Uncertainties in Hydrological Predictions for the Baltic Sea:

In Today's and a Future Climate

Chantal Donnelly, Johan Strömqvist, Joel Dahné, Wei Yang, Patrik Wallman och Berit Arheimer
Department of Research, Hydrological Research, SMHI, Sweden

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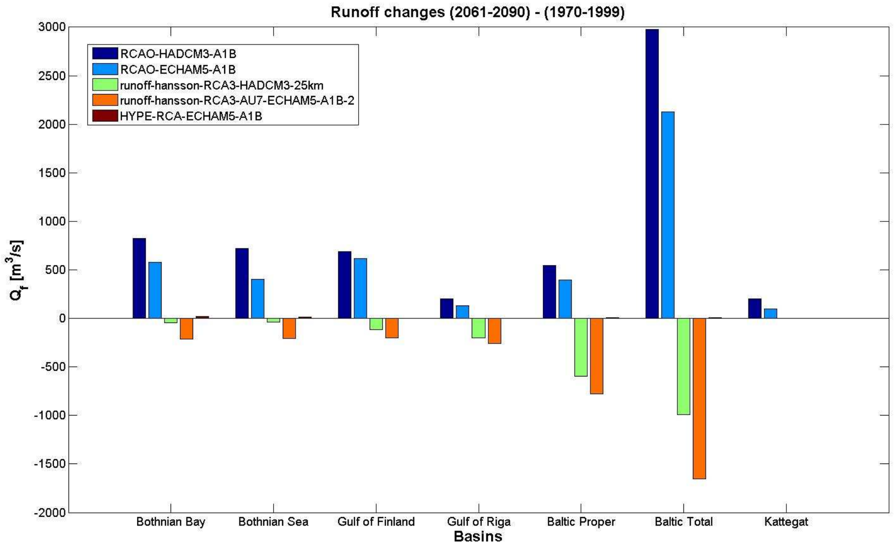
Will there be more or less freshwater/nutrients to the Baltic Sea??

- Estimates of ΔQ from Graham, Meier et al. 2006, Kjellström and Lind 2009, Hansson et al. 2010, varying from around -14 % to + 80 %.
- Our first estimate (ECHAM5-RCA3-A1B-50km) is for + 3 % increase (Balt-Hype)
- The only published estimates of changes to nutrient loads are based on assumptions of constant concentrations or simple empirical models. *Incorrect Assumptions!* (This study shows the need for a process based approach!!)



What affect's modelled hydrological scenario results?

- How well the model reproduces today's runoff and nutrient discharges
- Choice of climate scenarios, GCM/RCM combination and whether transient or time-slice runs.
- How to interpret the climate change scenarios: Precipitation, Temperature and Evapotranspiration as hydrological model inputs.
- Whether or not the model's process description responds correctly to changes in climate – Are processes 'climate-proof'?
- For N och P, what happens to the pools of nutrients in the ground over longer periods?
- Inputs to the Remedial scenarios: changes to farm management and waste water treatment
- Human Factors: Population change (demographics and behavioural changes), land-use changes, land management changes

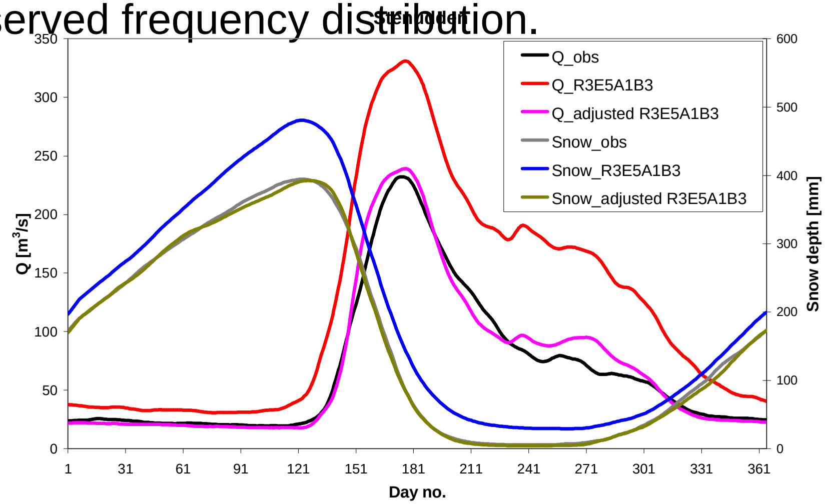
Inputs to the Climate change scenarios
Precipitation & Temperature

- ***Problem*** : Precipitation (and even temperature) from RCM over control period very different from actual. Can we use it to model hydrology?
- ***Interpretation of the GCM or RCM precipitation***:

  (a) Statistically downscaled from GCM

  (b) 'Delta' change method – the magnitude of the change from the climate model applied to today's climate

  (c) 'Bias Correction' – a statistical correction applied to RCM results such that the frequency distribution of rainfall events for a control period from the RCM matches the observed frequency distribution.

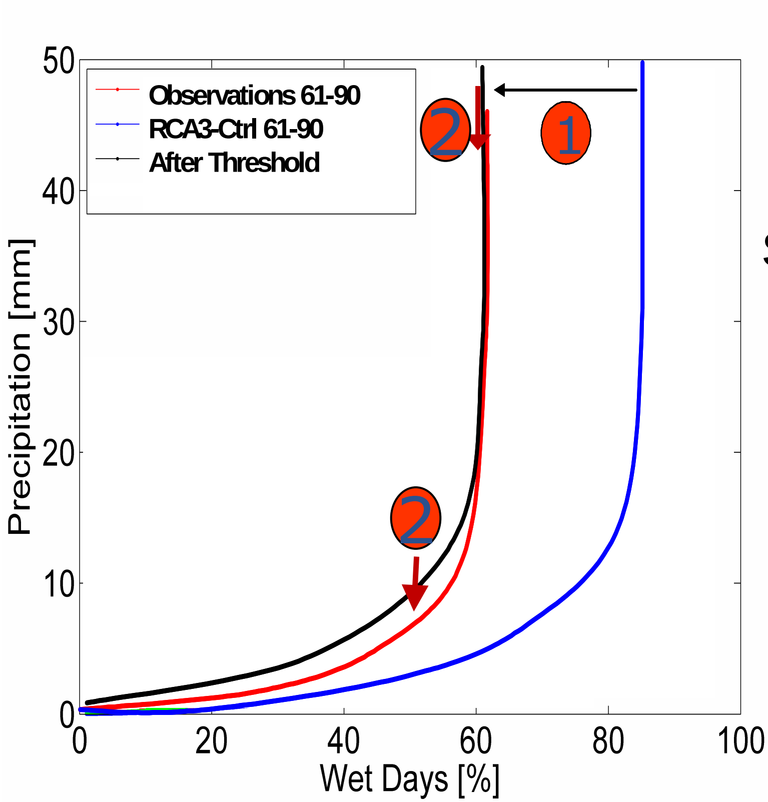


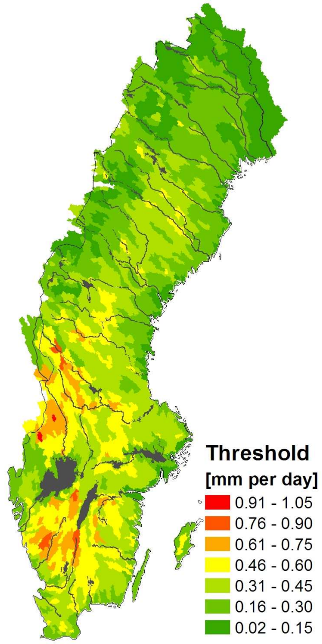
Distribution-Based-Scaling (DBS) method

Scale daily precipitation:

Step -1:

Identify a threshold value





Step-2 : Adjust rainfall intensity

- **Probability distribution well suited for precipitation**
- **Parameters are estimated for both observations and RCM-control (4 seasons)**

  ⇒ Scaling factors

Inputs to the Climate change scenarios

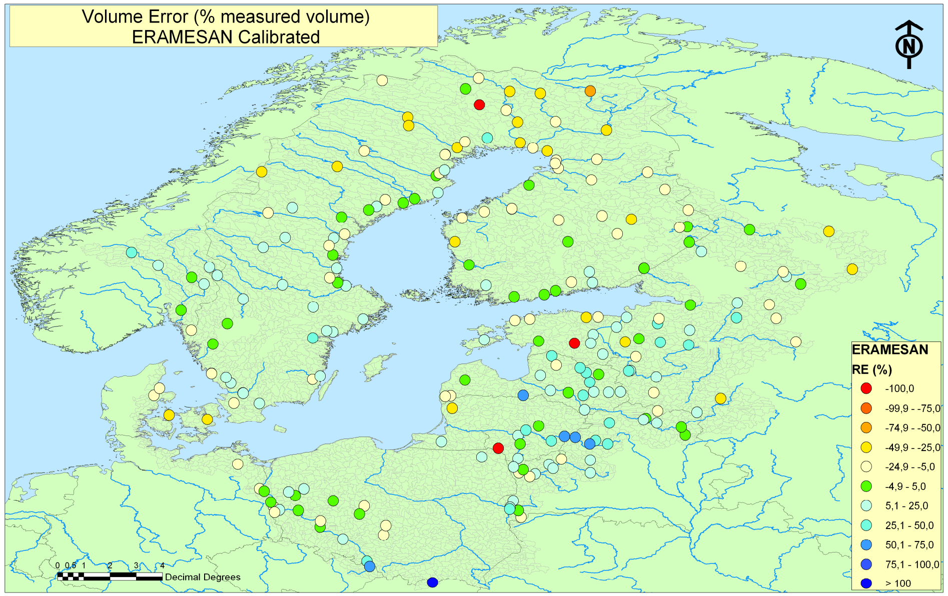
Evapotranspiration

- Using evapotranspiration directly from climate models usually gives incorrect water balance (systematically) and are generally high (Lind och Kjellström)
- State-of-the-art hydrological models still recommend using simple empirical temperature or temperature & radiation equations (Oudin et al. 2005)
- Therefore ΔE from climate model is not equal to ΔE from hydrological model

Which ΔE *should we use?*

$$E_{pot} = k * (T-T_o)$$

Is the hydrological method robust?



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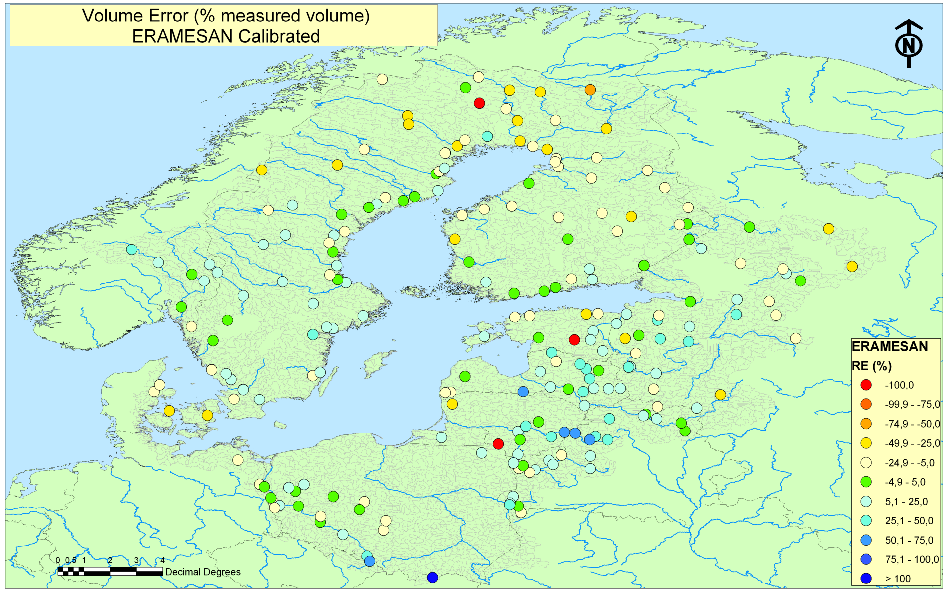
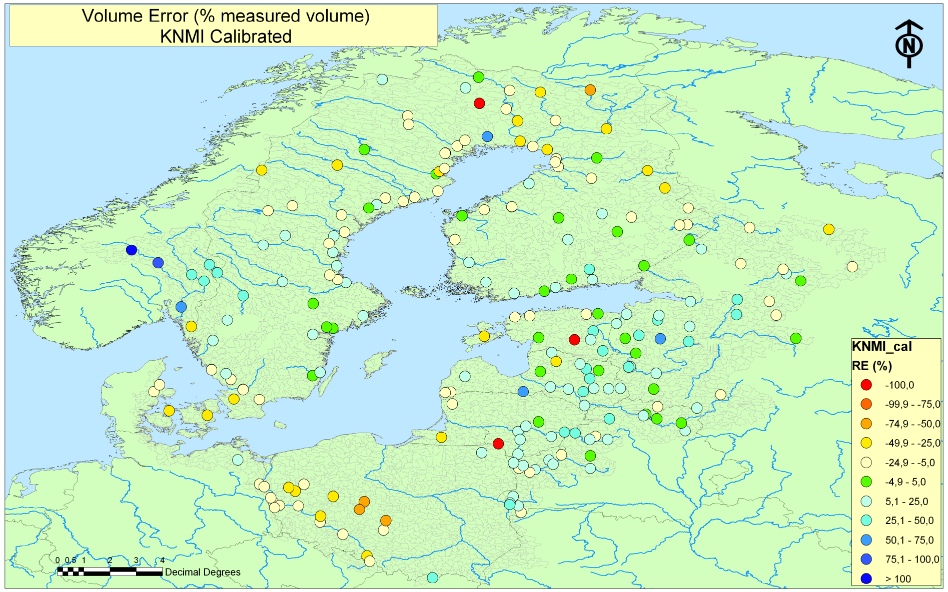
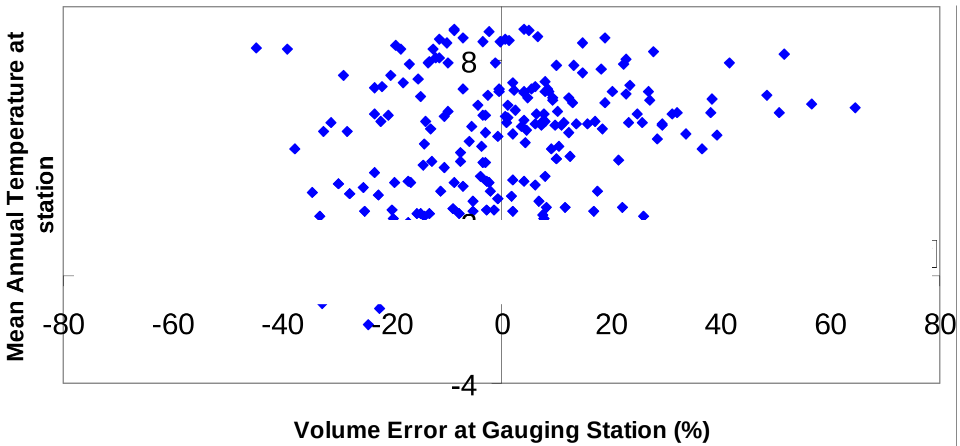
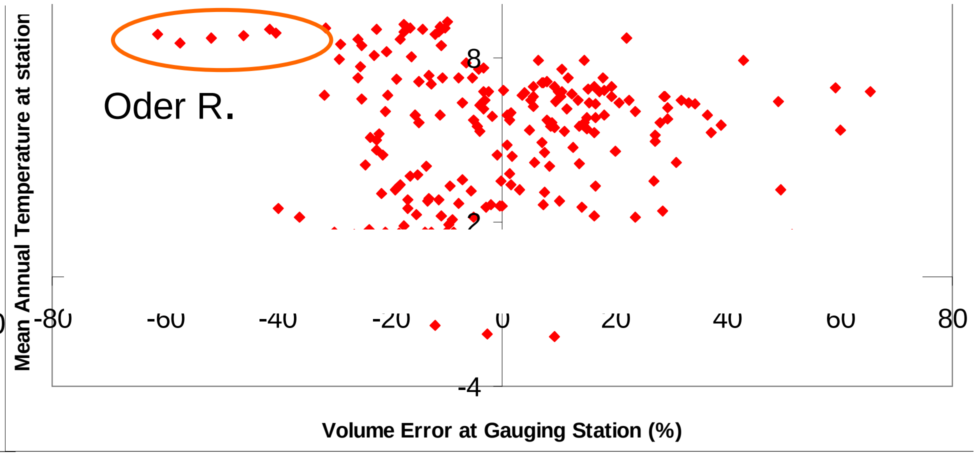
Inputs to the Climate change scenarios

Evapotranspiration









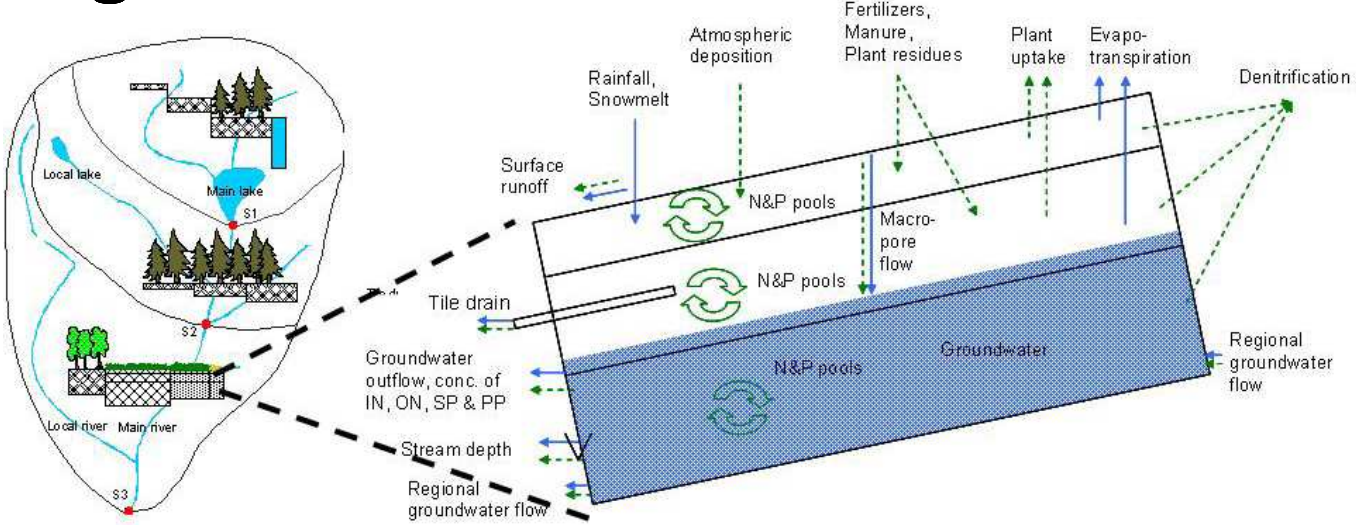
‘Climate-Proofing’ Models

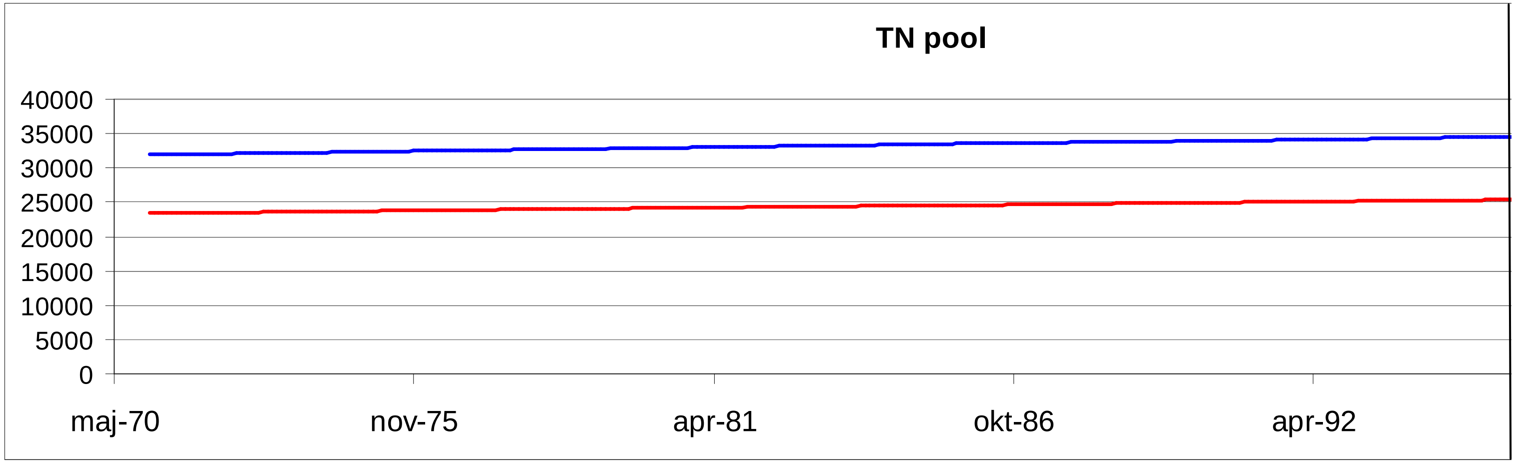
Particularly important in hydrological models which parameterise many processes

- *Which processes are climate dependent?*
- *Are the climate dependencies of these processes correctly represented in the hydrological model’s process descriptions?*

- Evapotranspiration: $E = f(T)$, or $E = f(k + \textit{other variables}?)$
- Glaciers: Need to connect to a glacier model with dynamic volume
- Ice damming of rivers: No T linked process description as yet.
- Mineralisation of N and P = Empirical f(T)
- Erosion of particulate P = Empirical f(vegetation cover, runoff)
- Denitrification in soil and water = Empirical f (T, residence time)
- Crop Growth Seasonality

Long-Term Development of N and P Storage in the Soil: 'Pools'





CLIMATE RUNS (ECHAM5-RCA3-A1B, 50km)

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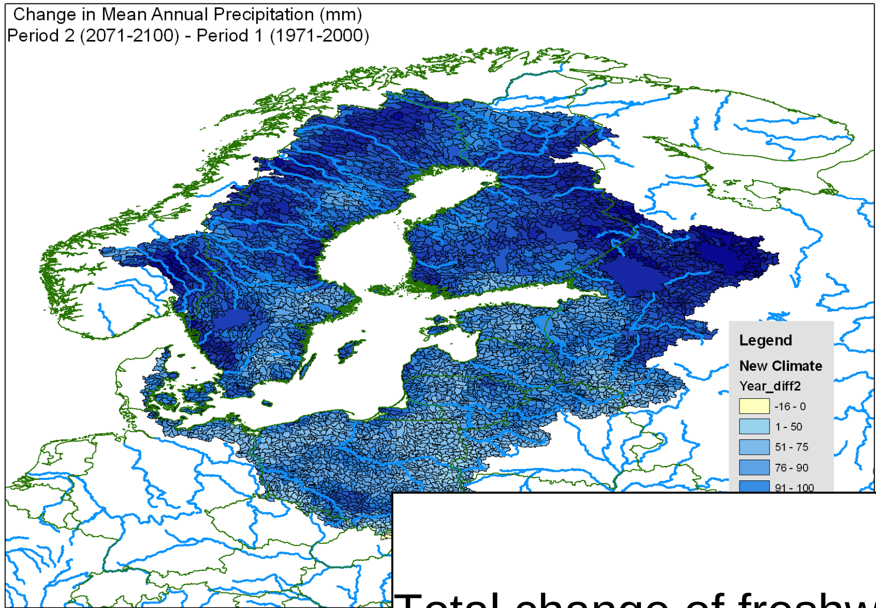
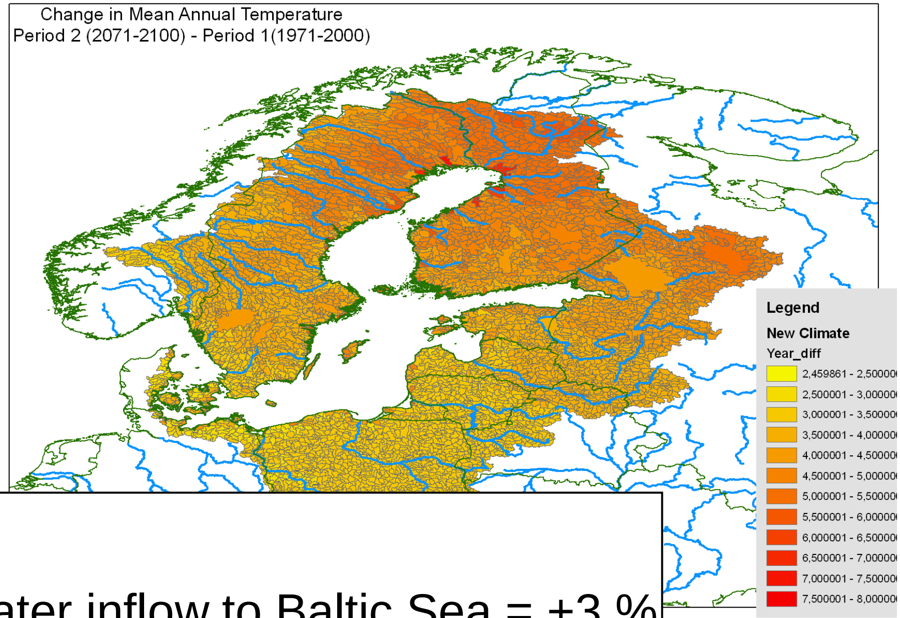
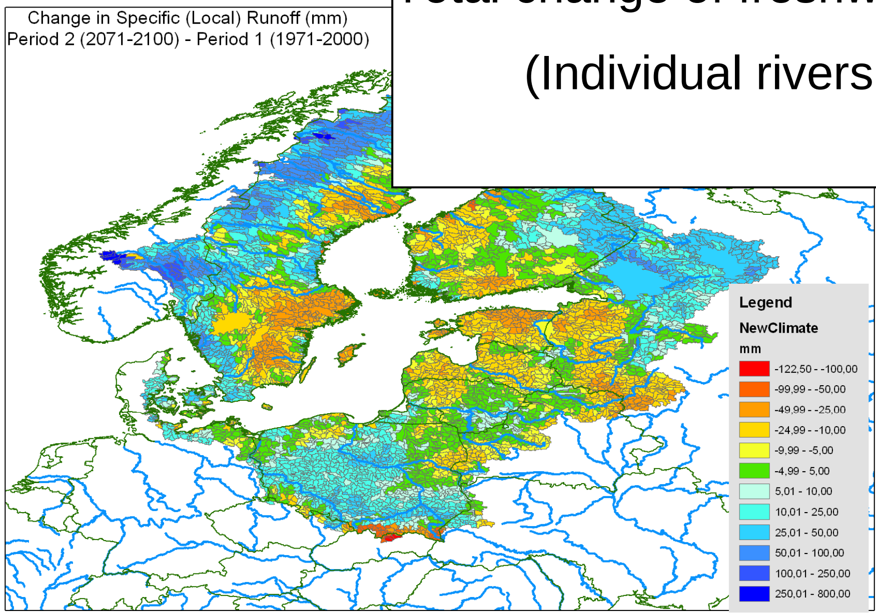
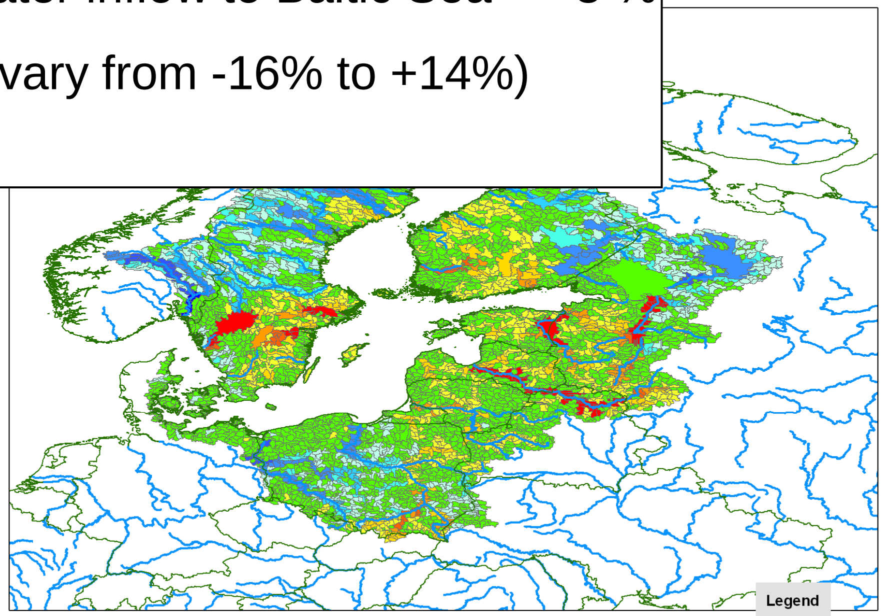




Total change of freshwater inflow to Baltic Sea = +3 %

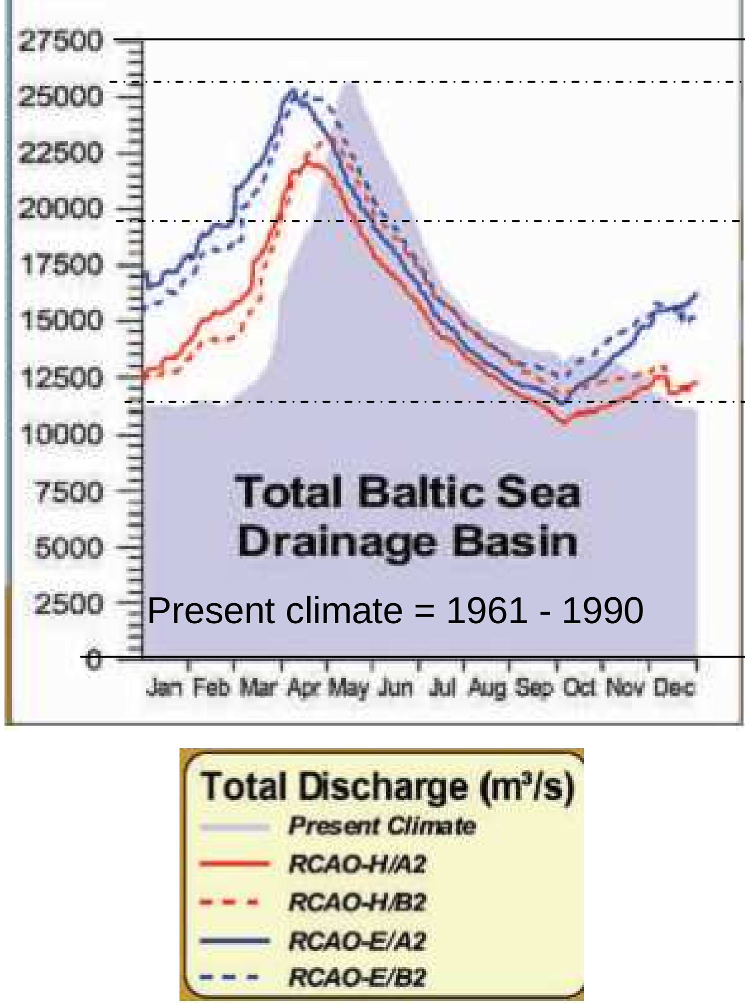
(Individual rivers vary from -16% to +14%)

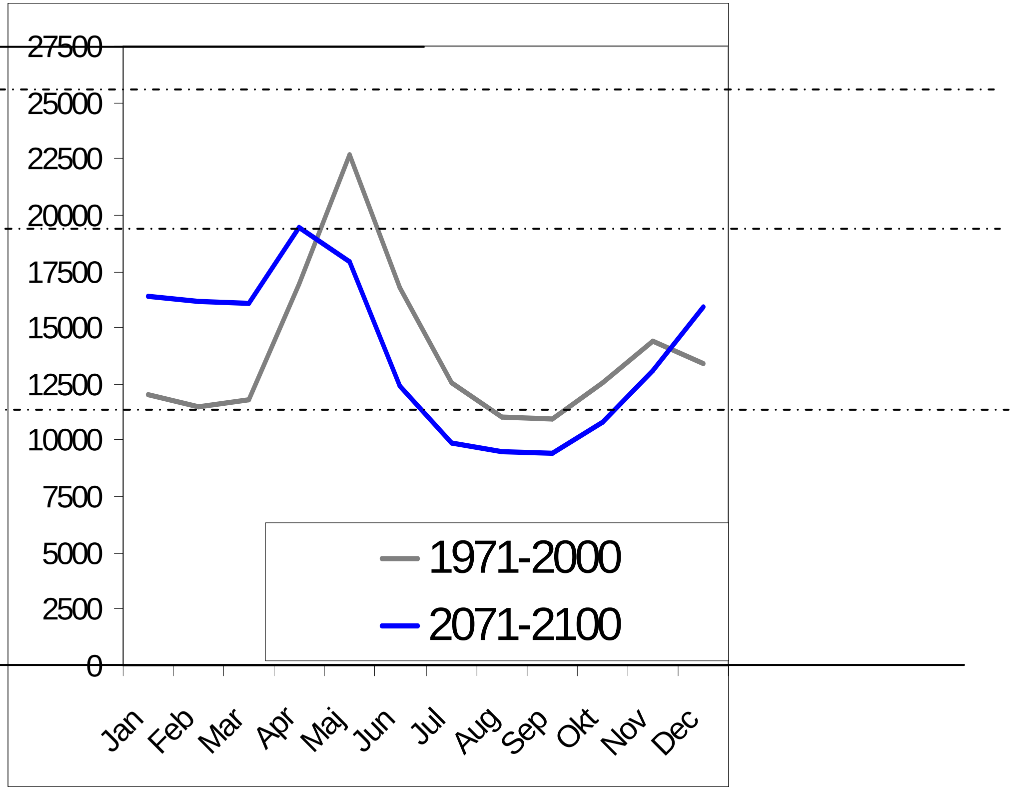




Comparisons, ΔQ, with Previous Studies

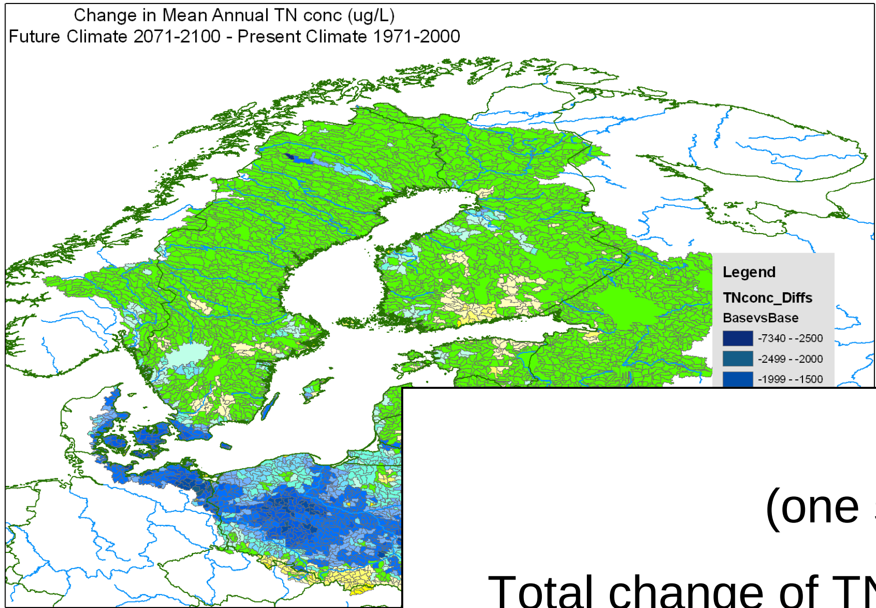
Graham et al. 2004, Ambio

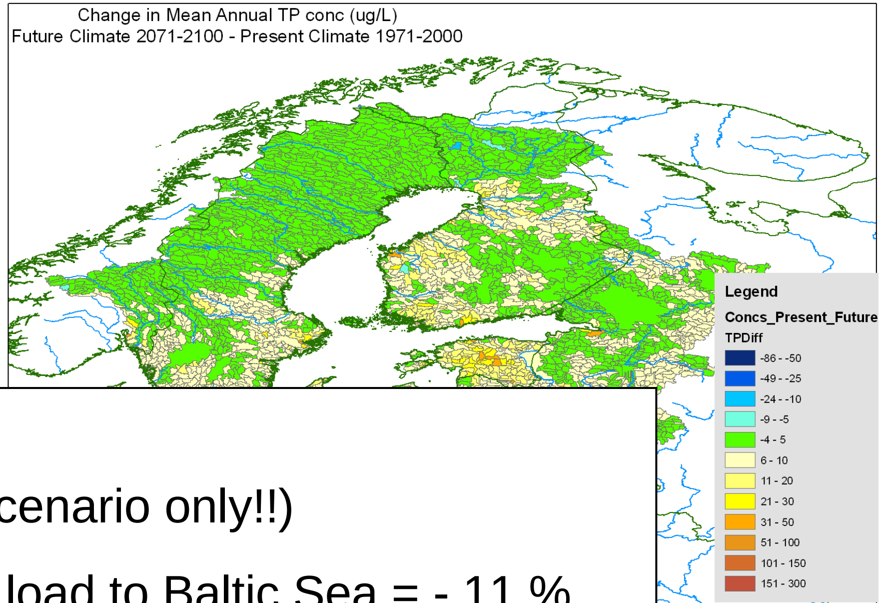




RCA3-E/A1B

Water Quality (N and P transports)





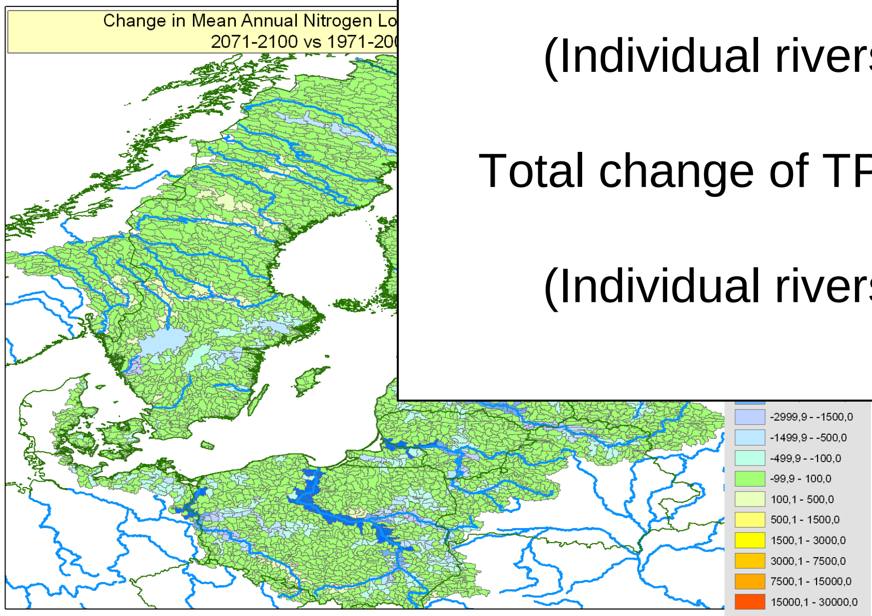
(one scenario only!!)

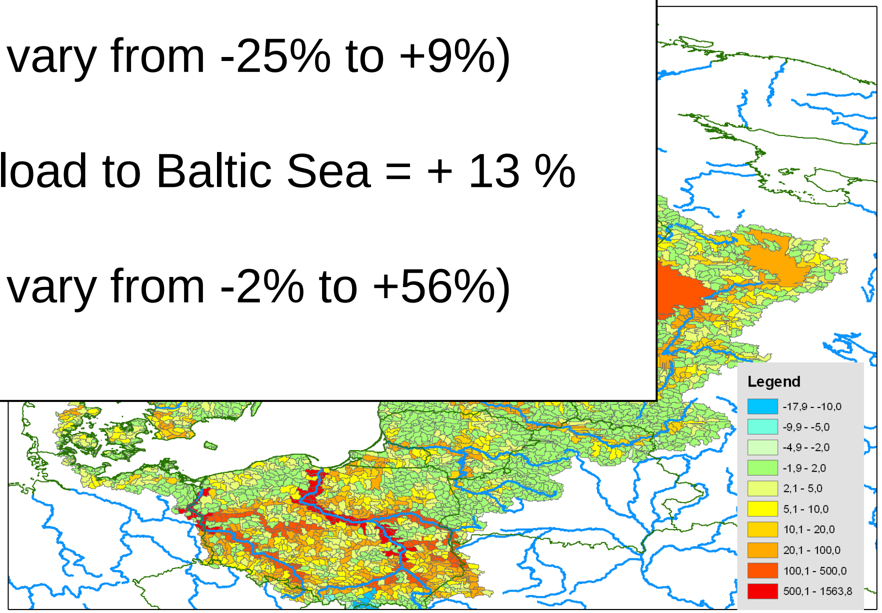
Total change of TN load to Baltic Sea = - 11 %

(Individual rivers vary from -25% to +9%)

Total change of TP load to Baltic Sea = + 13 %

(Individual rivers vary from -2% to +56%)





THANKS FOR YOUR ATTENTION

The hydrology research team at SMHI

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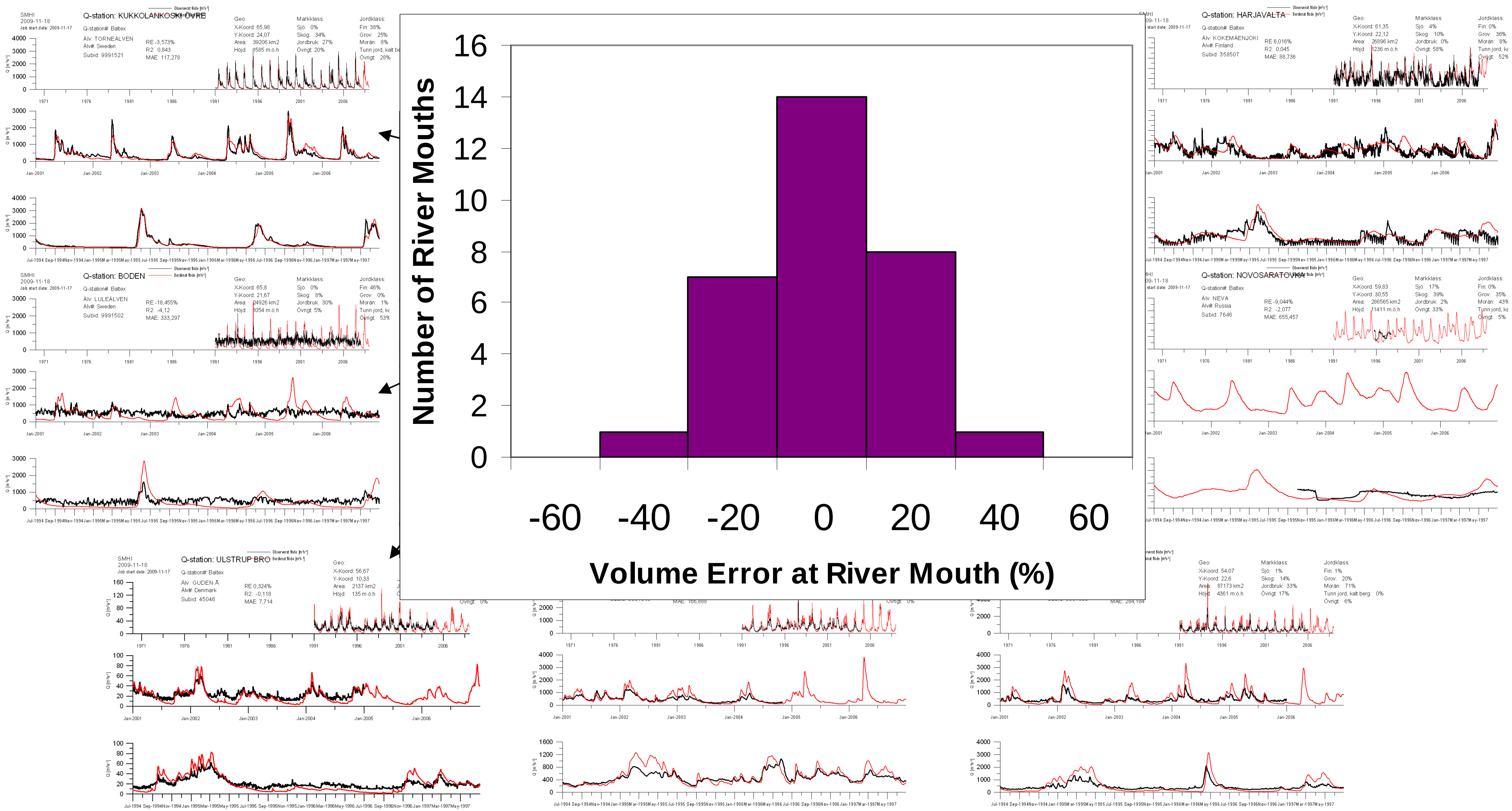
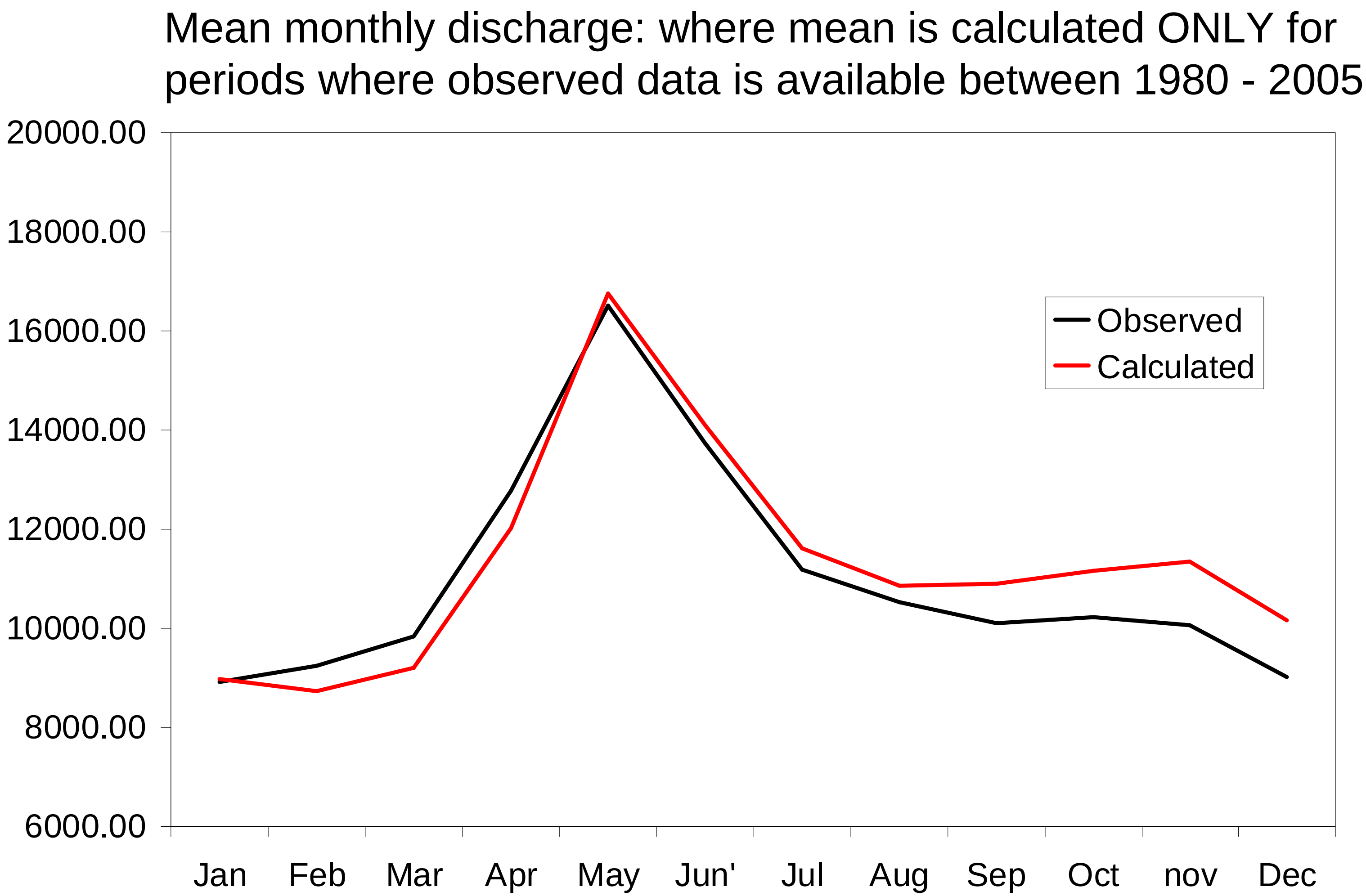
Today's Runoff and Nutrient Discharges

Discharge at Major River Mouths



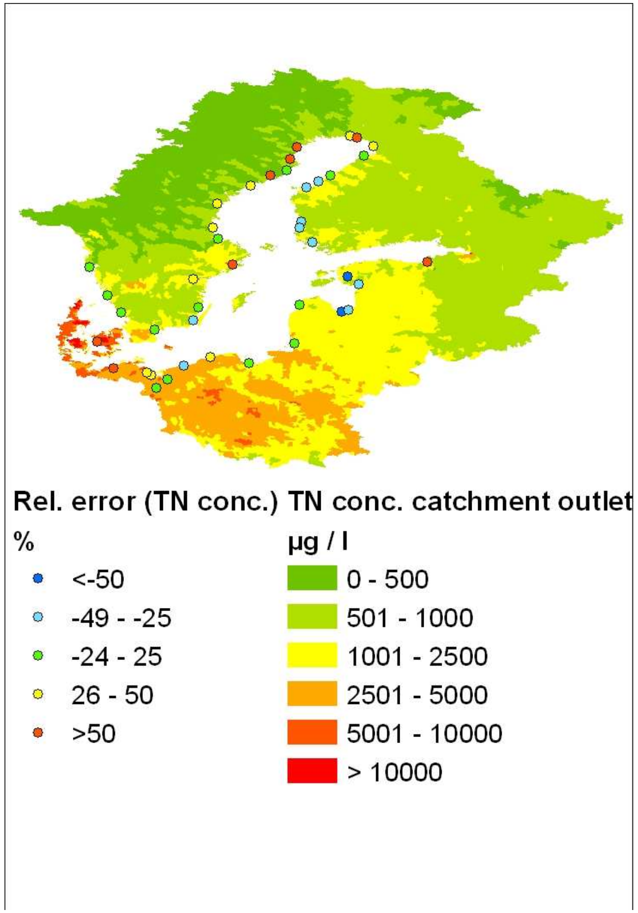
Today’s Runoff and Nutrient Discharges

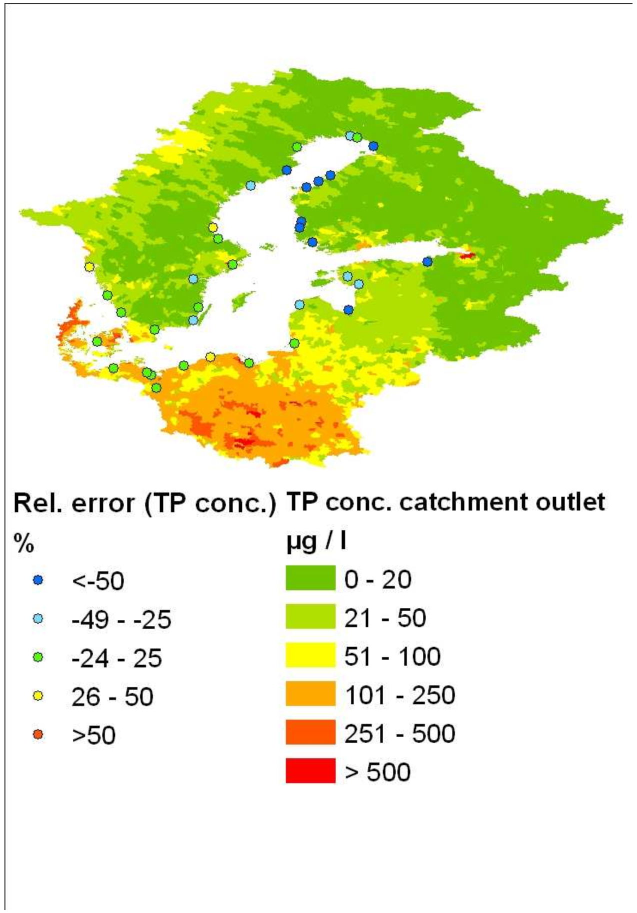
Seasonal Discharge Patterns



Today's Runoff and Nutrient Discharges

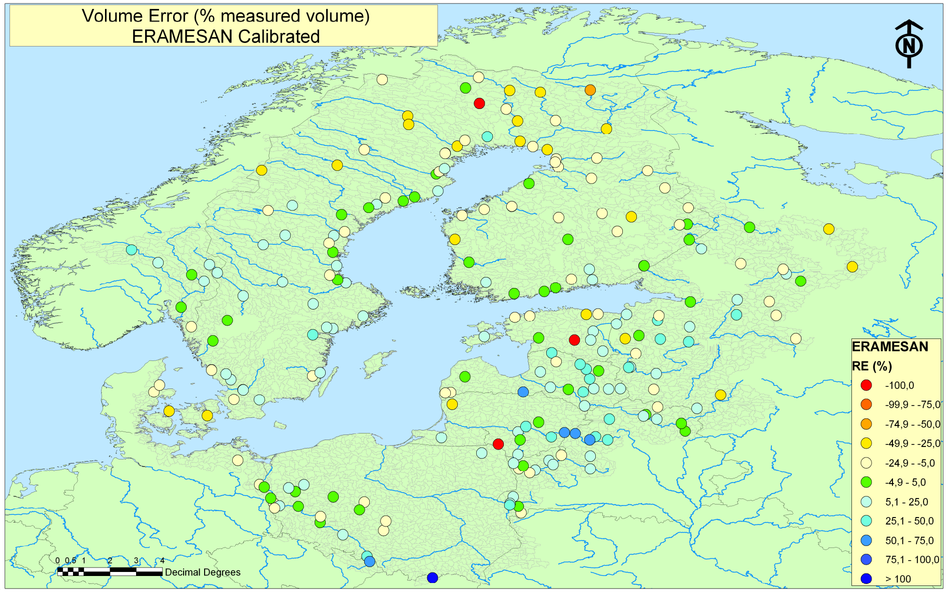
Nutrient Inflows

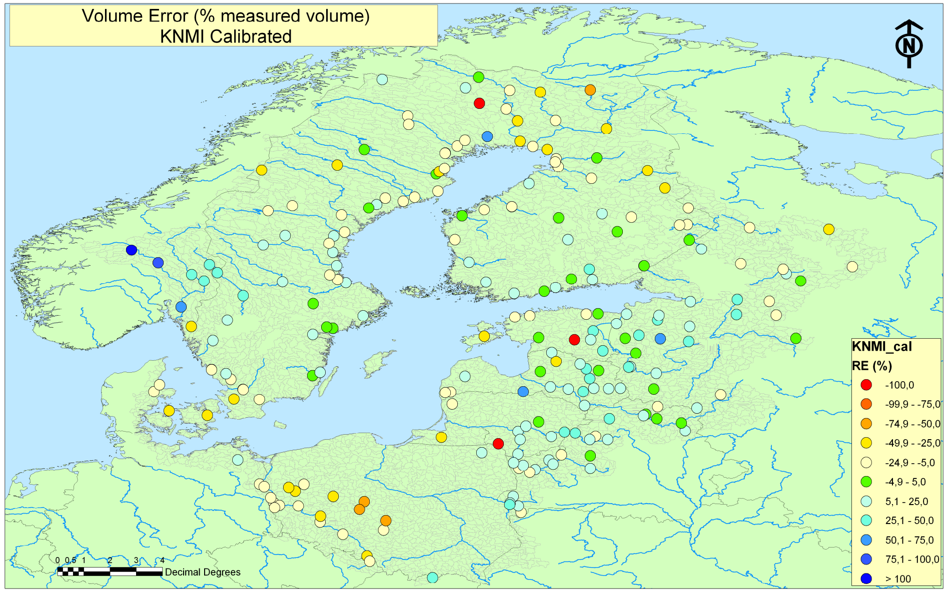


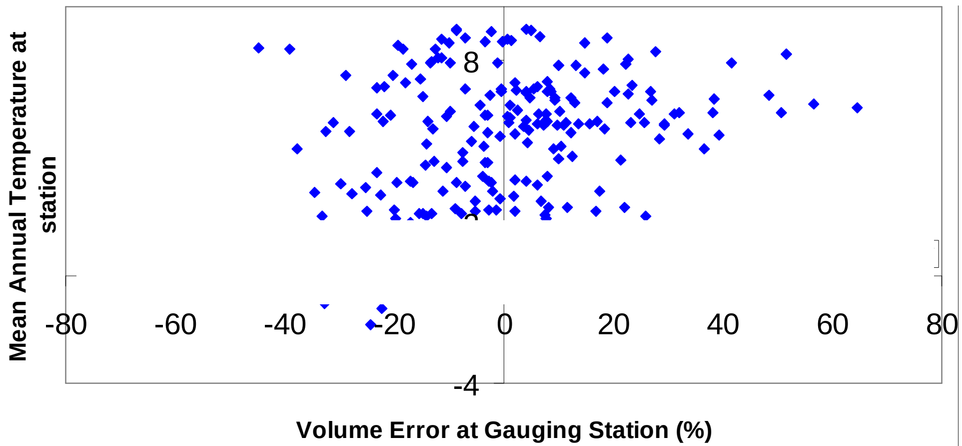


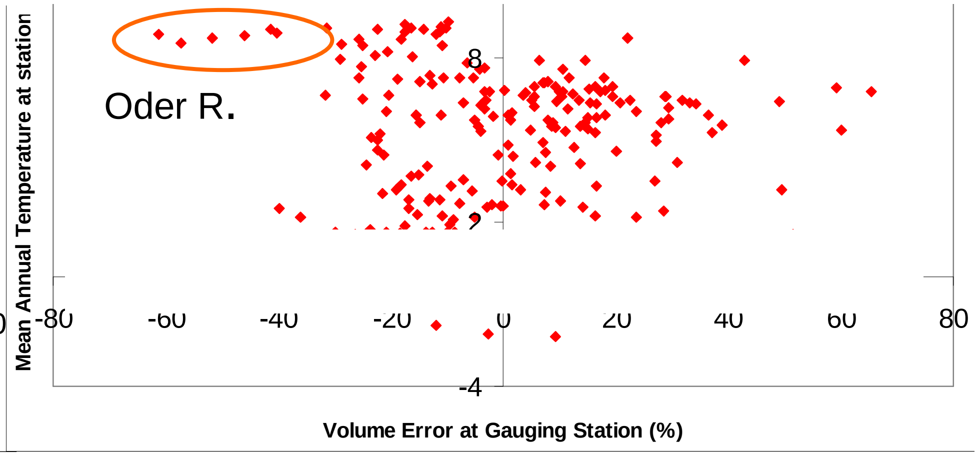
Inputs to the Climate change scenarios

Evapotranspiration









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Evapotranspiration