CHASE-PL

norway grants

POLISH-NORWEGIAN RESEARCH PROGRAMME

Projected climate change and its effects on mean and extreme runoff in Poland

Mikołaj Piniewski[1,2], Mateusz Szcześniak[1], Abdelkader Mezghani[3], Zbigniew W. Kundzewicz[2,4]

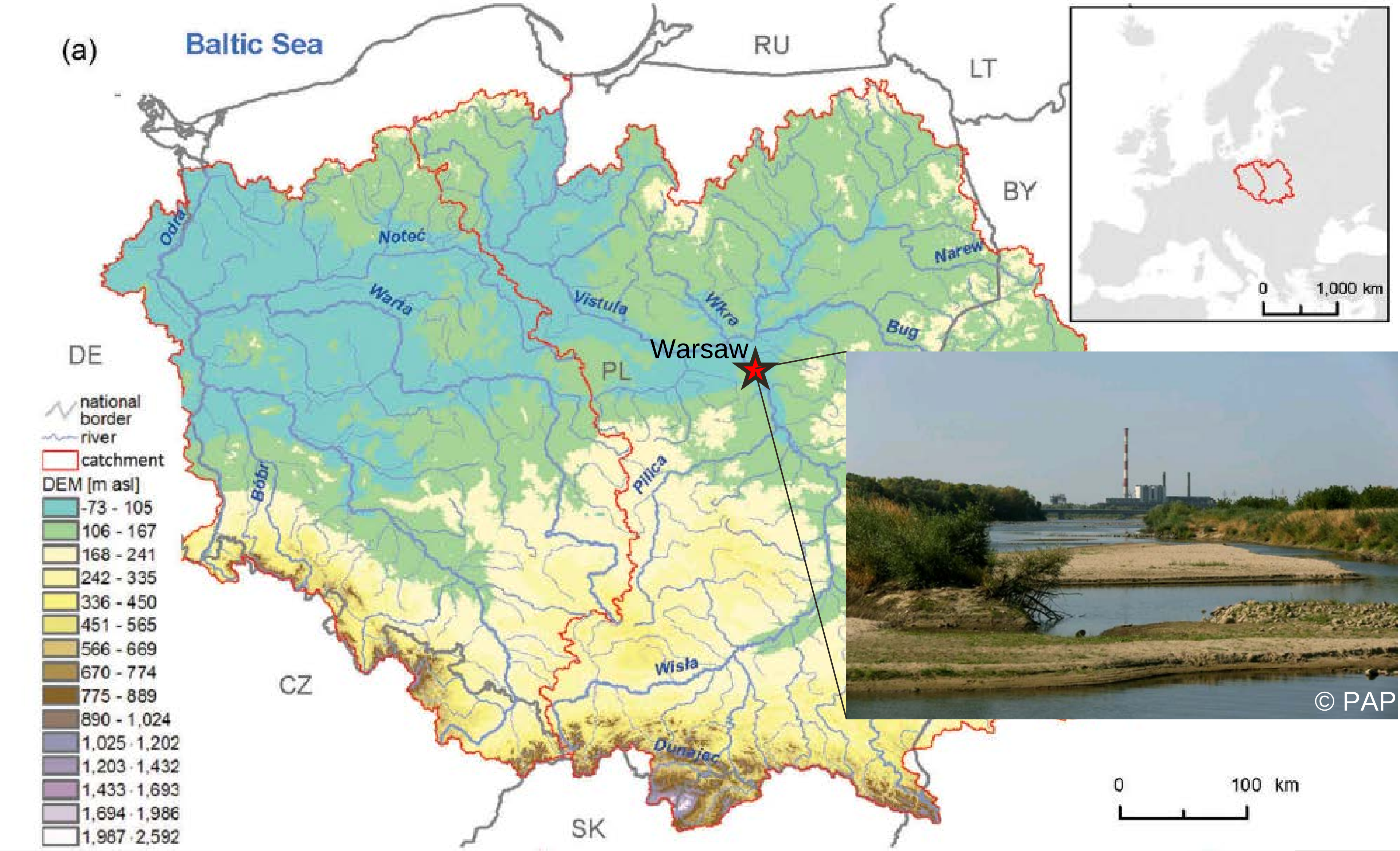
1. Warsaw University of Life Sciences
2. Potsdam Institute for Climate Impact Research
3. MET Norway
3. Institute for Agricultural and Forest Environment, Polish Academy of Sciences

Background and objective

- Climate change impacts in Poland understudied until recently
- Lack of process-based distributed hydrological models covering Poland until recently
- The objective was to fill these two research gaps and:
  - To assess impacts of climate change on hydrology of the Vistula and Odra basins
  - To build a multi-purpose, „high-resolution" hydrological model covering most of Poland, with freely available inputs and outputs

Study area (Vistula and Odra basins)

A = 313 000 km^2



Data sources for model inputs

Data type	Source	Resolution
DEM PL	ESRI TIN (CODGiK)	TIN interval 10-50 m Vertical 0.8-2 m
DEM non-PL	SRTM v4.1 (NASA)	Horizontal 90 m; Vertical 16 m
Rivers and lakes PL	MPHP2010 (IMGW-PIB)	1:50,000
Rivers and lakes non-PL	CCM2 (IES)	1:500,000
Reservoirs PL	KZGW	128 objects
Land cover EU	CLC2006 (EEA)	100 m
Land cover non-EU	MODIS Landcover	500 m
Land cover (urban, EU)	Imperviousness 2012 (CLMS)	20 m
Land cover (crops, PL)	2002 Census data (GUS)	345 districts
Soil map PL	IUNG-PIB	1:500,000
Soil map non-PL	HWSD v 1.2	1: 1,000,000
Channel cross-sections PL	ISOK (KZGW)	20611 cross-sections
Climate PL	IMGW-PIB	687 stations
Climate DE, CZ	DWD	44 stations
Climate SK, UA, BY	ECAD, NOAA, NCDC	32 stations
Streamflow PL	IMGW-PIB	76 stations
Streamflow non-PL	GRDC and UA yearbooks	4 stations

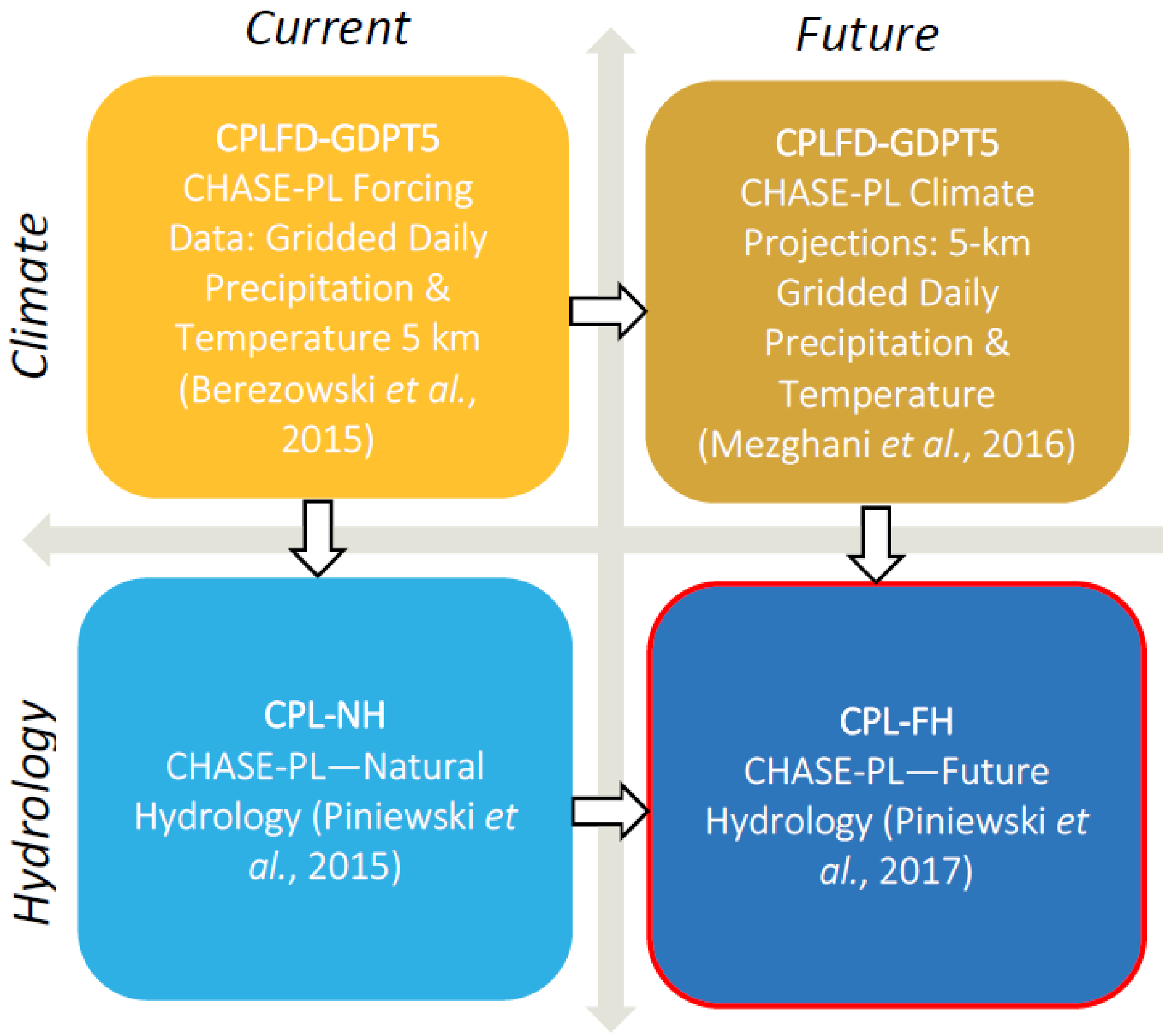
Note: Water management not considered in the model setup

- calibration of catchments with semi-natural streamflow
- capturing pure climate change effect
- fair spatial comparison of effects

CHASE-PL project: modelling workflow

Talk by I. Kardel
Thurs. session E1 =>

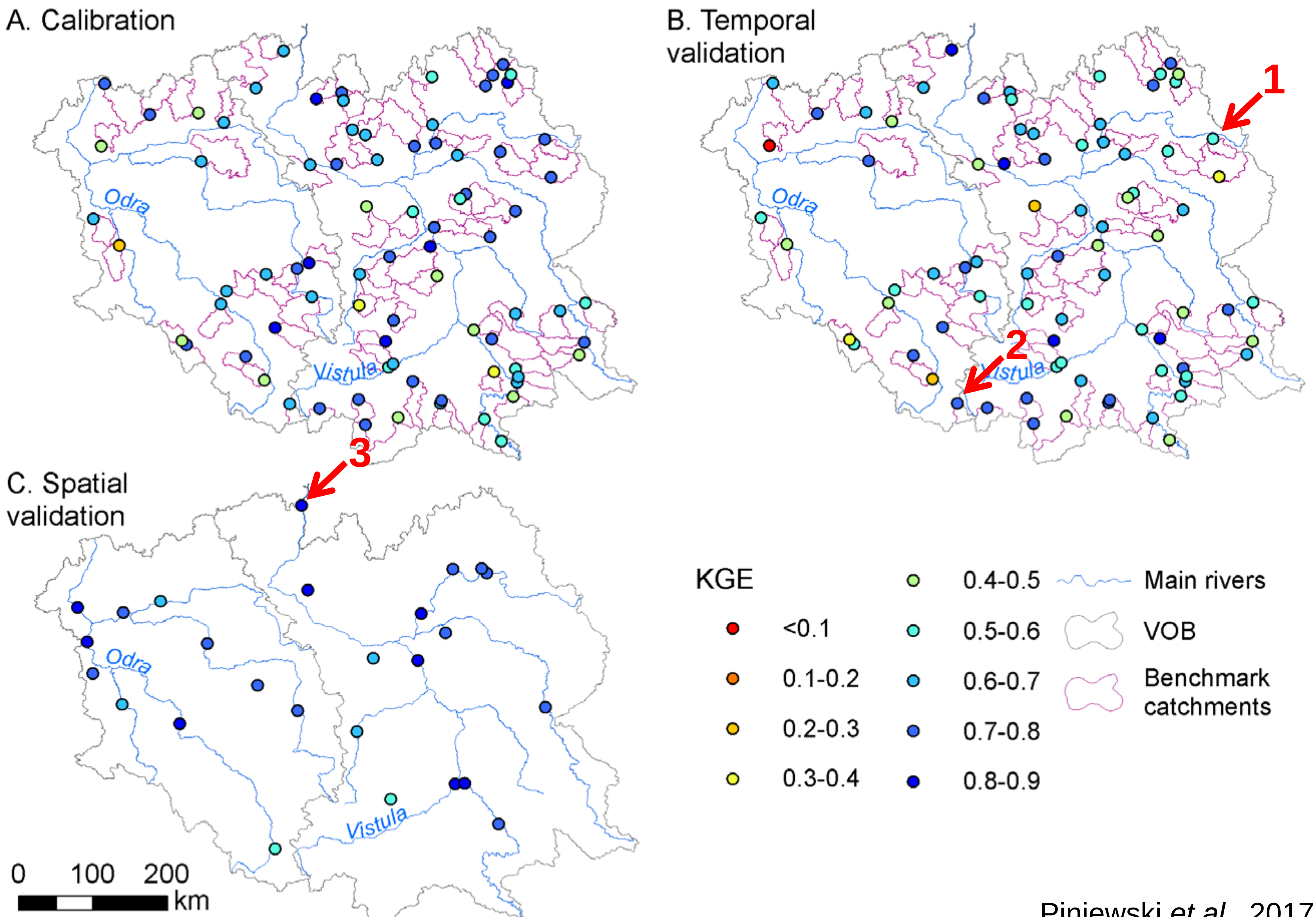
SWAT =>



Piniewski et al., 2017, *Data*

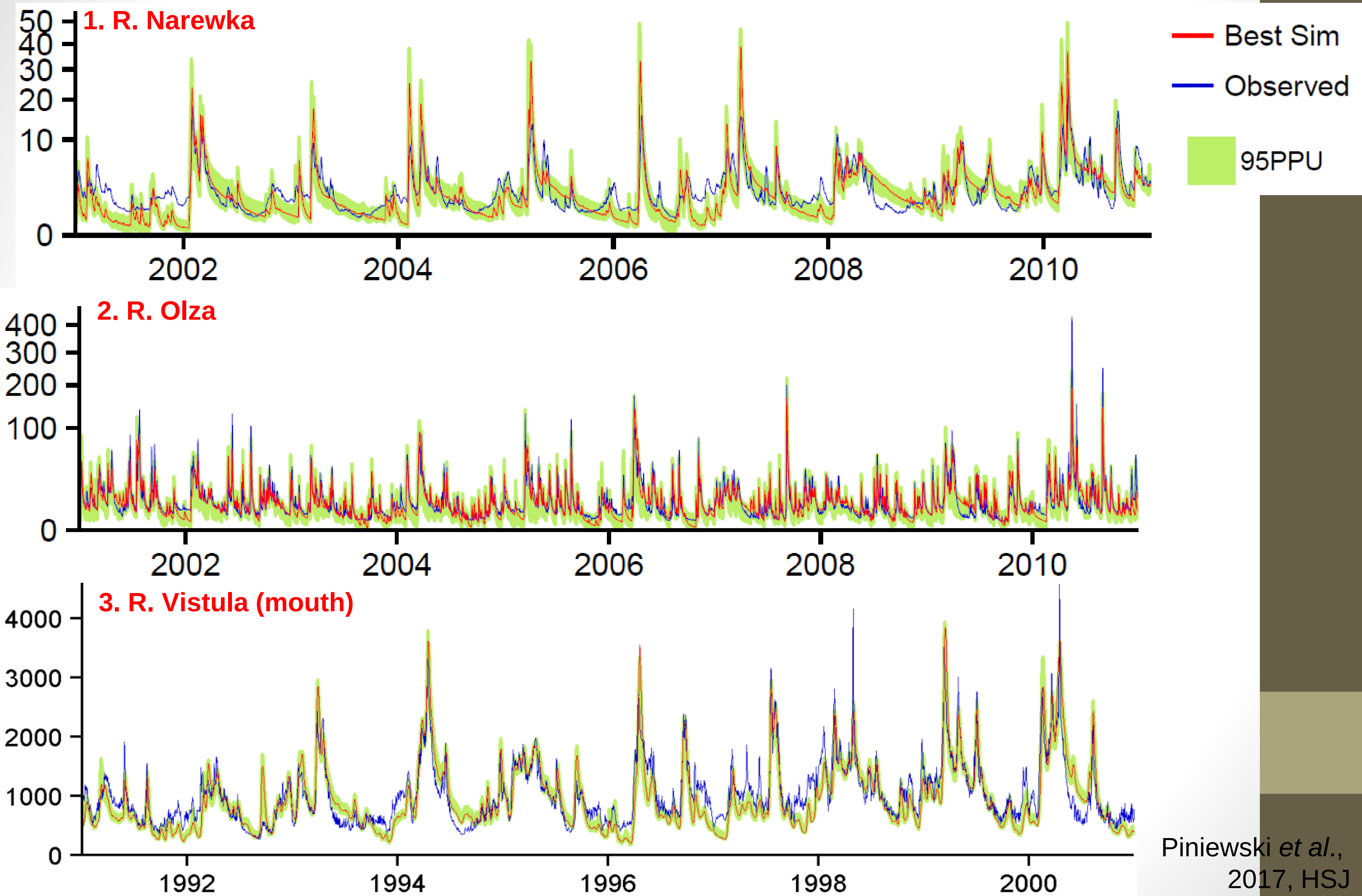
Calibration/validation (spatial)

KGE – Kling-Gupta Efficiency (model performance index after Gupta *et al*., 2009)



Piniewski *et al*., 2017, HSJ

Validation (hydrographs) – 3 examples



Piniewski *et al.*, 2017, HSJ

Climate change scenarios

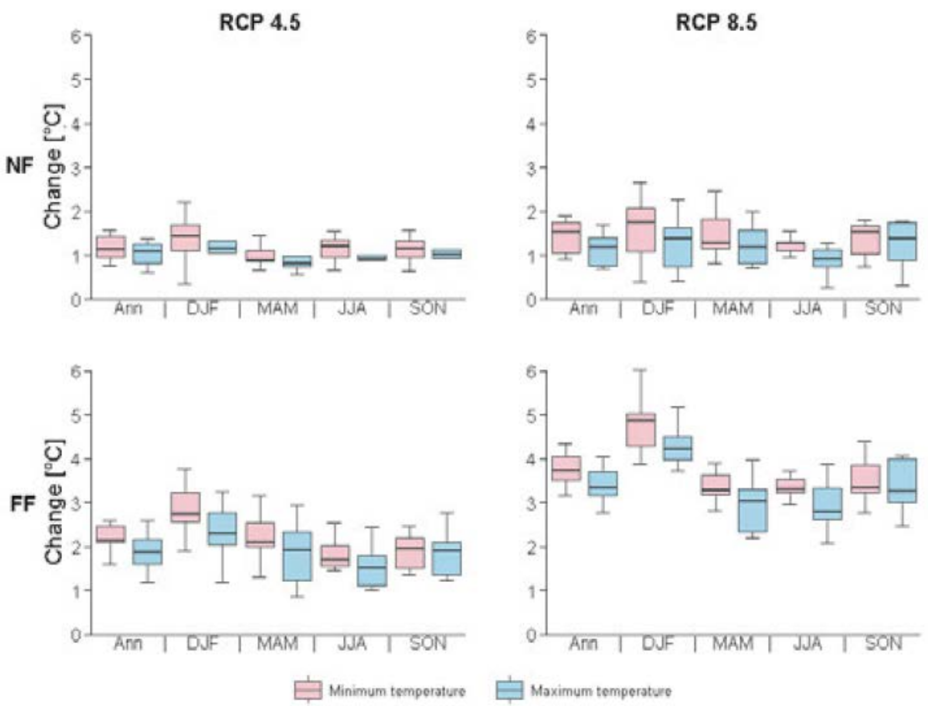
- Bias-corrected RCM climate projections
  - Quantile mapping method
  - 9 climate model simulations
  - 2 RCPs: 4.5 and 8.5
  - Reference period 1971-2000, 2 future horizons 2021-2050 (near future, **NF**), 2071-2100 (far future, **FF**)

N	Global Climate Model			Regional Climate Model	
	Institute	Model	Run	Institute	Model
1	CNRM-CERFACS	CNRM-CM5	r1i1p1	CLMcom	CCLM4-8-17
2	CNRM-CERFACS	CNRM-CM5	r1i1p1	SMHI	RCA4
3	ICHEC	EC-EARTH	r12i1p1	CLMcom	CCLM4-8-17
4	ICHEC	EC-EARTH	r12i1p1	SMHI	RCA4
5	ICHEC	EC-EARTH	r1i1p1	KNMI	RACMO22E
6	ICHEC	EC-EARTH	r3i1p1	DMI	HIRHAM5
7	IPSL	IPSL-CM5A-MR	r1i1p1	SMHI	RCA4
8	MPI-M	MPI-ESM-LR	r1i1p1	CLMcom	CCLM4-8-17
9	MPI-M	MPI-ESM-LR	r1i1p1	SMHI	RCA4

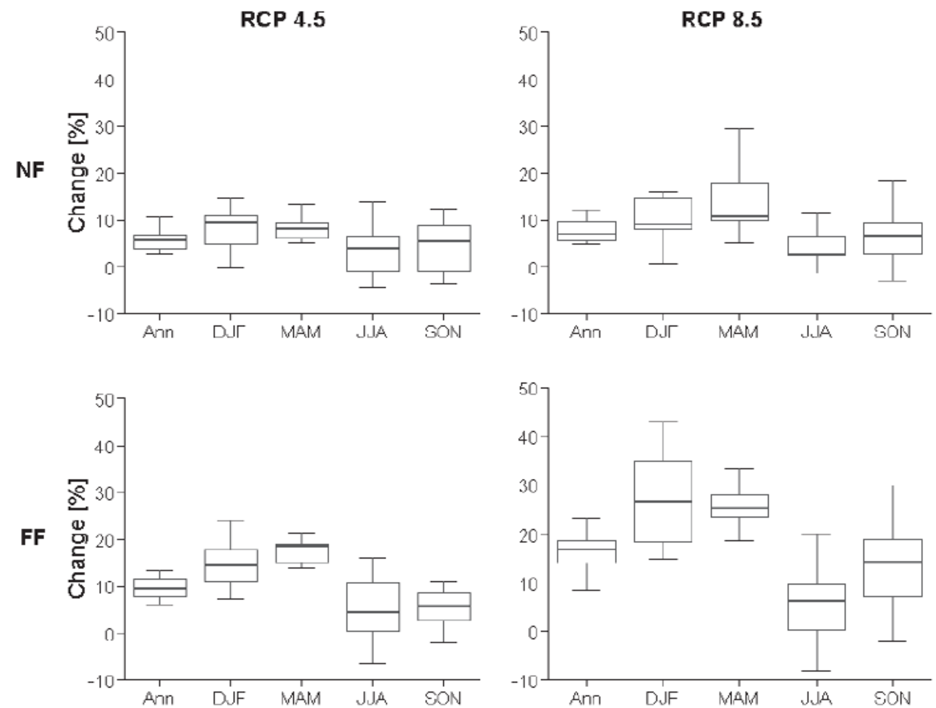
Mezghani *et al.*, 2017, ESSD

Projected changes in temperature and precipitation – ensemble range

T_{min}, T_{max}

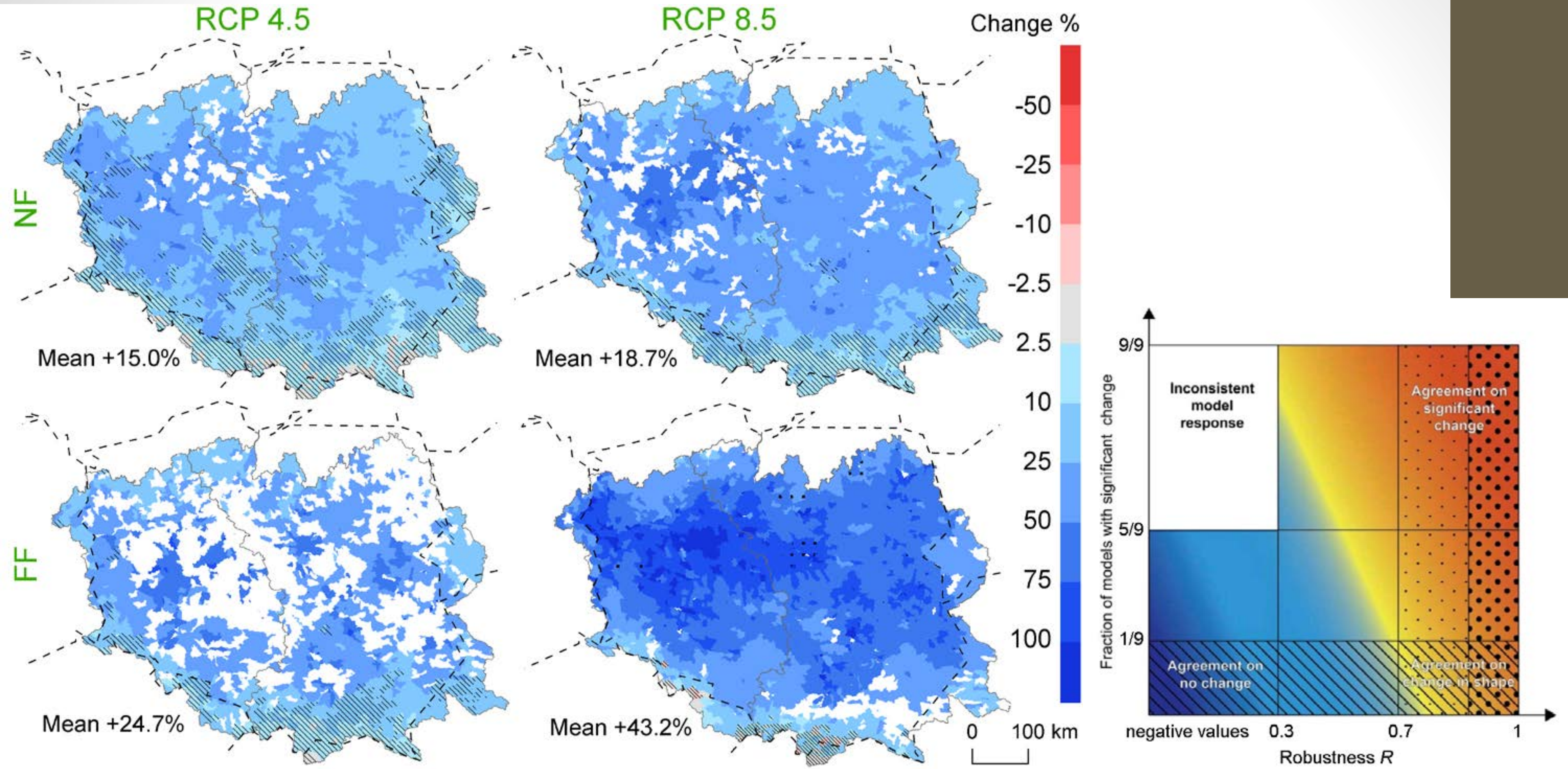


Precipitation



Piniewski *et al.*, 2017, Met. Z.

Projected changes in mean annual runoff (ensemble mean)

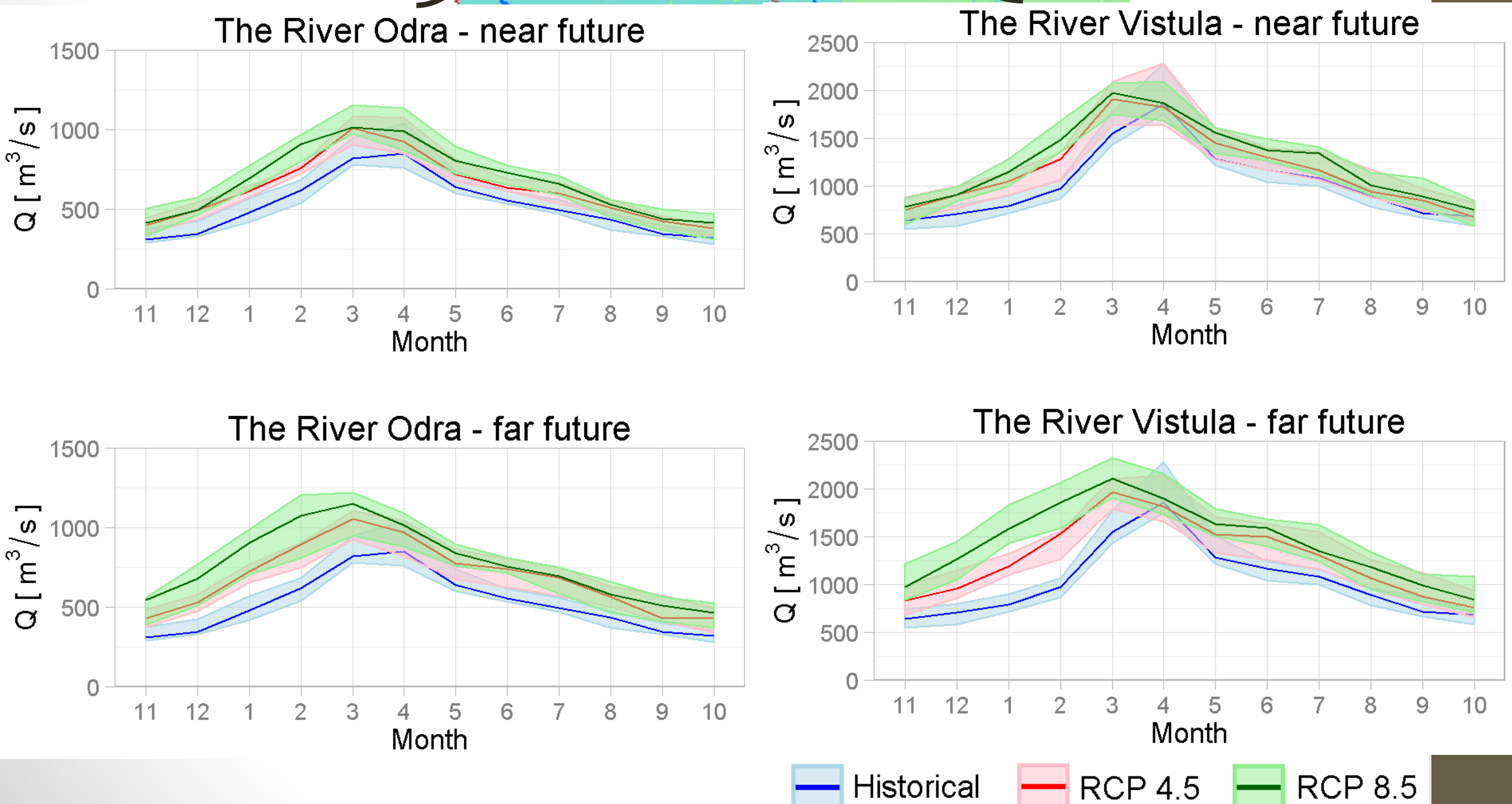


Knutti & Sedlacek, 2013, *Nat. Clim. Chan*

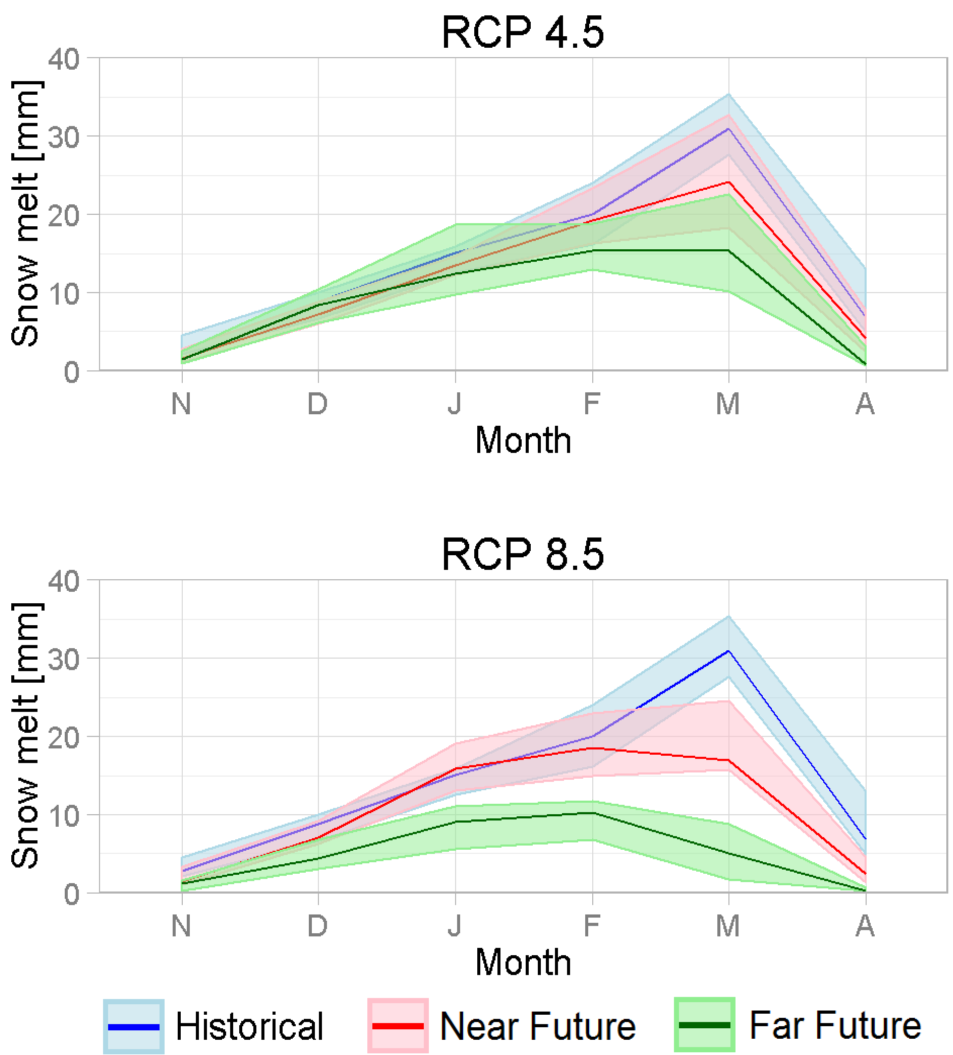
- Maps convey information about robustness (method used in IPCC AR5)
- **Robustness** of climate projections: a combination of an **agreement** between models and statistical **significance** of change

Piniewski *et al*., 2017, Hydrol. Res.

Projections of monthly discharge to the Baltic Sea

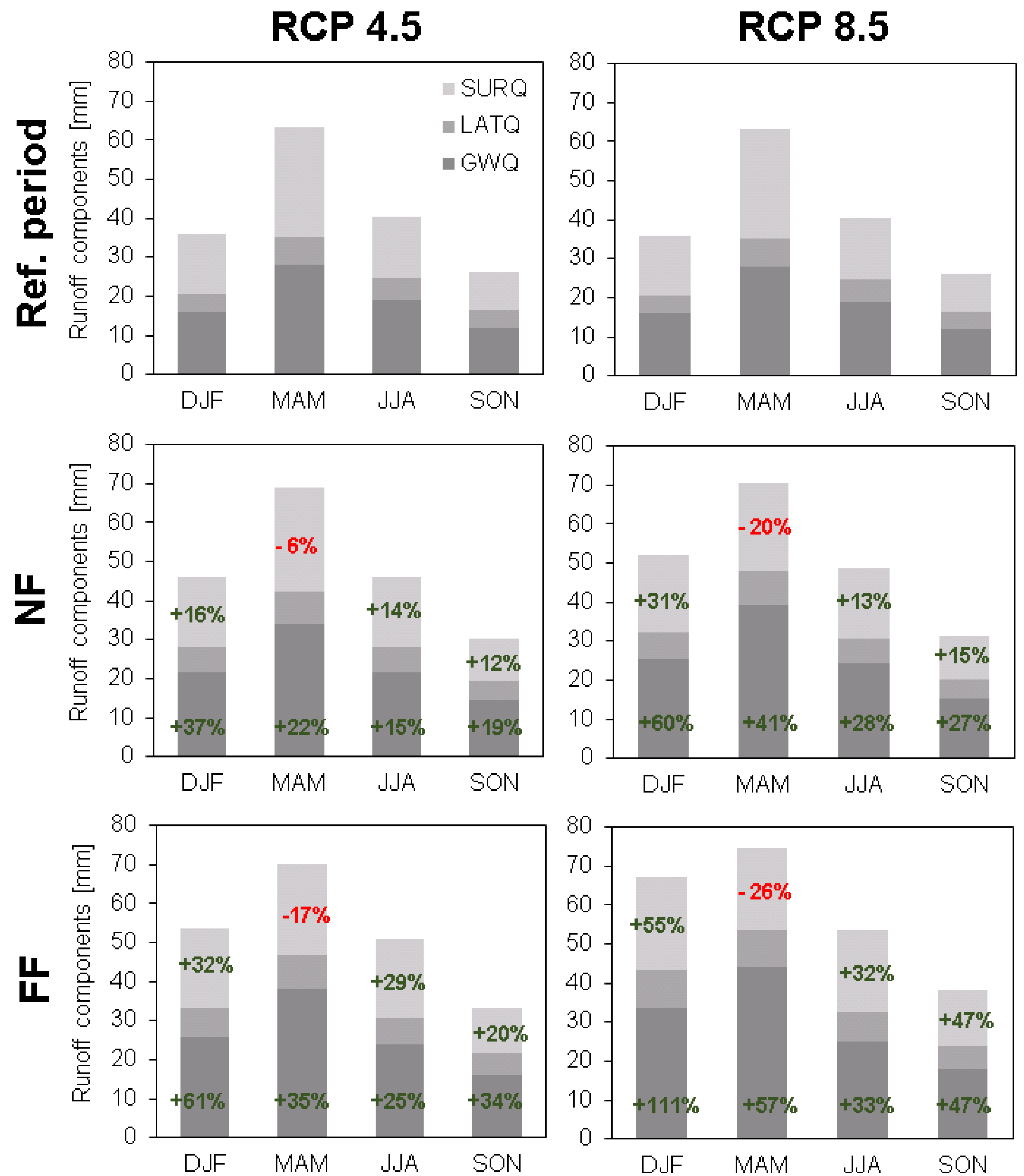


Projected changes in snow melt

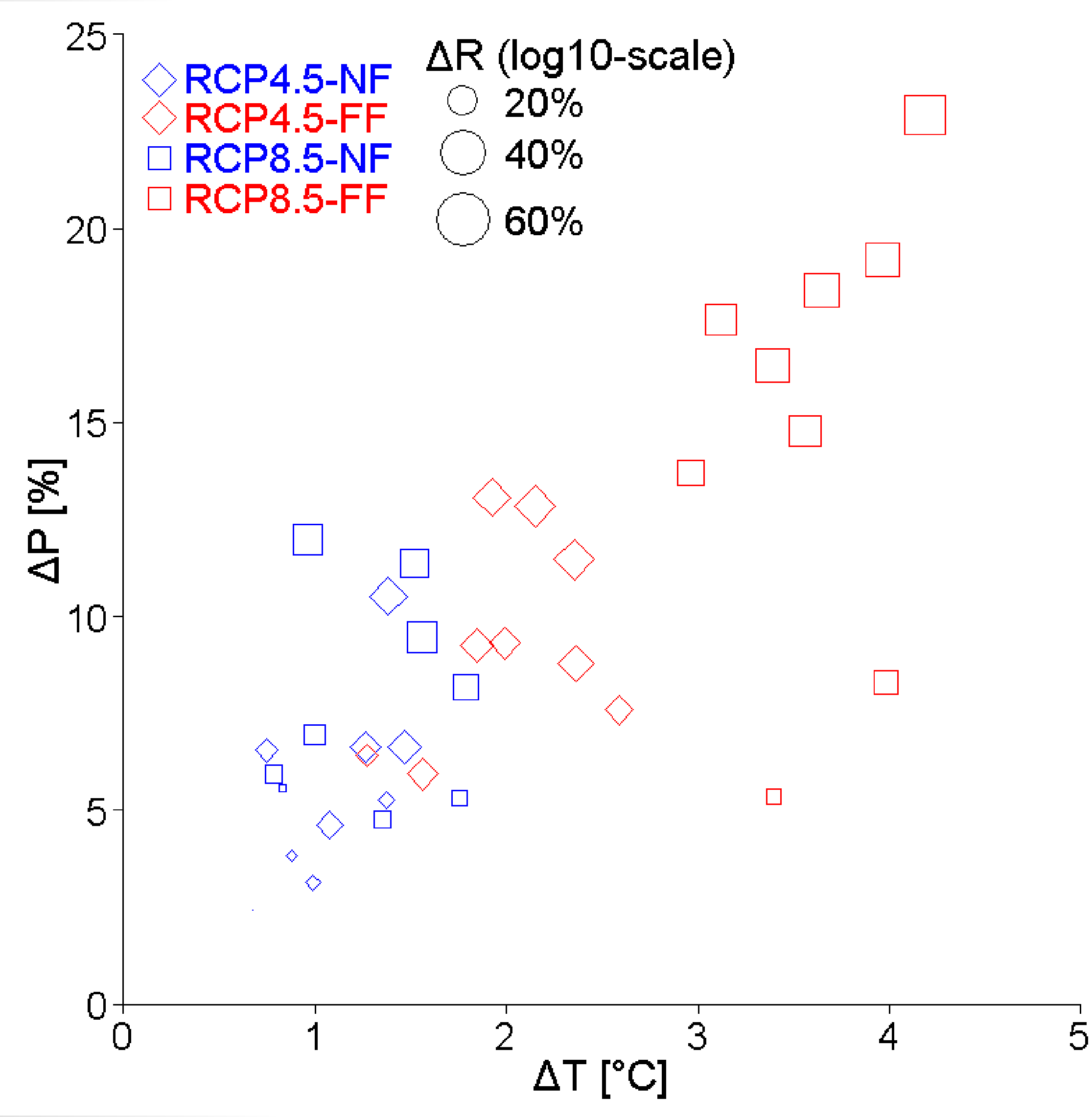


Projections of runoff components

- GWQ: baseflow
- LATQ: lateral flow
- SURQ: surface runoff



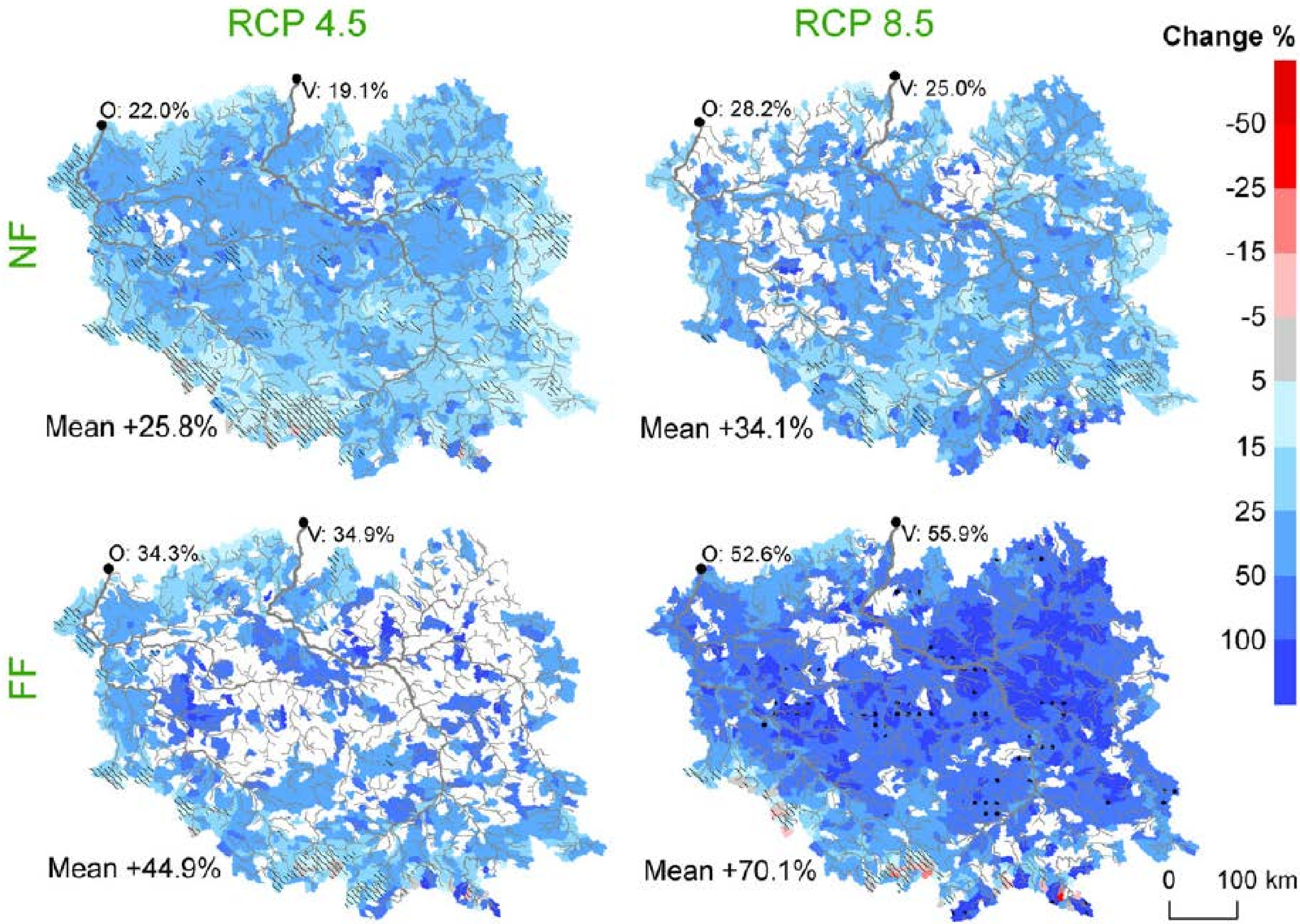
Runoff change vs. T and P change



- Each point represents one of 36 climate scenarios
- Symbol size represents the magnitude of mean runoff increase

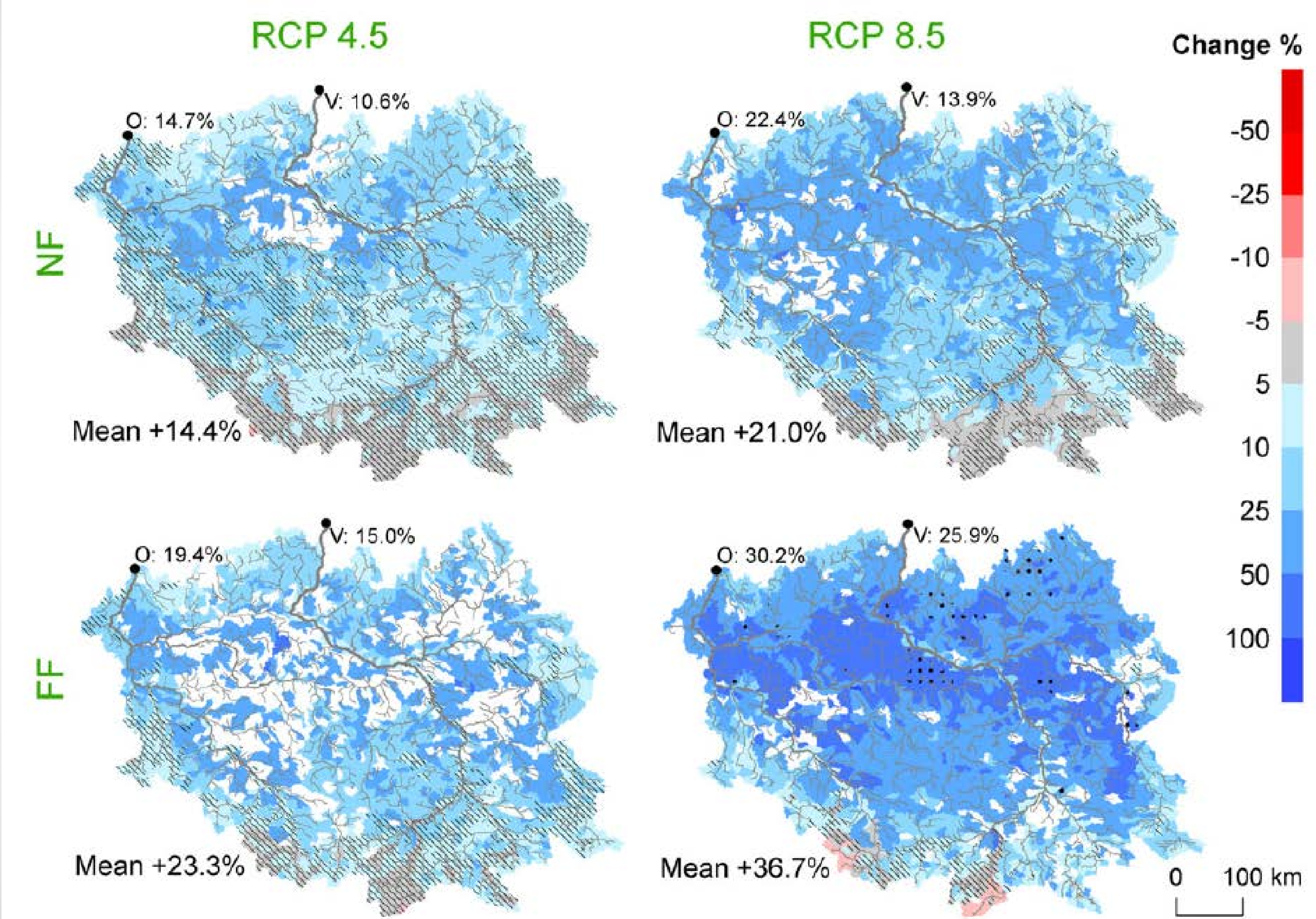
Piniewski *et al.*, 2017, Hydrol. Res.

Changes in low flow indicator (daily Q90)



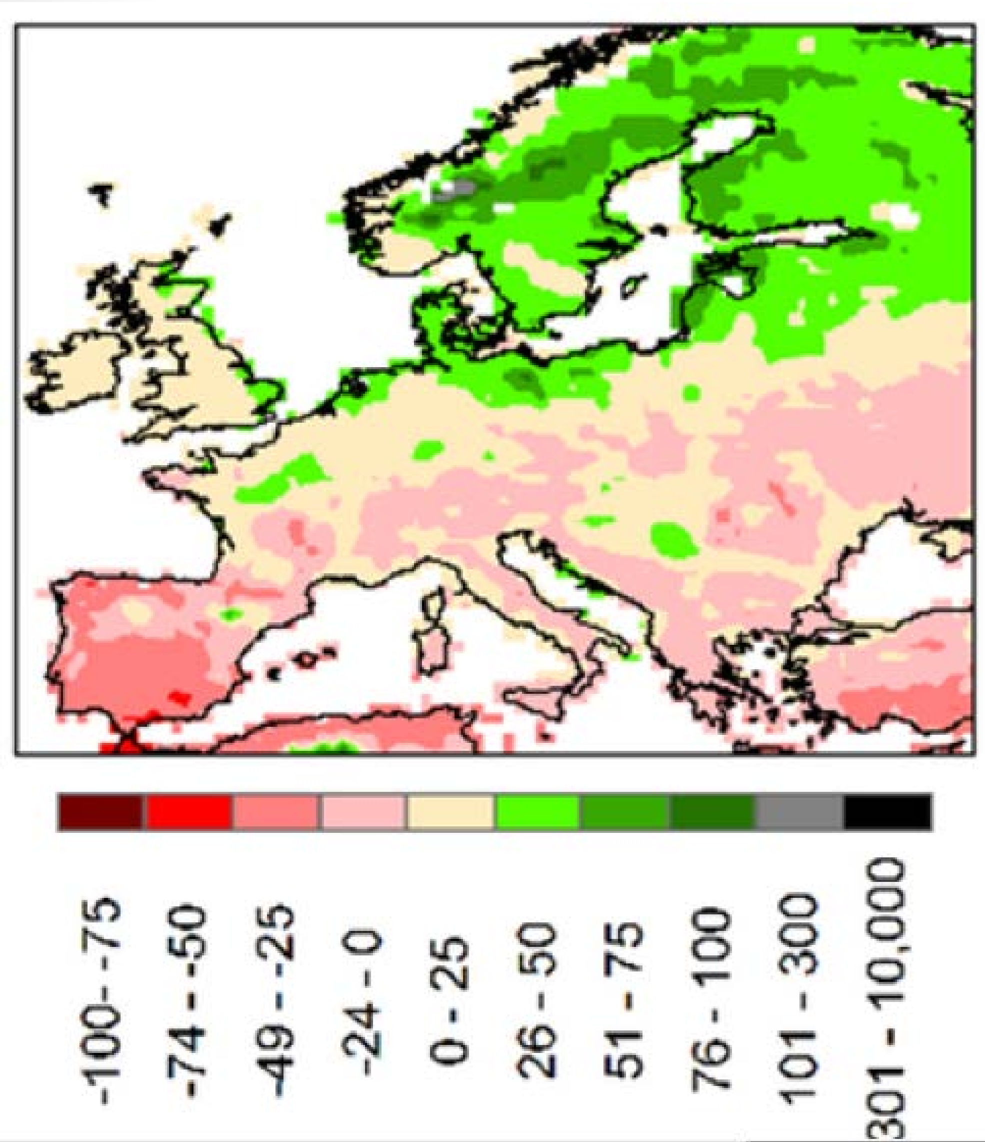
Piniewski *et al.*, 2017, Hydrol Proc.

Changes in high flow indicator (daily Q10)



Piniewski *et al.*, 2017, Hydrol. Proc.

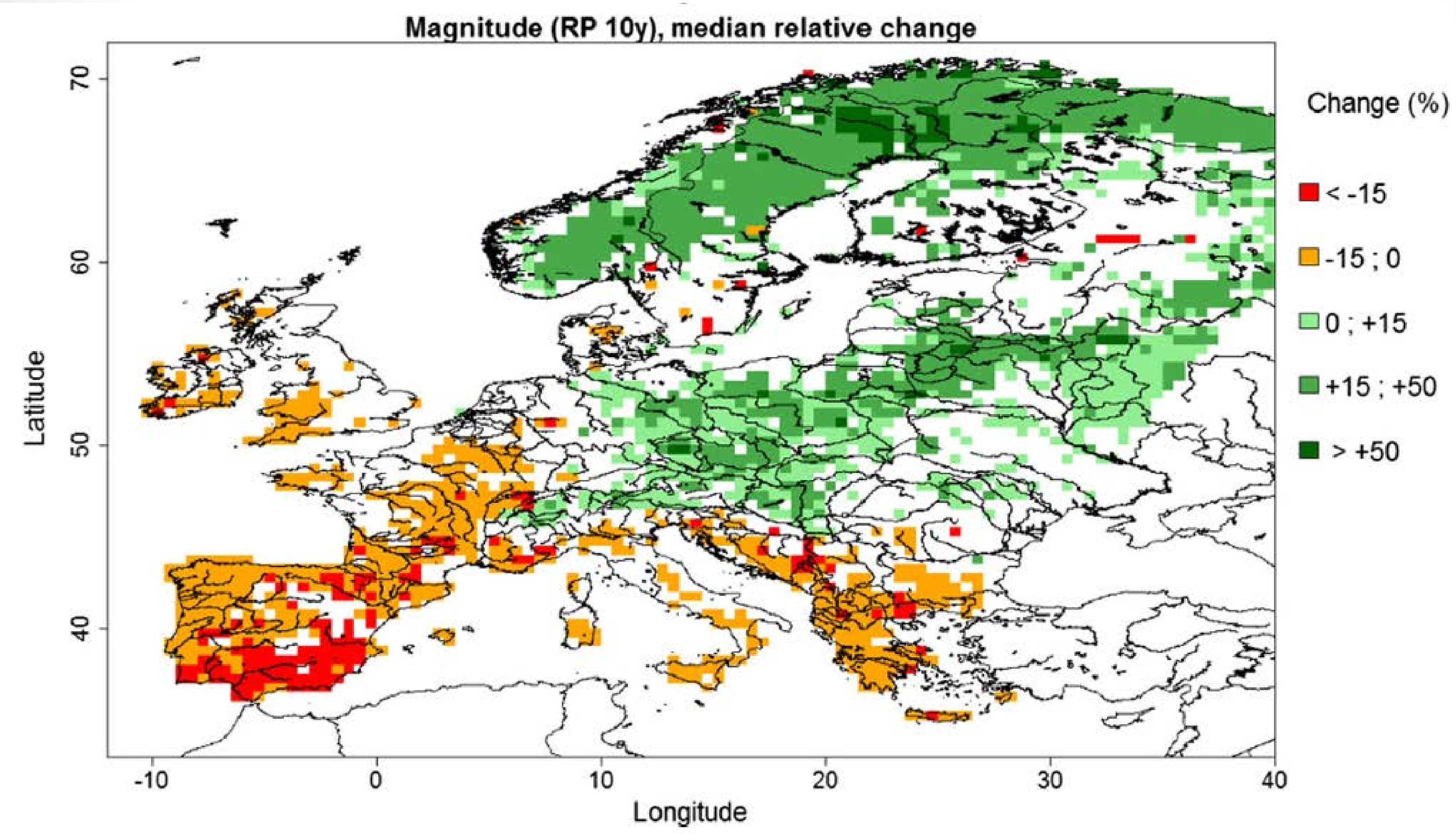
Comparison with large scale studies (mean flows)



Hydrological model: JULES LSM
Climate models: EURO-CORDEX
Ensemble: 5 members (5 GCM-RCMs and RCP8.5)
Bias-correction: YES
Future horizon: „+4 degrees"
Indicator: average runoff

Papadimitriou *et al*., 2016, HESS

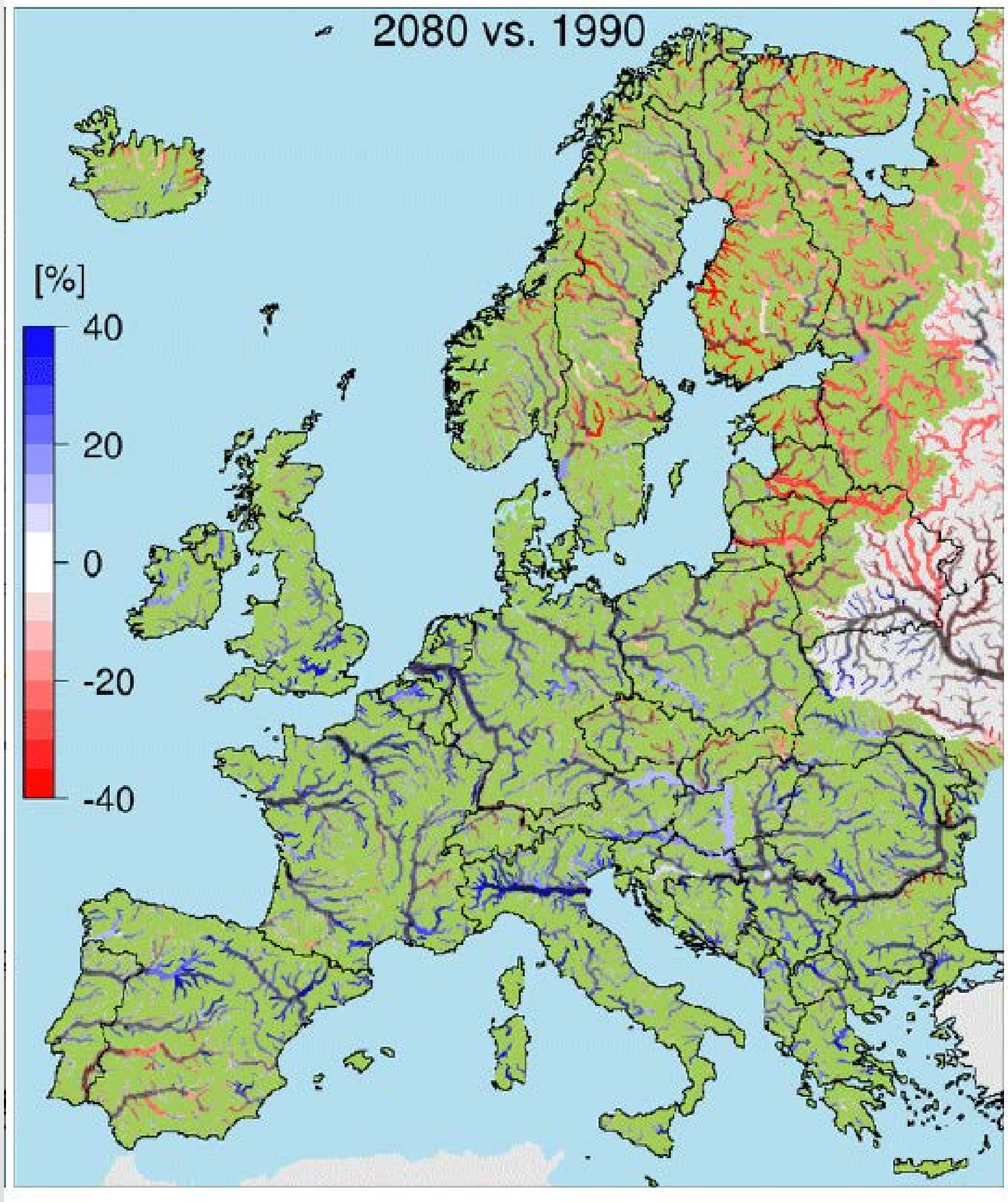
Comparison with large scale studies (low flows)



Hydrological models: Lisflood and E-HYPE
Climate models: EURO-CORDEX
Ensemble: 11 members (5 GCM-RCMs and 3 RCPs)
Bias-correction: YES
Future horizon: „+2 degrees”
Indicator: magnitude of low flow with 10-year return period

Roudier *et al*., 2016, Clim. Chan.

Comparison with large scale studies (high flows)



Hydrological models: Lisflood
Climate models: EURO-CORDEX
Ensemble: 7 members (7 GCM-RCMs and RCP8.5)
Bias-correction: NO
Future horizon: 2080s
Indicator: 100-year daily peak flow

Alfieri *et al*., 2015, HESS

Summary

- Uncertainty (as usual) high, but some signals emerge
- Runoff and streamflow increasing on annual and seasonal basis (although not everywhere)
- Relative changes in low flows higher than for high flows
- The later, the wetter + the higher RCP, the wetter
- Timing of maximum flow advanced by 1-2 months
- Precipitation (and snow melt) change as the main driver of runoff change
- Results consistent with large-scale EURO-CORDEX-driven models for Europe
- **Model inputs and outputs freely available in open repositories and geoportal**

Further reading

- Berezowski, T., Szcześniak, M., Kardel, I., Michałowski, R., Okruszko, T., Mezghani, A., Piniewski, M., **2016**. CPLFD-GDPT5: high-resolution gridded daily precipitation and temperature data set for two largest Polish river basins. *Earth System Science Data*. 8, 127-139.
- Mezghani, A., Dobler, A., Haugen, J.E., Benestad, R.E., Parding, K.M., Piniewski, M., Kardel, I., Kundzewicz, Z.W. **2017** *Earth Syst. Sci. Data Discuss*. (in review).
- Piniewski, M., Szcześniak., M., Kardel., I., Berezowski, T., Okruszko, T., Srinivasan, R., , Vikhamar-Schuler., D., Kundzewicz., Z.W., **2017** Hydrological modelling of the Vistula and Odra river basins using SWAT. *Hydrol. Sci. J.* 62(8), 1266-1289.
- Piniewski, M., Szcześniak, M., Kundzewicz, Z.W., Mezghani, A., Hov, O., **2017** Changes in low and high flows in the Vistula and the Odra basins: model projections in the European-scale context. *Hydrol. Proc.*
- Piniewski, M., Szcześniak, M., Kardel, I. **2017** CHASE-PL—Future Hydrology Data Set: Projections of Water Balance and Streamflow for the Vistula and Odra Basins, Poland. *Data*, 2, 14.
- Piniewski, M., Szcześniak, M., Huang, S., Kundzewicz, Z.W. **2017** Projections of runoff in the Vistula and the Odra river basins with the help of the SWAT model. *Hydrol. Res*. Nh2017280.

Acknowledgements

Polish-Norwegian Research Programme

CHASE-PL

norway grants

Unterstützt von / Supported by

Alexander von Humboldt Stiftung/Foundation

Thank you for your attention!