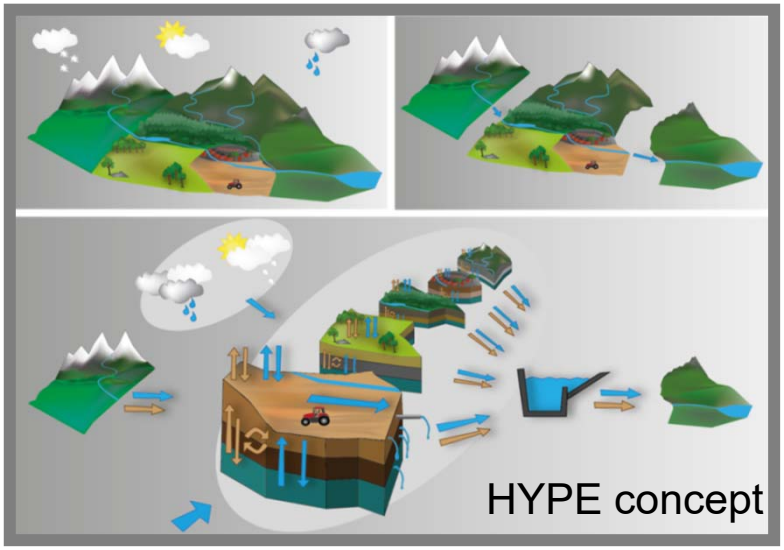
EGU 2020

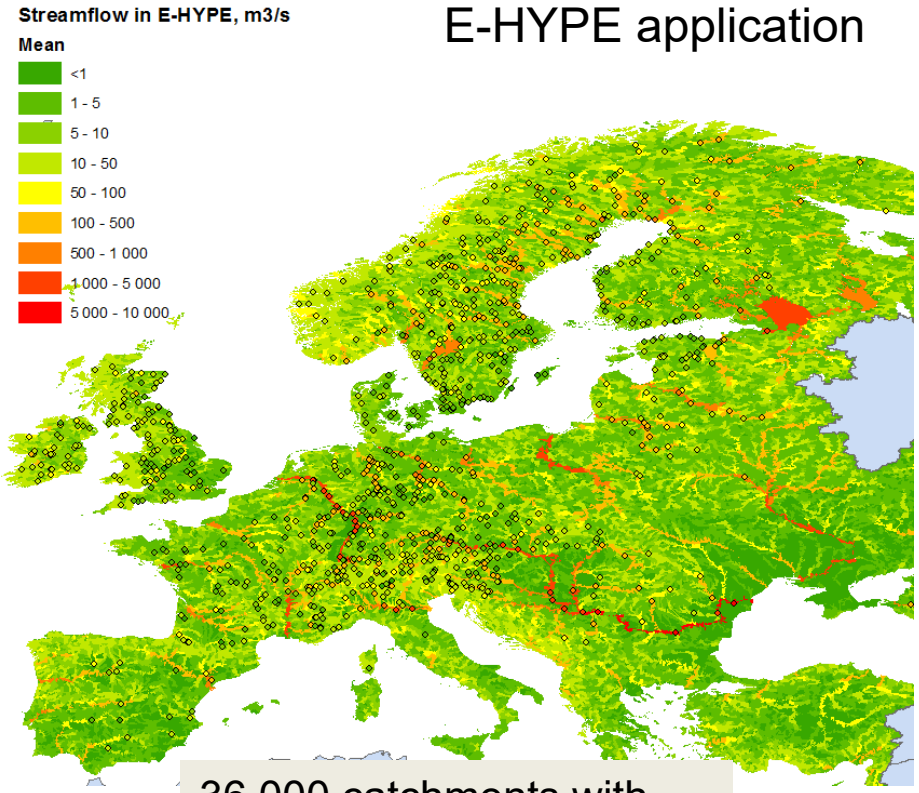
Past, current, and future freshwater inflows to the Baltic Sea under changing climate and socioeconomics

Alena Bartosova, René Capell, Jørgen E. Olesen, and Berit Arheimer

HYPE = ”Virtual hydrological laboratory”

HYdrological Predictions for the Environment





E-HYPE application

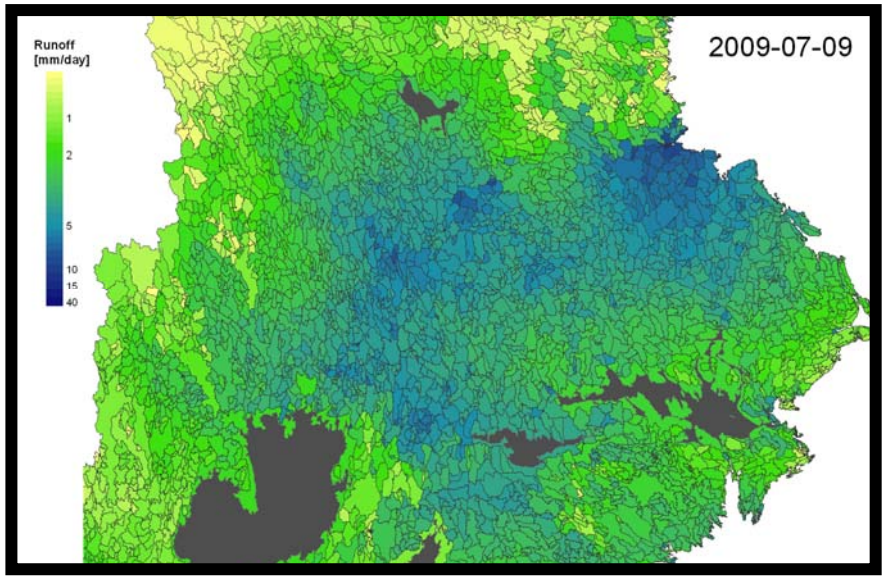
- HYPE: Computational tool that simulates flow and nutrients
- Hydrologically connected catchments further divided into HRUs
- Open data; Land use, crops, and wastewater discharges from 2010-2012
- Baltic Sea region extracted from E-HYPE v 3.1.4, a pan-European HYPE model

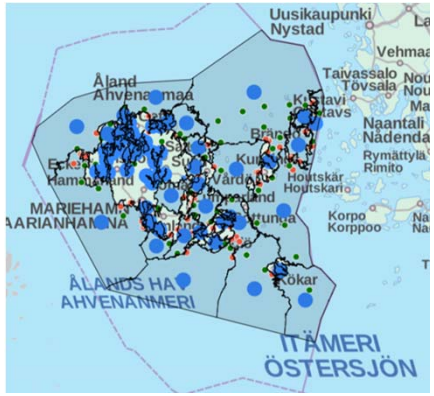
36 000 catchments with median size 215 km^2

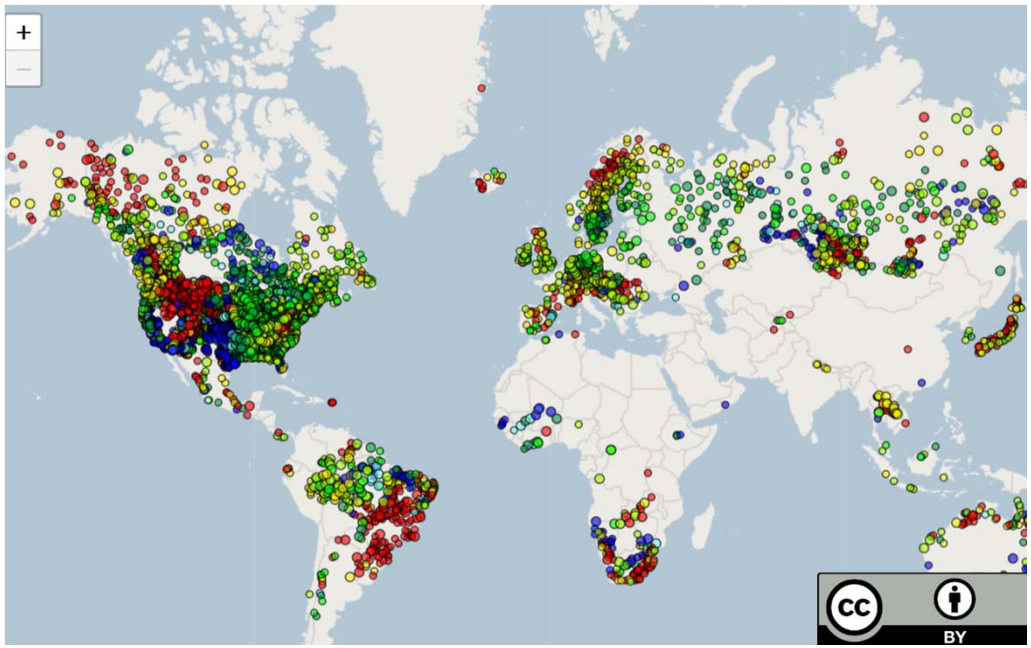
http://hypeweb.smhi.se/

HYPE Applications from field to ocean

- Catchment
  - Sweden, UK, Poland, Latvia, Germany, Denmark, …
- Basin
  - uMngeni (South Africa), Maumee (USA) Åland (Finland), Niger (Africa), Hudson Bay (Canada)
- Country
  - Sweden (S-HYPE): 35 000 subcatchments
  - Czech Republic, India
- Continent
  - Europe (E-HYPE): 36 000
  - Arctic
- World: WW-HYPE: 131 000







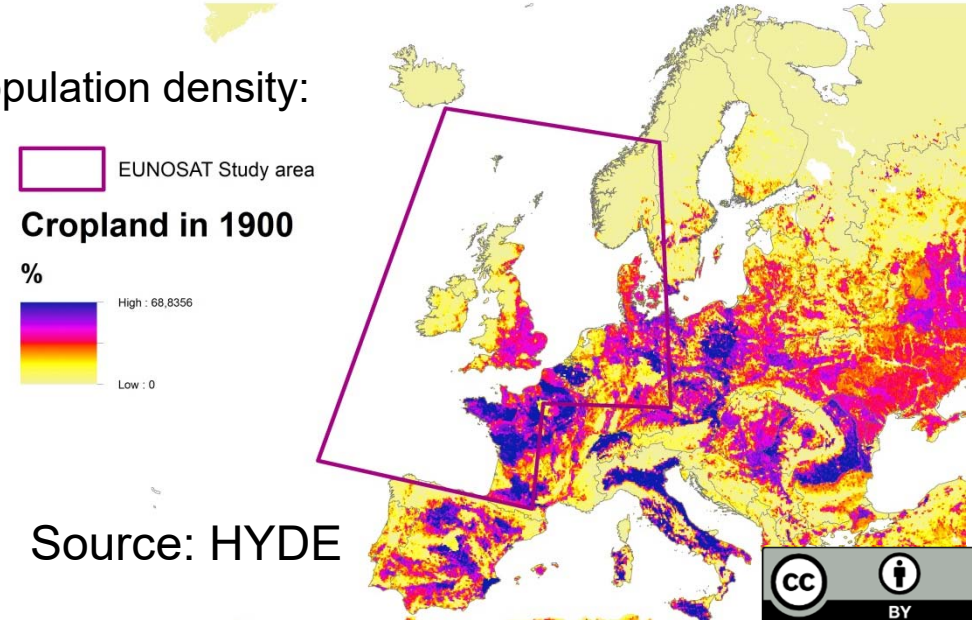
1900s-equivalent reference conditions

Purpose: to estimate reference loads under current climate and management

- Current climate data
- Existing water resource management (reservoirs, dams, tile drainage, canals)
- 1900s Land use: HYDE (Klein Goldewijk et al. 2010, Klein Goldewijk et al. 2011)
  - Agriculture
    - Crops kept the same; irrigation from HYDE
    - P fertilizer pro-rated (Smil 2000; no inorganic N available)
- 1900s Atmospheric deposition: Engardt et al (2017)
- 1900s Point sources and rural sources:
  - Urban and rural population from HYDE
  - PE (Schmid 2000 and others)
  - Treatment level determined by population density:

No human sources

- No load from Point and rural sources
- Crops converted to unmanaged pastures
- No fertilizers applied, no atmospheric deposition



Source: HYDE

Bartosova et al, in preparation

Socioeconomic conditions in 2050s

SMHI

SSP1: Sustainability

Increased plant-based diet, Reduced and more efficient agriculture

Population shifts to urbanized areas, High efficiency wastewater treati

Significant decrease in atmospheric pollution/deposition

SSP2: Middle of the road

Current diet and agricultural maintained

Slower increase in urbanization, Current wastewater treatment trends
Rural areas lag behind

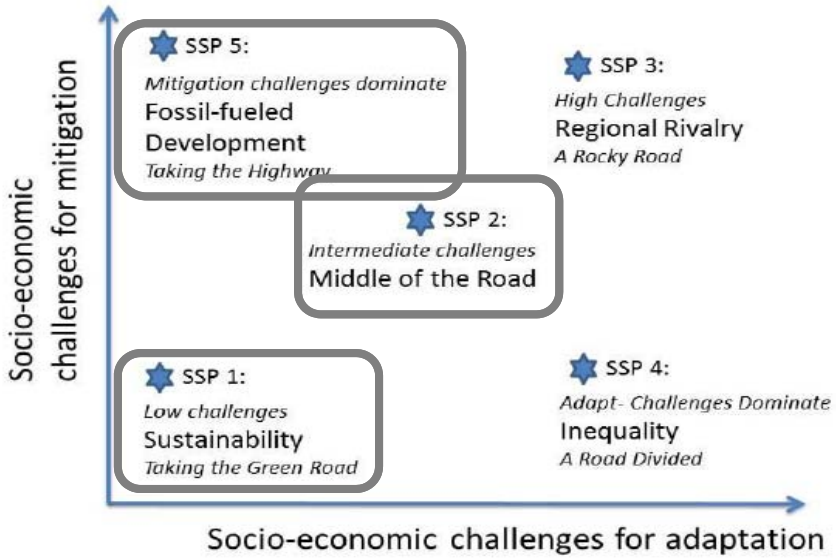
Decrease in atmospheric pollution follows current trends

SSP5: Fossil fueled development

Increased animal-based diet, Expanding agriculture with varying efficie

Population shift to highly urbanized areas, Varying efficiencies in wastewater treatment plants

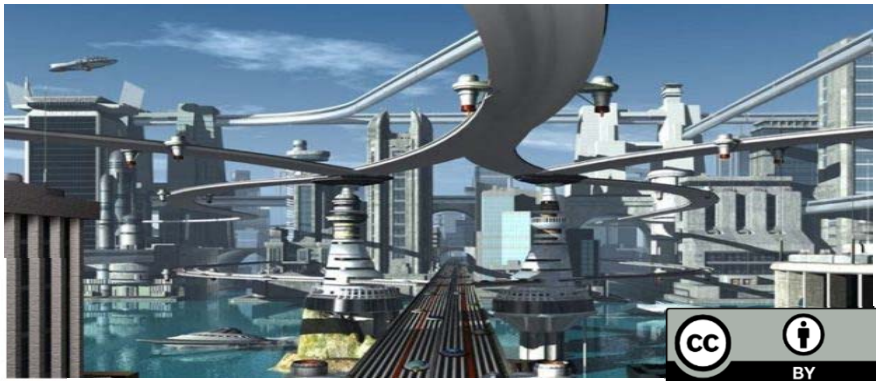
Slower decrease in atmospheric pollution/deposition



SSP= Shared Socioeconomic Pathway

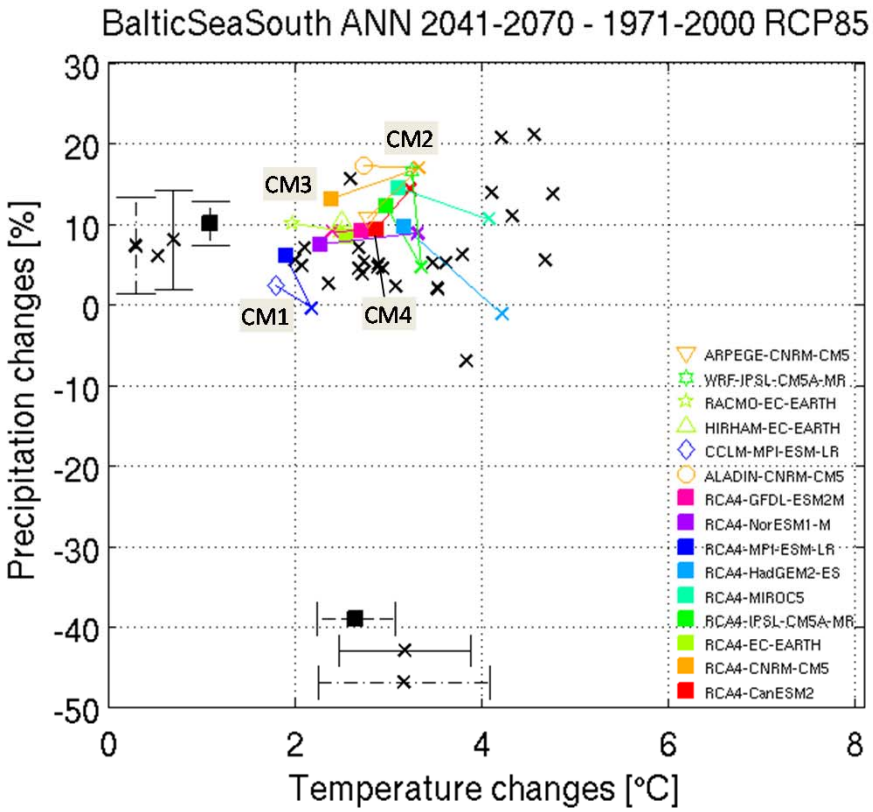
Average changes in	SSP1 Sustainable development	SSP2 Middle of the road	SSP5 Fossil fuelled development
Agricultural land use*	- 10%	0%	+ 10%
Livestock density	- 50%	0%	+ 50%
Manure nitrogen efficiency	+ 10%	+ 5%	- 10%
Applied effective nitrogen	- 5%	0 %	+ 5%
Atmospheric deposition of N	-40%	-30%	-15%
Urban wastewater**	-35% / -40%	-20% / -25%	-16% / -23%
Rural wastewater**	-30% / -30%	-17% / -17%	1% / -23%

Zandersen et al, 2019



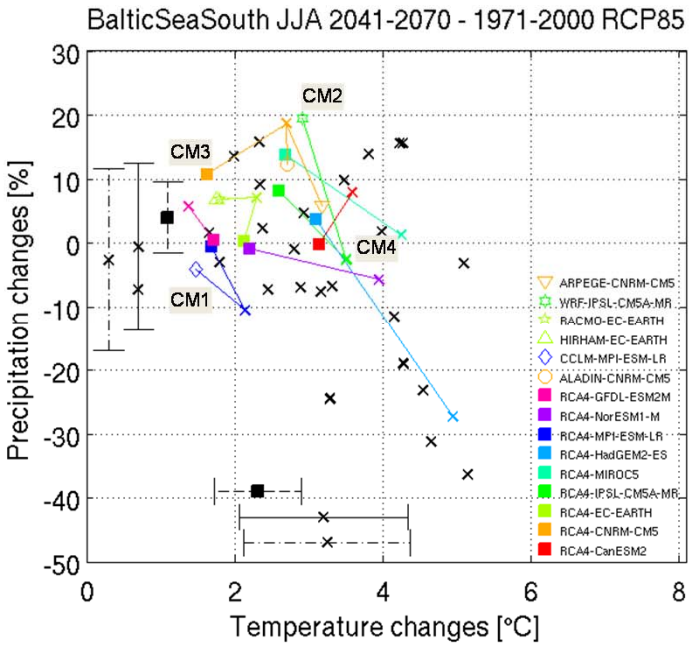
BONUS MIRACLE SOILS2SEA AARHUS UNIVERSITET

Climate conditions in 2050s (RCP8.5)



Change in annual averages

- Mini-ensemble of 4 climate models to bracket the impacts
- Ranges in both annual averages and summer averages represented

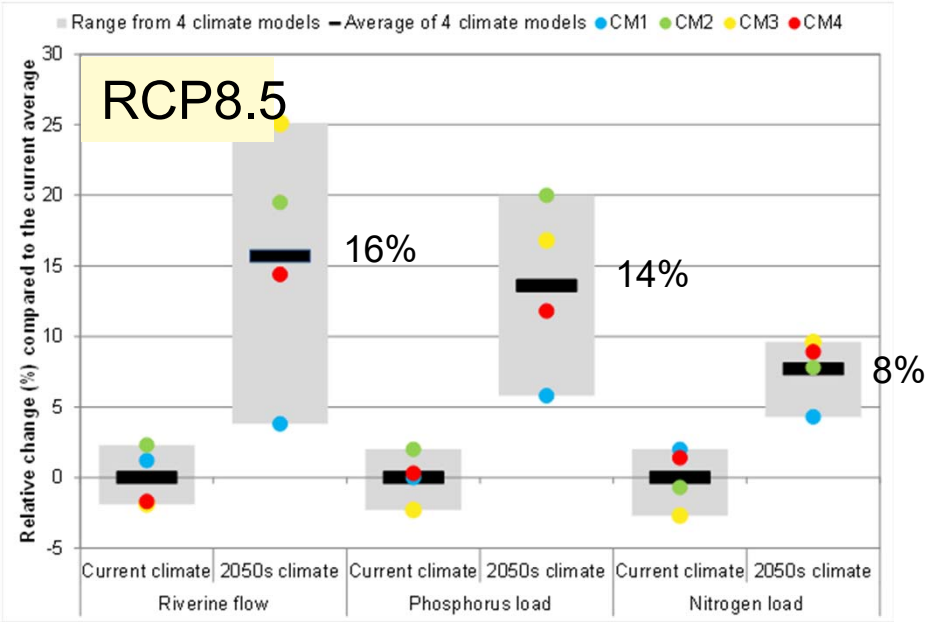


Change in summer averages

Bartosova et al, 2019

Bartosova et al, 2019

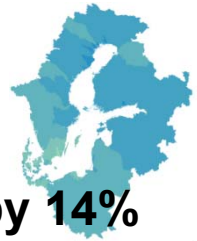
Inputs from land to Baltic Sea expected to increase due to the projected climate change



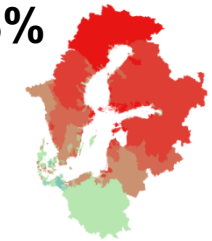
Runoff by 16%

Phosphorus load by 14%

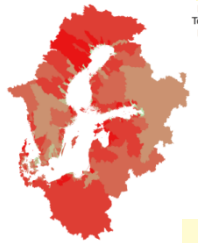
Nitrogen load by 8%



Runoff



Nitrogen

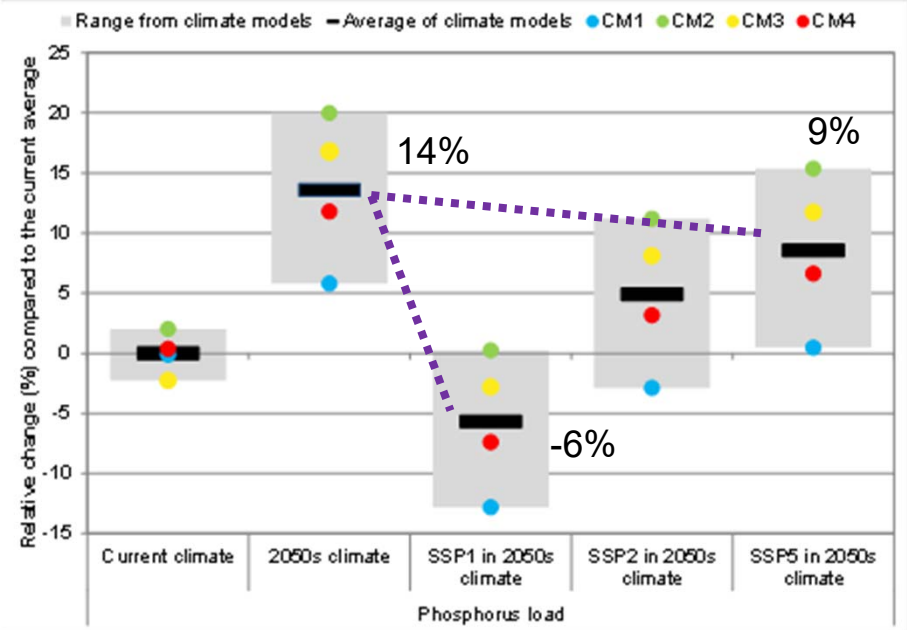


Phosphorus

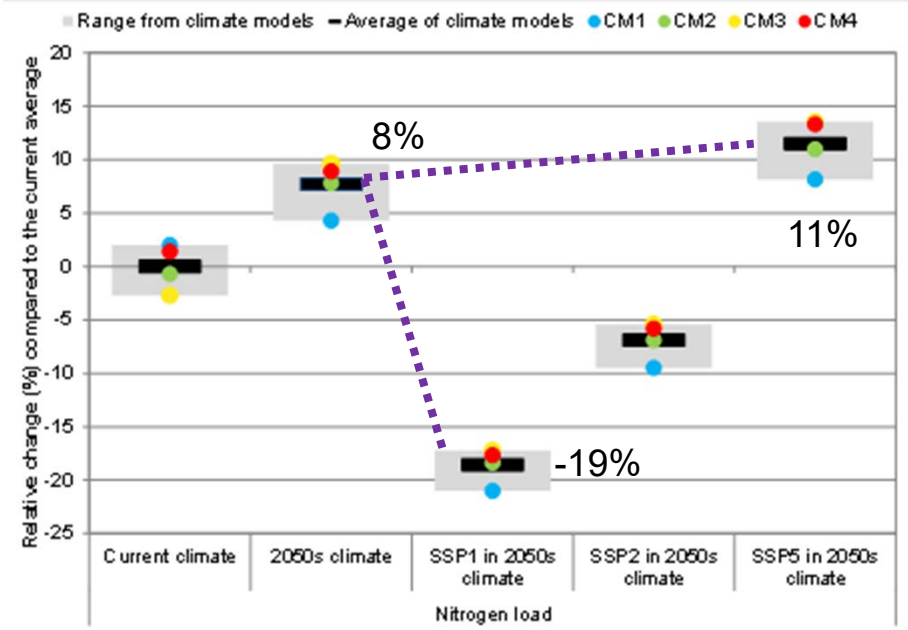
Bartosova et al, 2019

Socio-economics can play even more important role

Total Phosphorus Load



Total Nitrogen Load



- It can counteract or exacerbate the impact of climate
- Assumptions in SSP can be interpreted as measures targeting the N&P sources
- Note that socio-economic projections include projected climate impact

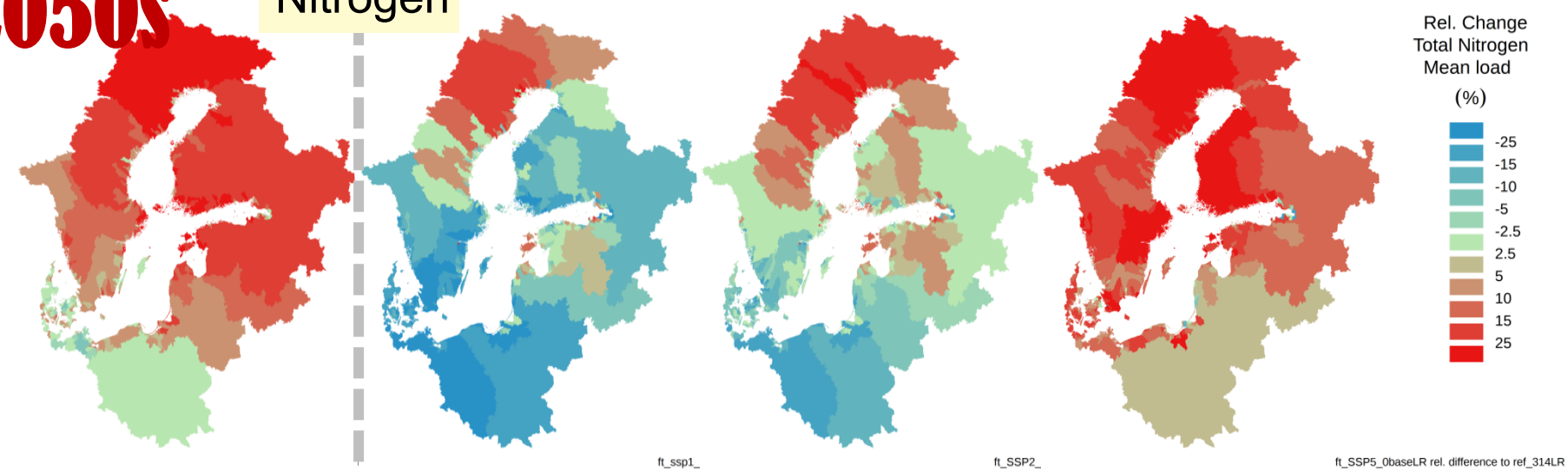
BONUS MIRACLE SOILS2SEA *Bartosova et al, 2019*

Different areas affected differently

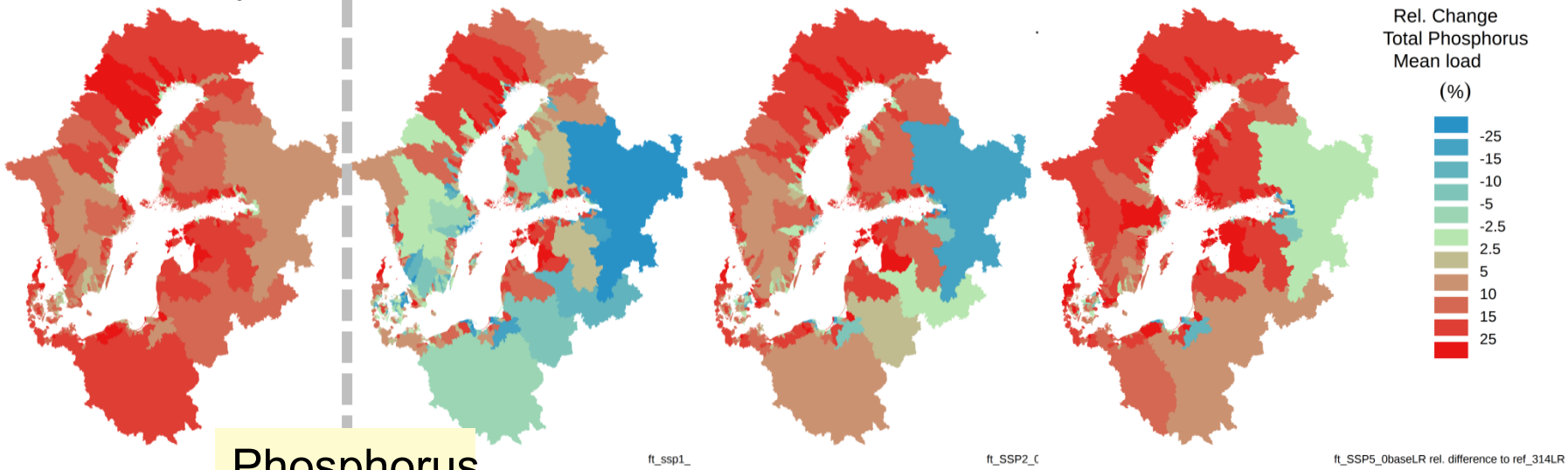
SMHI

2050s

Nitrogen



Climate only | Climate+SSP1 | Climate+SSP2 | Climate+SSP5

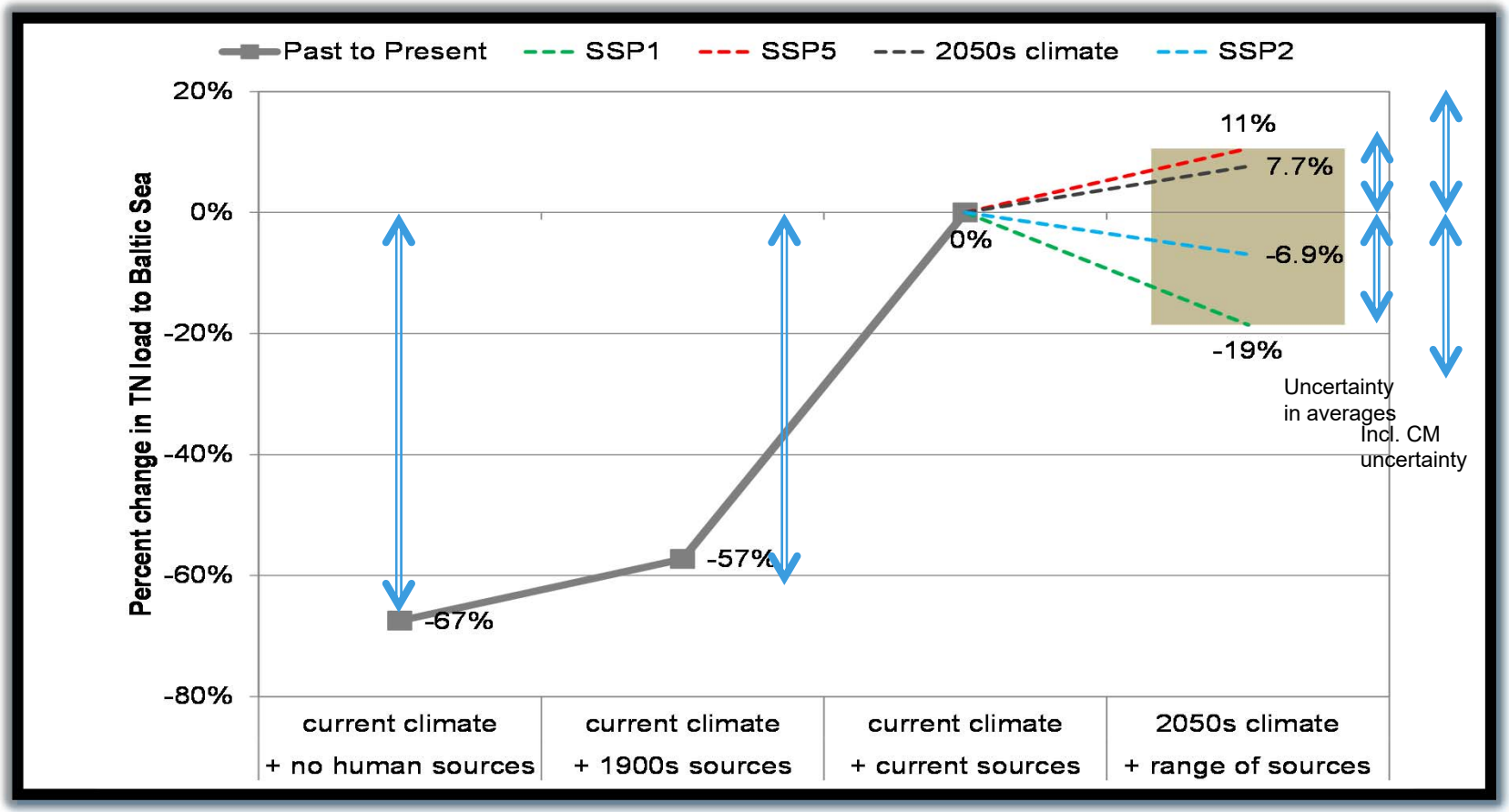


Phosphorus

BONUS MIRACLE SOILS2SEA

Bartosova et al, 2019

The past human impacts much larger than climate impact projected by 2050s



Bartosova et al, in preparation

Summary

- Nutrient loads increase by 2050s
- Choices we make as a society can mitigate or exacerbate the increase

- Our past impacts have already surparsed the additional impacts projected from now to 2050s;
- Future impacts, even if of a smaller magnitude, can have large consequences as they build on the past

http://hypeweb.smhi.se/soils2sea/

Bartosova, A., Capell, R., Olesen, J.E. et al. (2019). Future socioeconomic conditions may have a larger impact than climate change on nutrient loads to the Baltic Sea. Ambio 48, 1325–1336 doi:10.1007/s13280-019-01243-5

SMHI

Annual Open HYPE course:
September 2020, Norrköping, Sweden

Free and open to anyone with a technical background in hydrological modelling
"Get yourself a piece of the world": http://hypeweb.smhi.se