
Menden	0.91	0.93
Hattingen	0.80	0.80
Schermbeck	0.78	0.74
Altenahr	0.89	0.79
Opladen	0.70	0.48
Boos (Nahe)	0.80	0.84
Emmerich	0.91	0.87

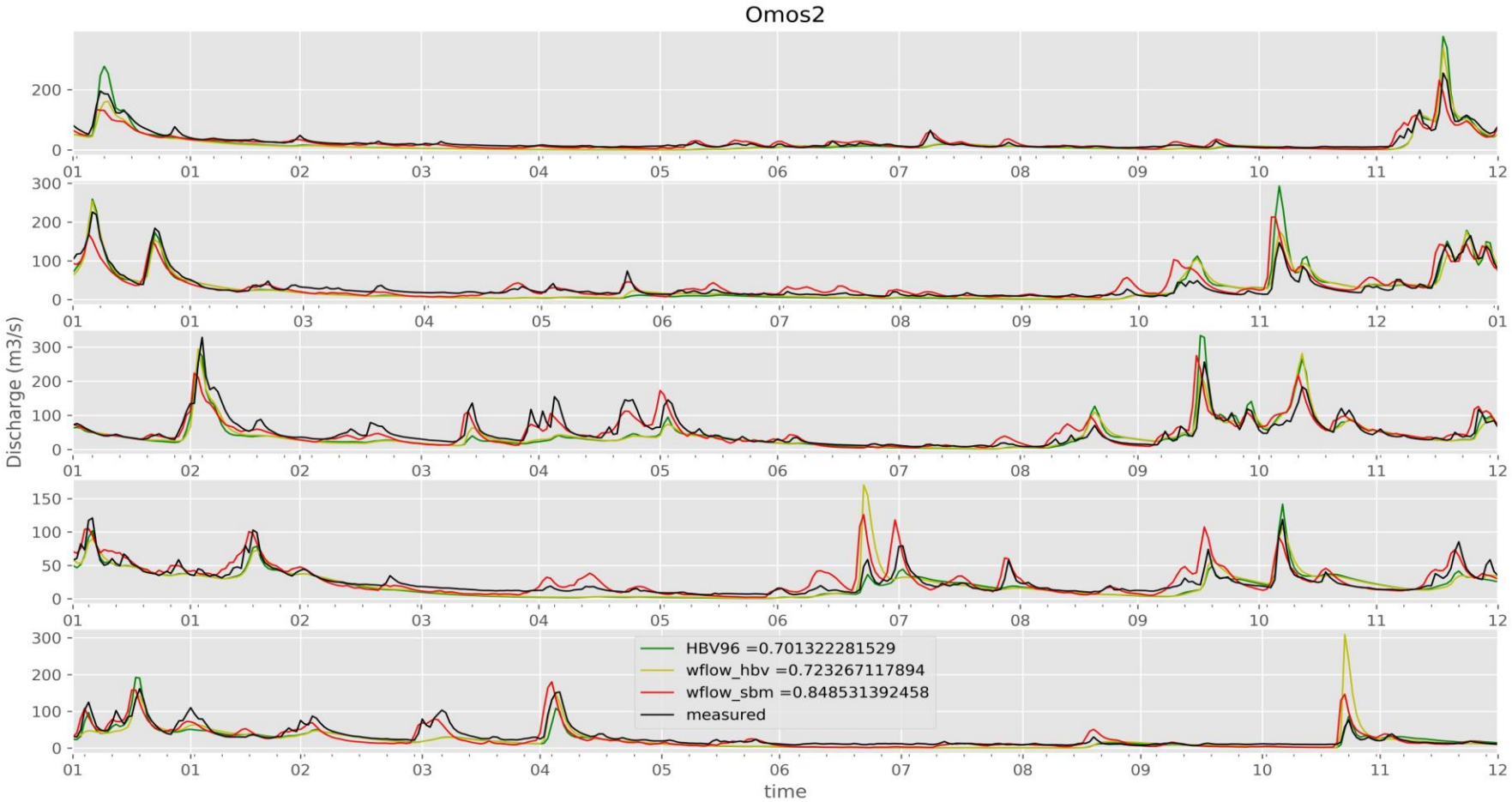
Discharge - Emmerich

wflow_hbv vs HBV96



Conclusions

- Hourly gridded forcing dataset Rhine river developed and is/will be made available
- Verification of P,T, Rg, Makkink Eref shows that main limit is skill of P in Rhine (no skill after ~5-10 days)
- Conversion of HBV96 to wflow_hbv shows
  - behaviour largely the same except for snow dominated areas;
  - Actual evaporation HBV96/wflow_hbv is overestimated when comparing with Landsaf;
  - TT parameter gets much more sensitive (and needs tuning especially over Alps);
  - Several errors/issues detected in calibration/config. lumped model
- Investigate DA on improving forecast skill will start now (=> also HEPEX DA testbed)
- First results into use of combining gridded forcing data, MODIS based LAI and wflow_sbm (topog) model based on PTF (so far no calibration) are promising



Work by Ruben Imhoff (MSc student WUR)

imprex

Learn from today to anticipate tomorrow

Acknowledgement

IMPREX is a research project supported by
the European Commission under the Horizon 2020
Framework Programme

Grant Agreement No 641811

Duration: 01/10/15 - 01/10/19

Contact details

Deltares

Albrecht Weerts
Albrecht.weerts@deltares.nl