



  
G E U S

# The Danish National Water Resources Model (DK-model)

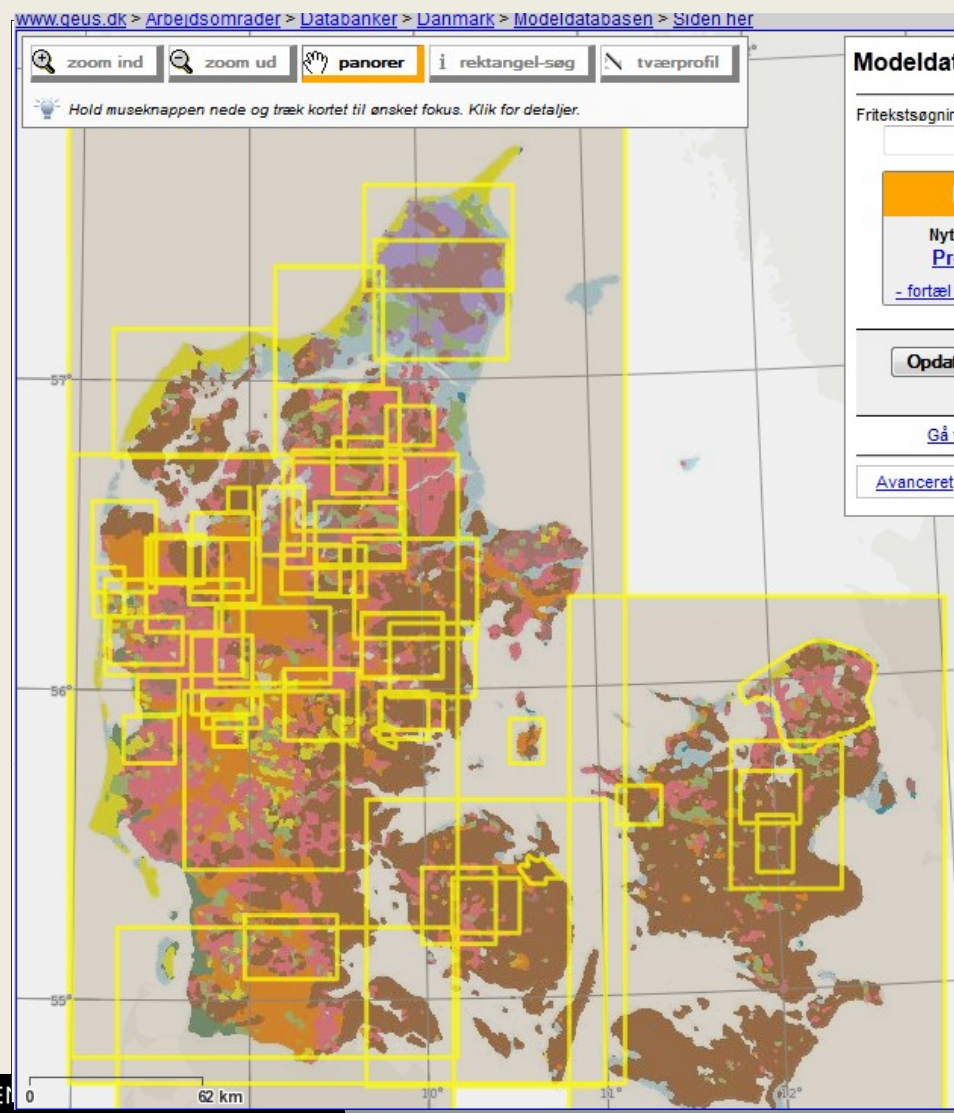
- **Support for decision making and WFD implementation**

Anker Lajer Højberg & Klaus Hinsby

Geological Survey of Denmark and Greenland  
Danish Ministry of Climate, Energy and Building

# The National Water Resources Model (DK-model)

- **Numerical hydrological model**
  - 43,000 km<sup>2</sup>, 7 sub-models
  - Coupled SW-GW model (MIKE SHE/MIKE 11)
  - Data from national databases
  - Hydrogeological description
    - 3D geological interpretation
  - Inverse calibration - PEST
  - Public accessible
    - Stored in national model database

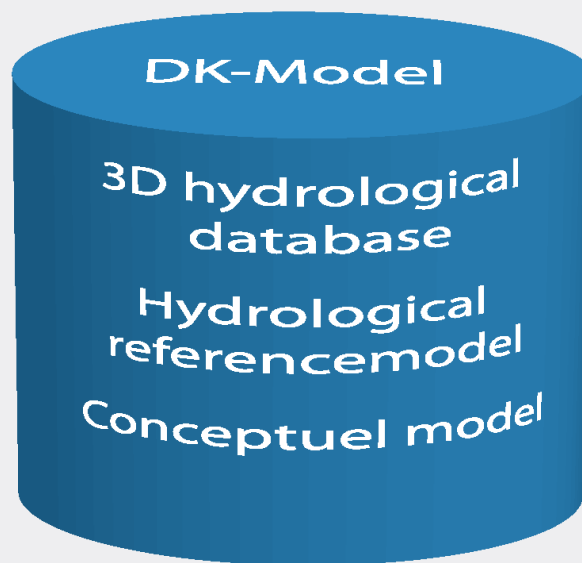


(Højberg et al., 2013; Stisen et al., 2012)

# Vision

- DK-model – unifying platform
  - Hydrological model and database
  - Reference for all water management related aspects at all levels
- Regularly update as new knowledge and data becomes available
- Continuous development

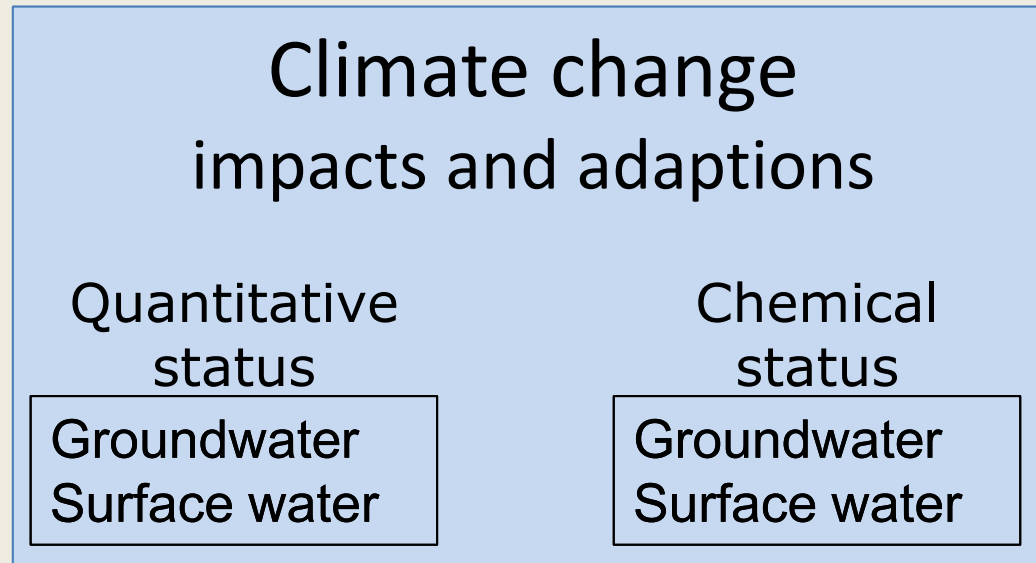
*Geological knowledge  
Observation data  
Input data  
Development*



*Support NOVANA, GW. mapping, Management  
National & regional reference model  
Link data and konceptuel understanding  
QA of data og konceptuel model  
Off-set for detailed models  
Platform for involvement*



# Model applications



## Applications

- WFD/GWD implementation
- National & regional assessments
- Basis for local studies
- Research projects

## Users

- Research institutions
- National water authorities
- Regional authorities
- Municipalities
- Water companies

~25 SCI listed papers since 2003, directly or indirectly based on the DK-model (> 2 per year)

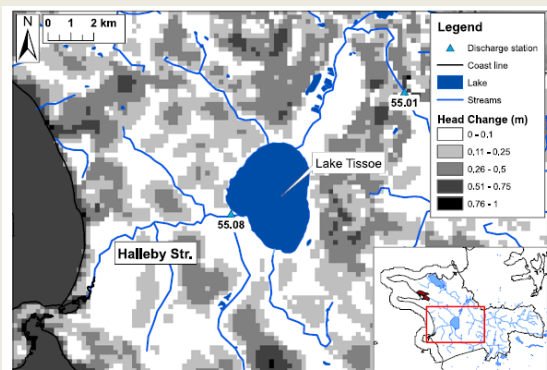
# The DK-model in WFD implementation

Groundwater quantitative status e.g.:

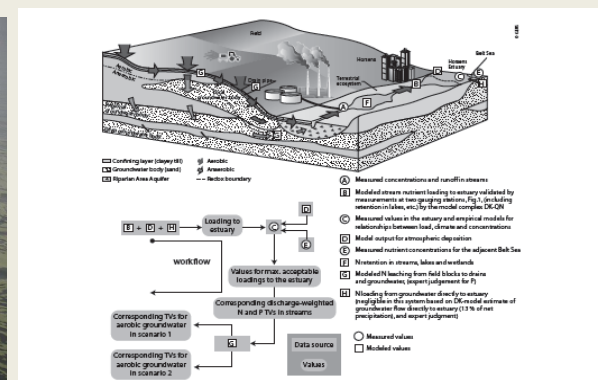
- 1) Aquifer safe yield (Henriksen et al., 2008)
- 2) Eflows (flow quantity and quality required to sustain surface water ecosystems) (Olsen et al., 2012)
- 3) Terrestrial ecosystems
- 4) Flooding risks (coastal and hinterland) (Sonnenborg et al., 2012)

Groundwater chemical status e.g.:

- 1) Threshold values to protect terrestrial ecosystems
- 2) Threshold values to protect aquatic ecosystems and e.g. reduce risk of harmful algal blooms (Hinsby et al., 2008, 2012)
- 3) Saltwater intrusion. (Rasmussen et al., 2013)



(Sonnenborg et al., 2012)



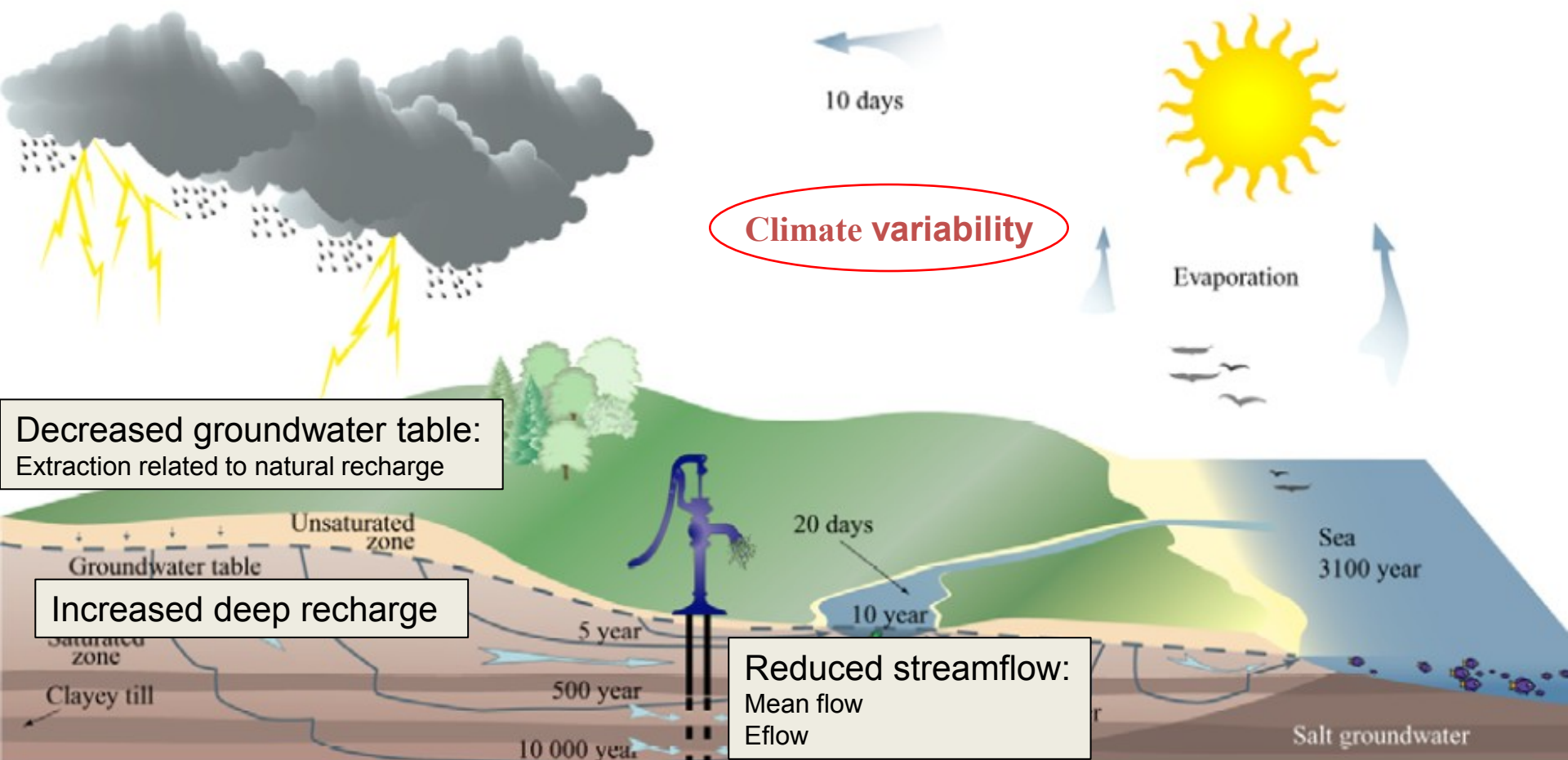
(Hinsby et al., 2012).

# Quantitative status

## Integrated national assessment

Circulation time

Henriksen et al., 2008



Climate variability

Decreased groundwater table:  
Extraction related to natural recharge

Increased deep recharge

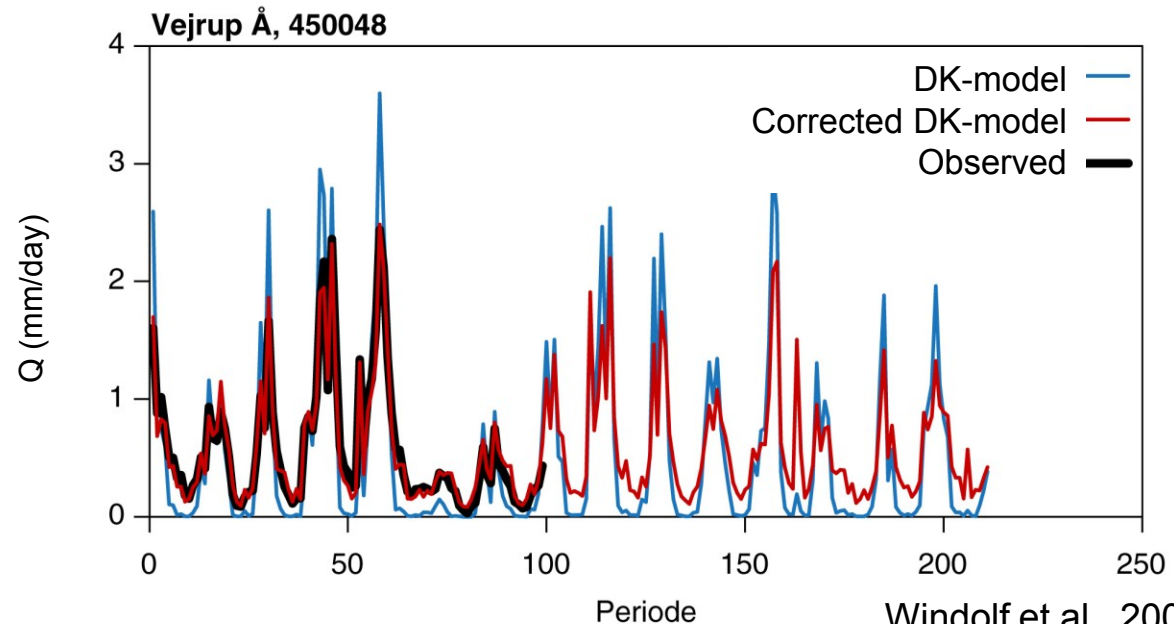
Reduced streamflow:  
Mean flow  
Eflow

Salt groundwater

# Monitoring programme

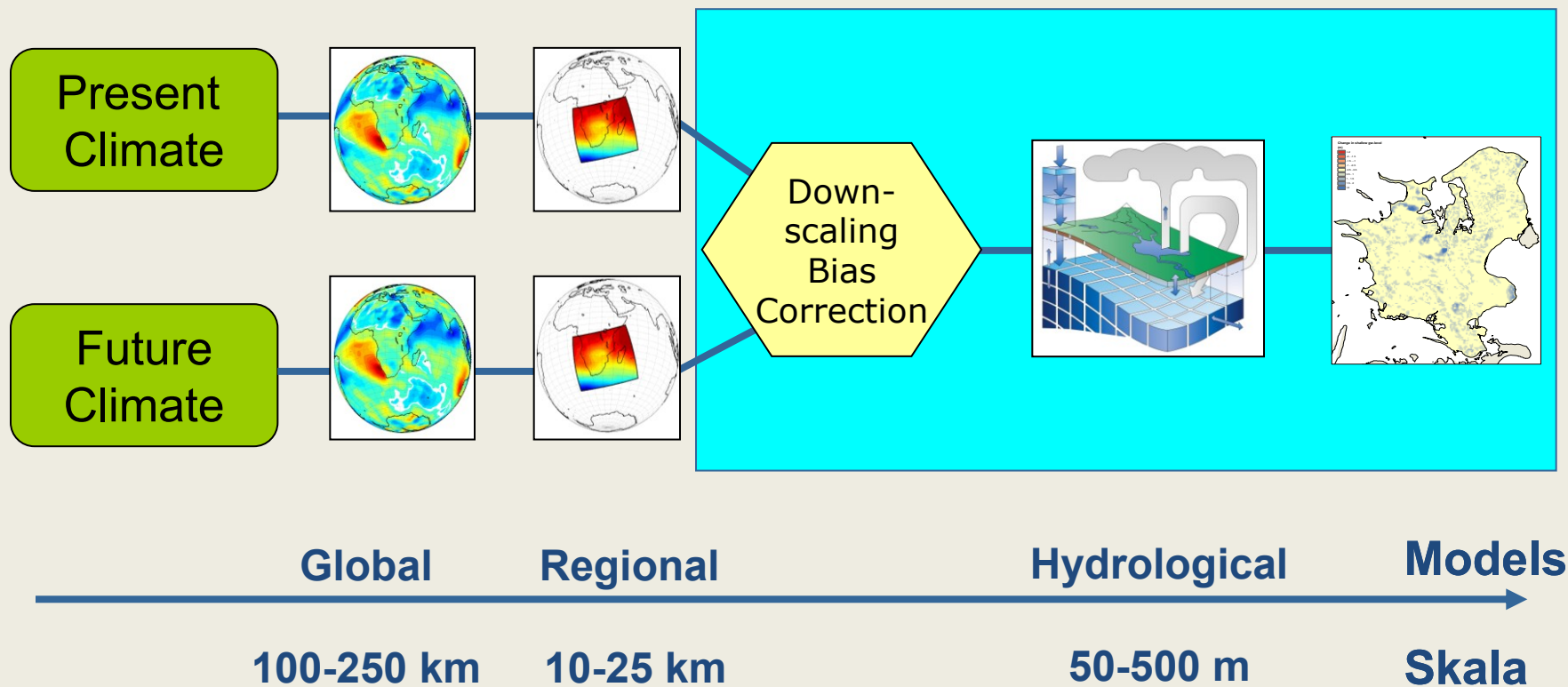
- Conceptual hydrogeological model -> 3D delineation of GW bodies and link to national database on quantity and quality
  - Basis for reporting to EU
- Design of GW monitoring programme
- Estimates of water balance – quantitative status

- Interpolation and extrapolation of freshwater discharges





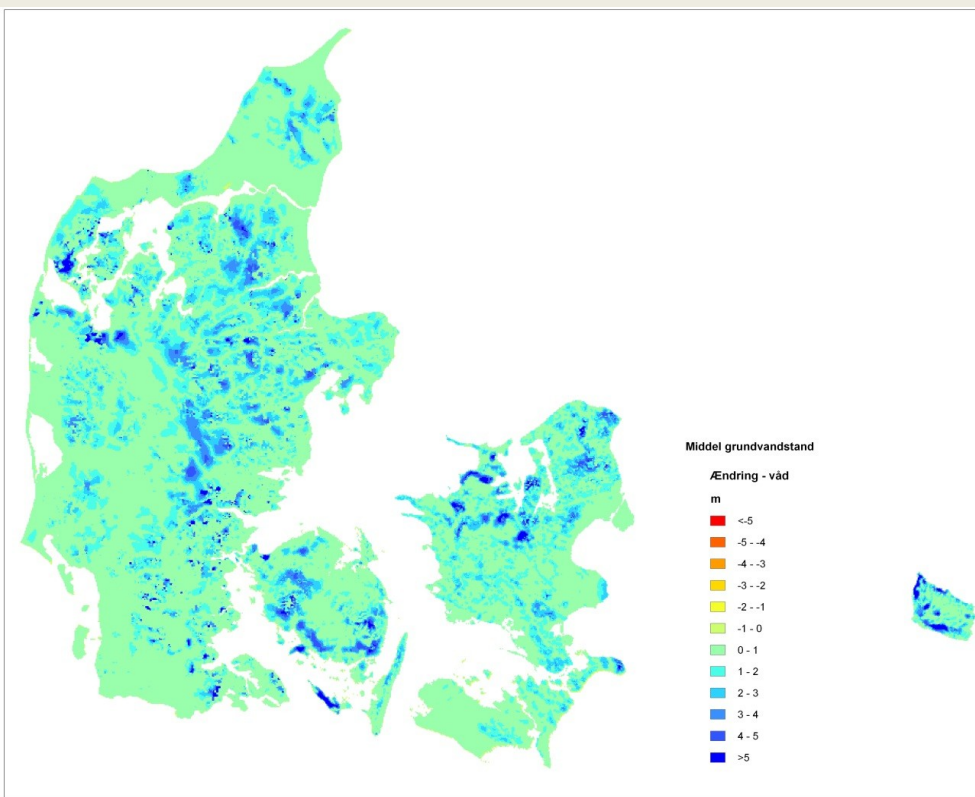
# Calculations of climate change effects on hydrology and groundwater



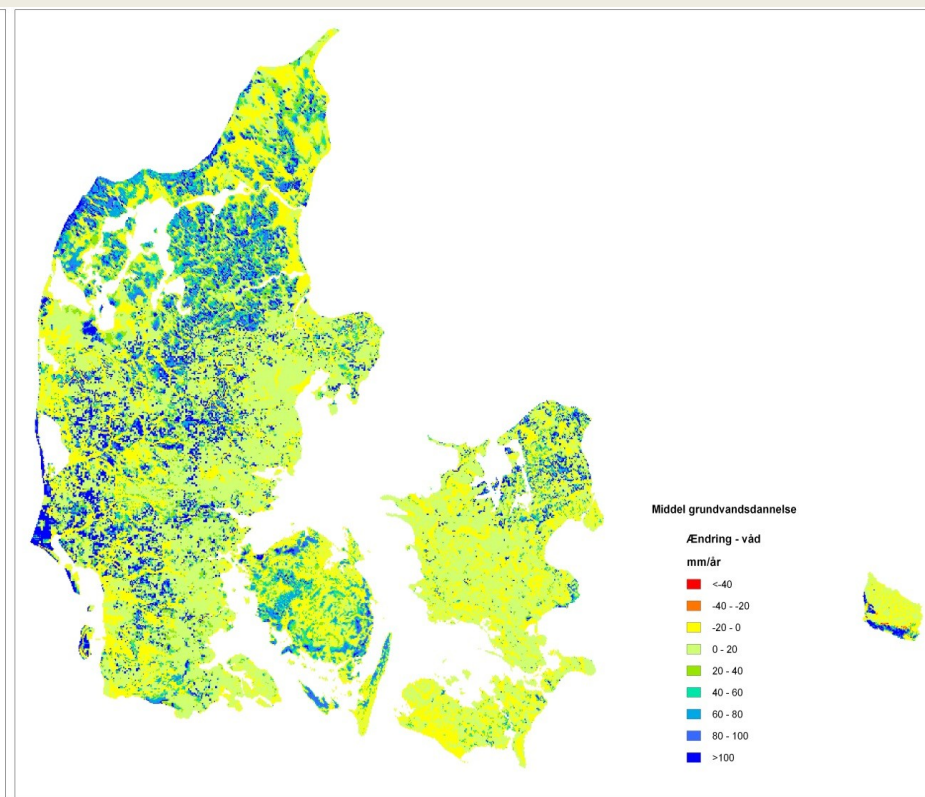
Several regional studies to estimate effects of CC and uncertainty related to the simulations

# Risk for GW flooding or reduced recharge

Min, mean and max changes in GW levels based on analysis of 9 GCMRCM combinations



Groundwater level 2021-2050 versus 1961-1990  
Changes in meter

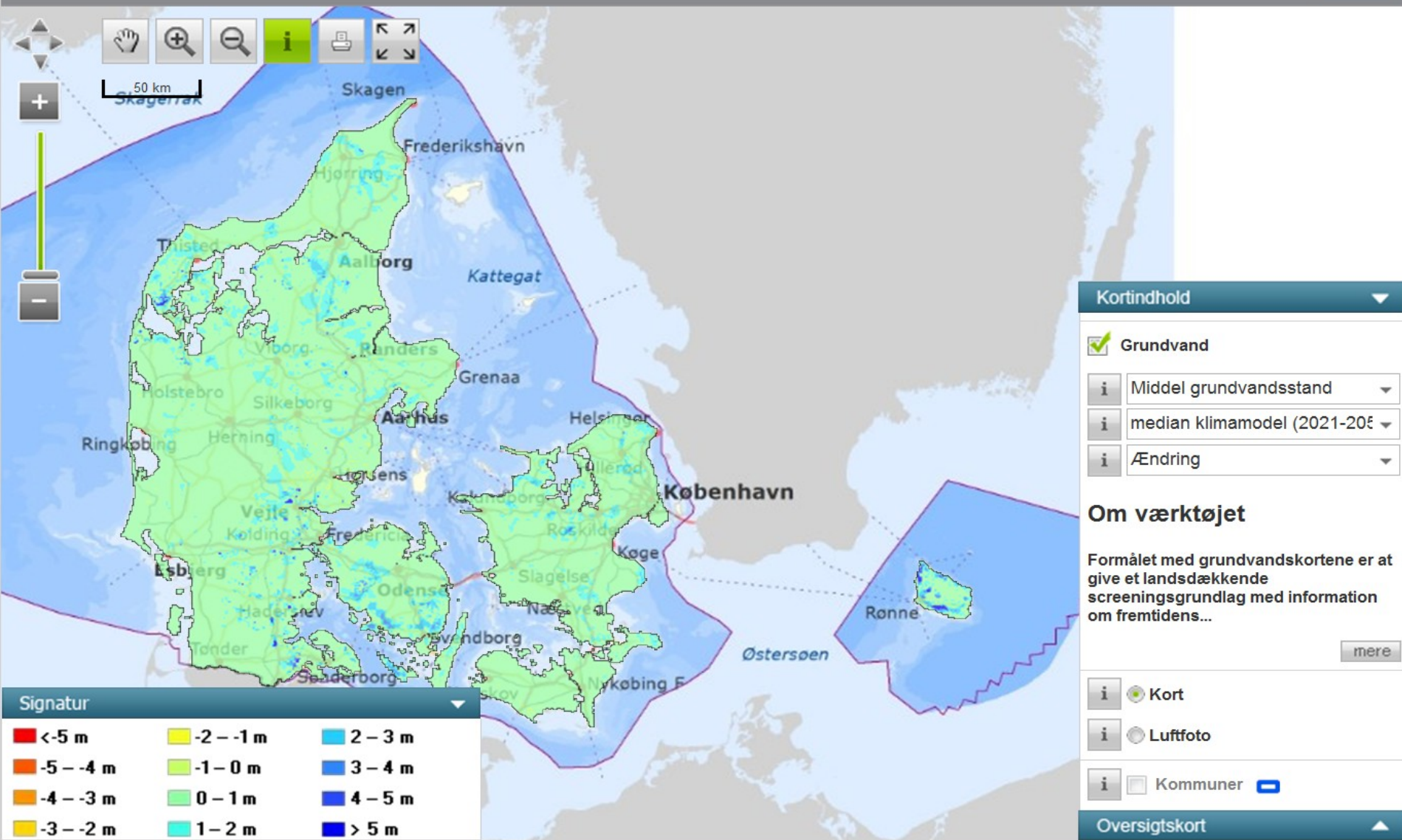


Groundwater recharge 2021-2050 versus 1961-1990  
Changes in mm/year

# Results available from public portal

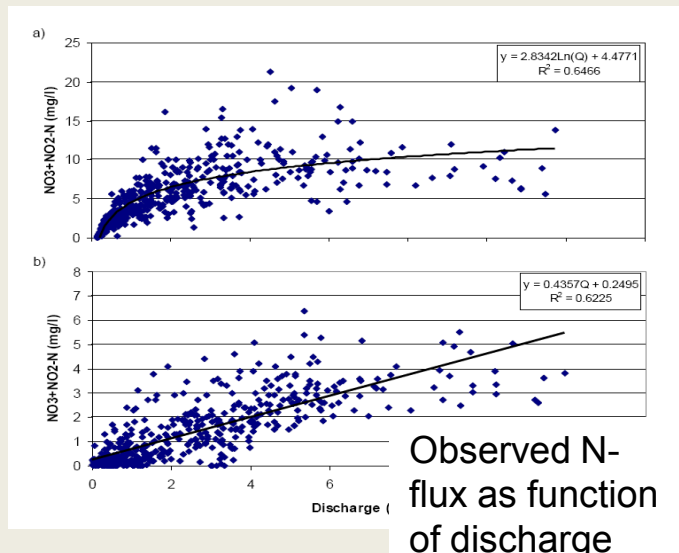
Ændring i middel grundvandsstand for median klimamodel for perioden 2021-2050 i forhold til 1961-1990

Kommune, by eller adresse  Søg >

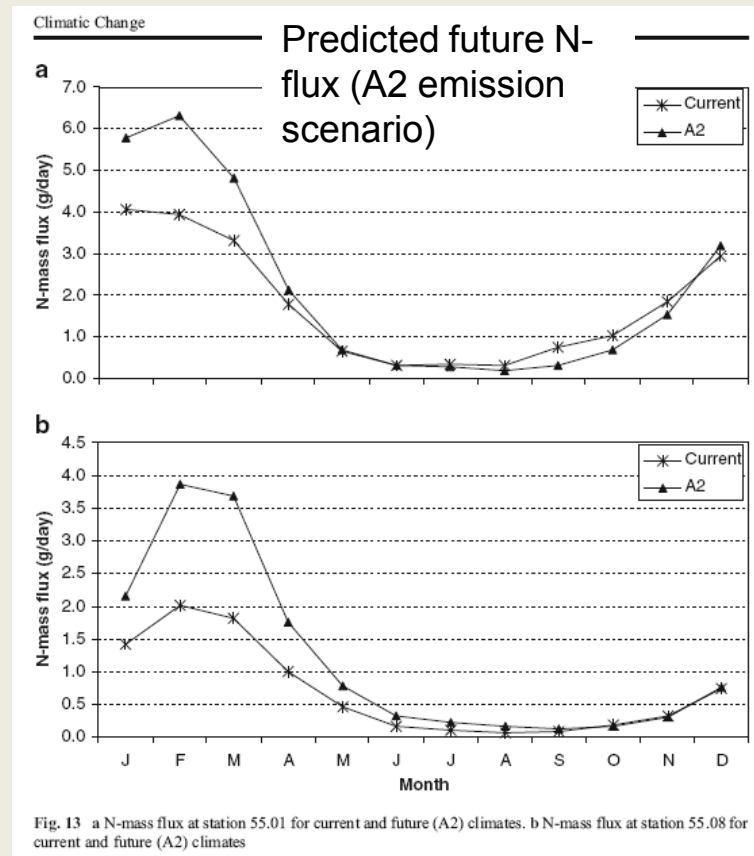


# CC effects on N-mass fluxes

CC will generally increase stream flow



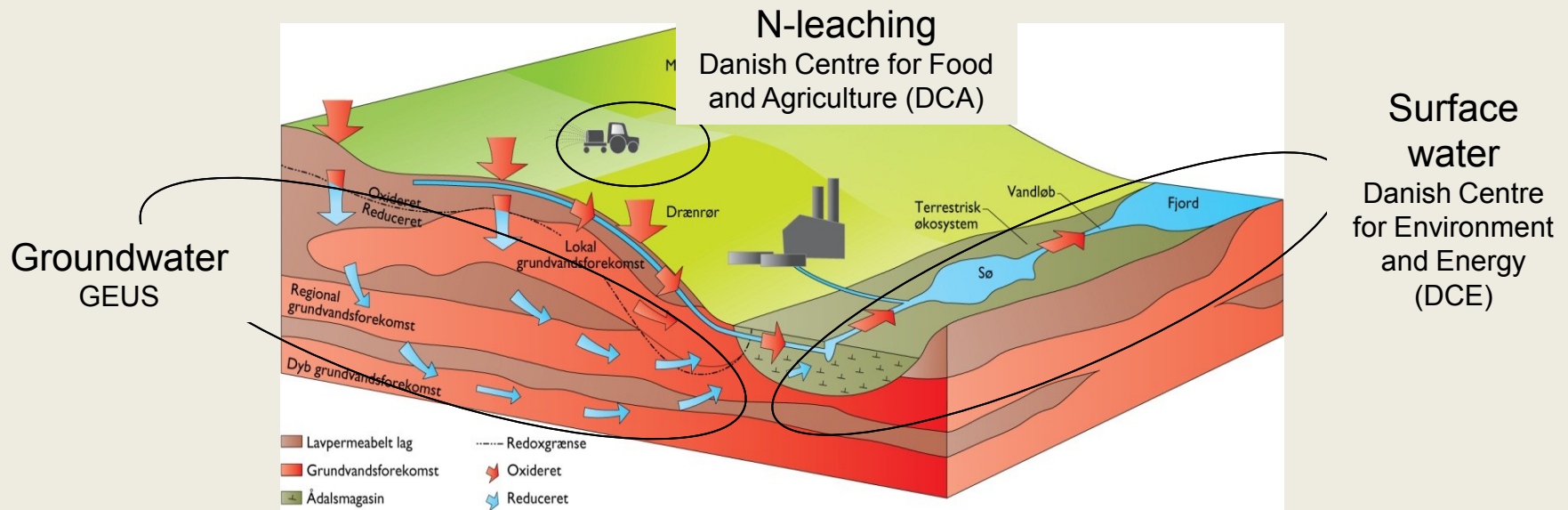
Increasing precipitation and runoff will increase nutrient loads– and hence require reduced groundwater threshold values (assuming no land use change)



(Sonnenborg et al., 2011)

# Present studies: Nitrogen load to coastal areas

Development of model complex (DSS). Collaboration between national research institutes



## Basis for implementation of the WFD – 2<sup>nd</sup> cycle

- Estimates of nitrate load to Fjords and marine areas
- Estimate reduction in GW and surface water systems
- Locate optimal mitigation measures and location
- Estimate effect of mitigation measures

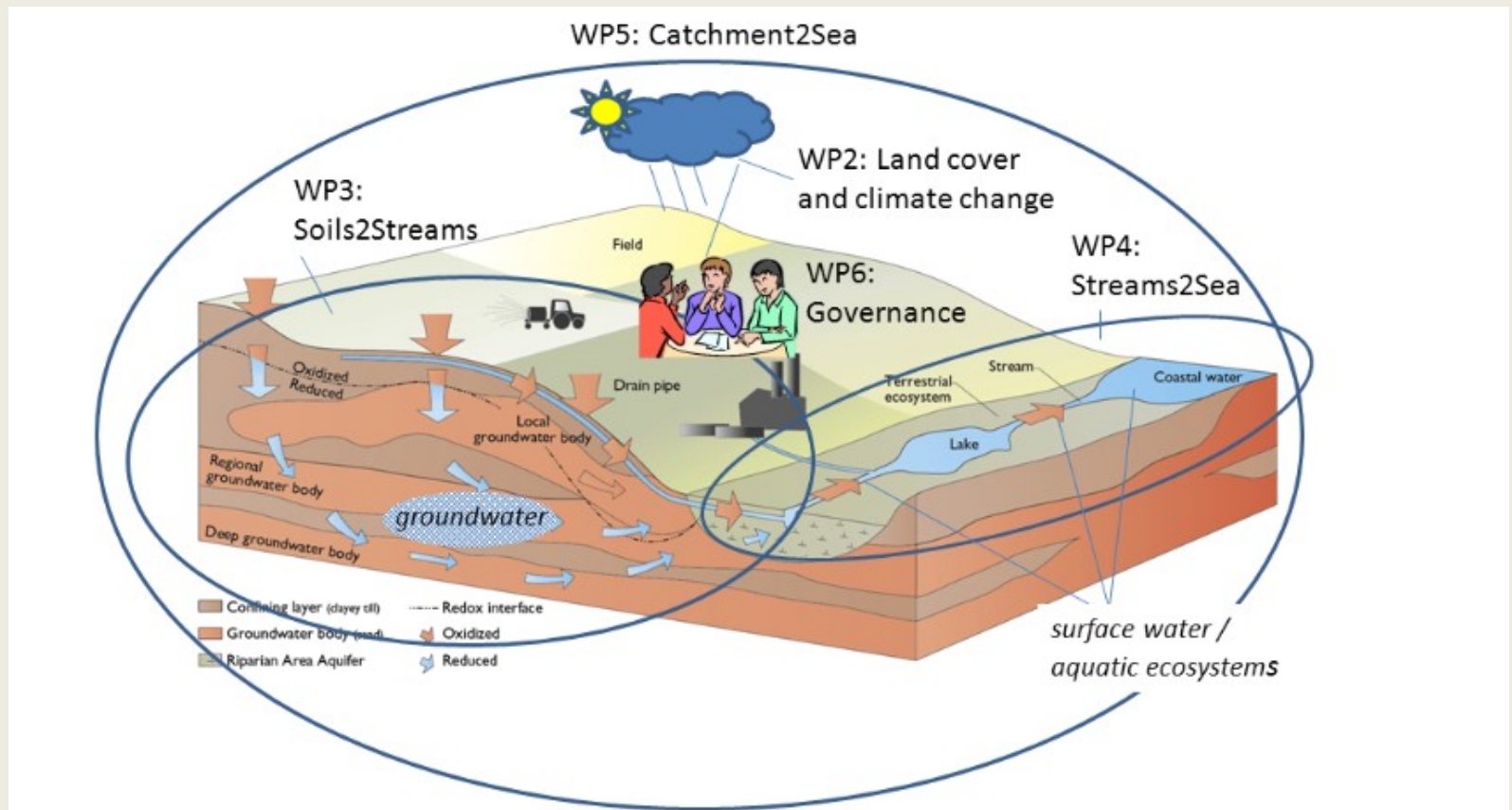
## Funded by

- Danish Nature Agency
- Danish Environmental Agency
- Danish AgriFish Agency

# New BONUS research project "Soils2Sea"

Partners from: DK (coordinator), DE, PL, RU and SE

Topic: reduction of nutrient loadings to the Baltic Sea and the impacts of climate change.



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