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Significance of hydrological model choice on climate change impact assessments for stream discharge and nitrogen load

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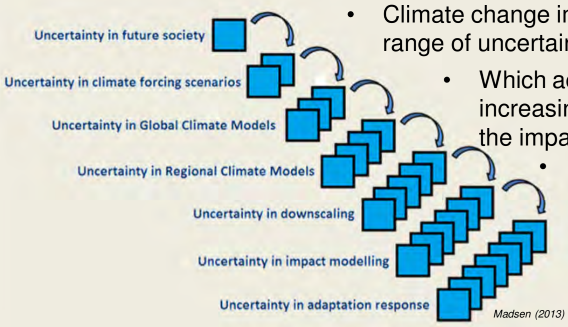
Introduction



- Climate change impact studies are affected by a range of uncertainties
  - Which accumulates with each step increasing the potential for uncertainty on the impact result
    - This has initiate the use of ensemble approaches to capture ranges of possible futures and uncertainties

The hydrological climate change impact in a Danish catchment in response to:

1. Different climate model projections (GCM-RCM combinations)
2. Different hydrological models
3. Different land use scenarios

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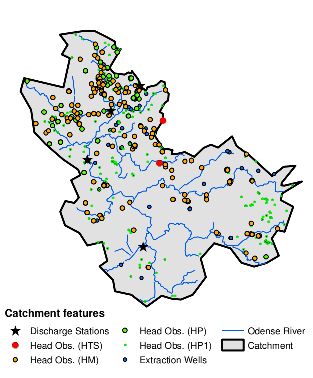
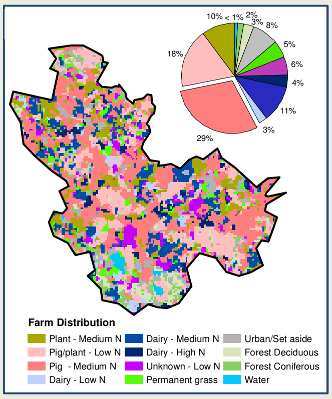
Study area and input data



Observation data consists of 4 discharge stations, 1 nitrate measuring station and 455 hydraulic head measuring wells

Odense sub-catchment 486 km^2



Land use consists of agricultural lands (68%), urban areas (16%), woodlands (10 %) and nature areas (6%).

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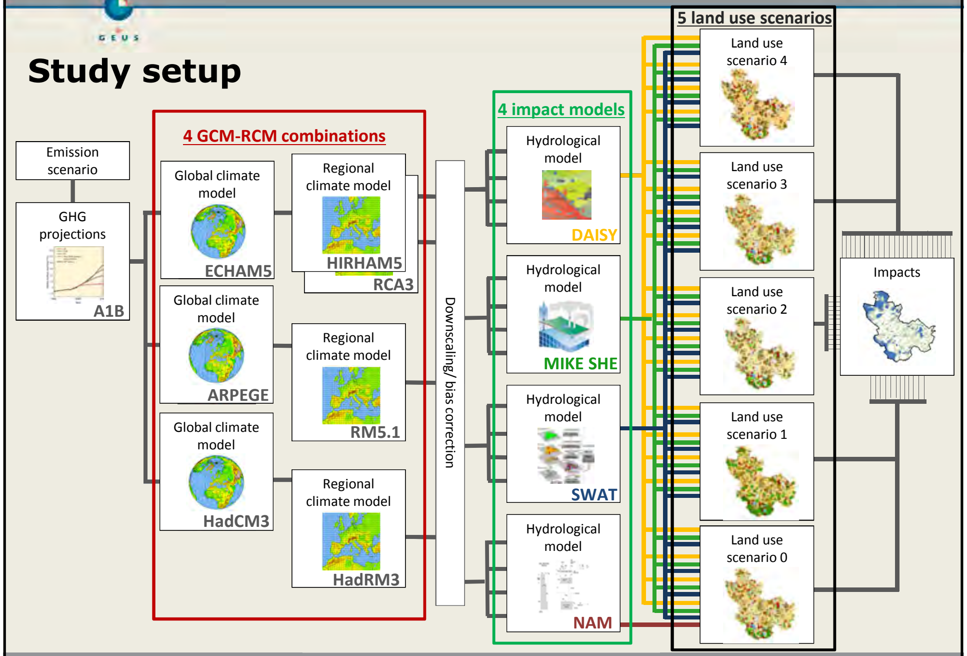
Study setup



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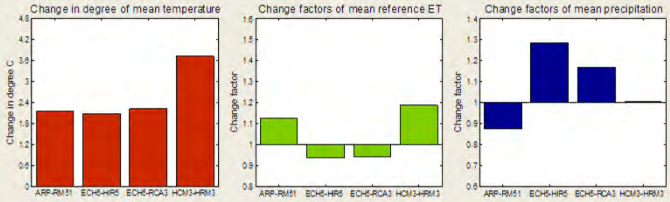
Ensemble spread – Climate models

Modelled data using four climate models based on impact signal



Wet: ECHAM5 – HIRHAM5
Median: ECHAM5 – RCA3
Dry: ARPEGE – RM5.1
Warm: HadCM3 – HadRM3

Downscaling of the climate model data is done to account for the coarse resolution of the climate, local scale variations and model biases.

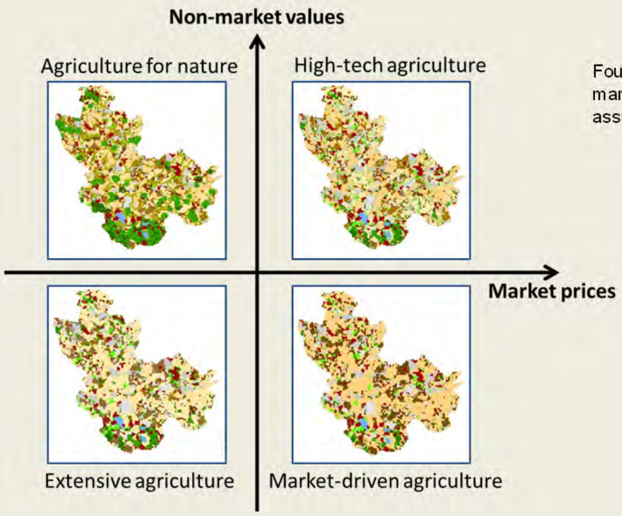
Downscaling was done using:

- Distribution Based Scaling (DBS) with double gamma functions (Precipitation)
- Bias correction of RCM data (Temperature, Ref ET)

Ensemble spread – Impact models

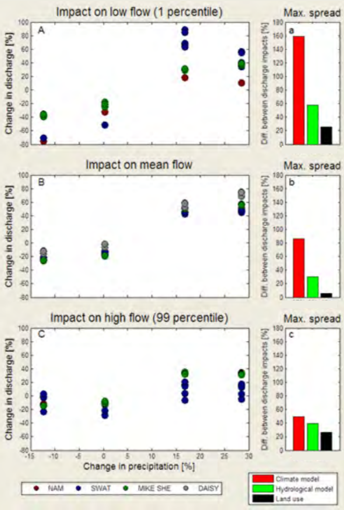
	Hydrological model NAM	Hydrological model SWAT	Hydrological model MIKE SHE	Hydrological model DAISY
Type	Lumped Conceptual	Semi-distributed Semi-physically based	Distributed Physically based	1D (distributed) Physically based
Unit	Catchment	HRUs	Grid-based	Blocks
INPUT	Climate	Climate Soil types Land use Topography Fertilizing	Climate Soil types Land use Topography	Climate Soil types Land use Fertilizing
CALIBRATION	AutoCal	PEST	AutoCal	Manual
OBJECTIVE FUNCTION	Discharge	Discharge Yield	Discharge Hydraulic heads	Discharge Yield
OUTPUT	Discharge	Discharge Nitrate leaching/load	Discharge Groundwater levels	Discharge Nitrate leaching/load

Ensemble spread – Land use scenarios



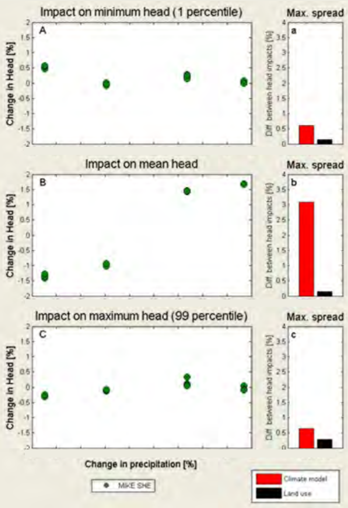
Four land use scenarios based on market price and non-market value assumptions were applied.

Impact on discharge

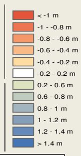


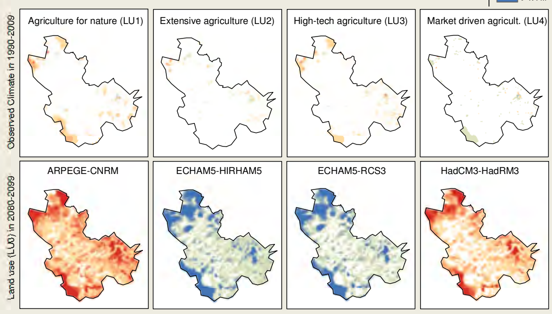
Variance Decomposition Analysis (VDA)	1 percentile (low)	Mean	99 percentile (high)
Variance due to climate model	98%	97%	83%
Variance due to hydro model	7%	5%	32%
Variance due to land use scenario	4%	1%	23%

Impact on hydraulic head

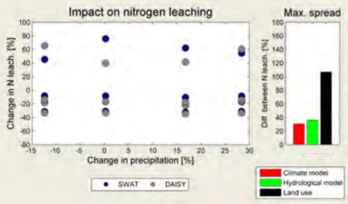


Variance Decomposition Analysis (VDA)	1 percentile (low)	Mean	99 percentile (high)
Variance due to climate model	98%	100%	98%
Variance due to land use scenario	16%	0.05%	4%





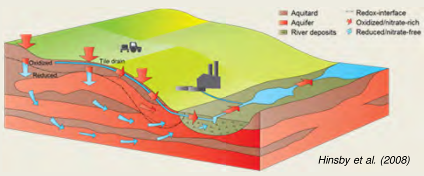
Impact on nitrogen



Variance Decomposition Analysis (VDA)	Mean (leach.)	Mean (load)
Variance due to climate model	11%	37%
Variance due to hydro model	15%	50%
Variance due to land use scenario	91%	82%

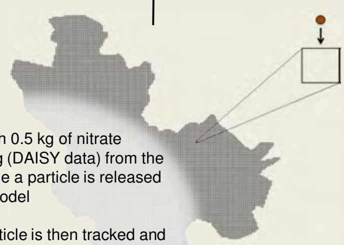
Calculation of nitrogen load in MIKE SHE

The redox interface distribution is generated using the downward recharge flux as a proxy, assuming abrupt degradation of nitrate beneath the interface.



Hinsby et al. (2008)

Concept developed by Hansen et al. (2014).



For each 0.5 kg of nitrate leaching (DAISY data) from the root zone a particle is released in the model

The particle is then tracked and any crossing of the redox interface is registered

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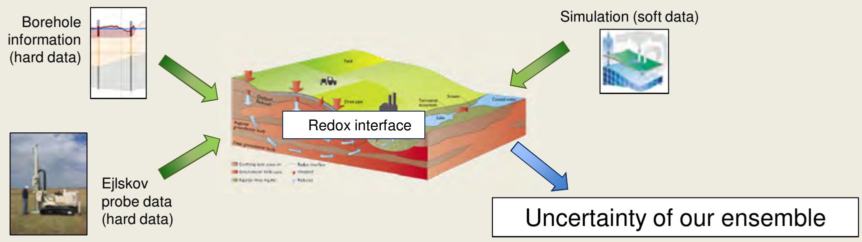
Transport and Reduction of Nitrate in Danish landscapes at various Scales

More cost-effective regulation of nitrate use requires information on effective and non-effective degradation areas.

As more than 50% of nitrate leaching in Danish catchments is removed by degradation in the saturated zone, it is important to attain information on the transport of nitrate in the sub-surface.

Further developing the redox interface modelling scheme (other proxies?)
Making a stochastic analysis of the redox interface using:



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Conclusions

For this ensemble of climate models, hydrological models and land use scenarios, we found that:

1. For discharge and hydraulic head climate model choice was always dominating. Followed by choice of hydrological model.
2. Even so choosing a different hydrological model affected mean climate impact results with up to 30%, and for extremes even more.
3. Oppositely nitrogen transport results indicate that land use is the dominating factor for leaching and loads.

The purpose of the climate impact study should thus be reflected in the setup of the study

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Thank you for your attention!