

Hydrological Predictions for the Arctic Environment



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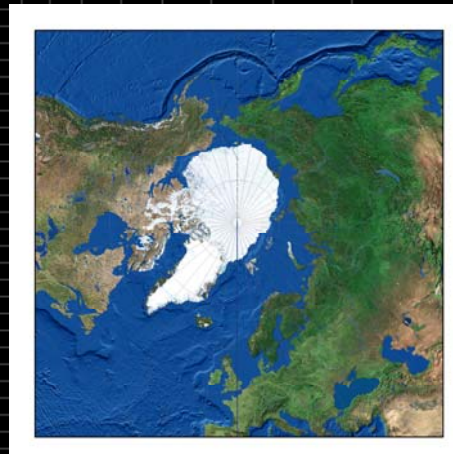
Outline:

HYdrological Predictions for the Environment (HYPE) model

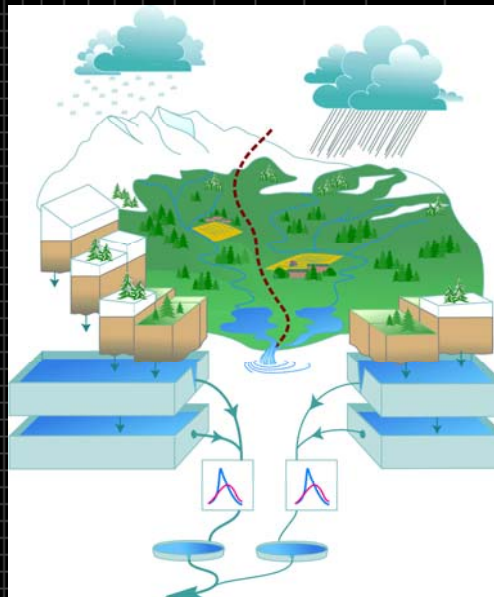
Model support systems

Global databases and needs of satellite data

Model output for sustainable exploitation of the Arctic?



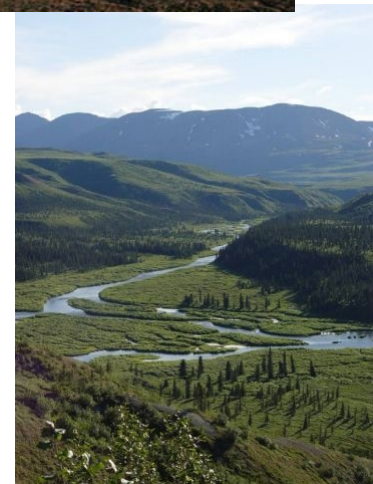
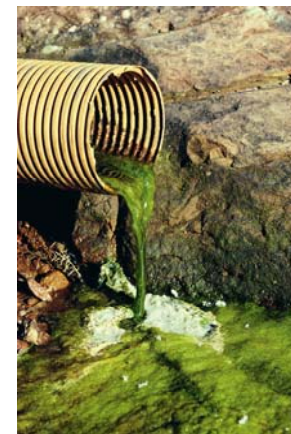
HYdrological Predictions for the Environment (HYPE) model



Objectives:

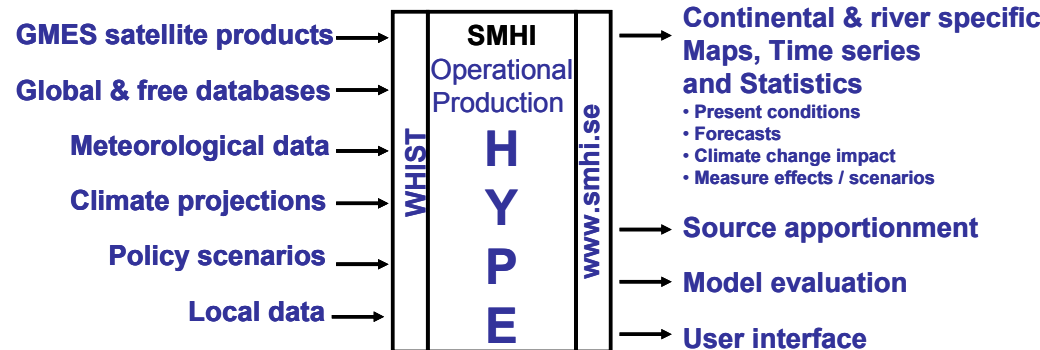
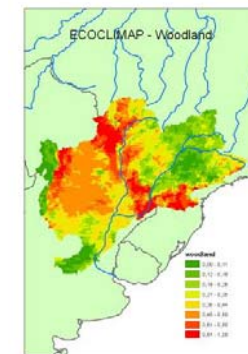
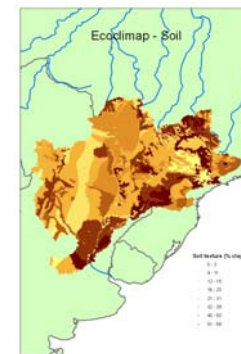
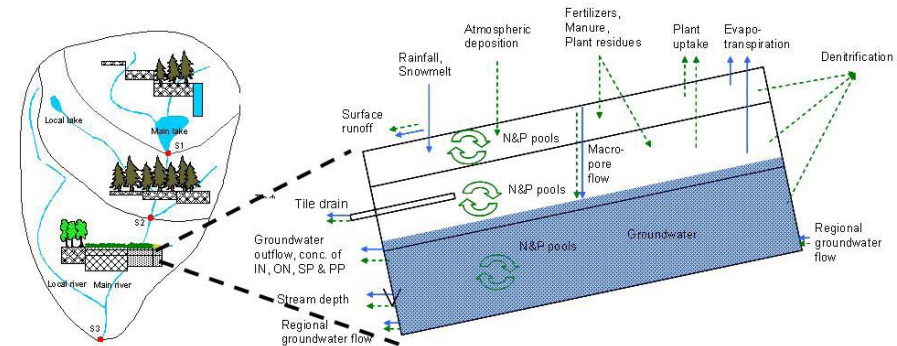
Provide a modelling tool that, on a daily timescale, and at a high spatial resolution:

- Calculates many hydrological variables, incl. water discharge and/or nutrient concentrations *at any site in the basin and to the Seas*.
- Can be used *operationally* to give *past* and *current* conditions and *forecast* all variables.
- Can be used as a tool for examining the effects of *climate change*, *landuse change* and/or *nutrient reduction scenarios*.
- Uses quality–assured data and is *calibrated* and *validated* according to sound scientific principles.



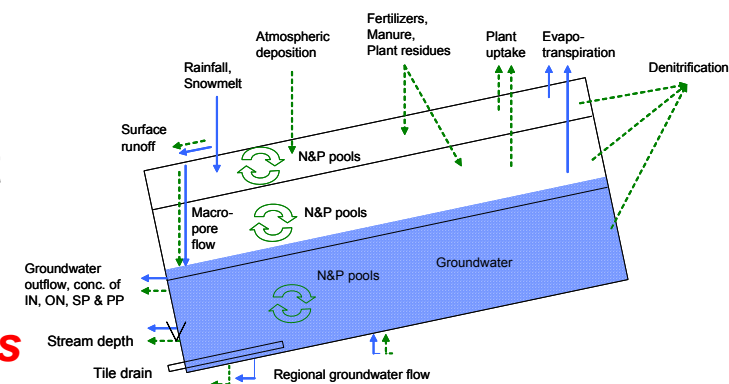
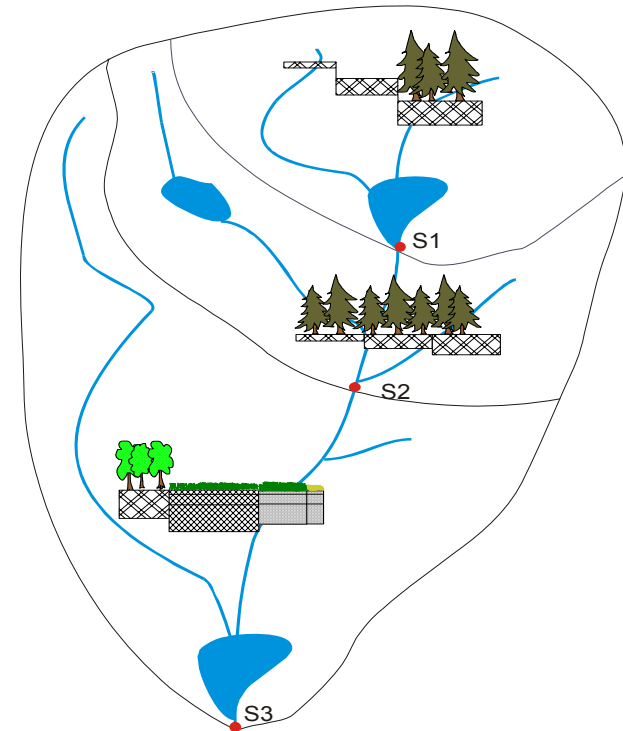
What is required for hydrological data production?

- Modelling tool: HYPE = Hydrological Predictions for the Environment
- Access to data required by model
- System for streamlining input data handling and model set-up: HYSS + WHIST
- Hydrological modelling competence
- SMHI's operational systems: e.g. technical forecast infrastructure, quality assurance
- Web services for data deliverable to stake-holders



Introducing the HYPE model:

- New, daily time-stepping, hydrological model based on widely accepted hydrological concepts (SMHI/HBV)
- Integrated modules for hydrological compartments and flowpaths, nutrient and conservative tracers
- Wide range of parameters modelled (runoff, turn-over, soilmoisture, snowdepth, groundwaterlevel, N, P, O¹⁸)
- Model already used at local, regional and pan-European scale for research purposes, and LaPlata
- A Pan-Sweden model (> 17 000 basins) has already been set-up, calibrated and placed into production at SMHI
- ***Introduces the ability to model very large regions at high resolution simultaneously***

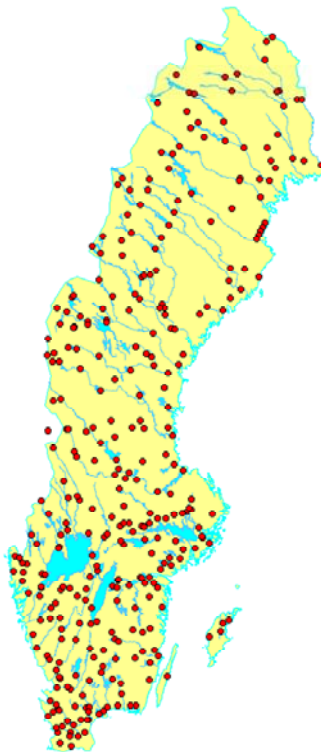


Models for predictions in ungauged basins

All models are wrong – but some may be useful!

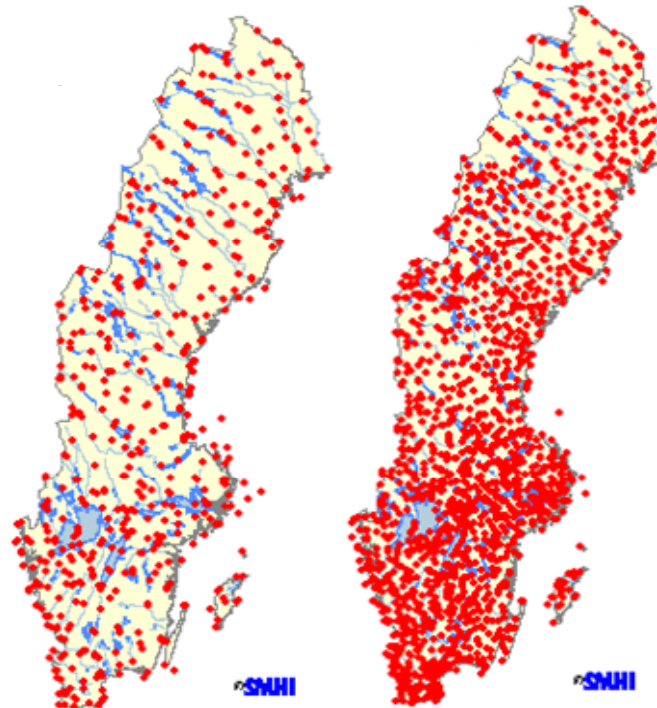
20 000 fresh-water bodies and 600 coastal zones in Sweden

300 Water discharge

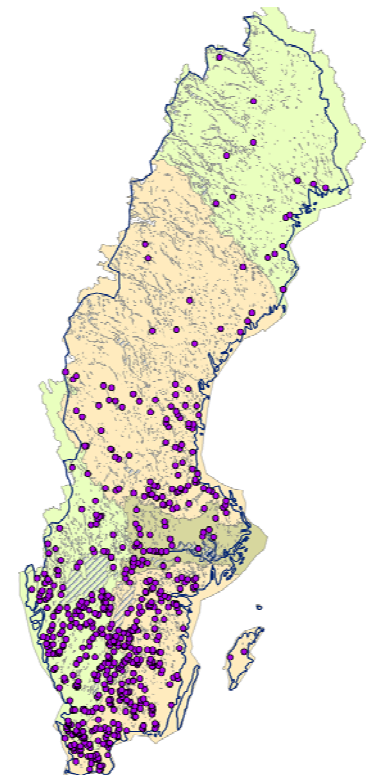


Forcing data:

300 Temperature, 800 Precipitation



900 Nutrient conc.



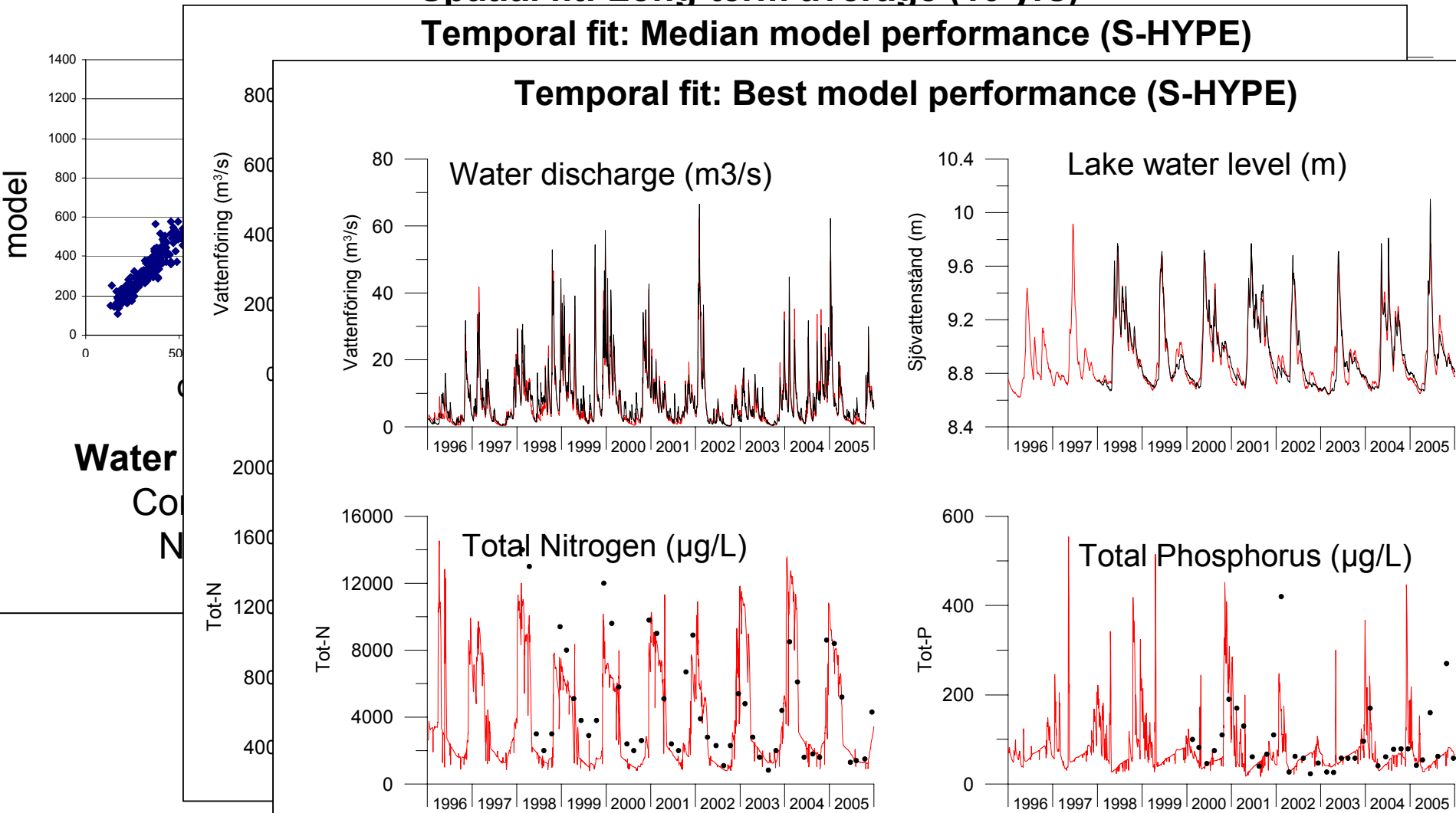
Sweden = 450 000 km²

Models for predictions in ungauged basins

Spatial fit: Long-term average (10 yrs)

Temporal fit: Median model performance (S-HYPE)

Temporal fit: Best model performance (S-HYPE)

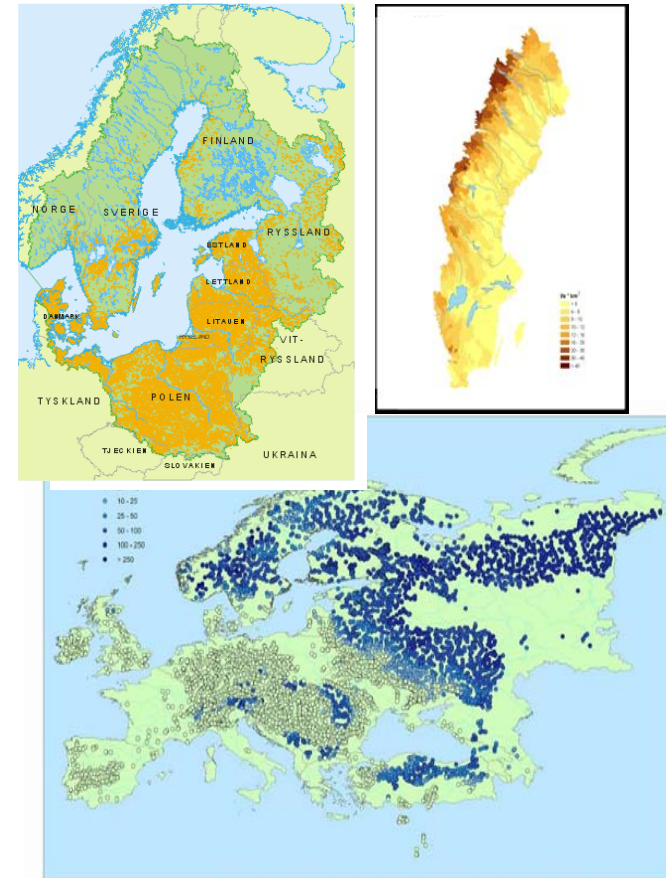


Model applications so far

- Sweden (**S-HYPE**): 450 000 km², 17 000 subbasins, 15 yrs
- Baltic Sea basin (**Balt-HYPE**): 1.7 milj. km², 5000 subbasins, 140 yrs
- Europe (**E-HYPE**): 7 milj. km², 8500 subbasins, 20 yrs
- La Plata basin (**LPB-HYPE**): 3.6 milj. km², 4000 subbasins, 30 yrs

Possible:

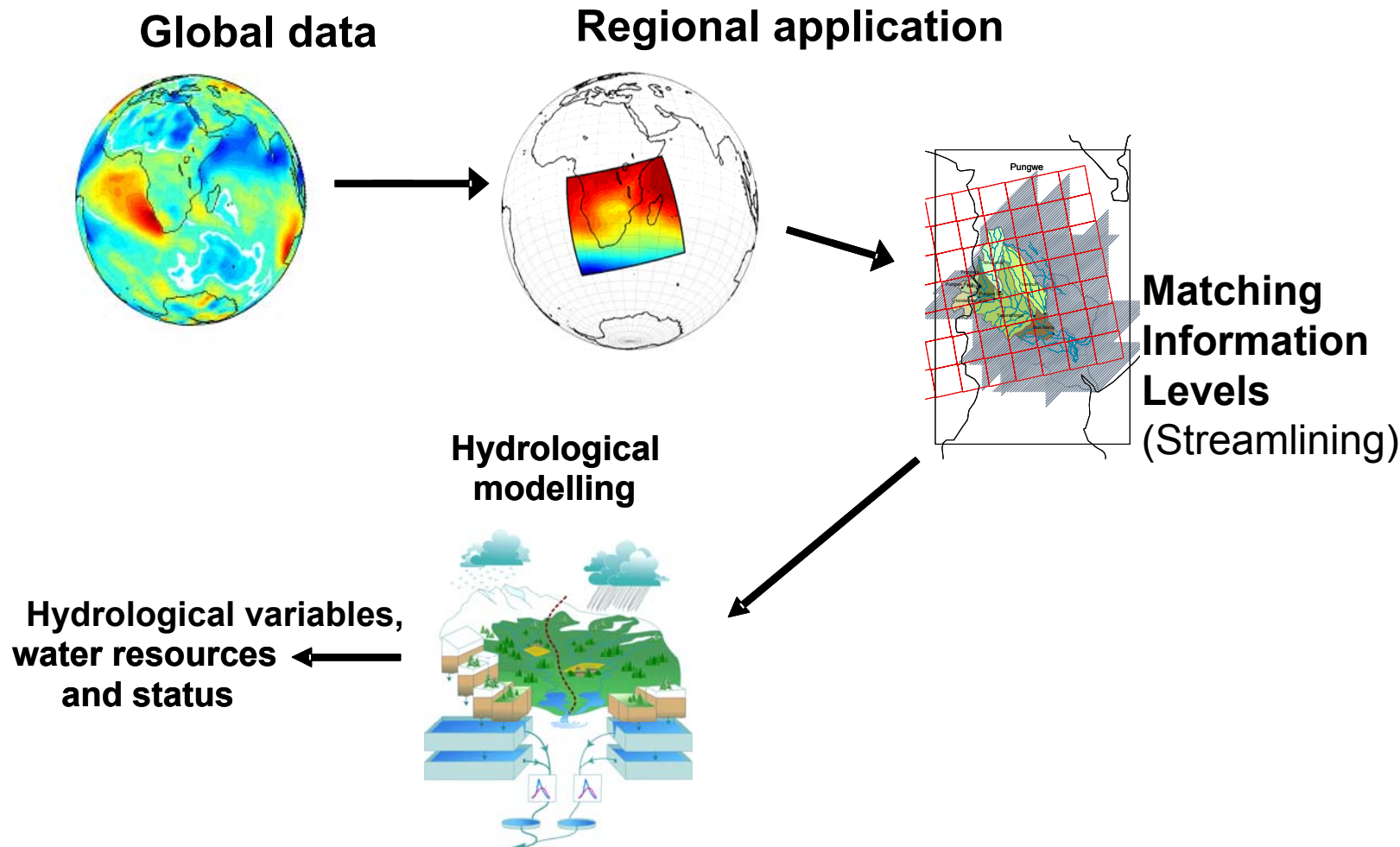
- Arctic (**Arc-HYPE?**): 2.9 miljoner km², 290 subbasins, 140 yrs?



Model support systems



Input data on relevant scale



Not just a model: Model support systems

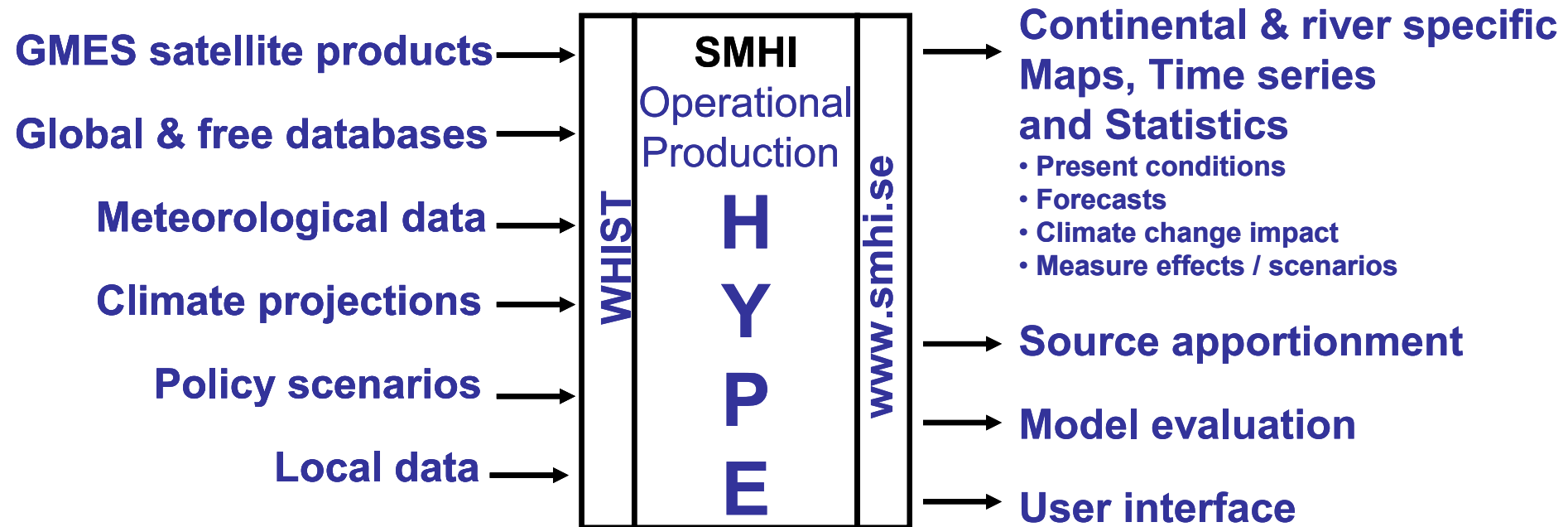
World Hydrological Input Set-up Tool (WHIST):

- Handles input data
- Can increase the model area and resolution without increasing model complexity
- Easy to compile input data to model new areas from existing (and free) databases

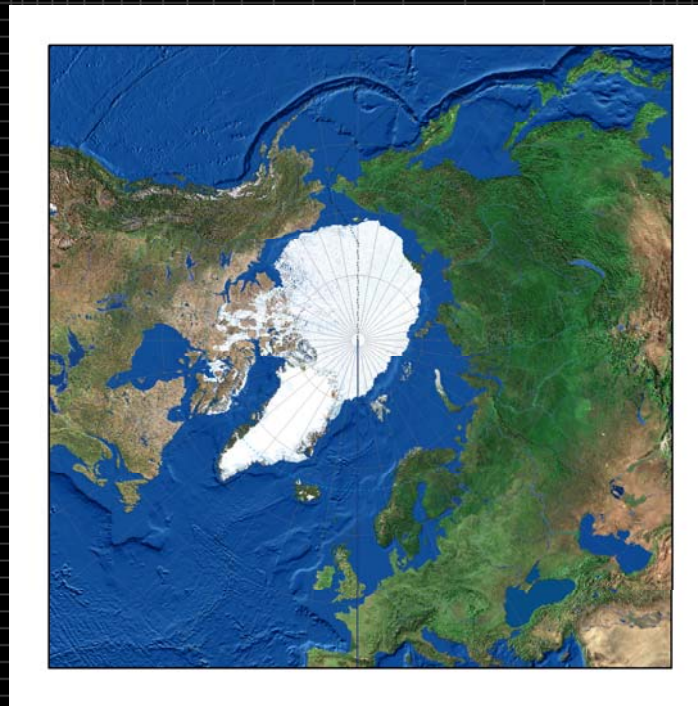
HYdrological Simulation System (HYSS):

- New environment for hydrological modelling
- Allows for different hydrological models to be used in the same modelling environment
- High portability, easy to extract submodels for stand-alone applications.

Not just a model: A production system

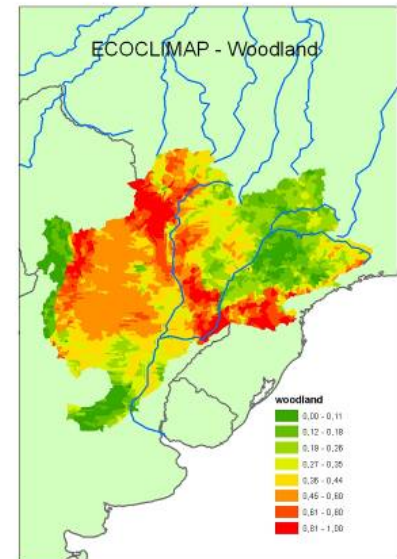
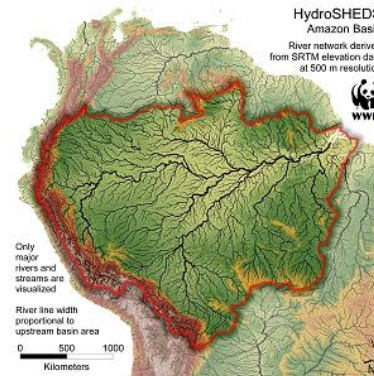


Global databases and future needs



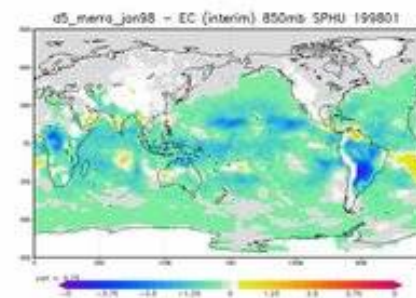
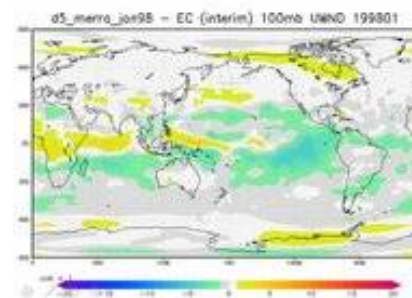
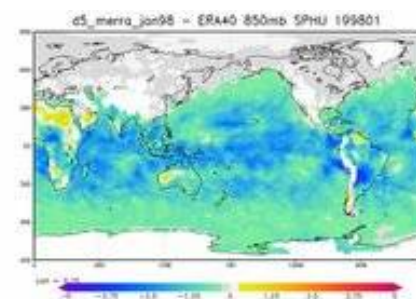
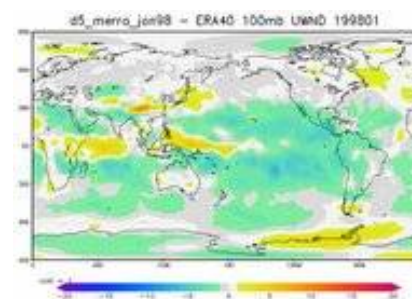
Readily Available Global Databases

- Topography: Hydro1k, Hydrosheds (USGS)
- Land use + soil: ECOCLIMAP (1 km), (MeteoFrance)
- Forcing data (P & T): A combination of ERA-40/Interim, and forecasts (ECMWF)



- Major Dams: ICOLD

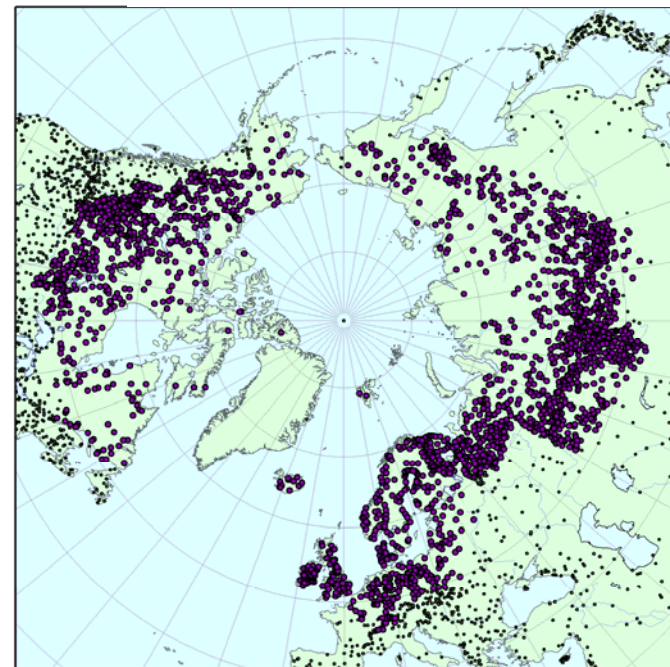
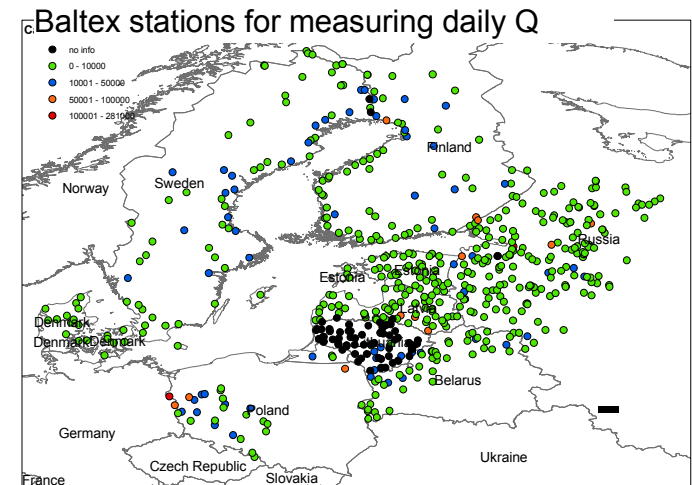
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- Agricultural Data: FAO
 - Point Sources: Population data from HYDE database, treatment level and standard values for emissions (van Drecht et al. 2009)
 - Atmospheric Deposition: Long term averages from national monitoring



Data for model calibration and evaluation

Readily Available Databases

- Observed river discharge: GRDC and BALTEX (daily and monthly)
- Possibility for additional data through collaboration and partnership?



Needs of satellite data for the Arctic

Model input:

- Land cover
- Water surface
- Leaf area index
- Phenology
- Glaciar, ice-sheets



Comparision and Validation:

- Soil moisture
- Water surface
- Snow cover
- Snow depths
- Ice caps

In the future (?):

- Discharge
- Lake level fluctuations
- Groundwater level fluctuations

Model output for sustainable exploitation of the Arctic?



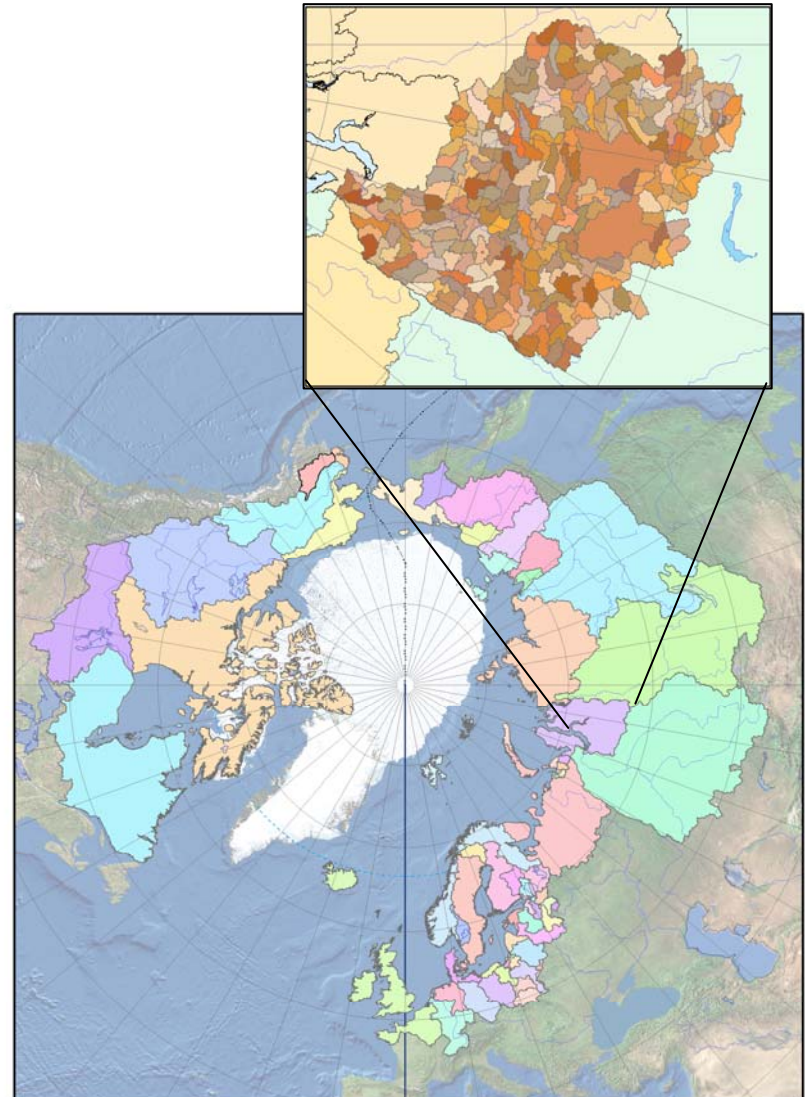
To sum up: High resolution hydrological model of the Arctic region?

WHAT?

Median resolution (10 000 km²), daily model of water variables (e.g. flow rates, soil moisture)
possibility of adding water quality
over *the entire region*

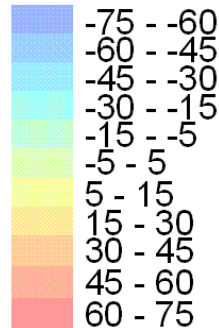
WHY?

- Homogenous model (impartial platform),
- Systematically-Implemented (easily run for new scenarios),
- Ensemble member and reference model
(compared with local and basin scale models)



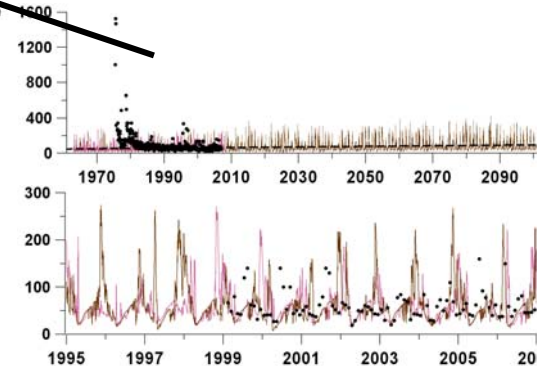
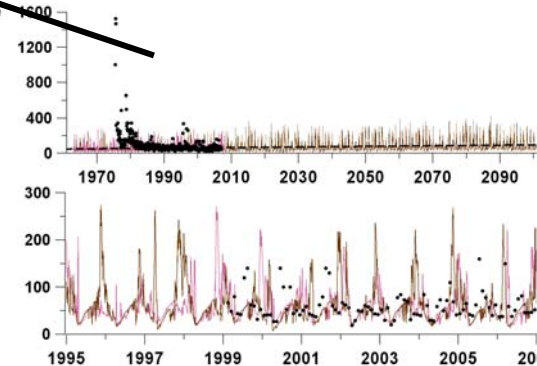
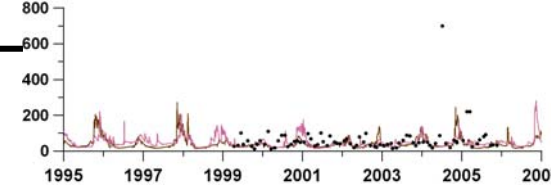
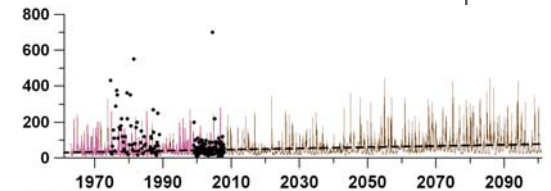
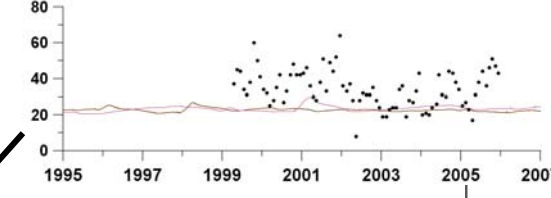
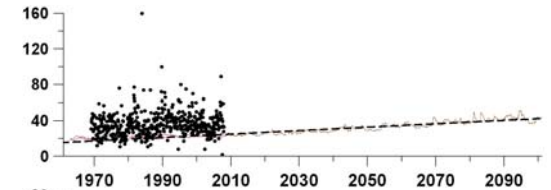
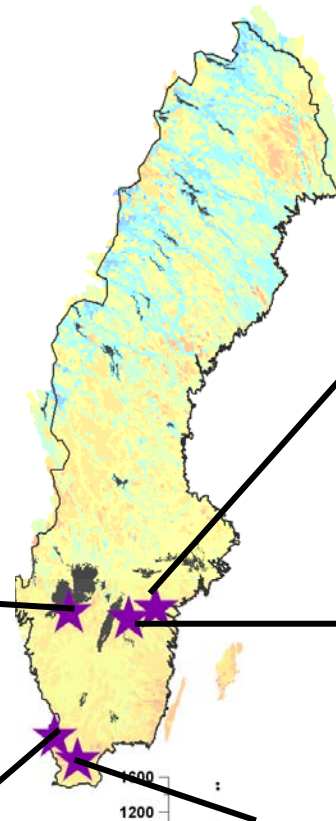
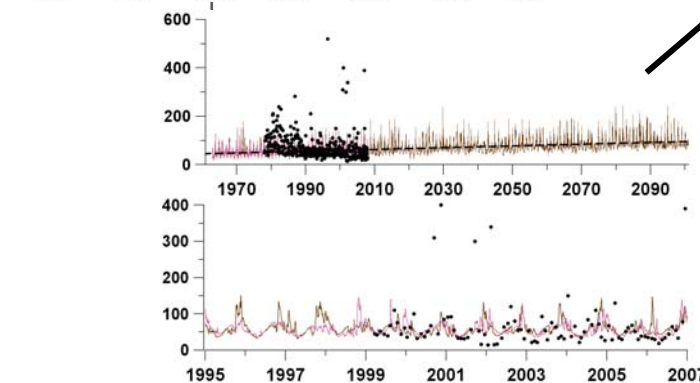
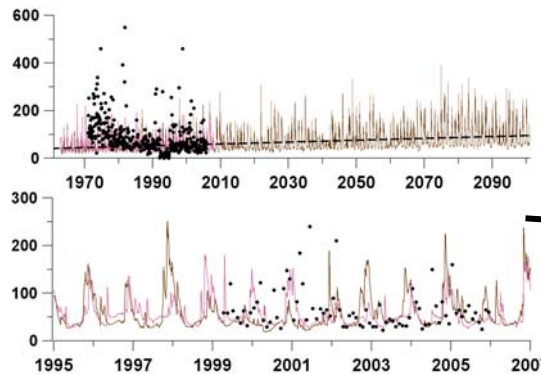
National HYPE modelling of P concentrations 1961-2100

% change of P concentration
in surface water



— Scenario: R3E53A1b as forcing
— Interpolated observation as forcing
• • • Obs

$\mu\text{g P L}^{-1}$

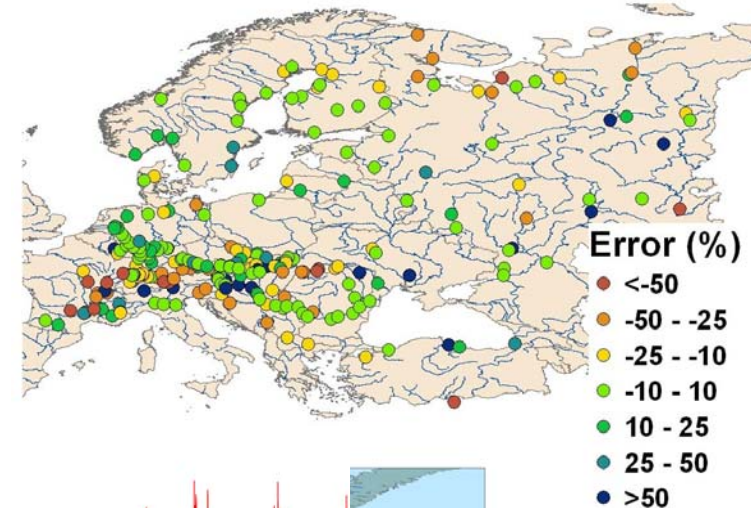
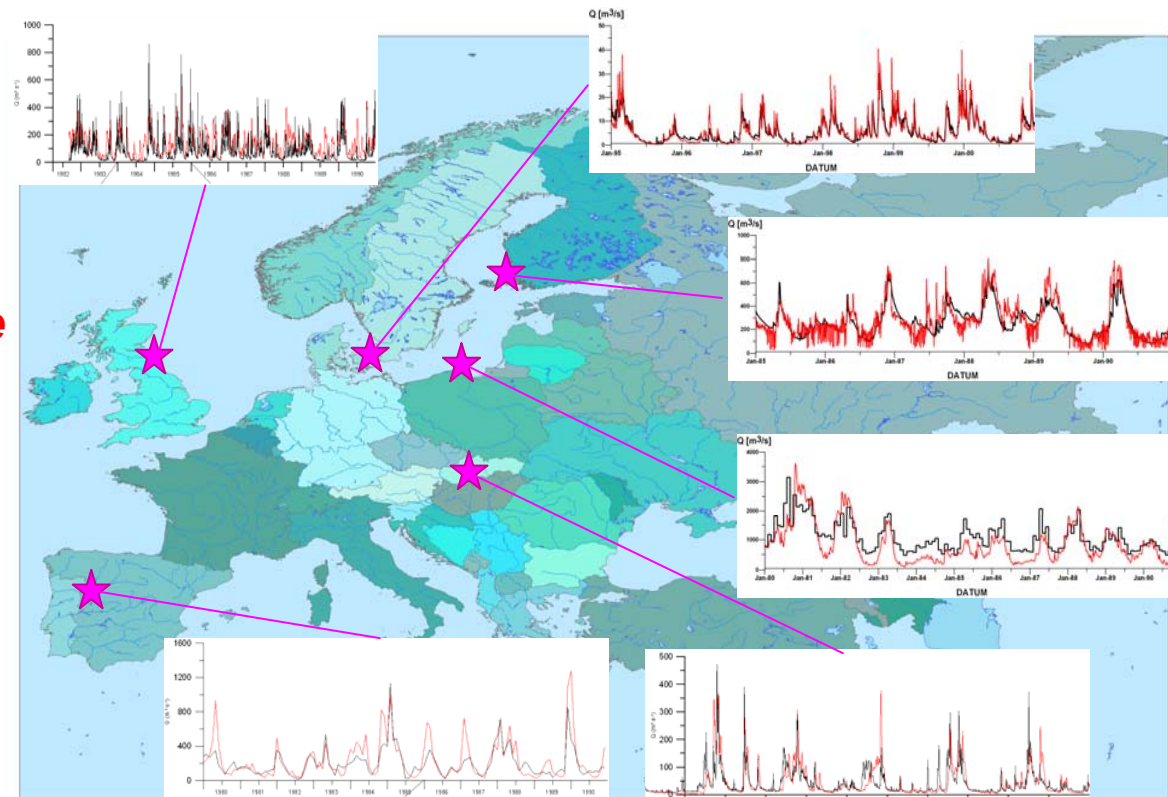


What sort of results can be expected?

So far:

Results of E-HYPE discharge modelling
(test run)

**Local corrections
are possible where
observed data
is available!**



Example of HYPE model output for sustainable exploitation of the Arctic

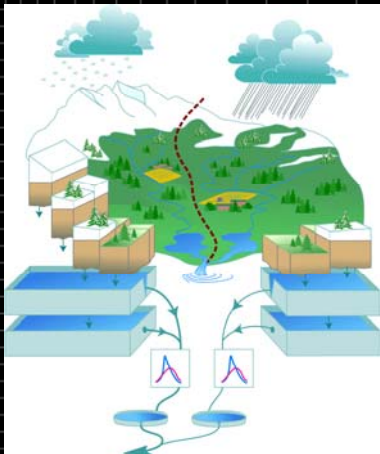
HYPE can assist in:

- Determining WMO:s Efficient Climate Variables (discharge and water use) of past conditions.
- Assessment of present ecological status.
- Climate change impact studies of future conditions.

e.g.:

- Oceanographic circulation patterns demand fresh-water inflow.
- Design of hydropower demands a hydrological tool.
- Prediction of biological status is related to hydrological variables (on land, in freshwater and eustaries).
- The model may calculate transport of substances and pollutants in the region, and to the sea.
- Changes in frozen soil is crucial for infrastructure and ecology.

Conclusions



Conclusions

- The HYPE model introduces the ability to model very large regions at high resolution simultaneously.
- The model is supported by tools for handling global databases and an operational production system at SMHI.
- The present need of satellite data include mainly: Land cover, Water surface, Leaf area index, Phenology, Glaciar and ice-sheets fluctuations, and Snow.
- In the future Discharge, Lake level and Groundwater fluctuations would be appreciated.
- This hydrological model can assist in many aspects of sustainable exploitation of the Arctic

Thank you!

