A Danish national nitrogen model
– input to a spatial differentiated regulation

- **Background**
- **Method**
- **Results**
- **Conclusions**

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Background

- Nitrate leaching reduced approx. 50 % since mid 1980s, but further reduction are required to some coastal areas
- Historical regulation: Uniform regulation on nitrogen application imposing same restriction everywhere
- Effect of different restrictions are depending on the local hydro- and biogeochemical conditions
- ”Nature and Agriculture Commission” recommendation of a spatial differentiated regulation – put restrictions where most effect
- Need for a national Nitrogen retention map

Retention map

Historical

- Used for regulating live stocks
- Coarse in large part of the country

New development

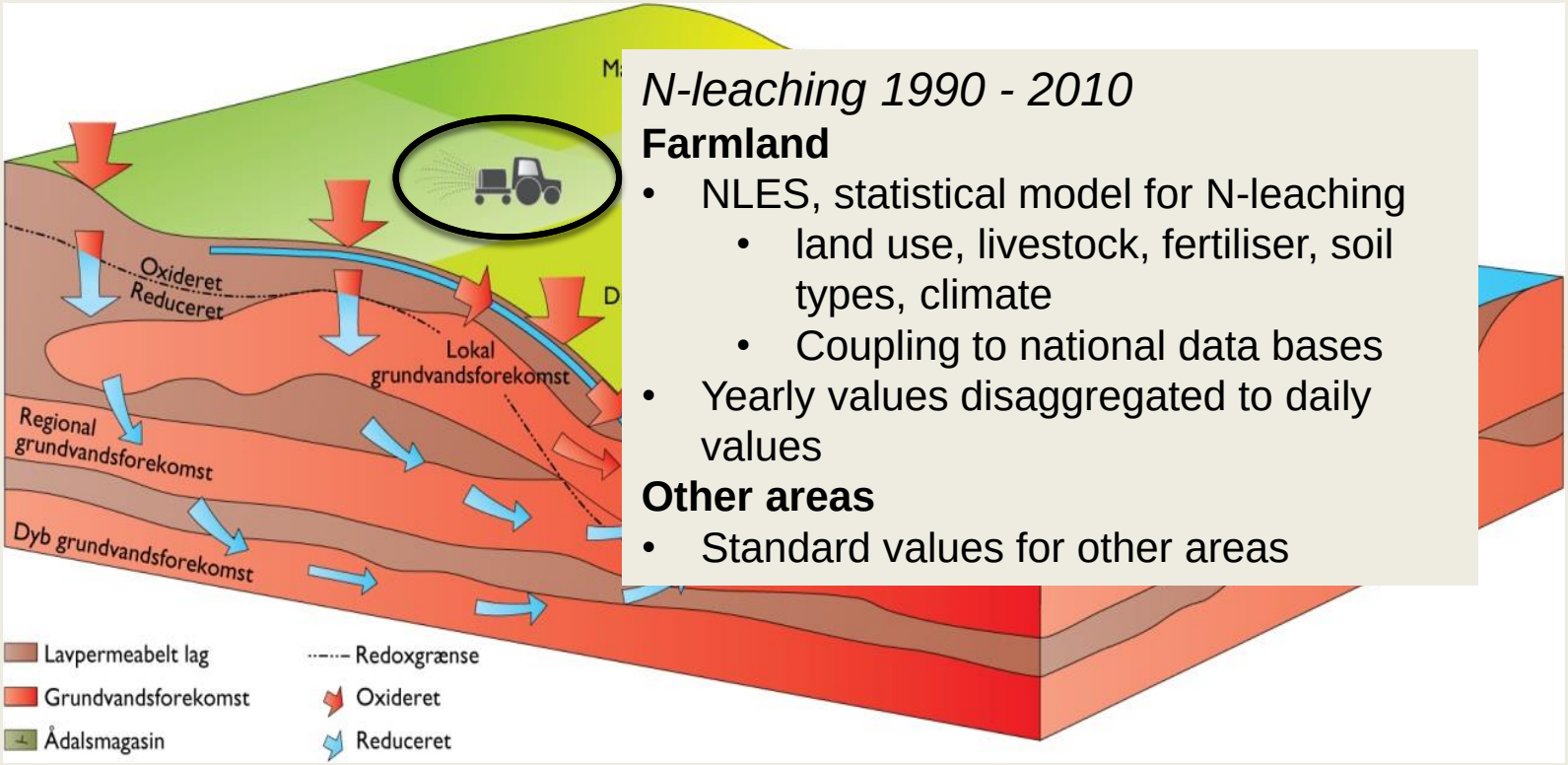
- Smaller and more uniform scale
  - "ID15" topographic catchments
  - Mean area ~ 15 km^2

Objectives

Development of a model/tool for a coherent estimate of N-transport and N-retention at a finer spatial resolution based on existing knowledge

- Utilise and couple existing tools and models developed at different national research institutions
- Utilise all observation data
- Assess uncertainty
- Explore how far can we can get
  - First attempt on common national approach
  - 1½ year for development

Model construction



N-leaching 1990 - 2010

Farmland

- NLES, statistical model for N-leaching
  - land use, livestock, fertiliser, soil types, climate
  - Coupling to national data bases
- Yearly values disaggregated to daily values

Other areas

- Standard values for other areas

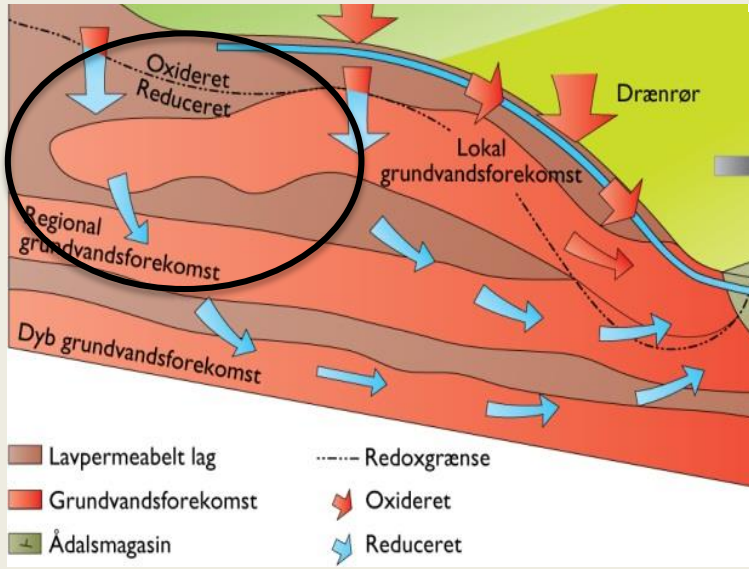
Transport and reduction in groundwater

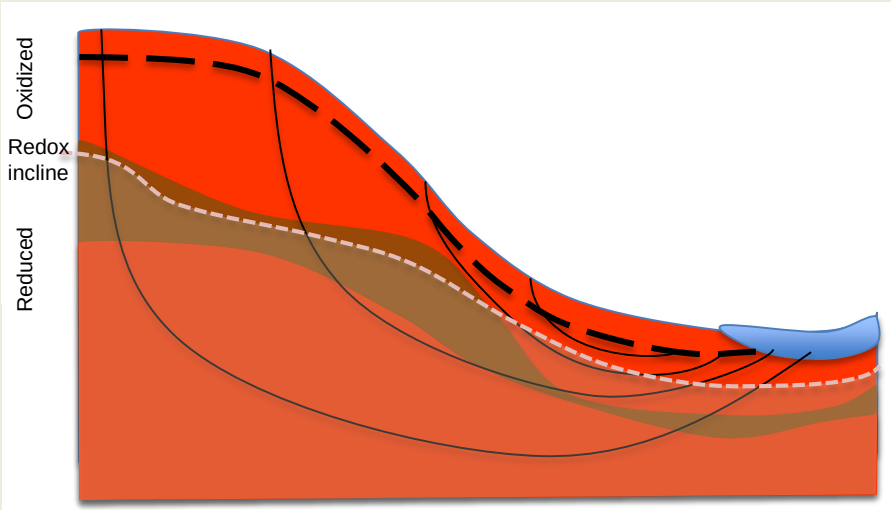
Partikel tracking

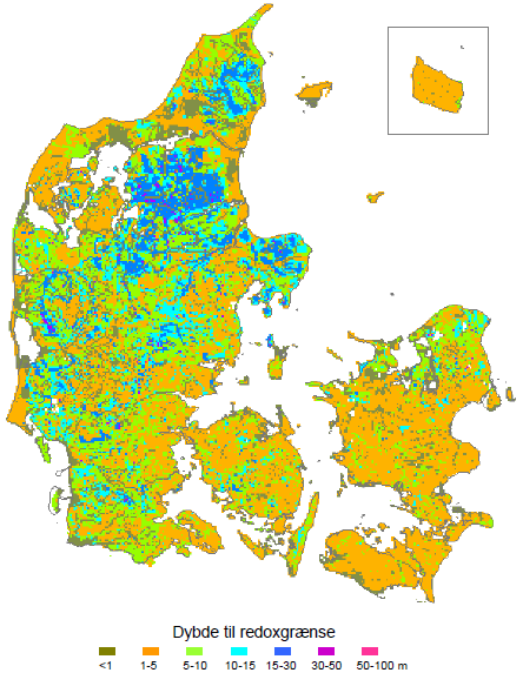
- National water resources model (DK-model)
  - Hydrological SW-GW model
  - Spatial distributed, based hydrogeological interpretation of DK

Redox interface

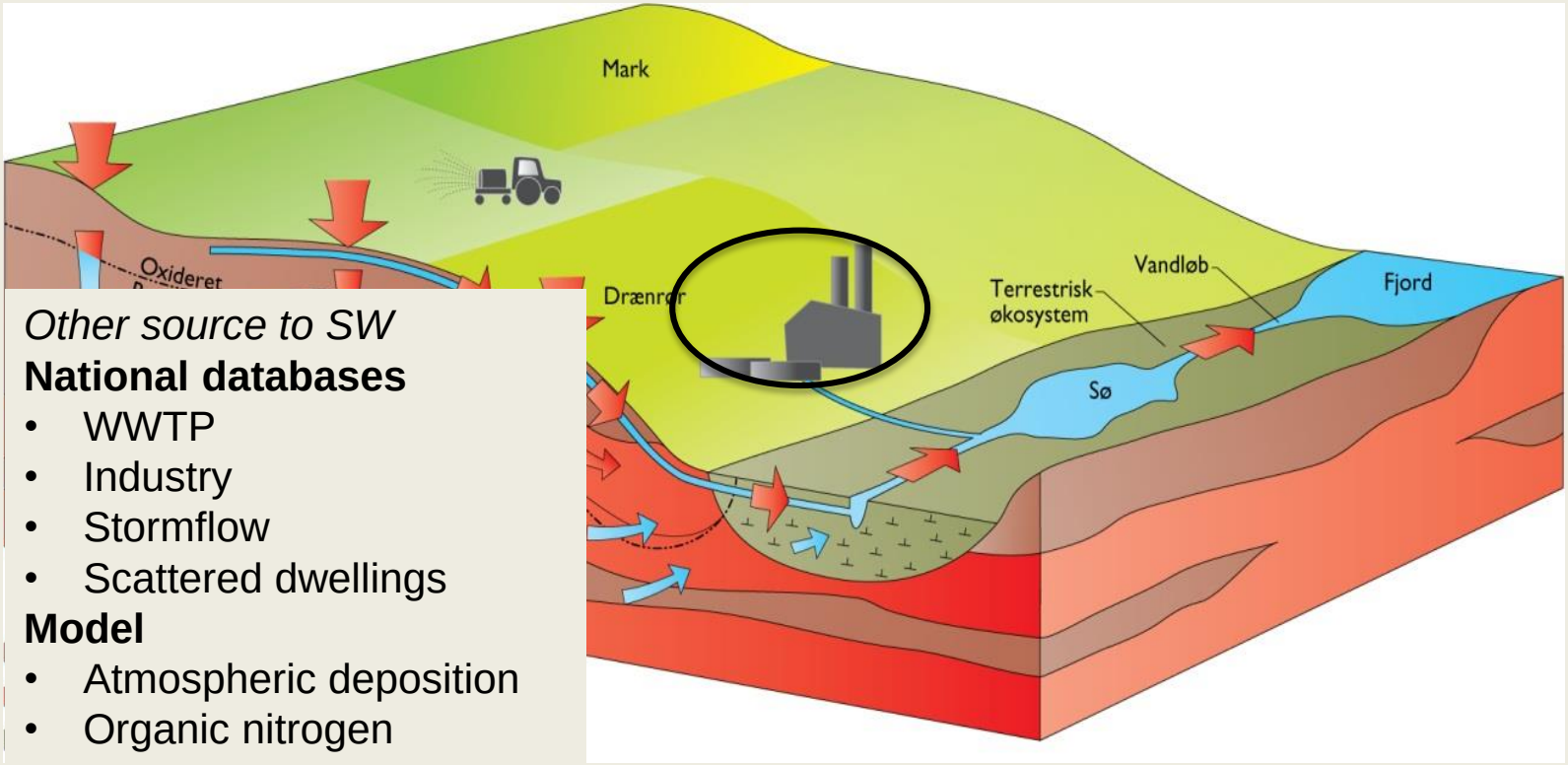
- National map
  - 13.000 boreholes + geological interpretation
- N-reduction below redox interface only







Model construction



Other source to SW

National databases

- WWTP
- Industry
- Stormflow
- Scattered dwellings

Model

- Atmospheric deposition
- Organic nitrogen

Model construction

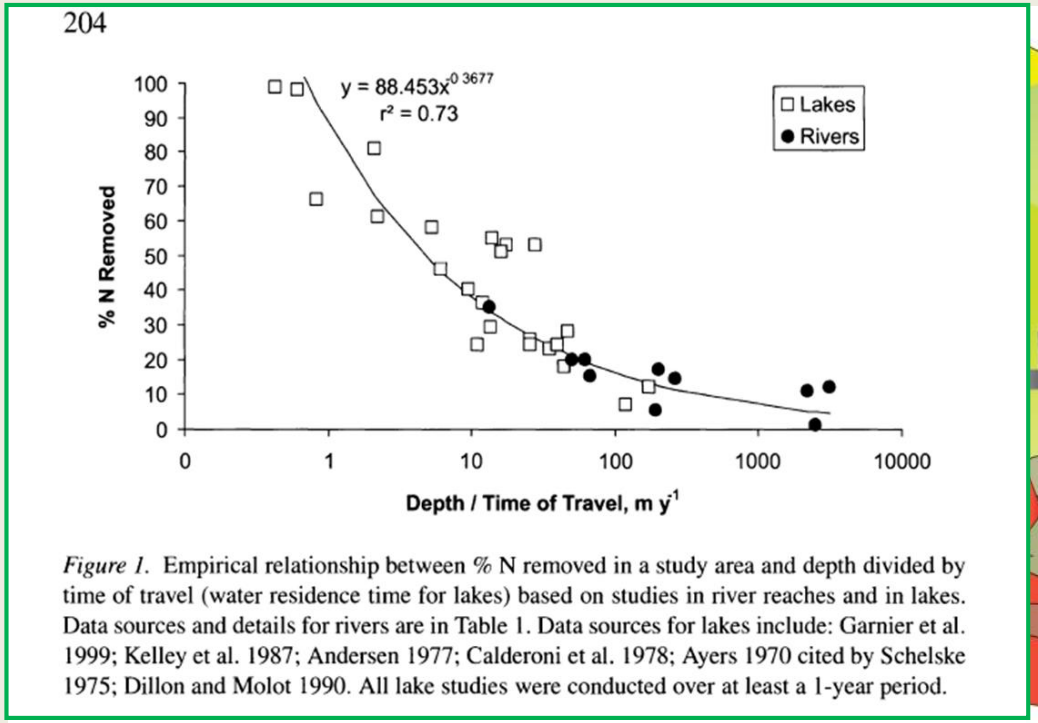
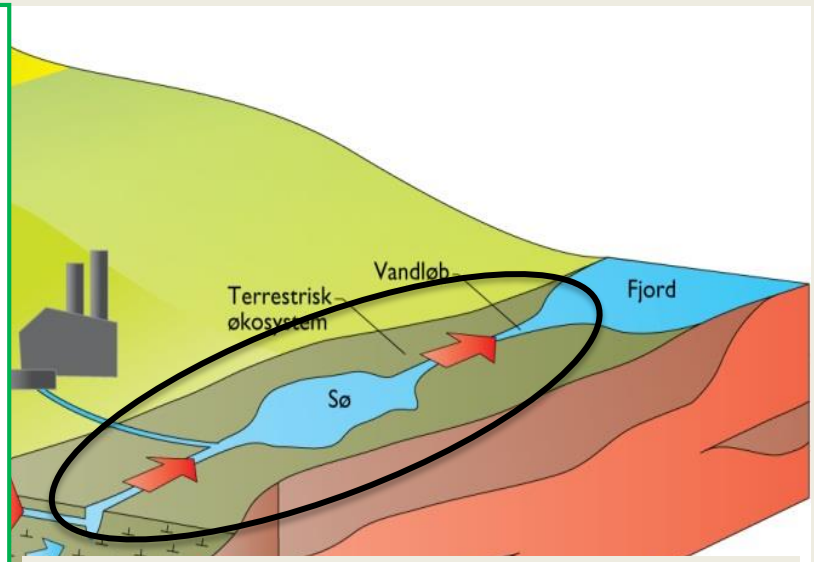


Figure 1. Empirical relationship between % N removed in a study area and depth divided by time of travel (water residence time for lakes) based on studies in river reaches and in lakes. Data sources and details for rivers are in Table 1. Data sources for lakes include: Garnier et al. 1999; Kelley et al. 1987; Andersen 1977; Calderoni et al. 1978; Ayers 1970 cited by Schelske 1975; Dillon and Molot 1990. All lake studies were conducted over at least a 1-year period.

Seitzinger et al. (2002)



Retention in surface waters

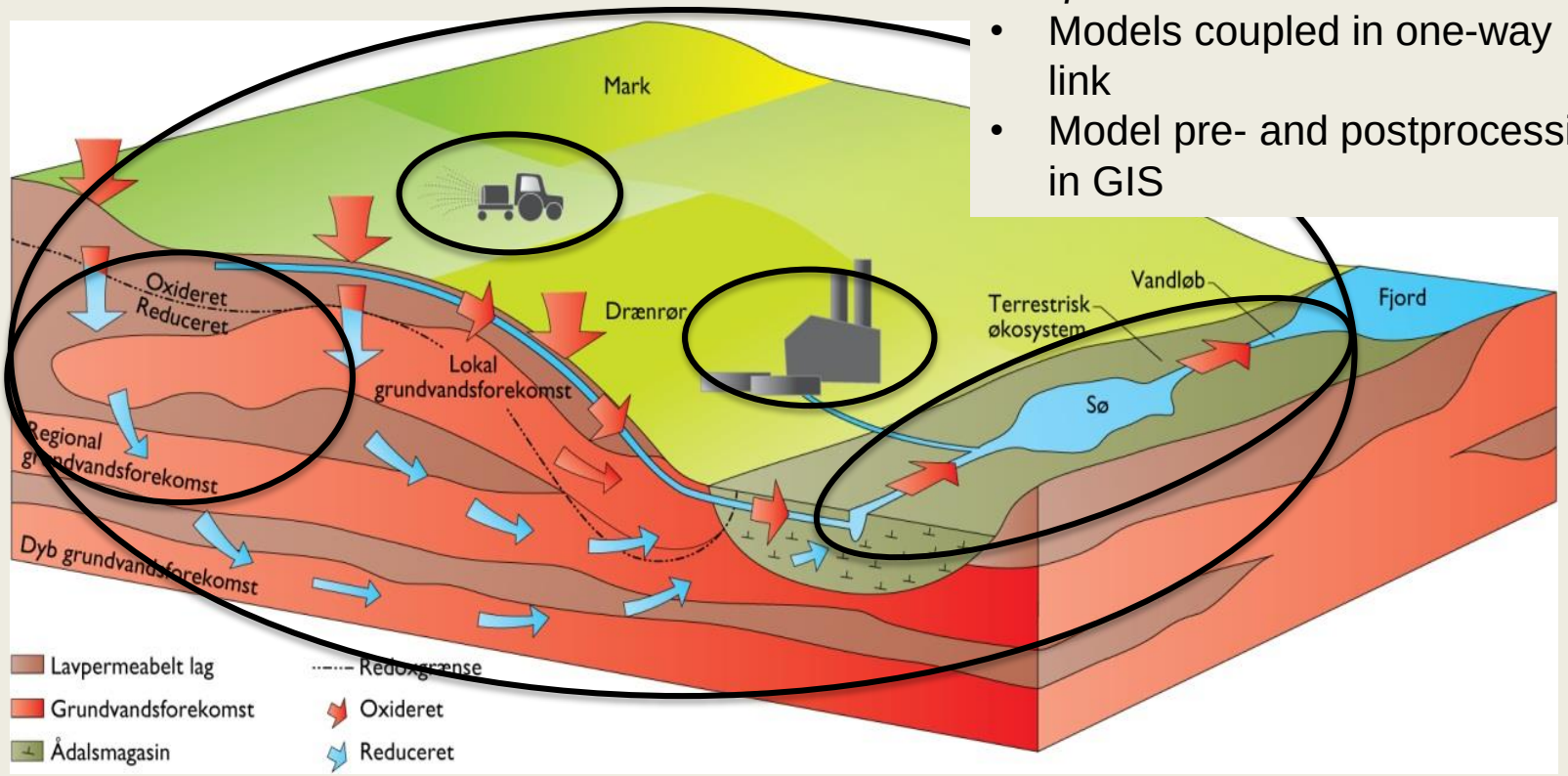
Statistical models and national monitoring data

- Streams
- Lakes
- Reconstructed wetlands

Model construction

Coupled model

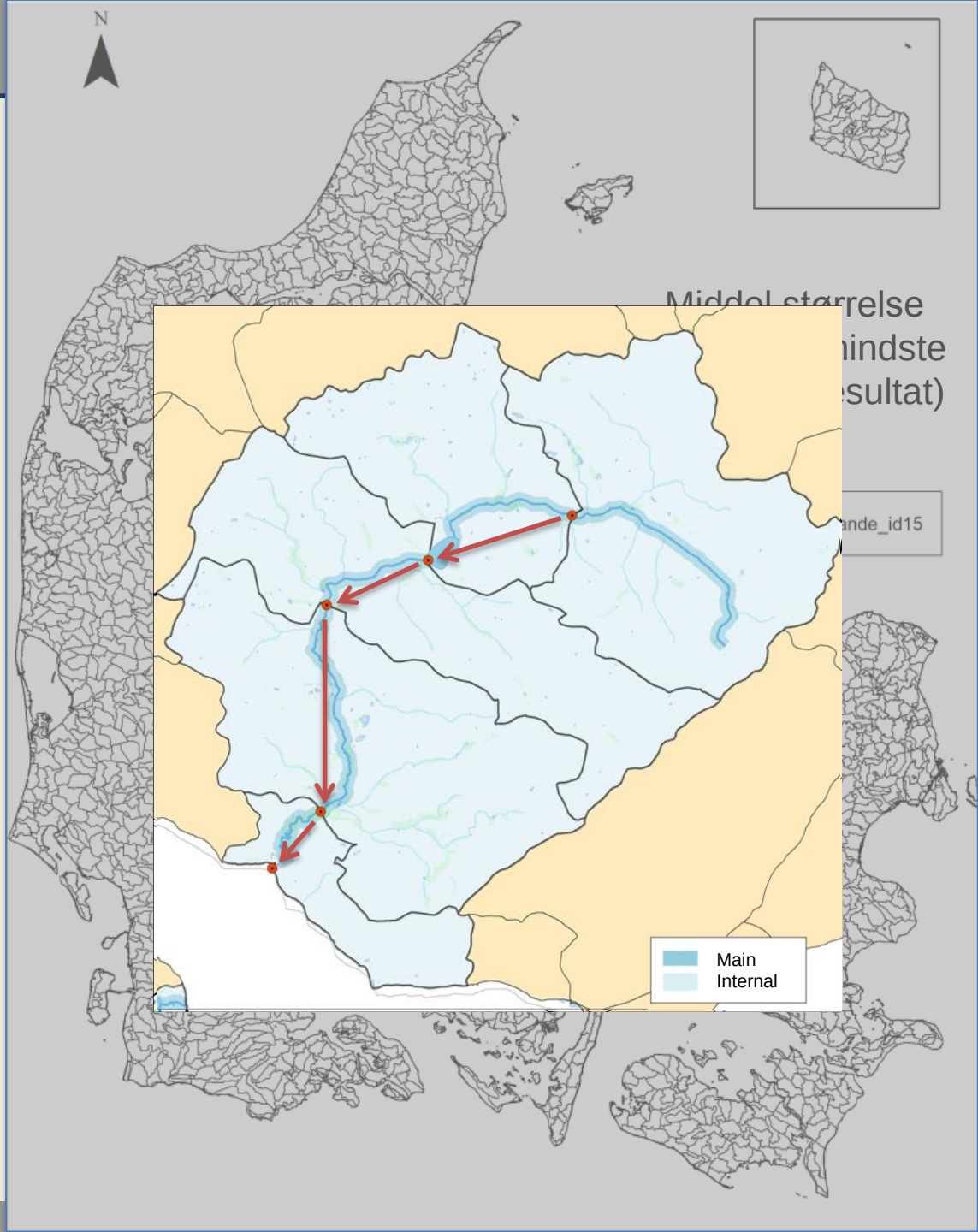
- Models coupled in one-way link
- Model pre- and postprocessing in GIS



N transport and retention

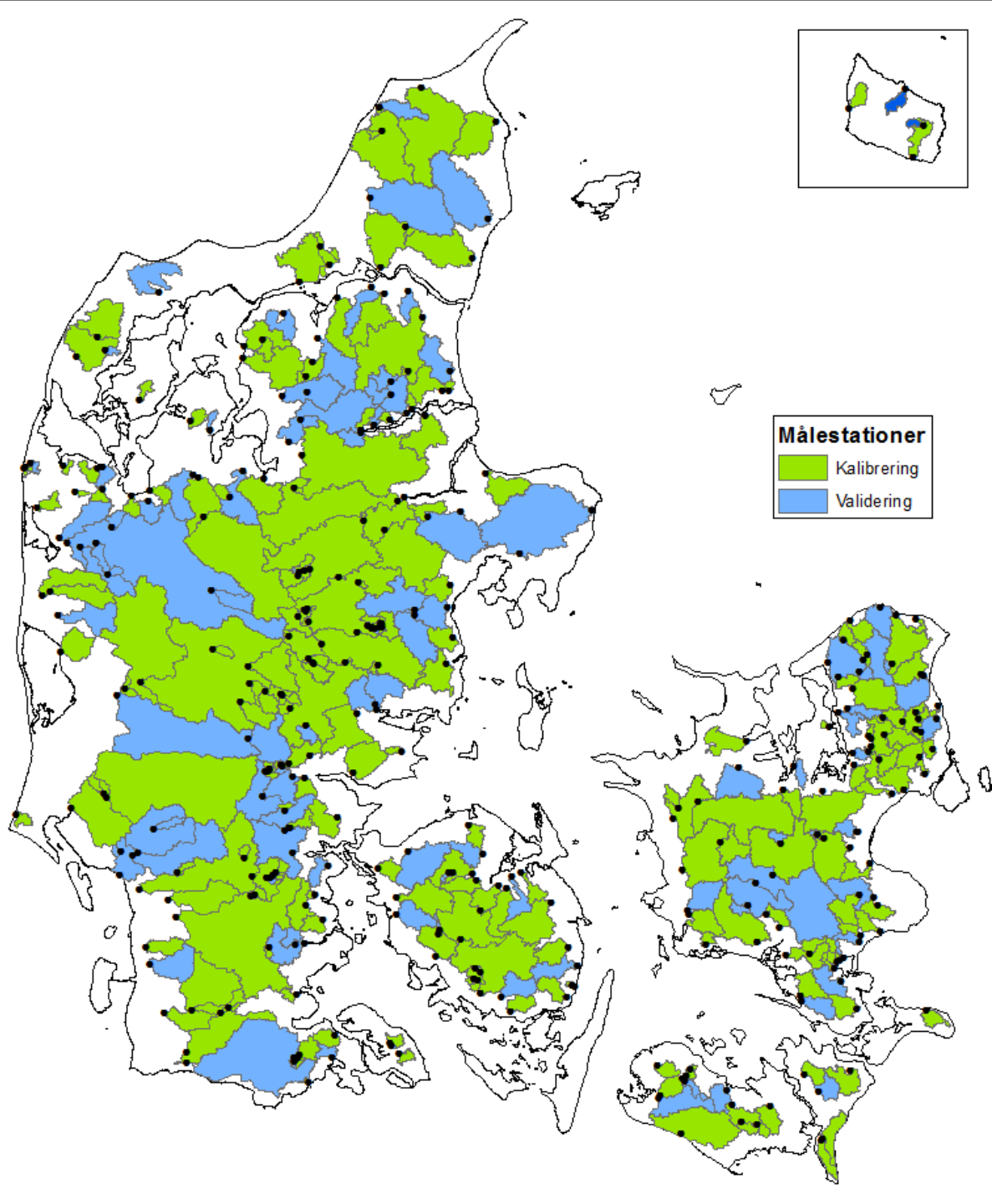
ID15 as computational unit

- Lumped approach in ID15 catchments: "Internal"
  - Sources:
    - Transport from root zone
    - Point sources
  - Sinks
    - Retention in streams, lakes and reconstructed wetlands from sizes and densities
- Book keeping within ID15 – no variation within sub-catchment
- Routing and retention in "main" stream

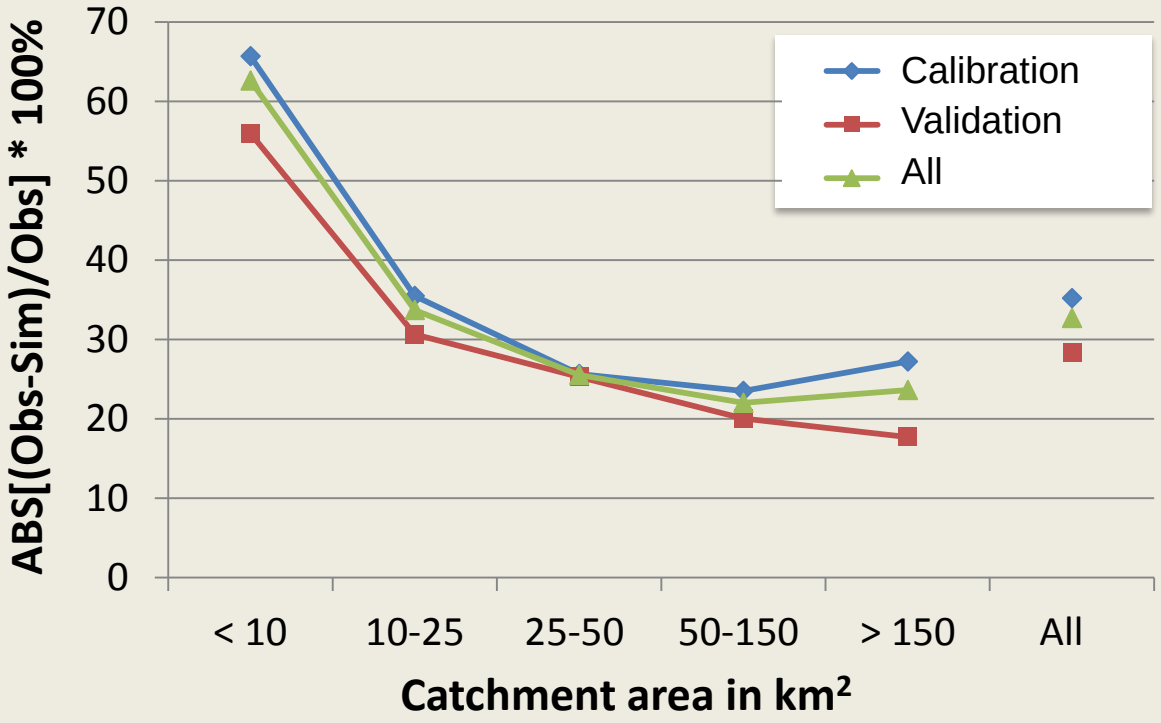


Calibration/ validation

- 183 calibration catchments
- 106 validation catchments
- Calibration and validation on yearly loads



Result – national calibration



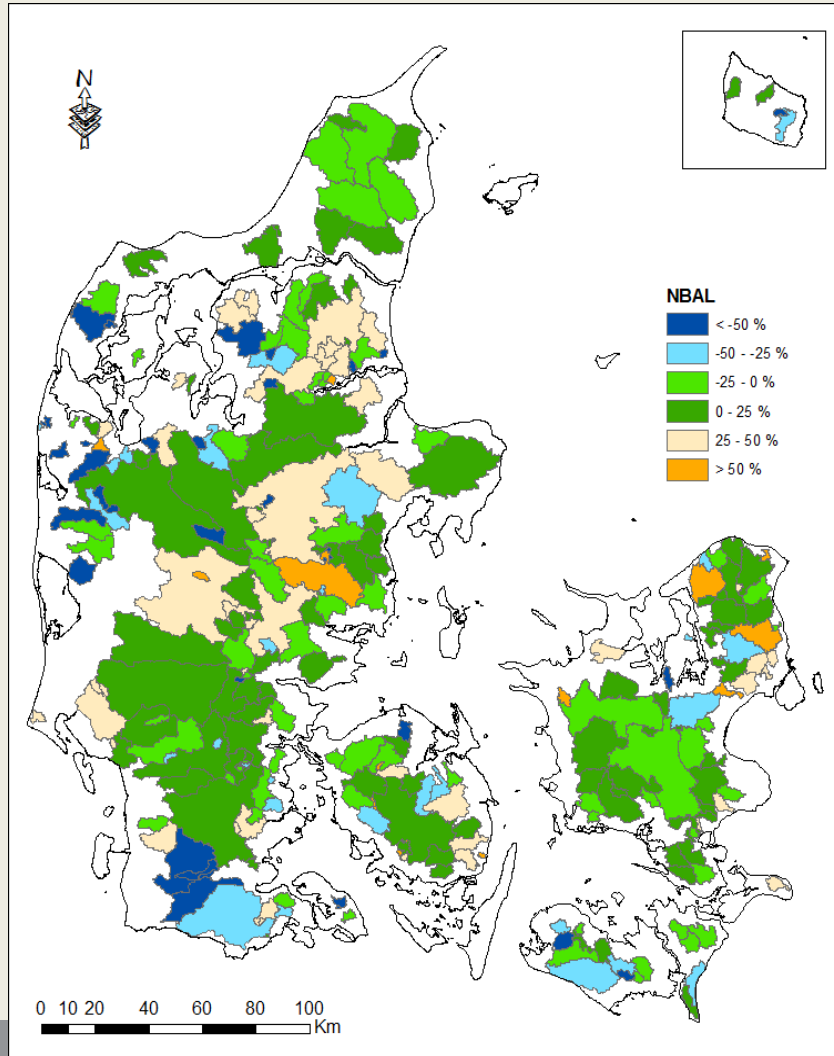
- Largest deviation in small catchments (smallest absolute load)
- Deviation generally decreasing with increase catchment scale, up to ~25-50 km^2
- Calibration and validation results comparable

Model application

Bias correction

- Station based correction
  - Correcting retention to fit observed transport at station with data
- Bias correction – unmeasured cathments
  - Analysing amount and spatial variation in correction factor

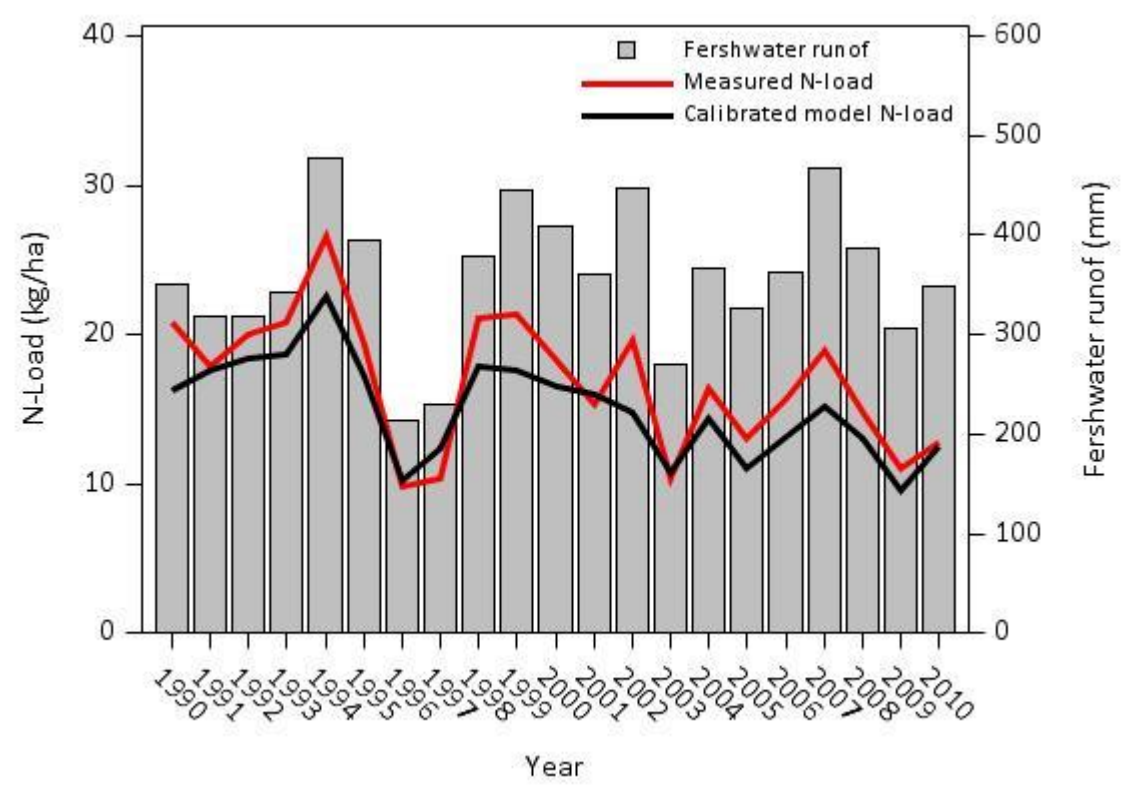
Spatial residuals



Simulated and observed loads to coast at national scale

”Observed” are 169 downstream stations

Calibrated model

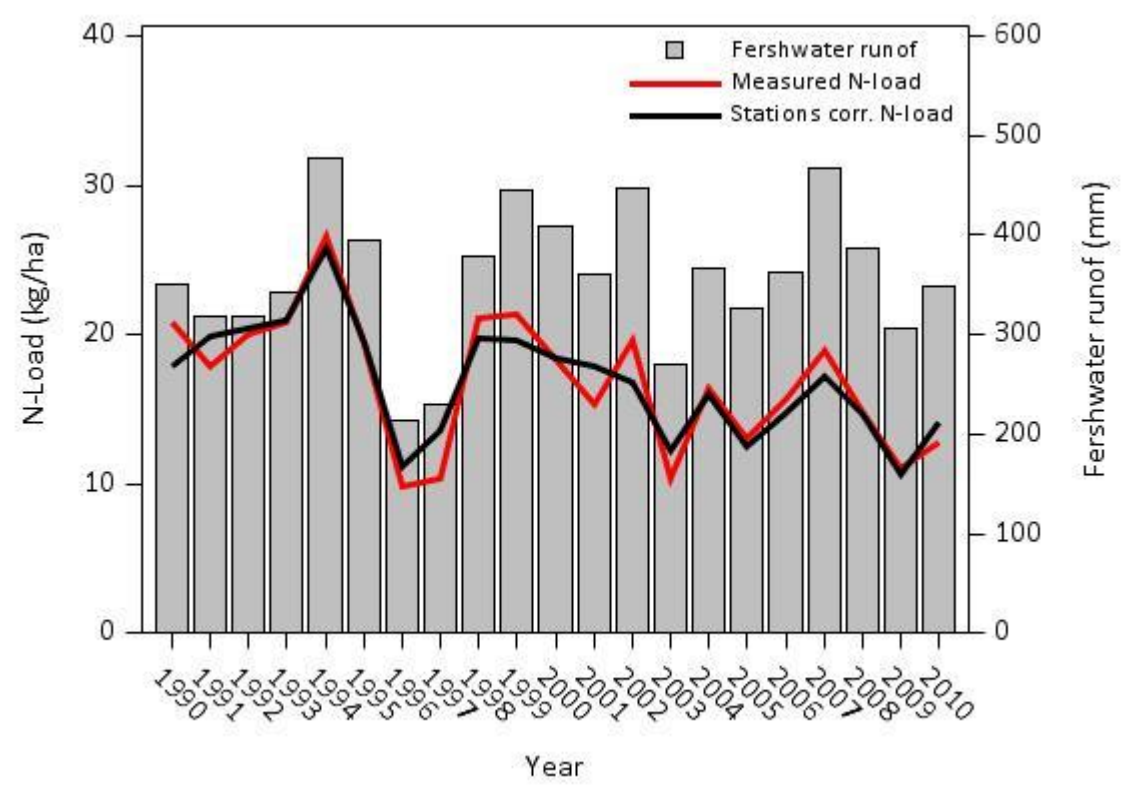


Simulated and observed loads to coast at national scale

”Observed” are 169 downstream stations

Calibrated and corrected model

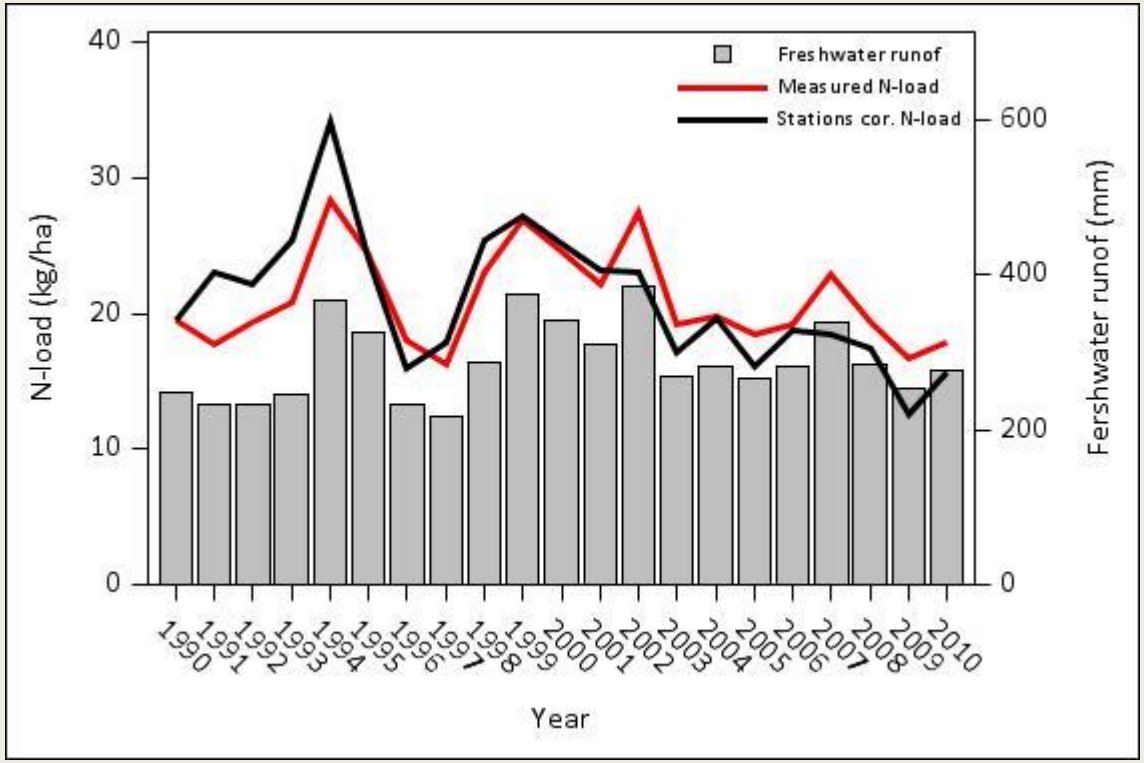
- Level of transport generally captured by model
- Some year to year dynamic is missed



Simulated and observed loads to coast – selected region

Calibrated and corrected model

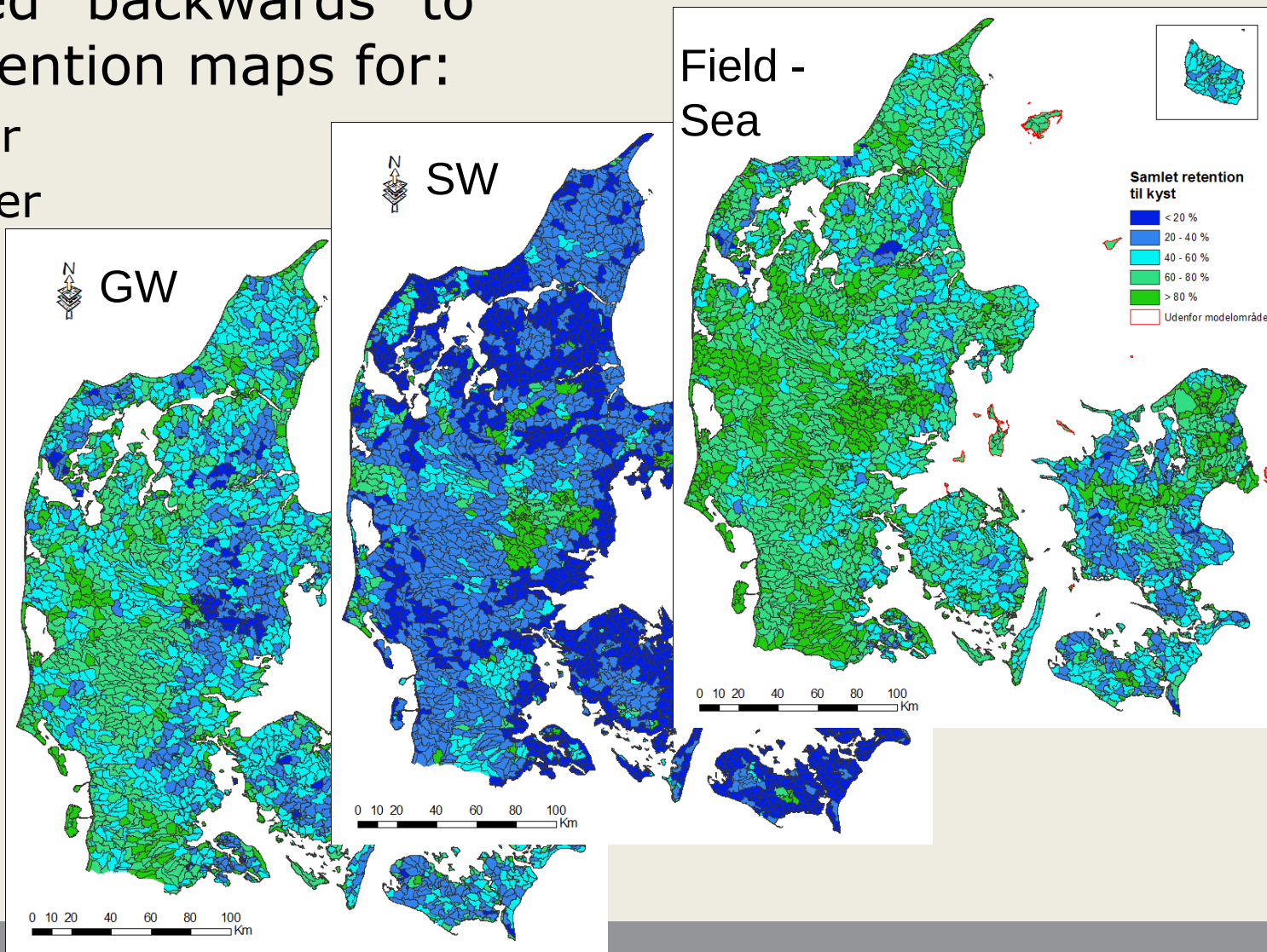
Some areas show little temporal development, which is not captured well by the model



Retention map

Model worked “backwards” to compute retention maps for:

- Groundwater
- Surface water
- Field to sea



Conclusion

- Model calibration
  - Generally captures regional but to a lesser extent local variations
  - Employing a bias correction
  - Model challenged in region with no development
- National modelling immature?

- First national nitrogen model
  - Development ~1½ year
  - Major achievement in coupling data and existing models
    - Spatial overview
    - QA of data/models/concepts
    - Identified gaps in knowledge on larges scale modelling -> new projects
    - Possibly to test and quantify different hypothesis and their national distribution

- Advancing quality modelling to support regional and national decision makers, we must pursue two paths
  - Local study for process understanding and quantification of heterogeneity
  - Regional/national development integrating local scale knowledge and develop large scale approaches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