Climate change impact on water management including point and diffuse sources of pollution - Polish perspective

Mikołaj Piniewski[1,2], Zbigniew W. Kundzewicz[2,3]
Tomasz Okruszko[1]

[1] Warsaw University of Life Sciences

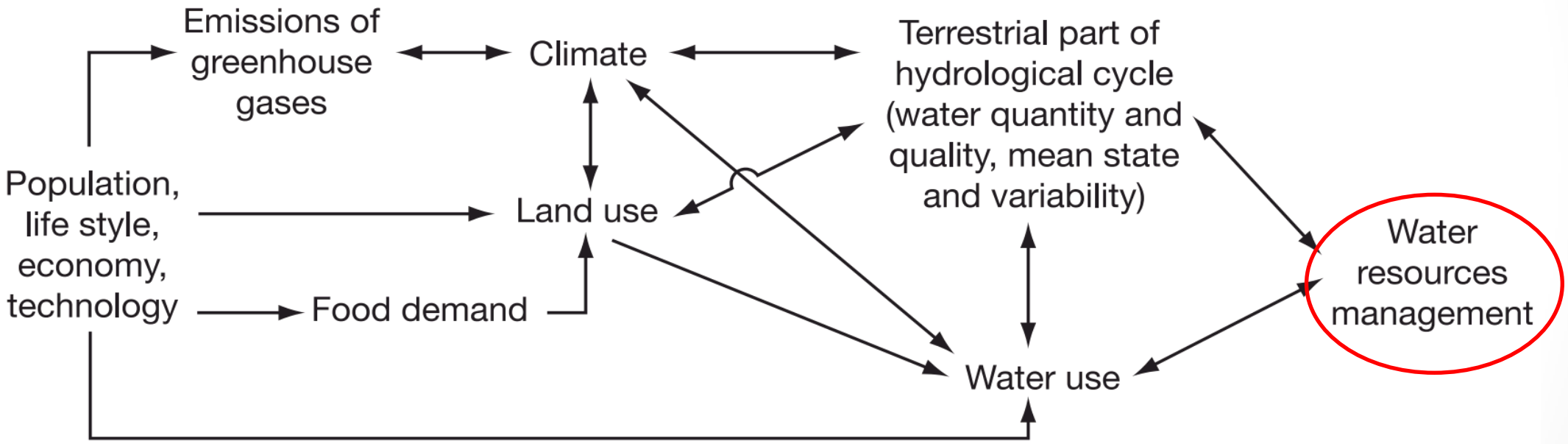
[2] Potsdam Institute for Climate Impact Research

[3] Institute for Agricultural and Forest Environment, Polish Academy of Sciences

9 November 2015 - Met Office data for 2015 so far shows that, for the first time, global mean temperature at the Earth's surface is set to reach 1 °C above pre-industrial levels

Human activities and freshwater resources

In the global system, everything is connected to everything else



Kundzewicz et al. 2007, *4AR IPCC*

Water problems

Too little

The lowest ever water level in the Vistula at Warsaw - power restrictions due to plant cooling problems, 09/2015

Too much

The highest ever water level in the Vistula at Świniary causing levee breach, 05/2010

Too dirty

High turbidity in the Biebrza after a rain event, 05/2015

On the other hand…

Little?

Good!

The lowest ever water level in the Vistula at Warsaw - archeological works, 09/2015

Much?

Good!

Typical flooding of the Narew floodplain at Strękowa Góra, 04/2010

Too dirty?

Always bad…

High turbidity in the Biebrza after a rain event, 05/2015

The objective of water management

The classical Polish definition of the objective of water management (adopted from the Inland Navigation Congress in Brussels!):

draining of precipitated water to the sea, while minimizing its harmful effects and maximizing its advantageous effects

[Romański, E. 1937 "Water management in Poland", *Water Management,* 1, 6-9 (in Polish)]

Now, the principal objective of water management in Poland also comes from Brussels and it is to implement the EU Water Framework Directive and

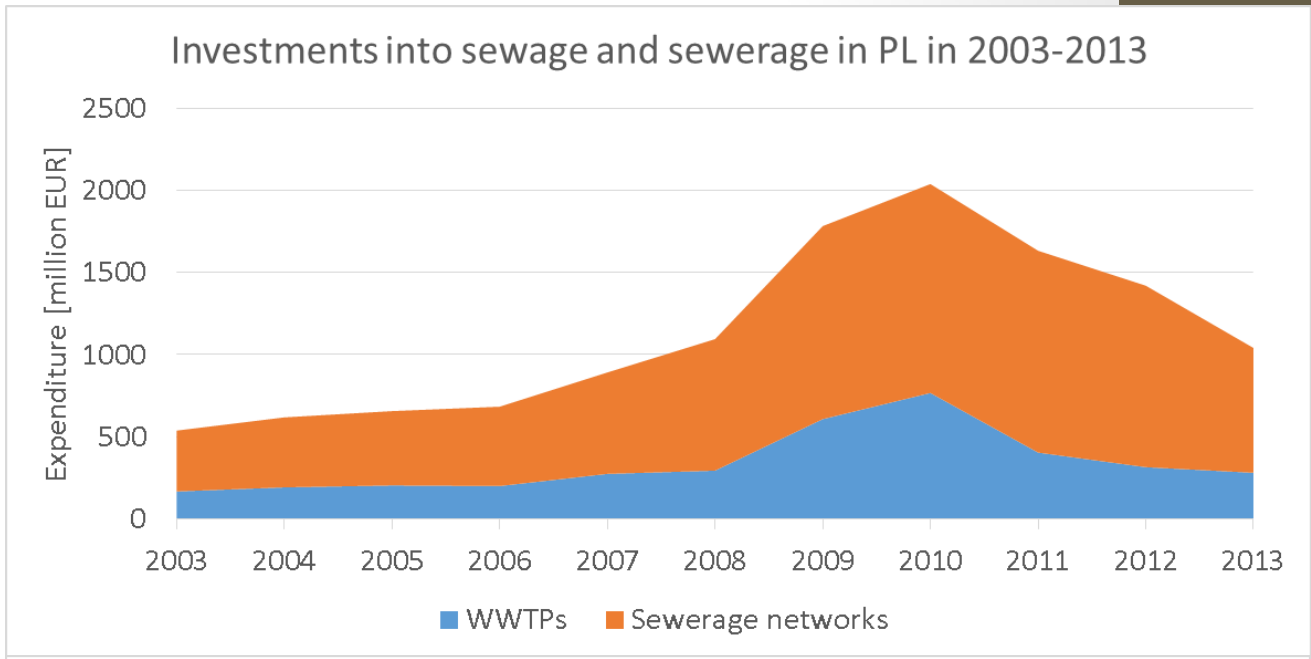
to achieve good status of all water bodies

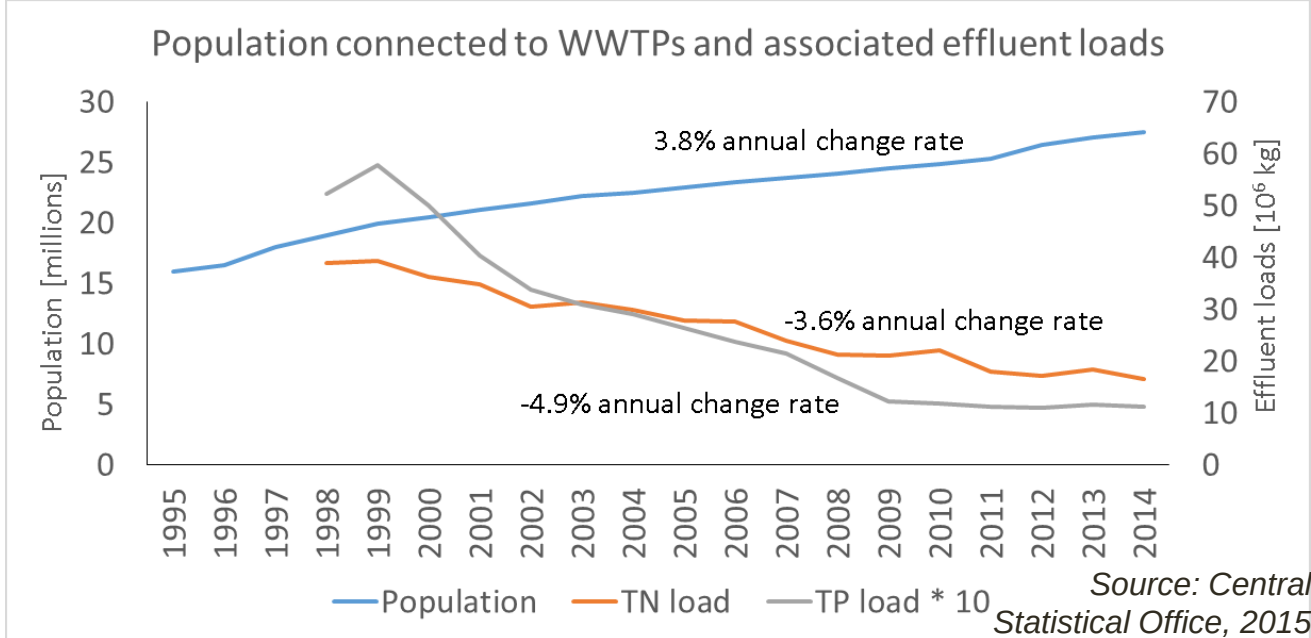
A considerable progress in water quality has been achieved (by massive extension of sewage treatment), but the goal of the Directive will not be met in all waters of Poland, as well as in other EU countries before the end of 2015.

Trends in urban wastewater treatment in Poland

- Development largely due to the National Urban Wastewater Treatment Program (KPOŚK) – government program put into force in 2003 in response to Urban Waste Water Directive
- Construction, expansion and modernization of wastewater treatment plants and combined sewerage networks in agglomerations above 2000 pe (population equivalent)
- In total 12,400 milion EUR invested in 2003-2013, of which much financed by the EU

WWTP „Czajka" in Warsaw, MPWiK

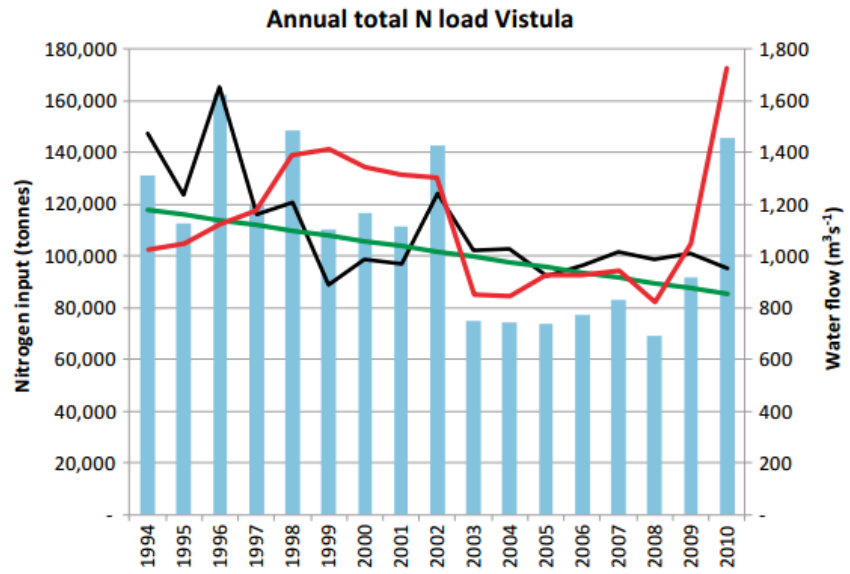


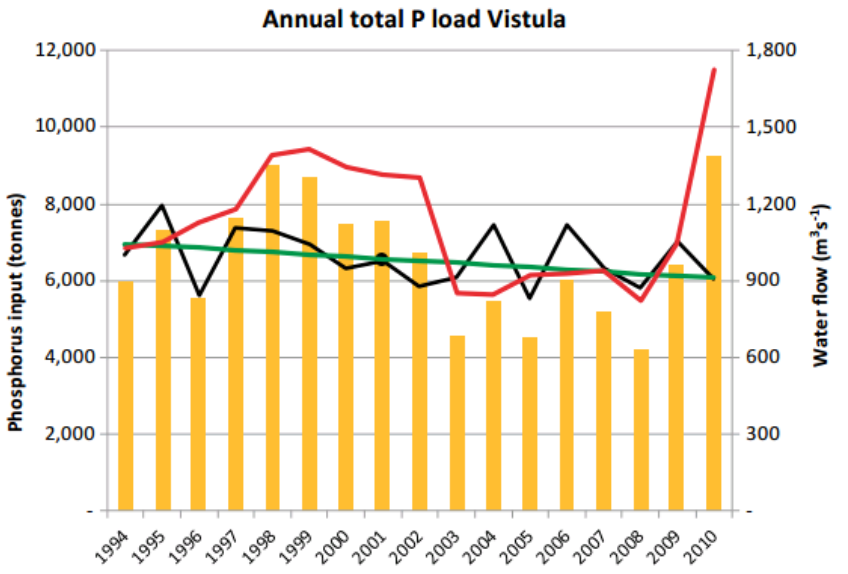


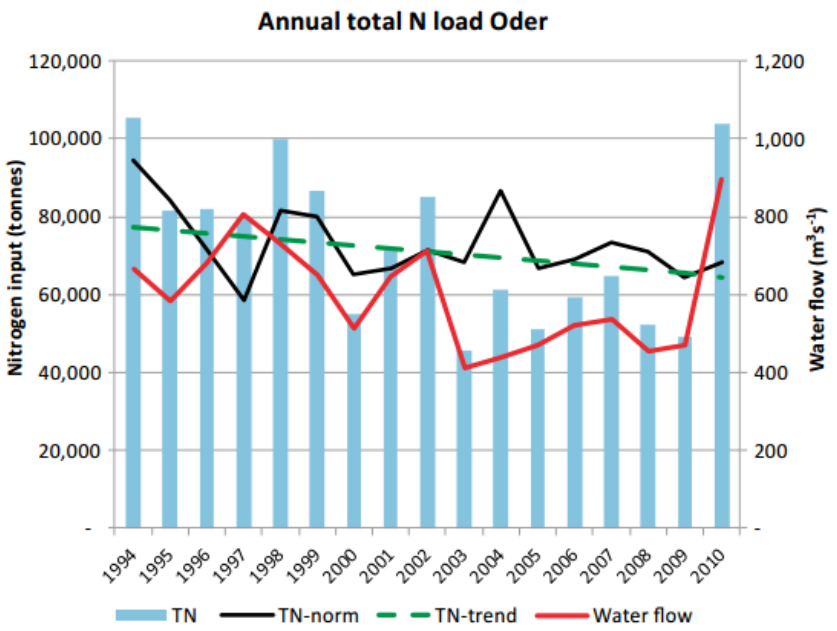
Source: Central Statistical Office, 2015

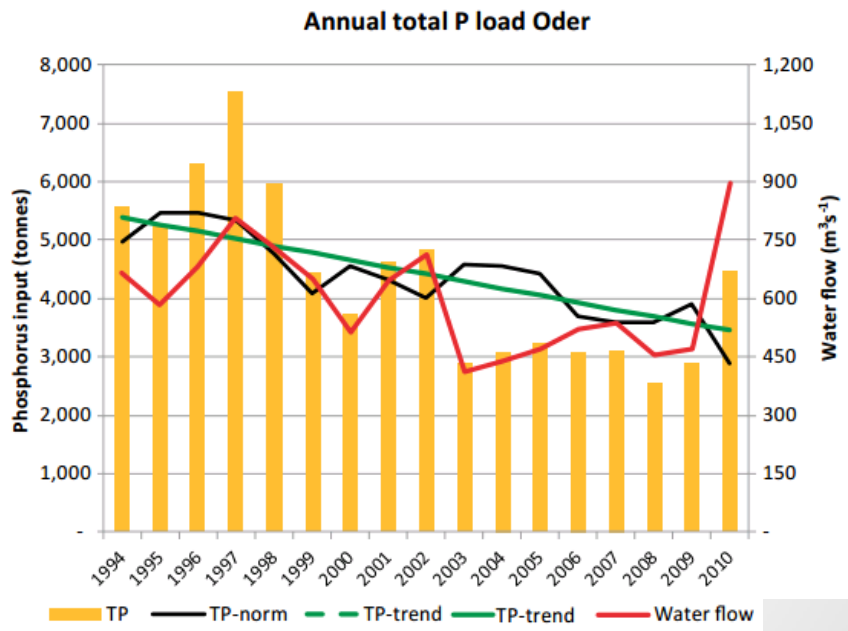
Trends in riverine TN and TP loads from two largest Polish rivers

- Statistically significant trends for (flow-normalized) TN and TP loads in the Vistula and for TP in the Odra
- Yet, the slope is lower than for WWTP effluent loads… **Why and what does this mean?**



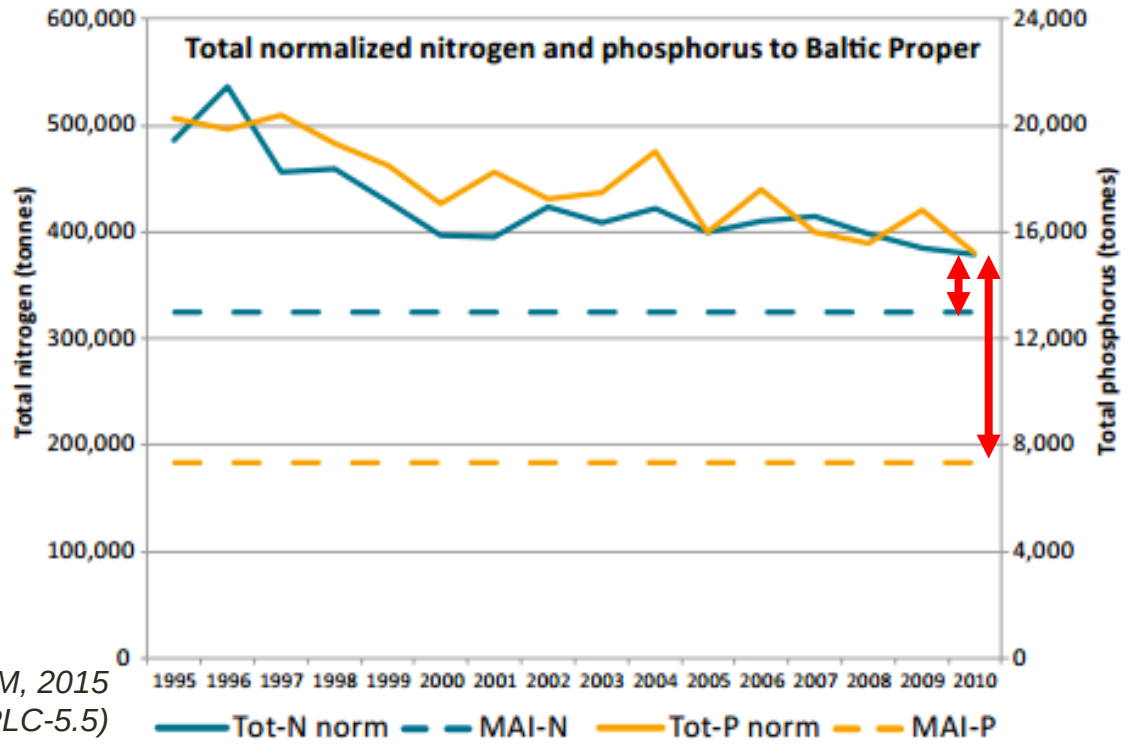






HELCOM, 2015 (PLC-5.5)

Nutrient inputs to the Baltic Proper vs. Maximum Allowable Inputs (MAI)



HELCOM, 2015 (PLC-5.5)

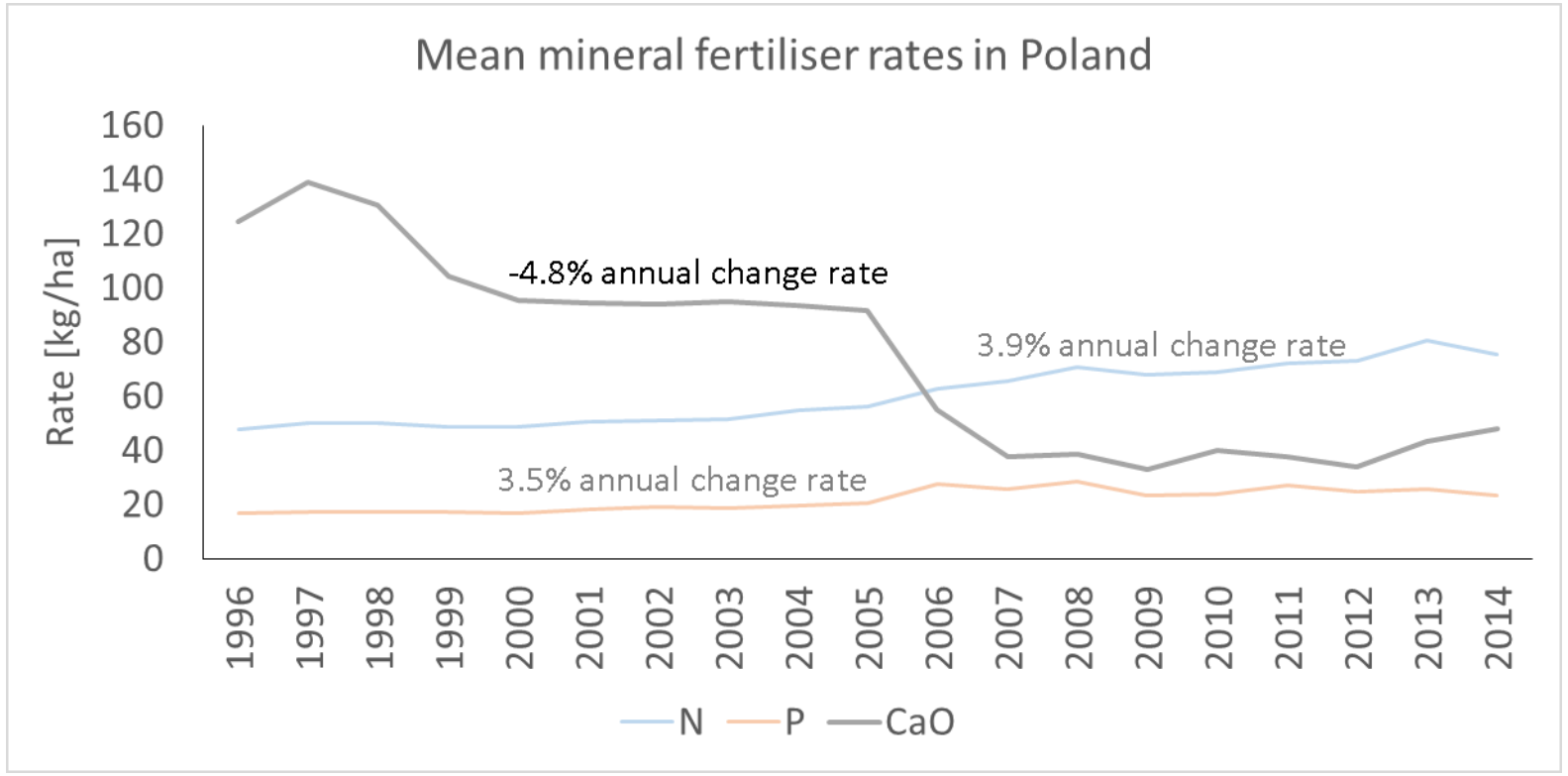
Revised Country Allocated Reduction Targets (CARTs), covering both pollution from land and airborne

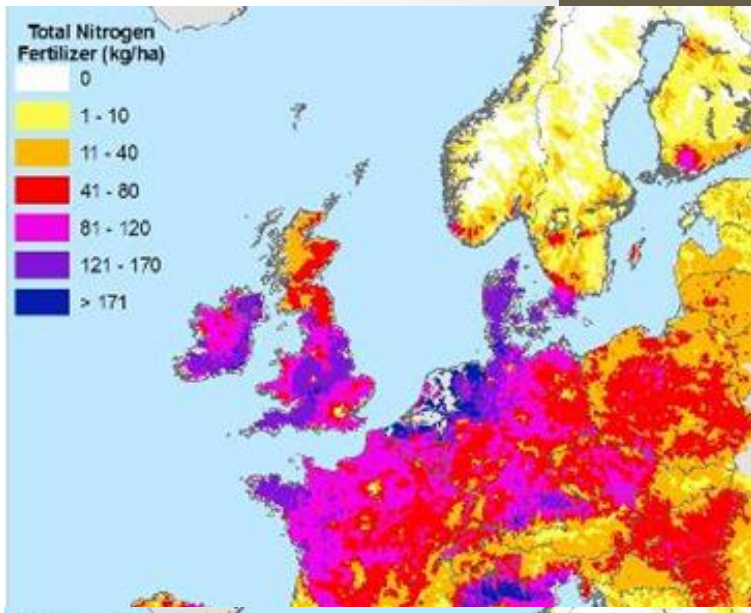
	Nitrogen	Phosphorus
Denmark	2890	38
Estonia	1800	320
Finland	2430 +600*	330 +26*
Germany	7170 +500*	110 +60*
Latvia	1670	220
Lithuania	8970	1470
Poland[2]	43610	7480
Russia	10380*	3790*
Sweden	9240	530

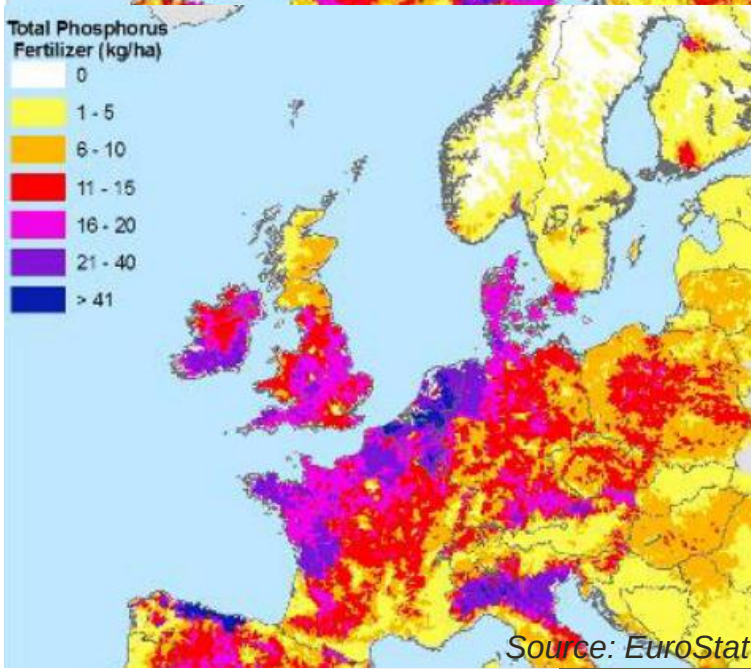
HELCOM, 2013

- A new set of MAI and CART for total air- and waterborne N and P inputs to the Baltic Sea sub-basins was agreed in the **2013 Copenhagen Ministerial Declaration**
- In the case of the Baltic Proper, despite a considerable improvement in 1995-2010, **further reduction** (particularly large for TP) **is still needed**

Trends in mineral fertiliser rates in Poland







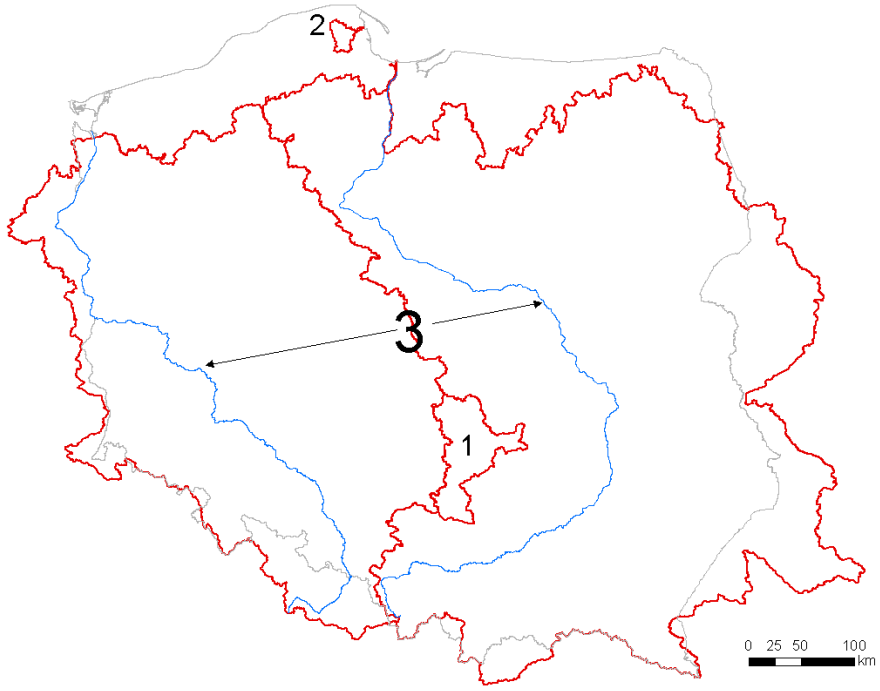
- Even though current NP fertilizer use is rather low compared to DE and FR, the emmission from diffuse sources is substantial
- Also important: soil pH < 5.5 for 43% of PL soils
- With dramatically low calcium content, N and P uptake by plants is limited, while **N and P leaching is likely to accelerate**

Source: EuroStat

Case studies

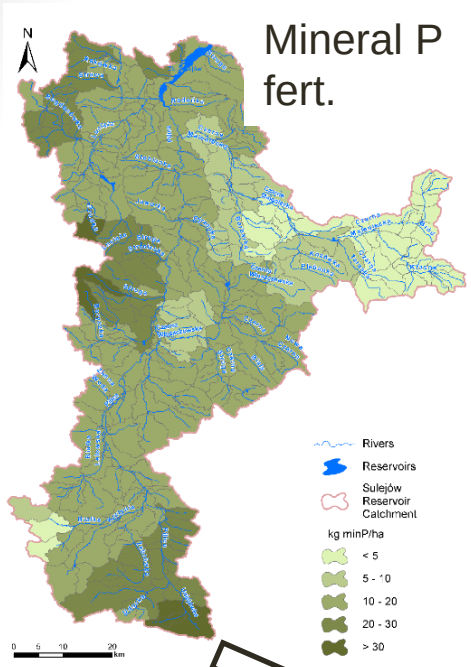
1. Pilica catchment: quantification of N and P pollution sources upstream of Sulejów reservoir (*LIFE+ EKOROB*)
2. Reda catchment: relative contribution of climate change and agricultural intensification to future nutrient loads (*Baltic COMPASS*)
3. Vistula and Odra river basins: large-scale and high-resolution modelling of climate change impacts on water resources (*CHASE-PL*) => Poster session

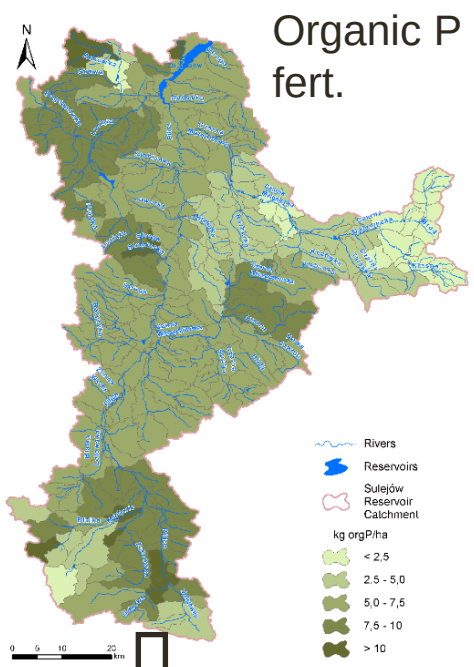
SWAT as the modelling tool

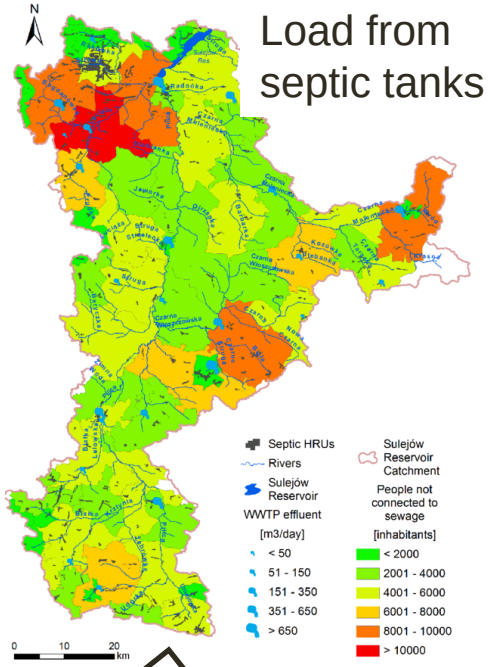


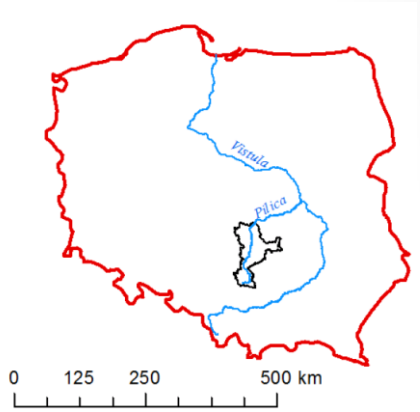
Modelling team: T. Berezowski, M. Giełczewski, I. Kardel, P. Marcinkowski, M. Szcześniak, T. Okruszko (WULS-SGGW)

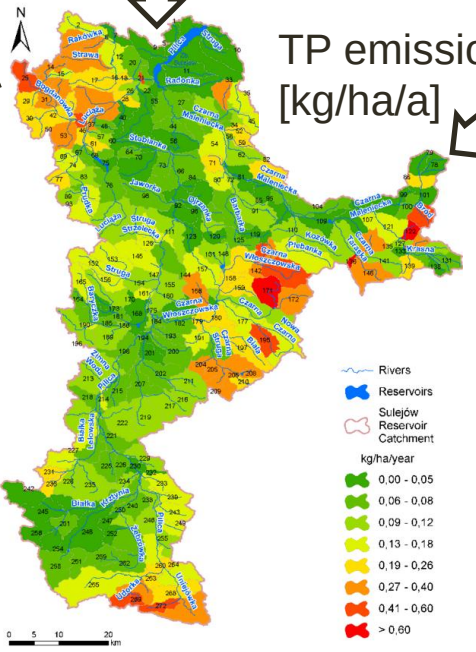
Case study 1: spatial quantification of pollution sources



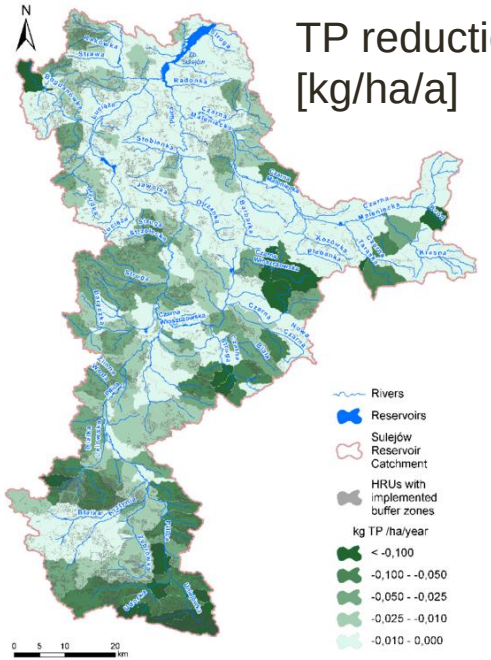








+ Buffer zone scenario



Piniewski et al. 2015, *Water*

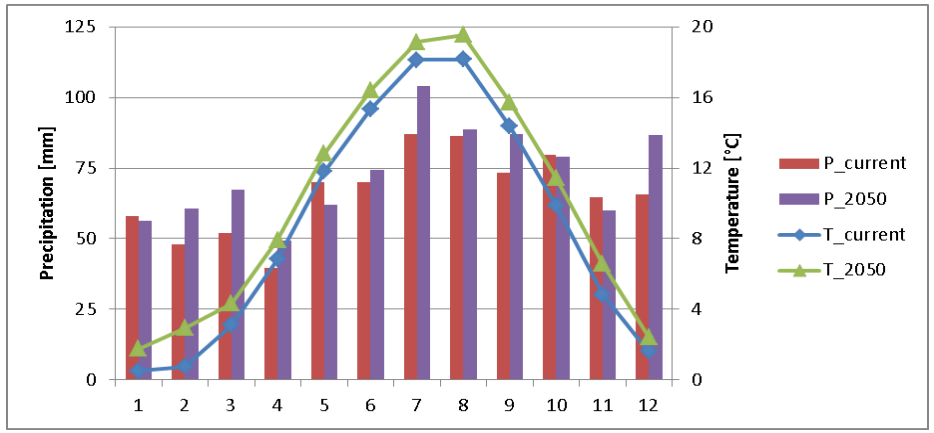
Action Plan for reduction of diffuse pollution in the Pilica catchment

- Spatial model output as supplementary data for designing the Action Plan
- Good agricultural practices
  - Appropriate dosage of fertilisers based on crop requirements and soil chemistry measurements
  - Control of soil pH through liming
  - Vegetative cover in autumn and winter (catch crops)
  - Improved manure storage
  - Natural buffer zones
- Ecohydrological biotechnologies
  - Enhanced high-performance buffer zones
  - Denitrification walls
  - Sequential biofiltration systems

EKOROB: K. Izydorczyk, W. Frątczak

Case study 2: nutrient load scenarios for 2050

Climate change (**CC**) scenario from ECHAM5-RCA3-A1B

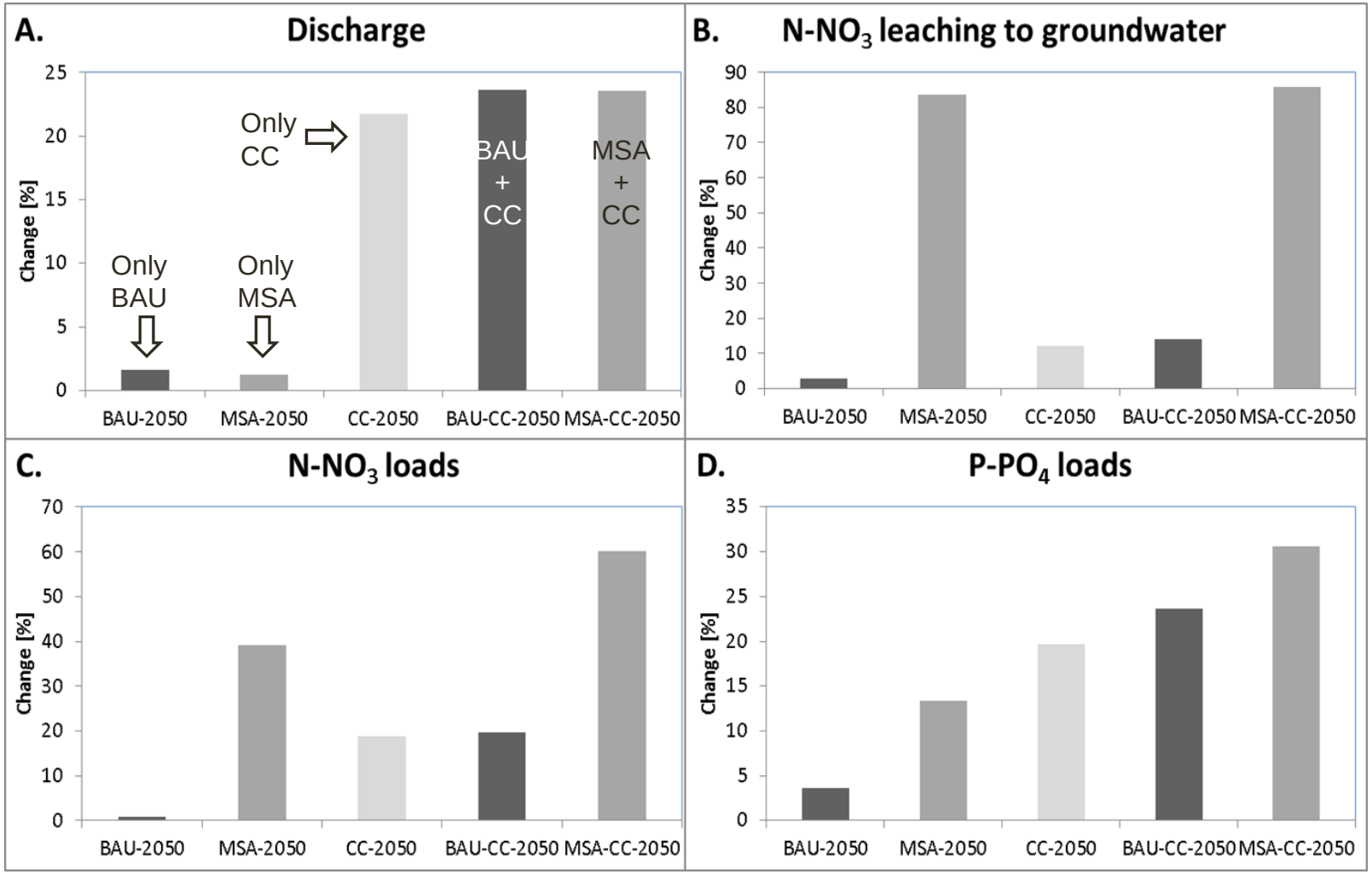


Agricultural scenarios:

1. Business-As-Usual (**BAU**)

2. Major Shift in Agriculture (**MSA**)

Simulated changes of different variables (2050 vs. baseline)

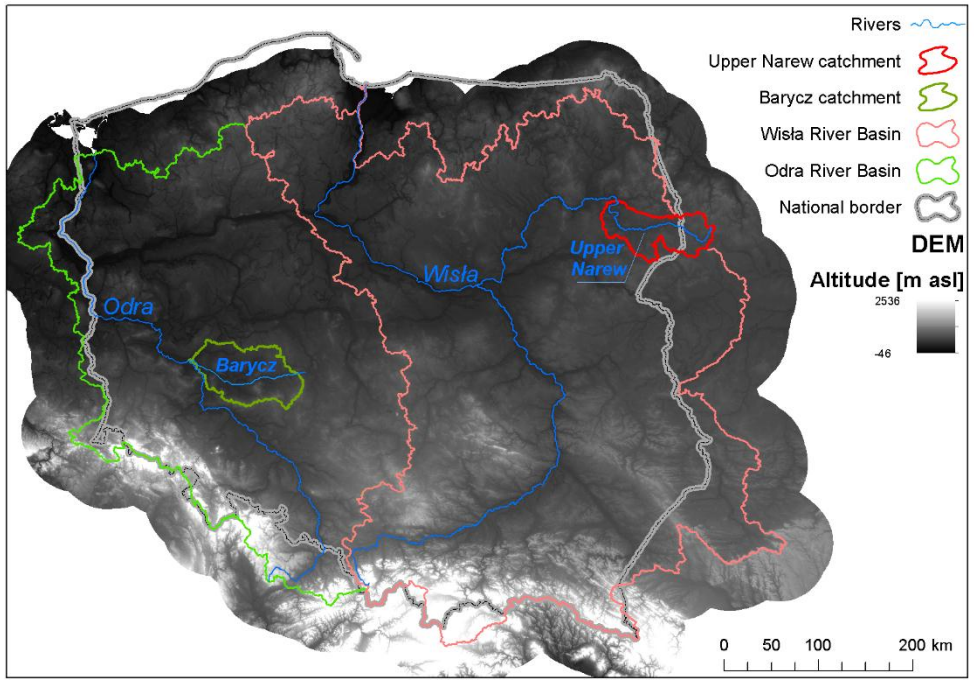


- Both CC and intensified agriculture lead to increased N and P loads
- Trade-offs between agricultural profitability and water quality

Piniewski et al. 2014, *Ambio*

CHASE-PL Project (Climate Change Impacts for Selected Sectors in Poland)

- The project addresses the following topics
  - Change detection in **observed** climate
  - **Projections** of climate variability and change
  - Model-based assessment of climate change impacts in **water** system
  - Assessment of climate change impacts on **ecosystems and agriculture**
  - **Uncertainty** in observations, understanding and projections
- Aiming to study changes in hydrological systems in Poland, in several scales, the project is likely to produce results of considerable importance for water management in the context of climate change
- So far the following parts are ready:
  - High-resolution gridded daily precipitation and temperature dataset
  - The ensemble of bias-corrected EURO-CORDEX projections
  - SWAT model of the Vistula and Odra basins in high resolution
- Web maps for end-users (under construction) http://climateimpact.sggw.pl/chase/



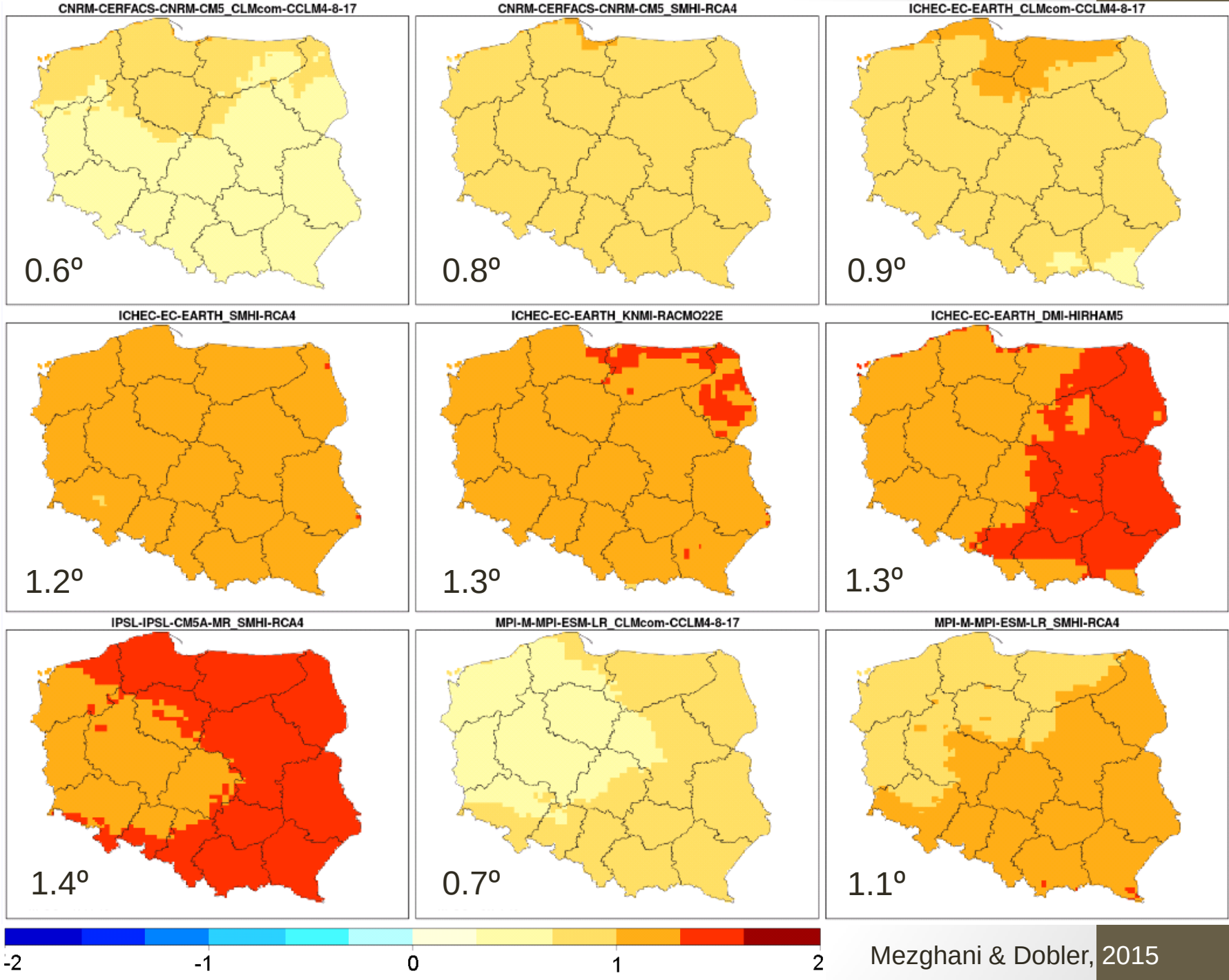
CHASE-PL: Bias-corrected EURO-CORDEX projections for Poland

Absolute change of **daily maximum temperature** [^{o}C]

2021-2050 with respect to 1971-2000

RCP 4.5

Ensemble mean: 1.0^{o} increase



Mezghani & Dobler, 2015

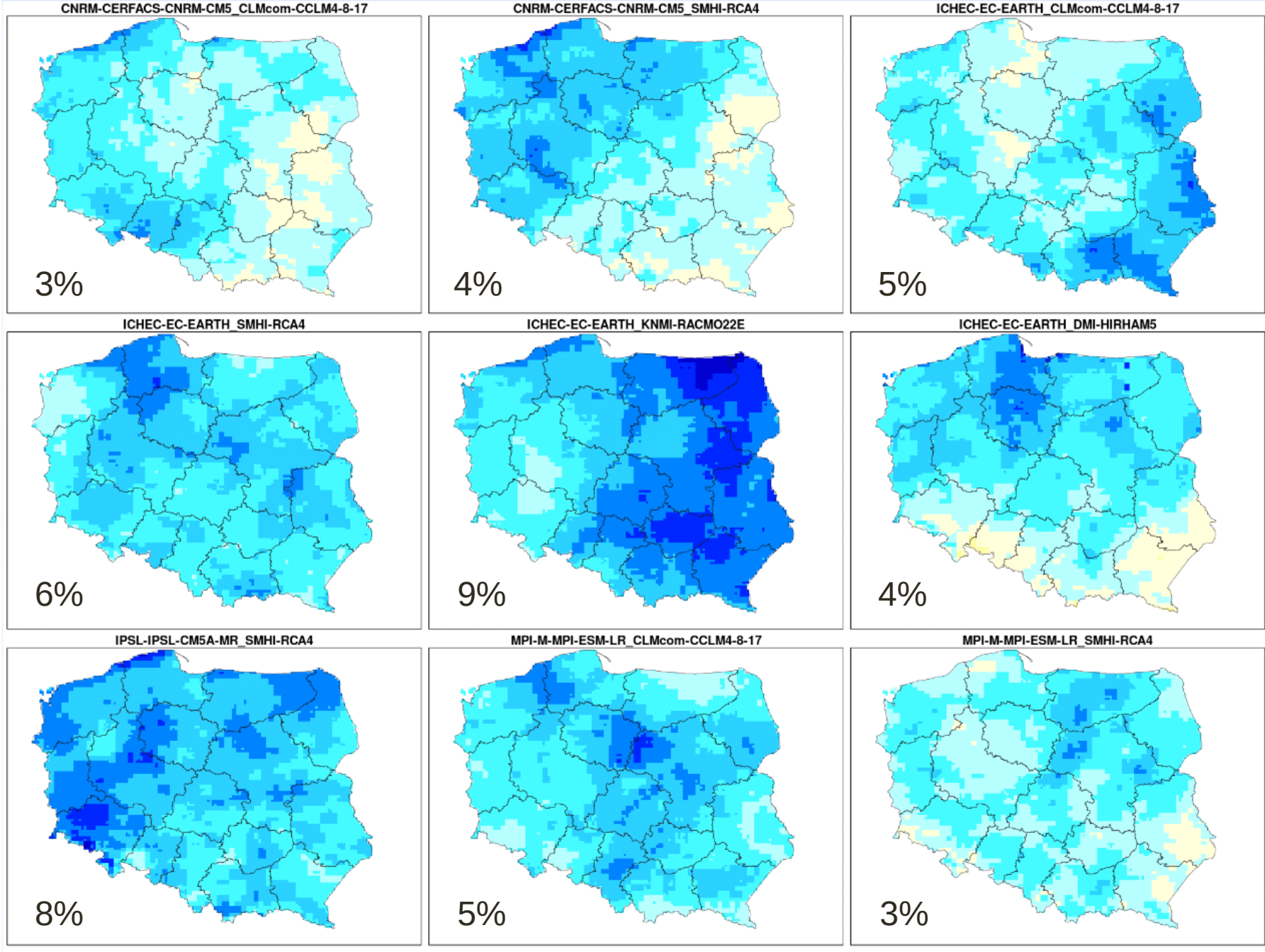
CHASE-PL: Bias-corrected EURO-CORDEX projections for Poland

Relative change in **annual precipitation** [%]

2021-2050 with respect to 1971-2000

RCP 4.5

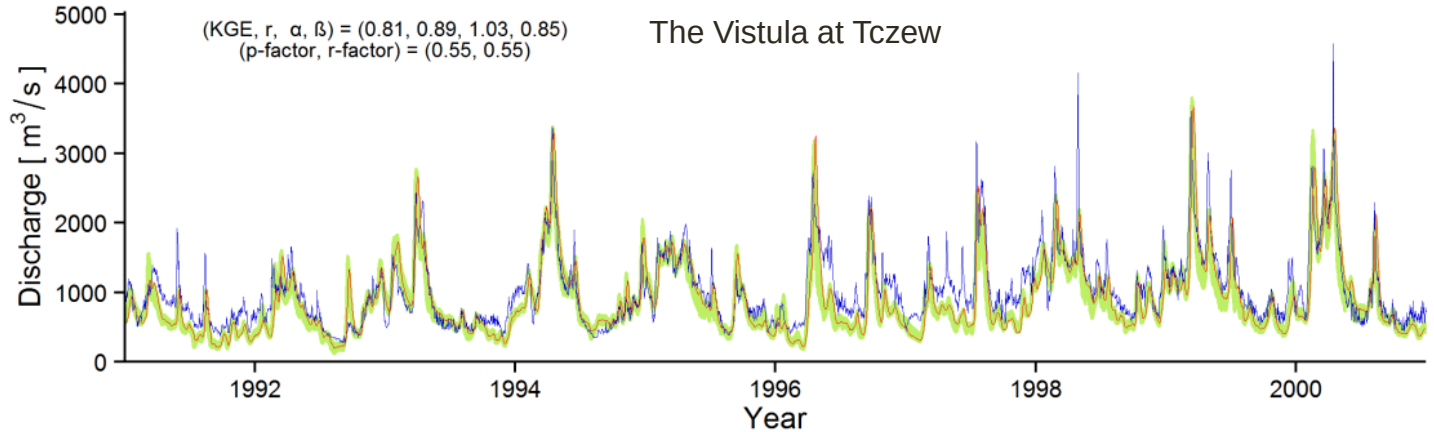
Ensemble mean: 5.2% increase

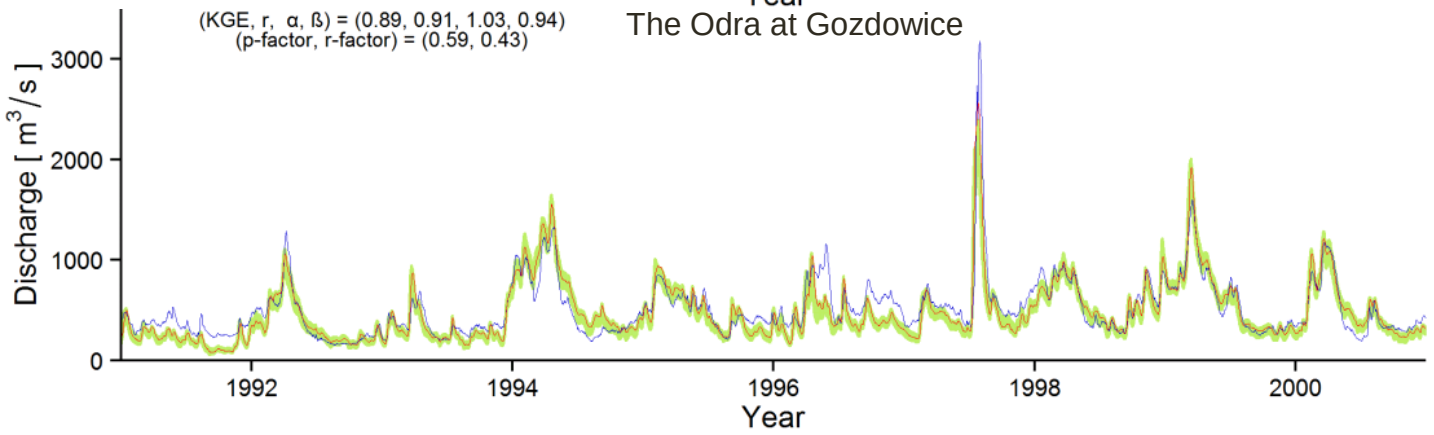


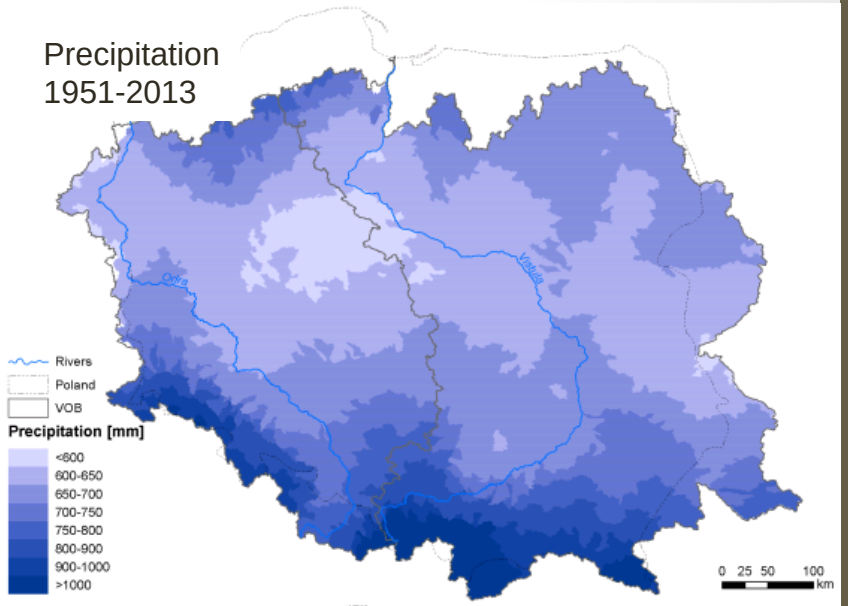
Mezghani & Dobler, 2015

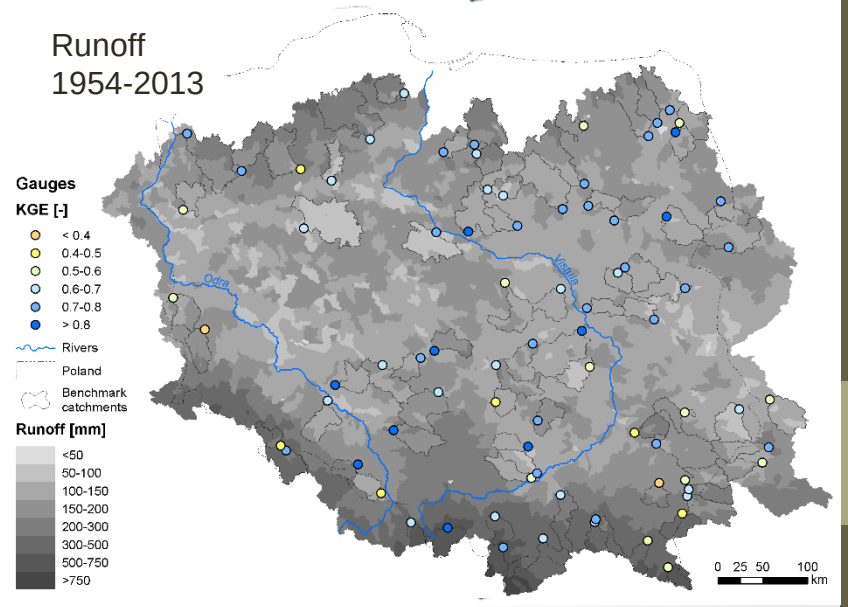
Case study 3: large-scale modelling

- The modelling results available as the CHASE-PL – Natural Hydrology (CPL-NH) open dataset
- The model lays the groundwork for future applications including climate change, water quality and water management









Piniewski et al., submitted, *WRR*

Conclusions

- EU environmental directives and HELCOM have played a positive role, stimulating the gradual progress in water management in Poland
- Poland reduced its point source input significantly but will soon be reaching the limit
- Further progress will hopefully be achieved mainly by reduction of diffuse sources (esp. for N), provided that:
  - Farmers' awareness is increased
  - Agricultural policy stimulates farmers to environmentally-friendly actions
- The new RCM projections for Poland show a robust signal of 3-9% increase in annual precipitation by 2050. This, together with high likelihood of more frequent extreme events, can result in higher N and P leaching
- Mathematical models are useful for estimating impacts of different driving forces and measures
  - The research community benefits more if the simulation results are shared as open datasets through online repositories

Acknowledgements

Unterstützt von / Supported by

Alexander von Humboldt
Stiftung/Foundation

Thank you!