NATURVIDENSKAB
KØBENHAVNS UNIVERSITET

HOBE – Danish Hydrological Observatory

Center of Excellence in Catchment Hydrology

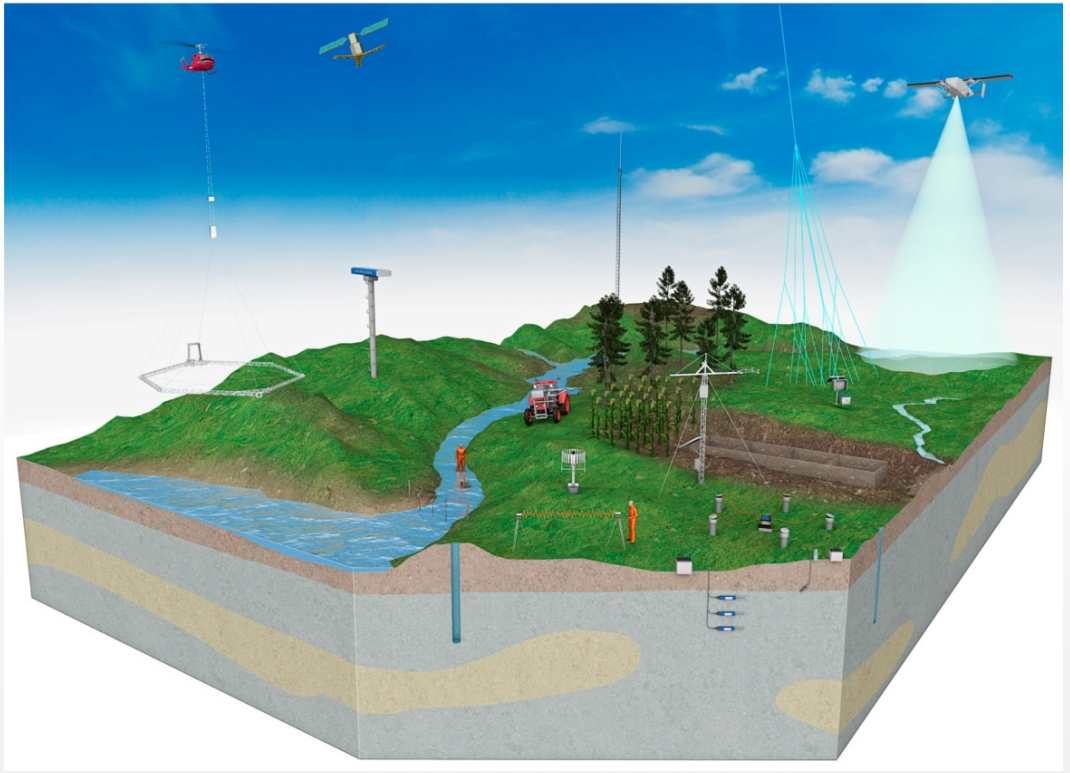
Karsten Høgh Jensen
University of Copenhagen

HOBE: Program context

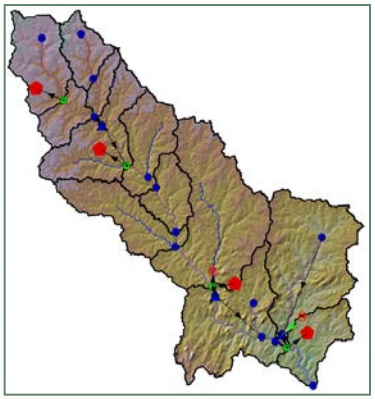
- Project period 2007-2017
- 8.8 M€ (65 mill. DKK) donation from the VILLUM FOUNDATION
- 3.0 M€ (22 mill. DKK) from Strategic Research Council, Ministry of Education and Science, Universities
- Partners: University of Copenhagen, University of Aarhus, Technical University of Copenhagen, Geological Survey of Denmark and Greenland, Danish Meteorological Institute
- 26 PhD students
- 12 Postdocs

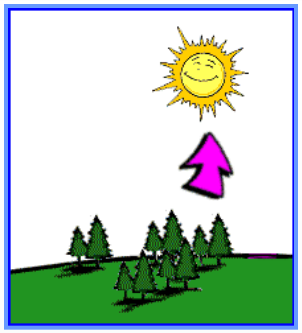
Hydrological observatory: Key objectives

- Establish an observatory and outdoor laboratory
- Test new innovative field instrumentation and observation techniques
- Establish scientific datasets to support fundamental research of hydrological processes
- Integrate knowledge across hydrological disciplines
- Integrate monitoring, measurements, experiments, modeling and scaling
- Provide a basis for international research collaboration



Problems with closure of water budget





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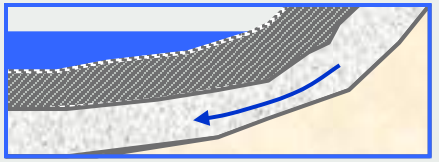
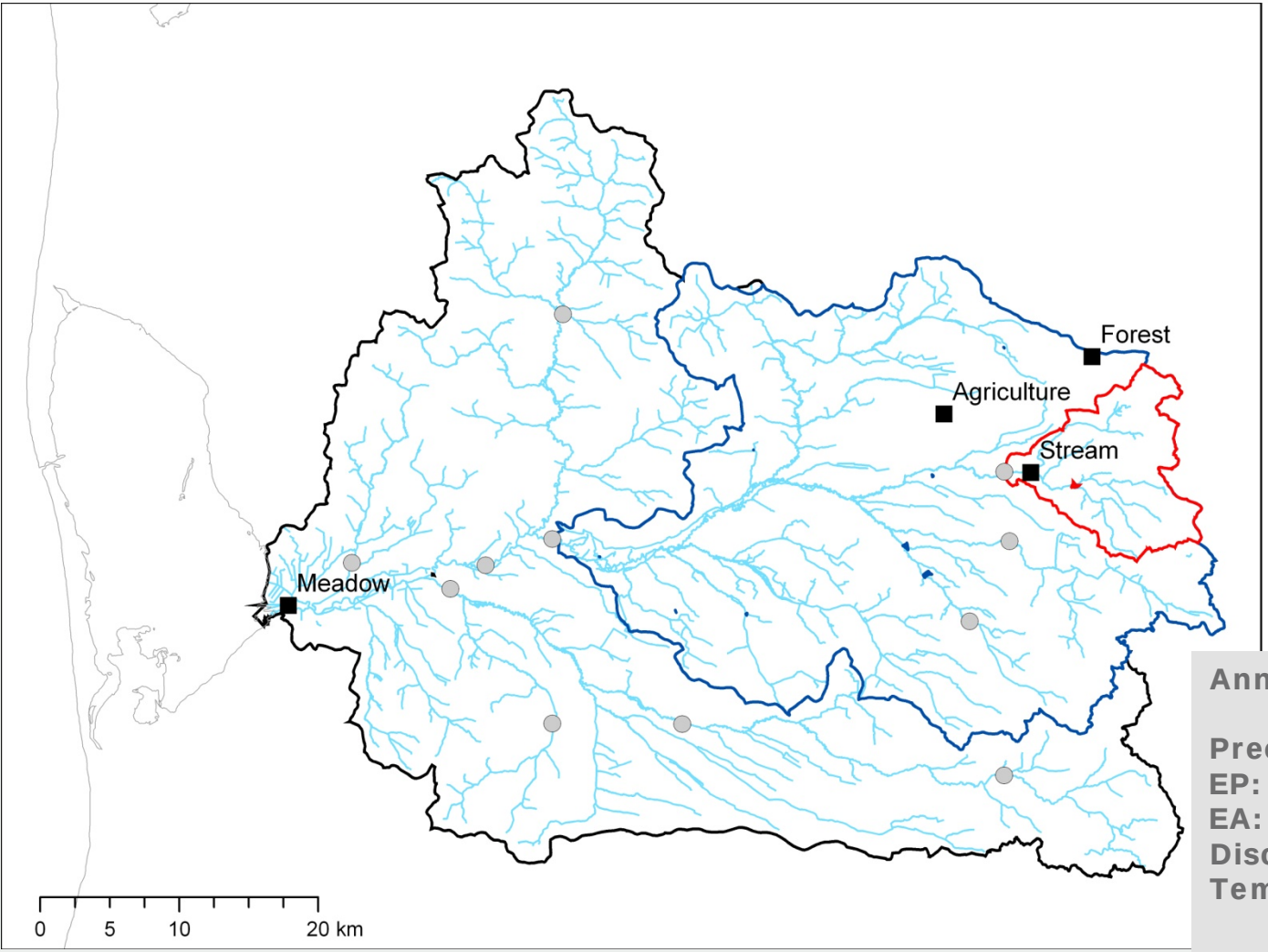


Precipitation = Evapotranspiration +
Stream flow +
Groundwater pumping +
Irrigation +
Submarine groundwater discharge

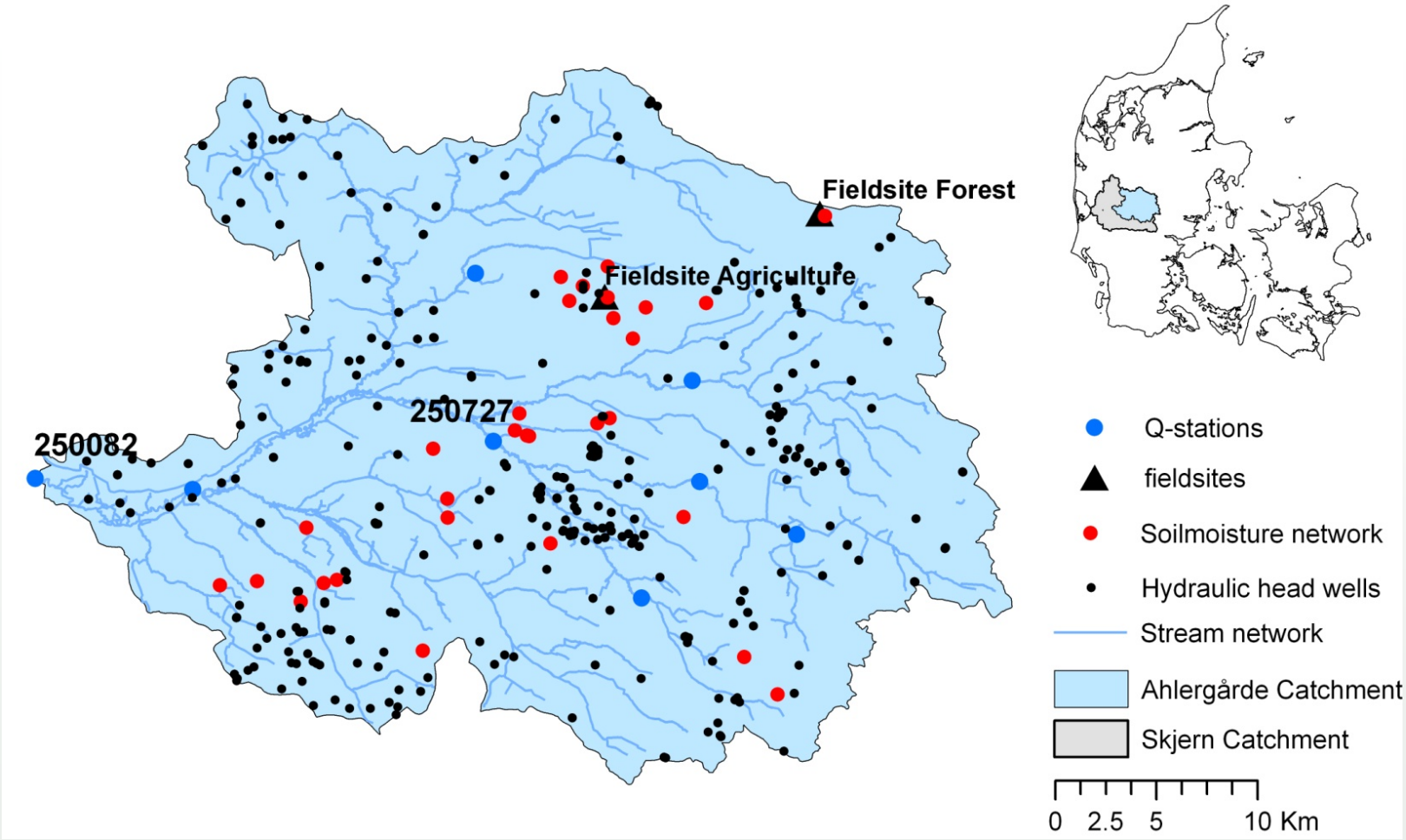
Study area - Skjern catchment and associated subcatchments – nested approach



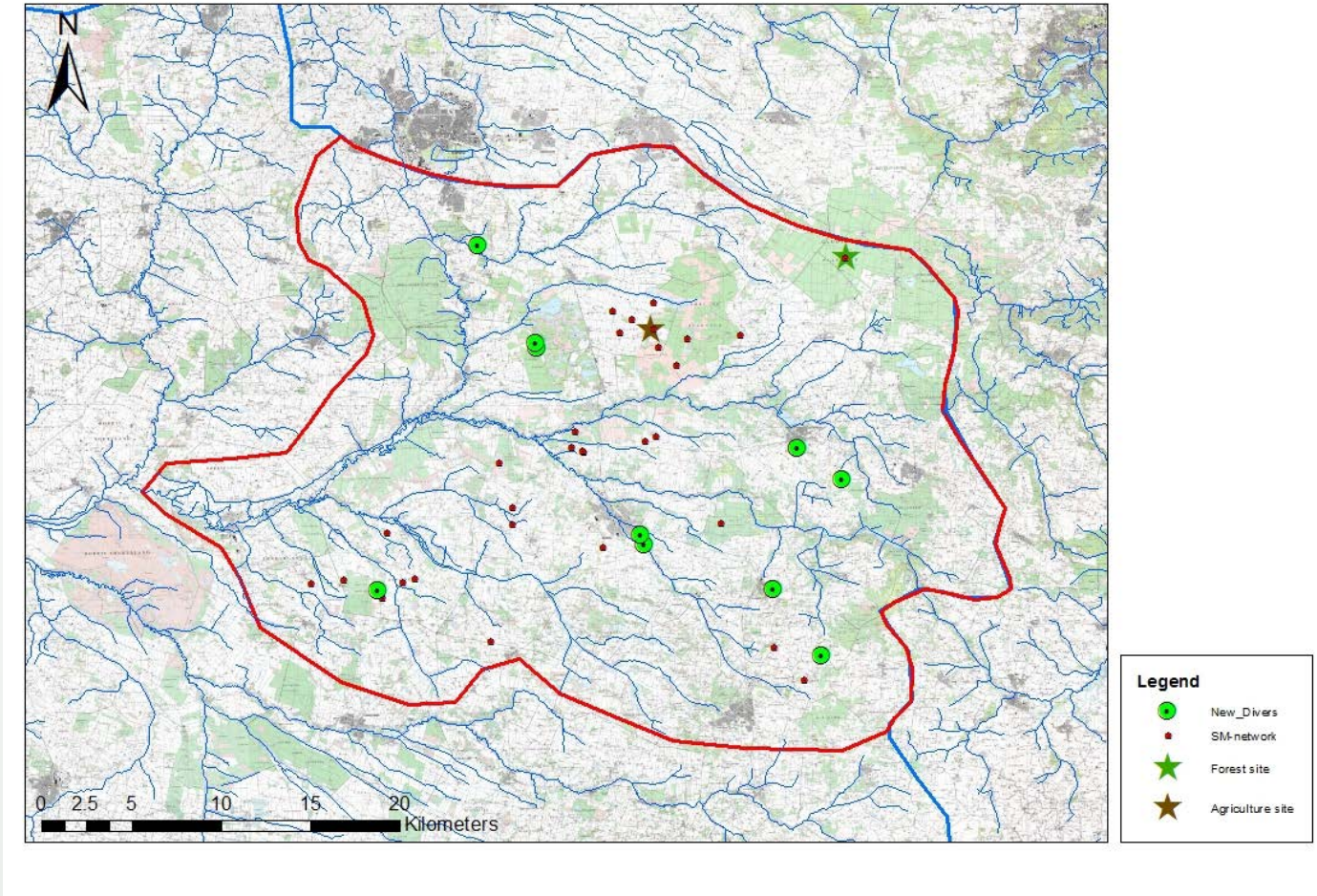
Annual water balance metrics

Precipitation:	**990 mm**
EP:	**600 mm**
EA:	**515 mm**
Discharge:	**475 mm**
Temperature:	**8 ^{0}C**

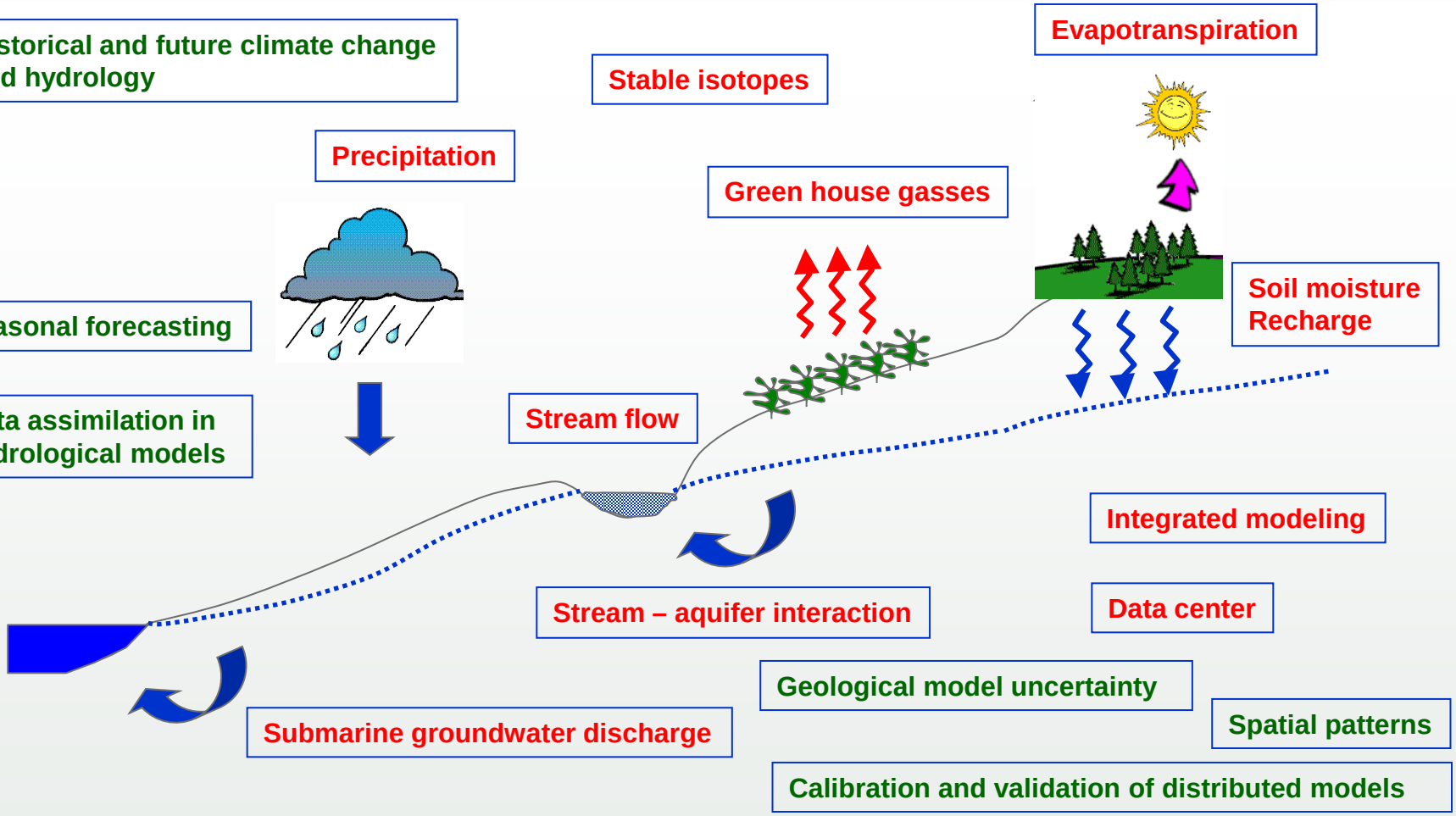
Flux stations, stream flow, soil moisture and groundwater



Groundwater divers



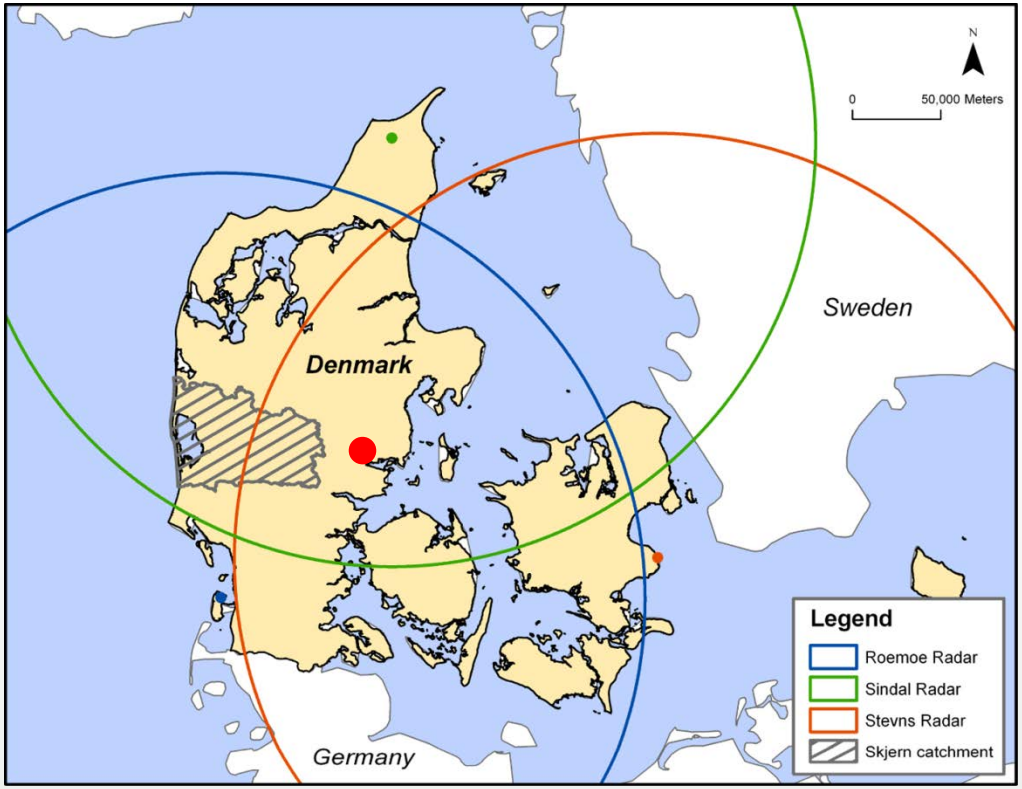
Project components

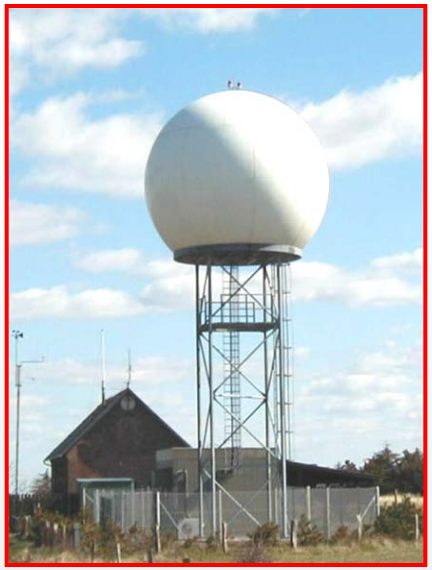


Research issues: Precipitation

- Measurement and bias-correction of precipitation at local scale (rain gauges)
- Estimation of precipitation at catchment scale (weather radar)
- Quantification of uncertainty propagation in the hydrological system

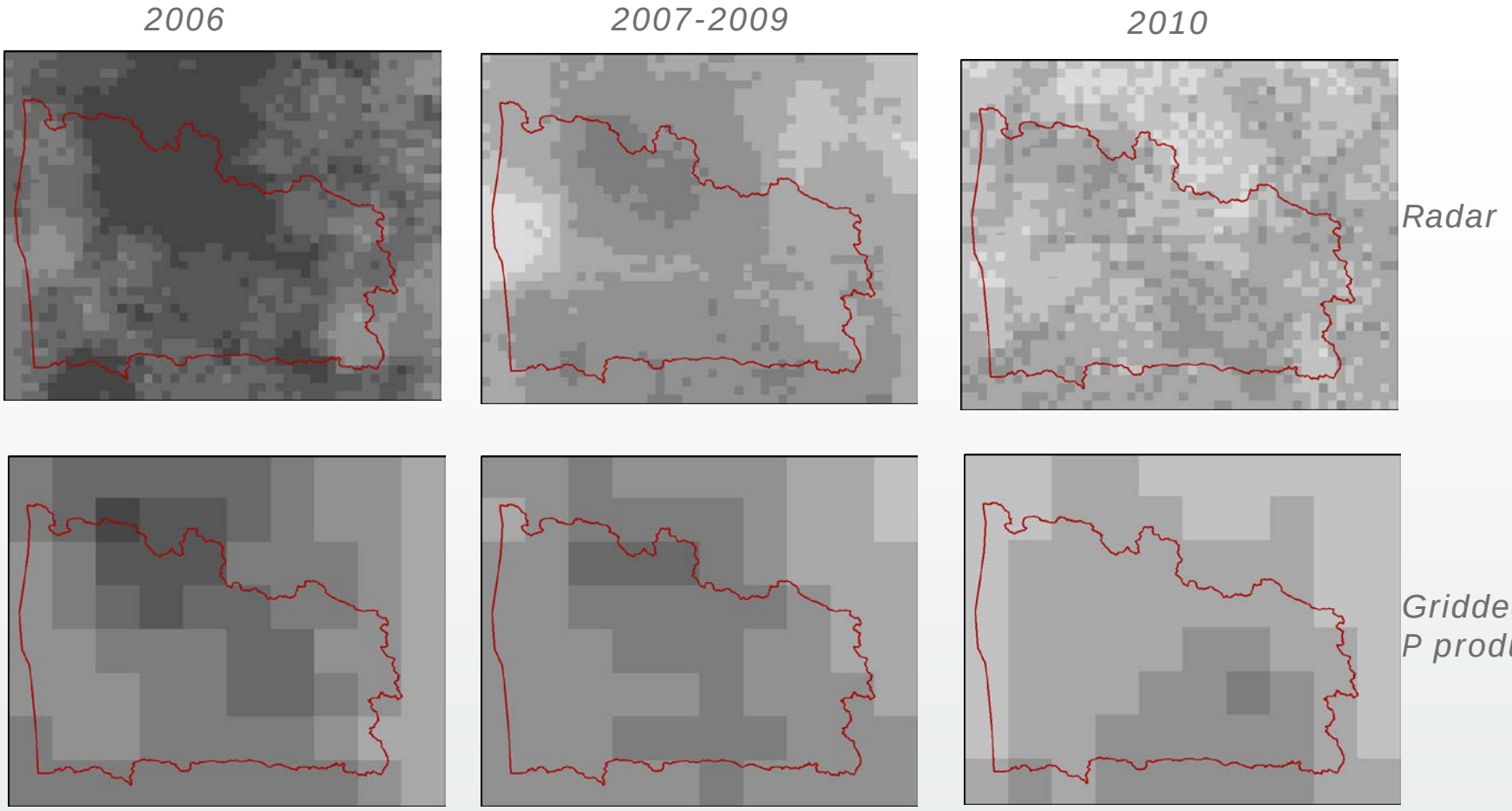
Precipitation estimate at catchment scale: Weather radars





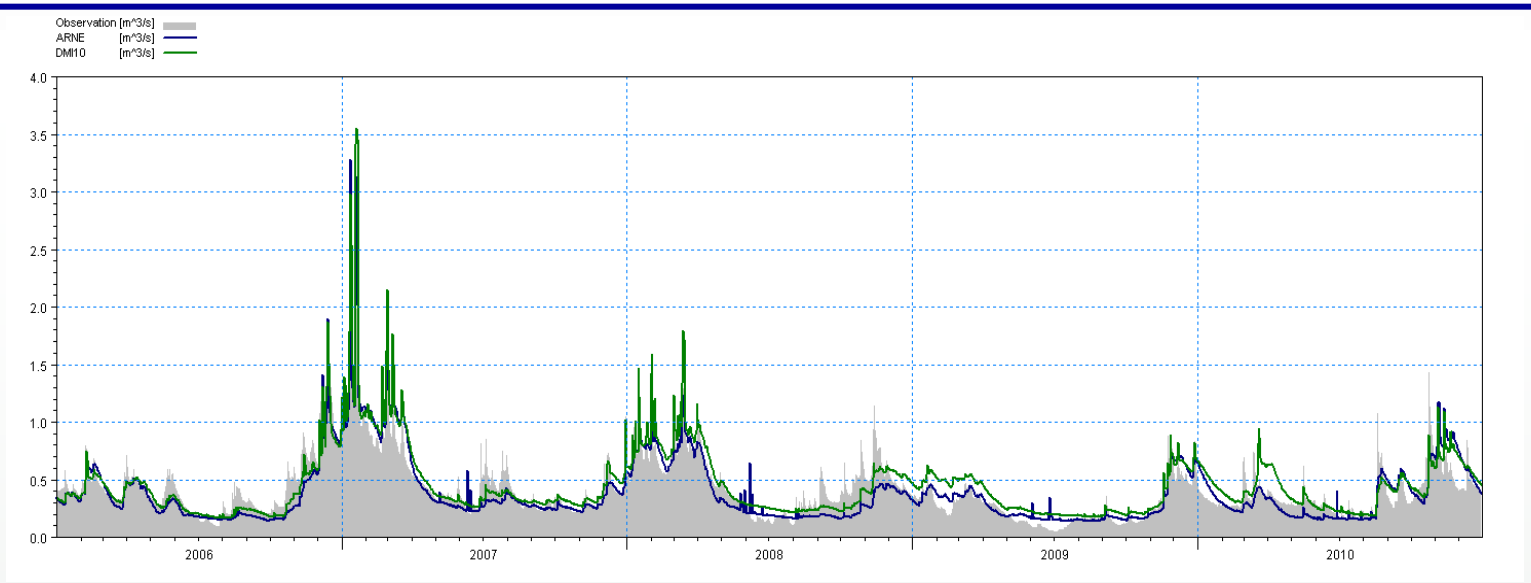
- Dual polarization radar

Radar and rain gauge based precipitation

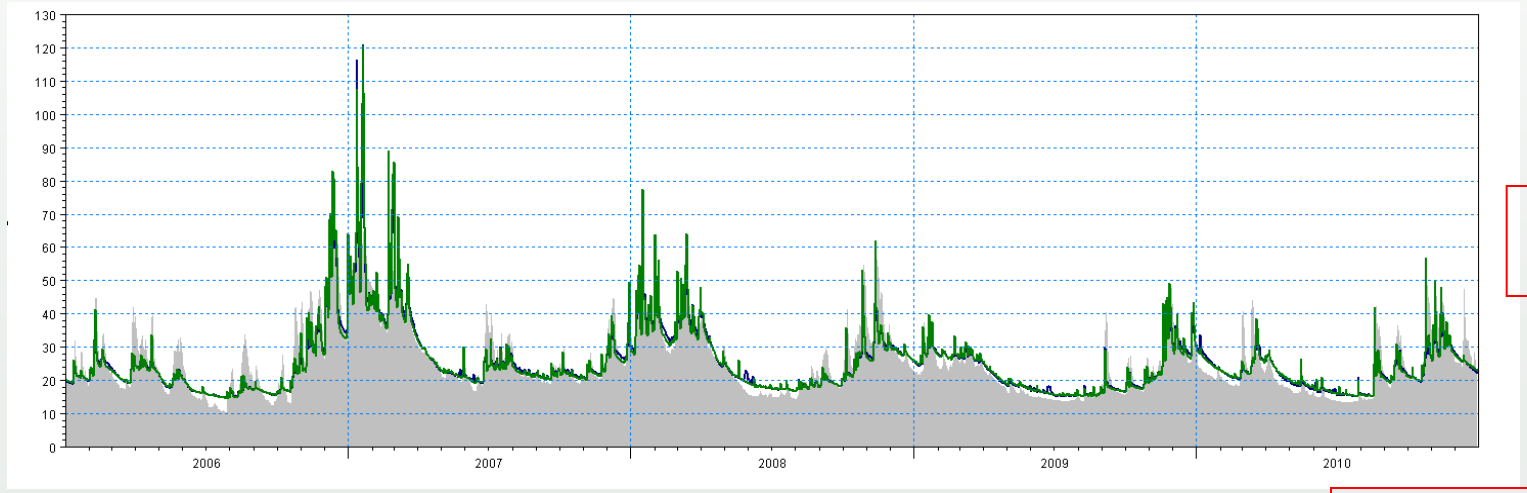


He et al., WRR, 2013

Simulated discharge of upstream and downstream stations



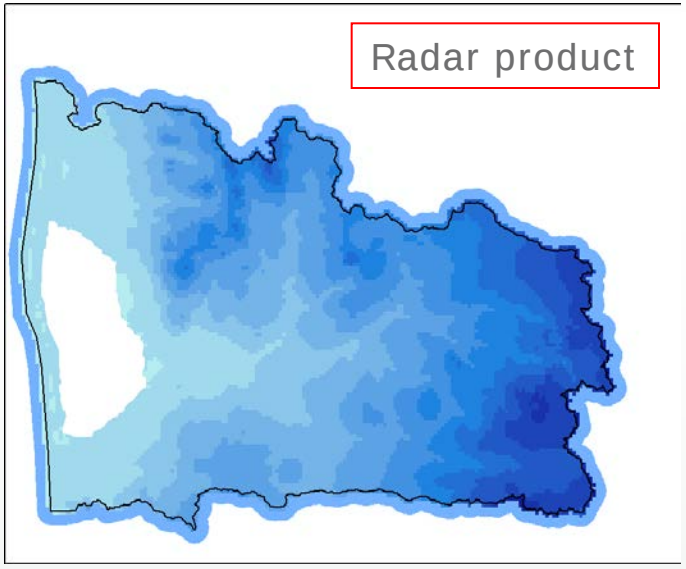
Upstream 47 km²

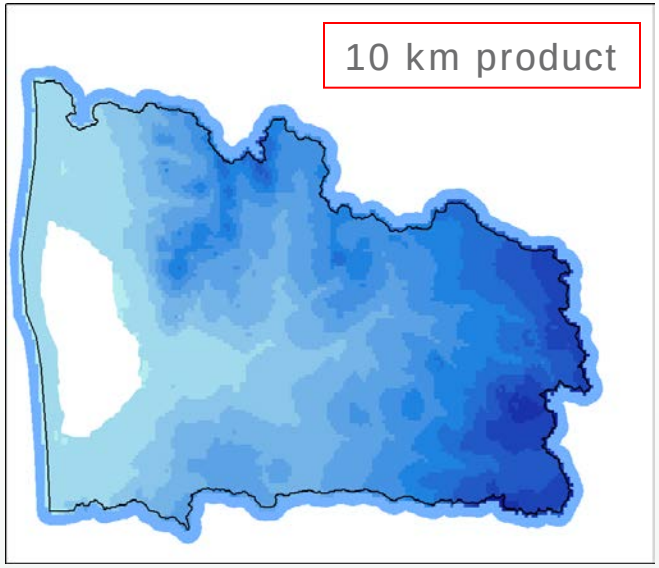


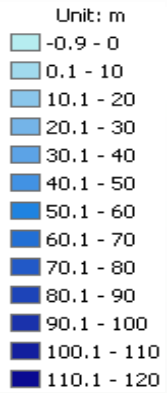
Downstream 1550 km²

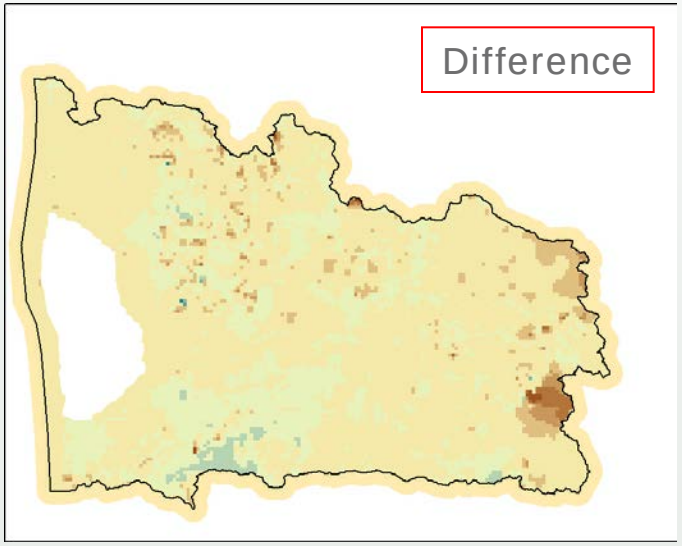
He et al., WRR, 2013

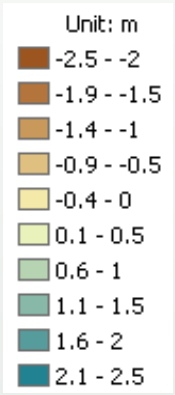
Average groundwater head (2006-2010)









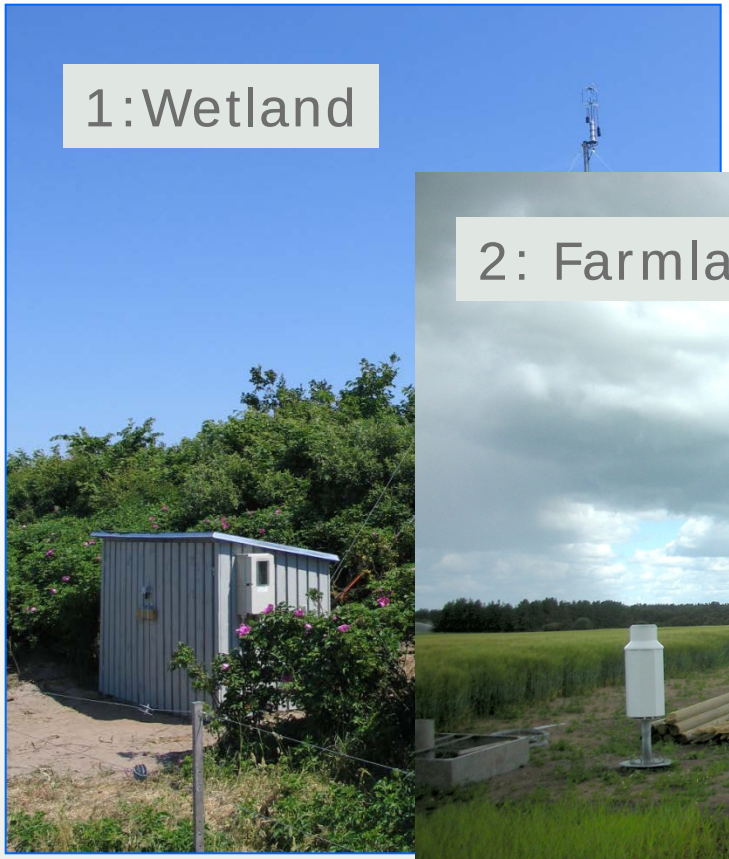


He et al., WRR, 2013

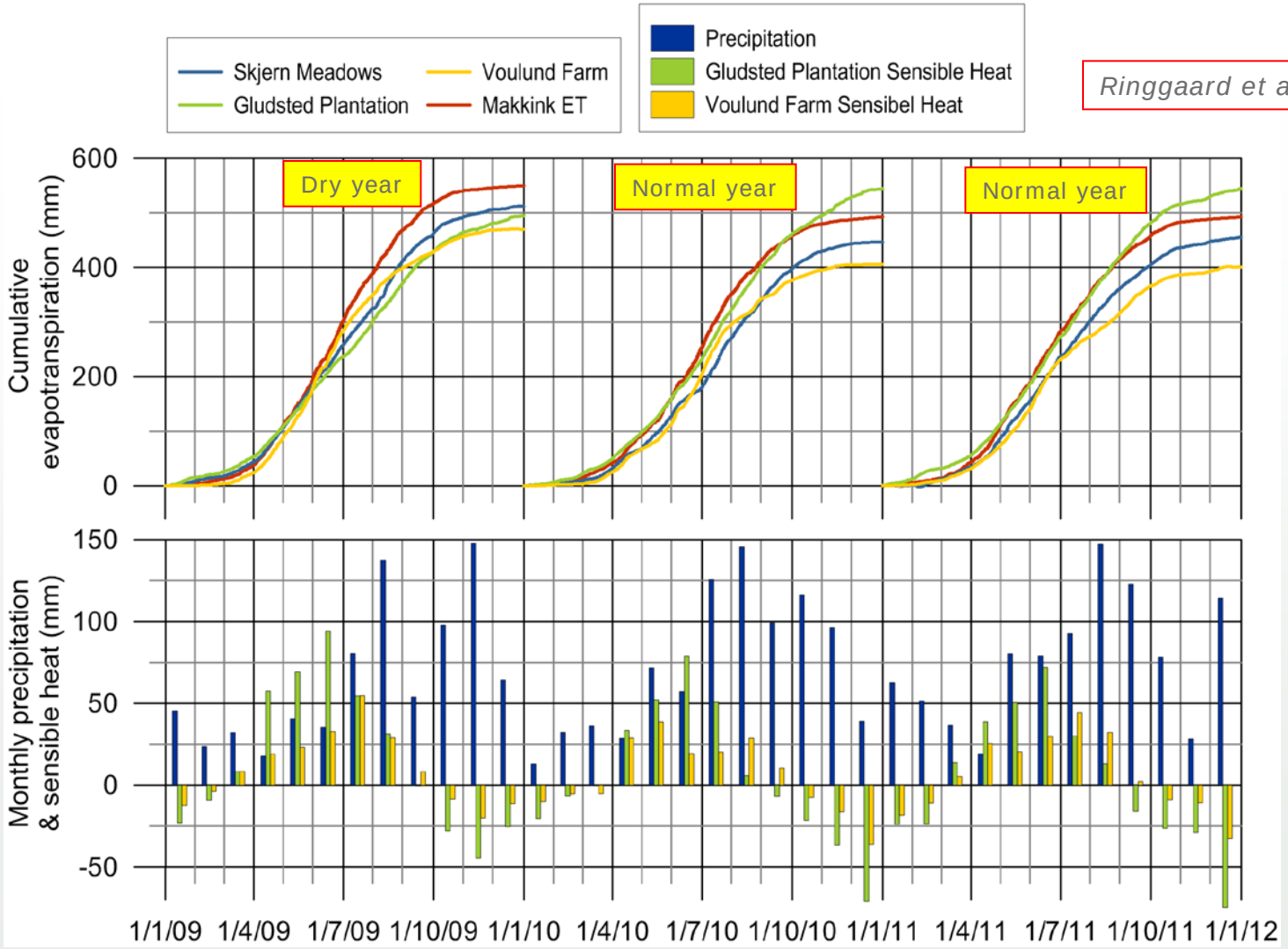
Research issues: Evapotranspiration

- Impact of land surface on ET at local scale
- Estimation of ET at catchment scale
- Upscaling - integration of observation data, remote sensing products and UAV data
- Quantification of uncertainty propagation in the hydrological system

Evapotranspiration: Local eddy flux measurements



ET for three land surfaces

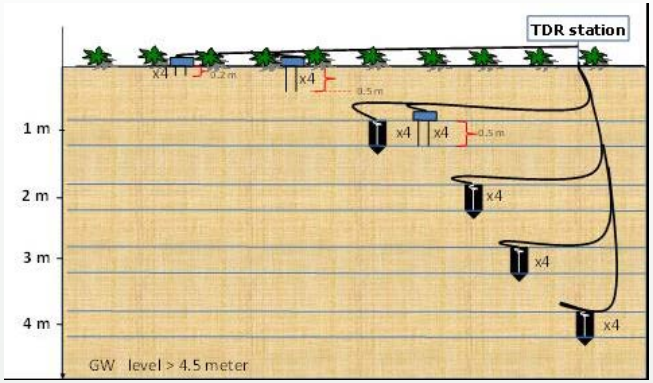


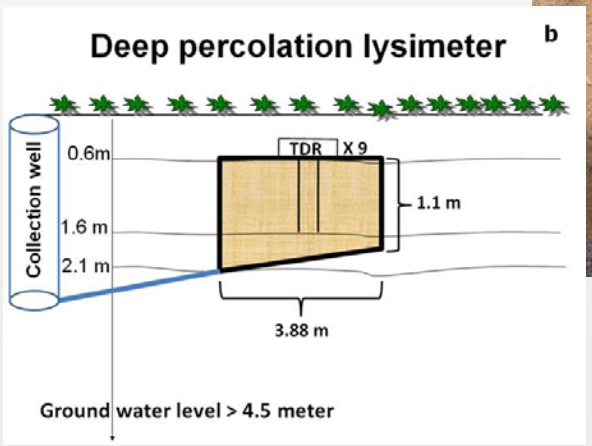
Ringgaard et al., VZJ, 2012

Research issues: Soil moisture

- Measurement and estimation of soil moisture at different spatial scales
- Interaction between vegetation and soil moisture
- Up- and downscaling of soil moisture
- Use of soil moisture for estimating water balance at the local scale
- Use of soil moisture for constraining distributed models
- Use of soil moisture for data assimilation in distributed models

Soil moisture: Field observatories





Cross-borehole geophysics

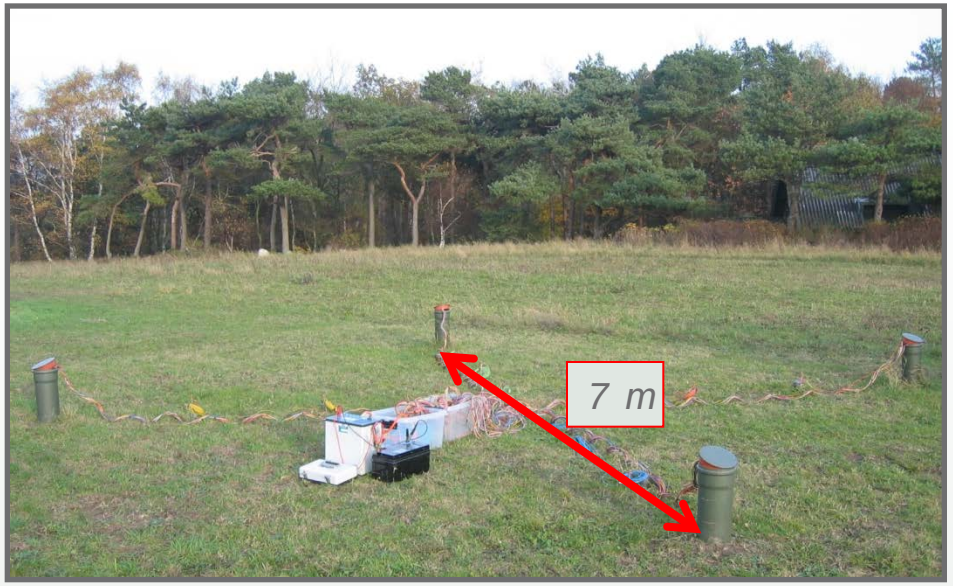
GPR (ground penetrating radar)

Measure traveltime of EM wave

- → *EM velocity*
- → *Dielectric permittivity*
- → *Soil moisture*

1D profiles, 2D images, psudo 3D images

ERT (electrical resistance tomography)

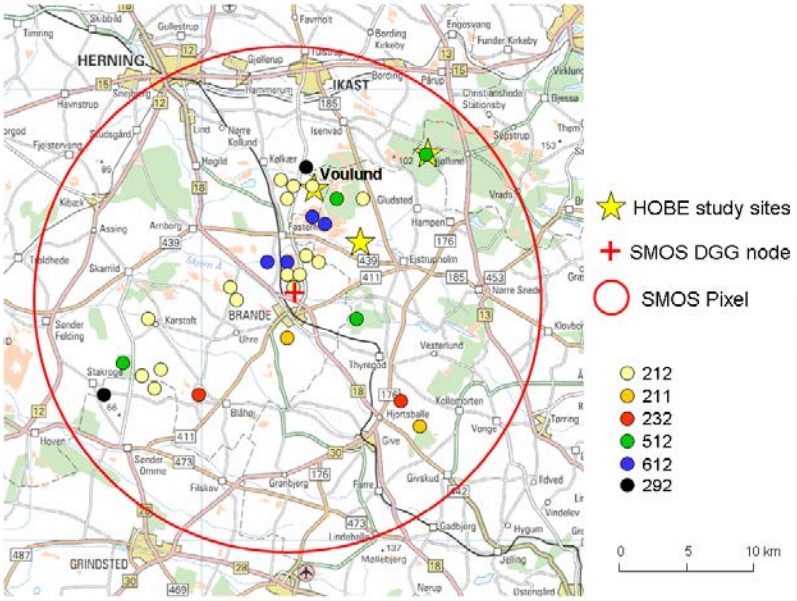


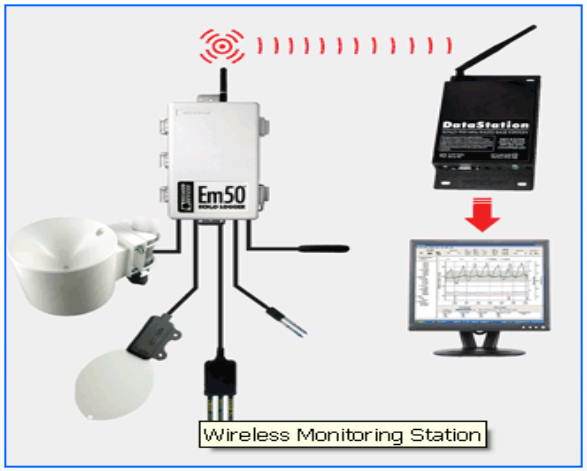
Measure resistance

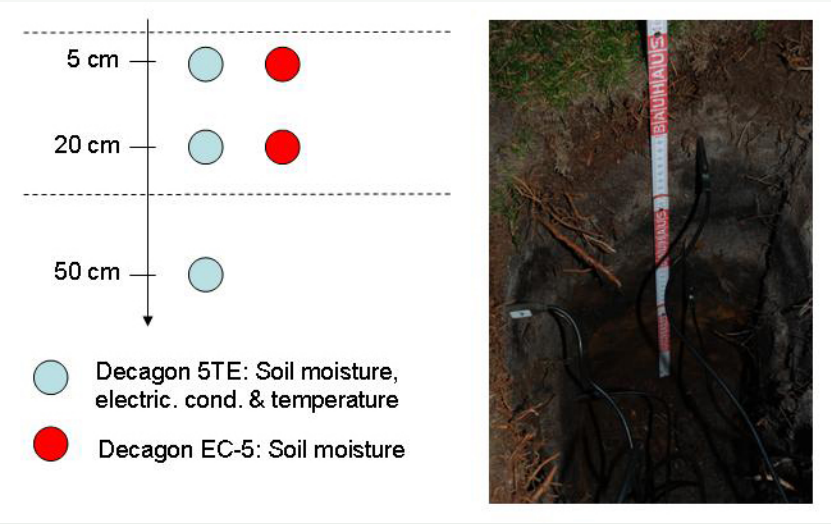
- → *Invert to resistivity*
- → *Soil moisture & porewater conductivity*

3D images, convert to 1D & 2D images

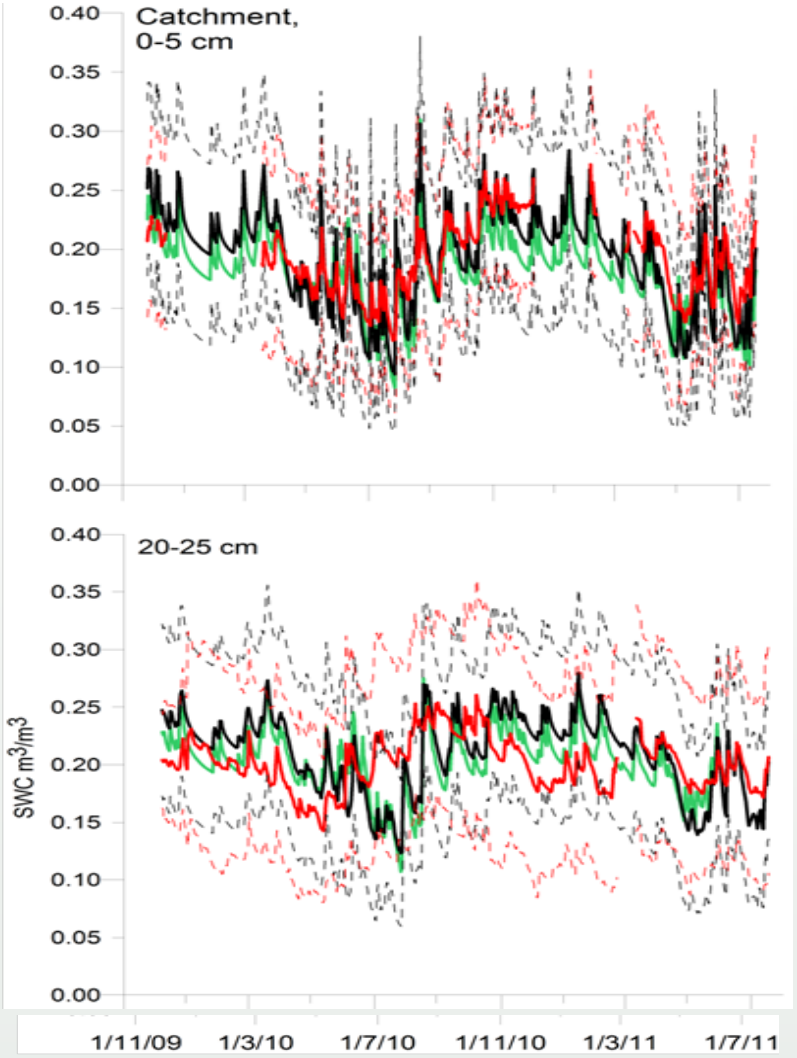
Soil moisture: Distributed soil mositure, electric conductivity and temperature network

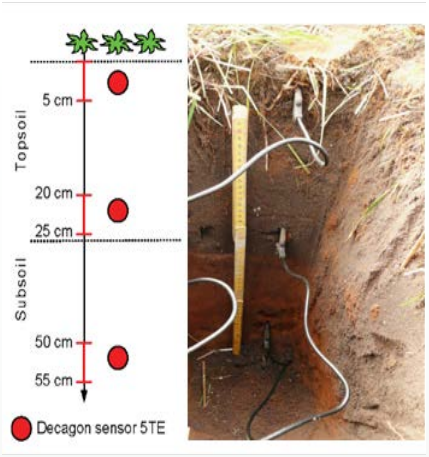




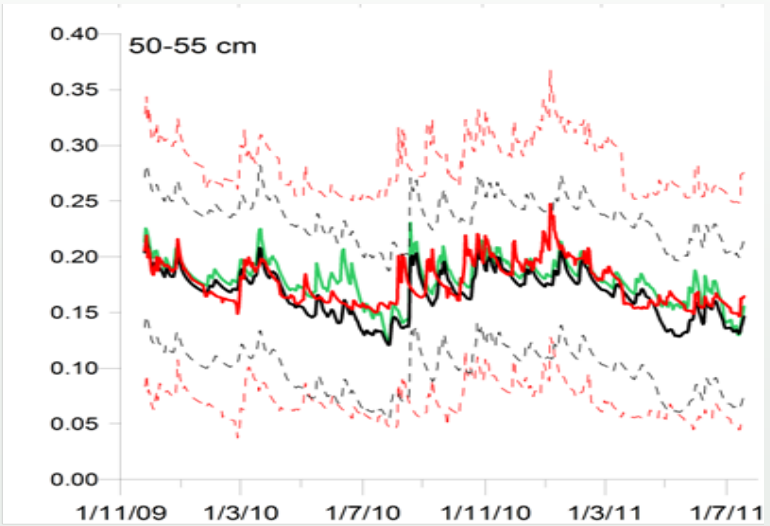


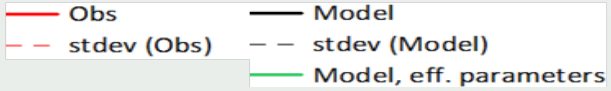
Soil moisture: Results from soil moisture network



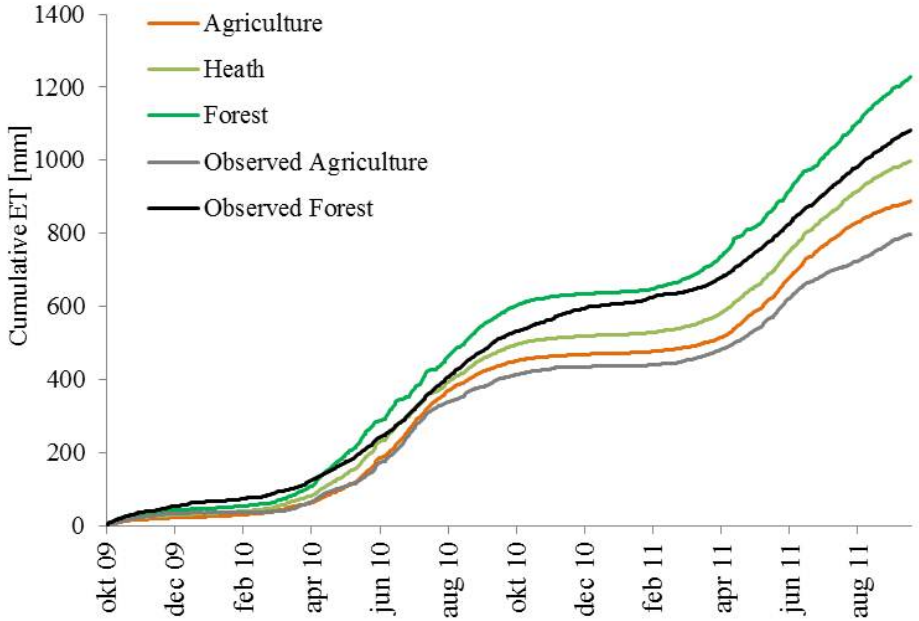


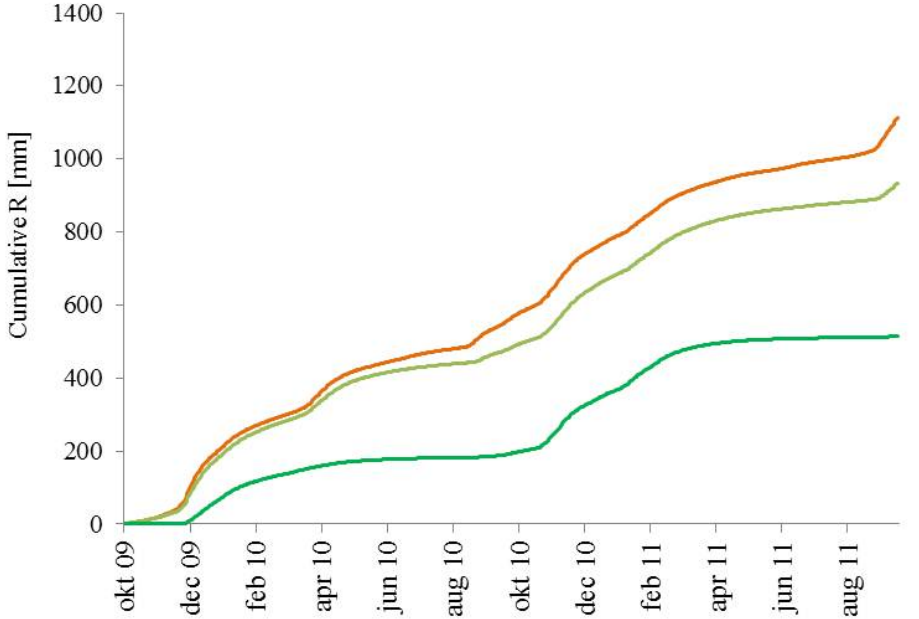
Andreasen et al., VZJ, 2013





Modeling of ET and recharge based on soil moisture network data





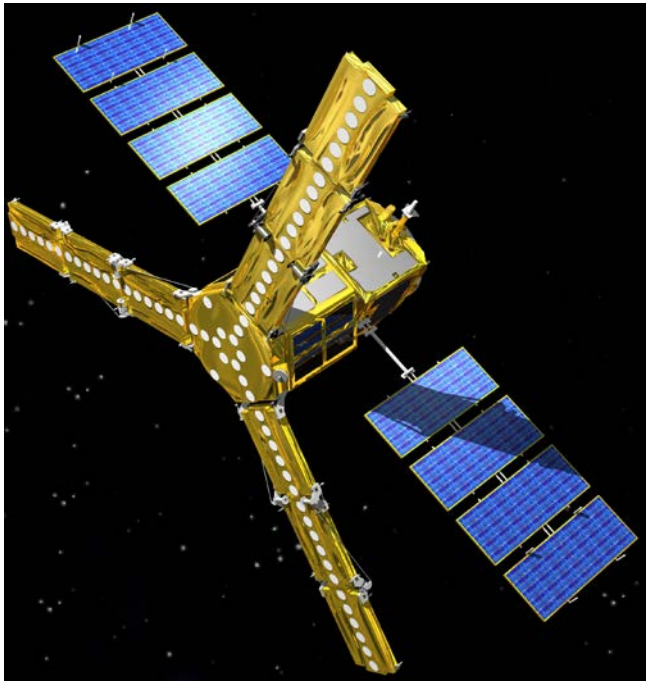
Soil moisture: SMOS - Soil Moisture and Ocean Salinity

Passive L-band MW radiometer

(1.4 GHz, λ = 21.4 cm)

Global fields of surface soil moisture every 3rd day

Goal: 4 % accuracy

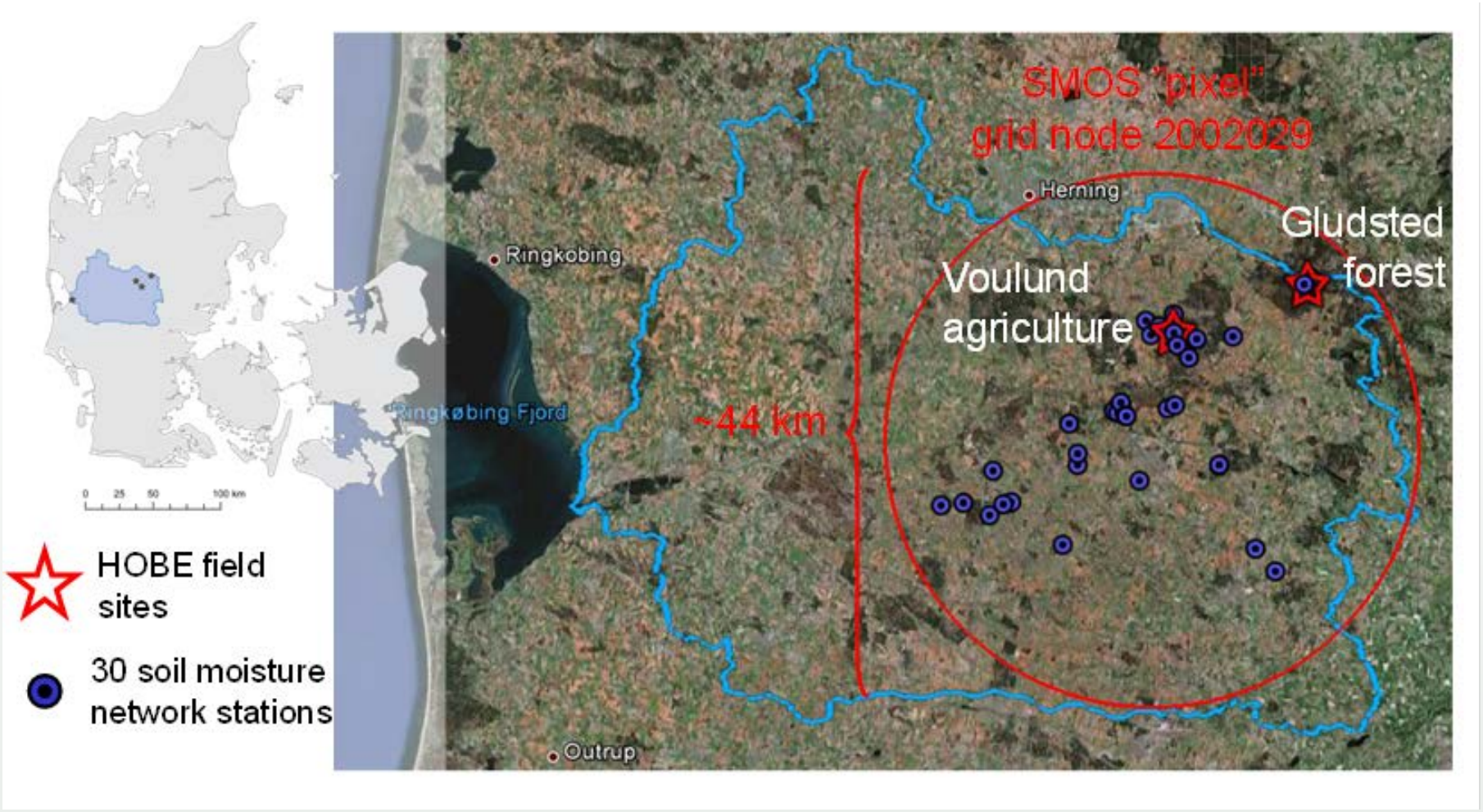


Limitations:

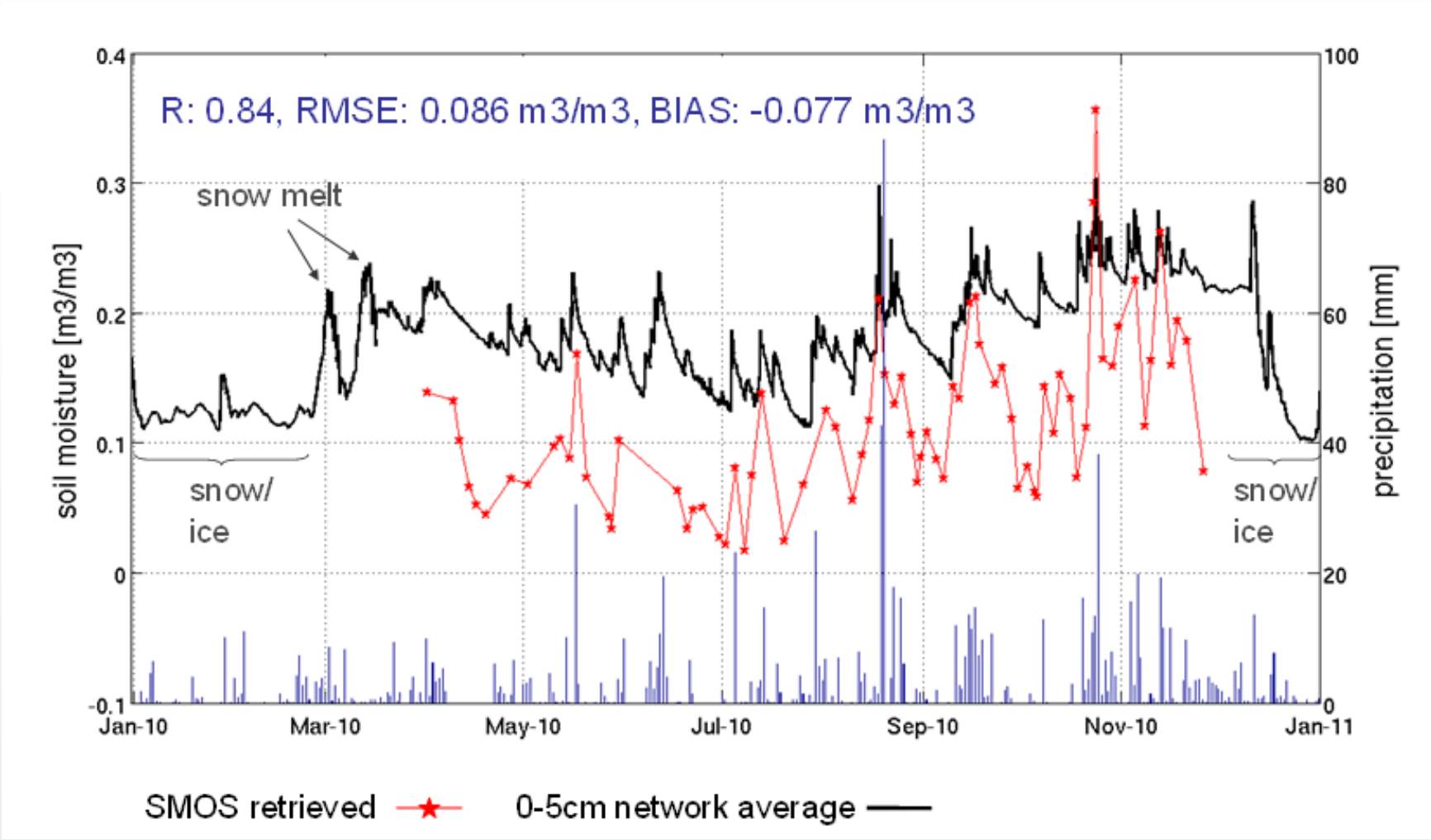
- Spatial resolution: ~ 44 km
- Penetration depth: ~ 5 cm (<5 cm in wet cond.)

Launched: November 2009

Soil moisture: SMOS spatial scale



Soil moisture: SMOS retrieved soil moisture and measurements

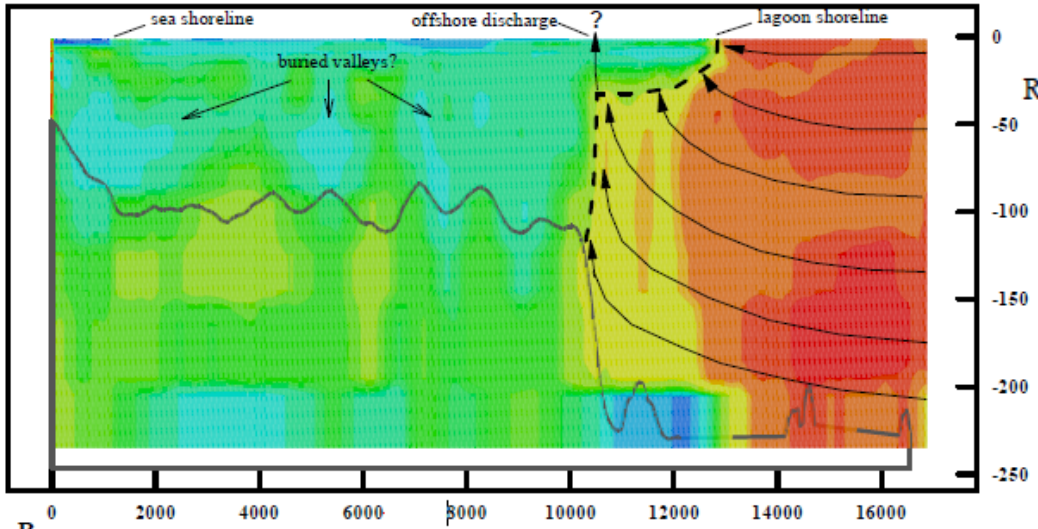


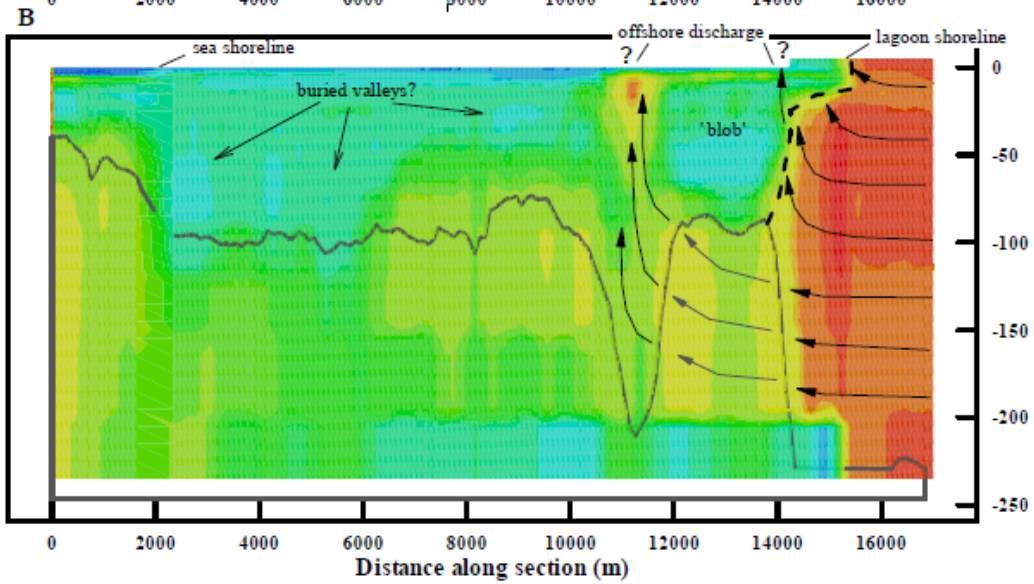
Bircher et al., HESS, 2012

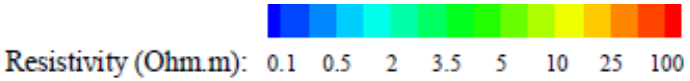
Research issues: Submarine groundwater discharge

- Analyze temporal and spatial patterns of submarine groundwater discharge (SGD) to coastal lagoon using hydrogeological, geophysical, and tracer techniques
- Contribution of SGD to overall water balance

Submarine groundwater discharge

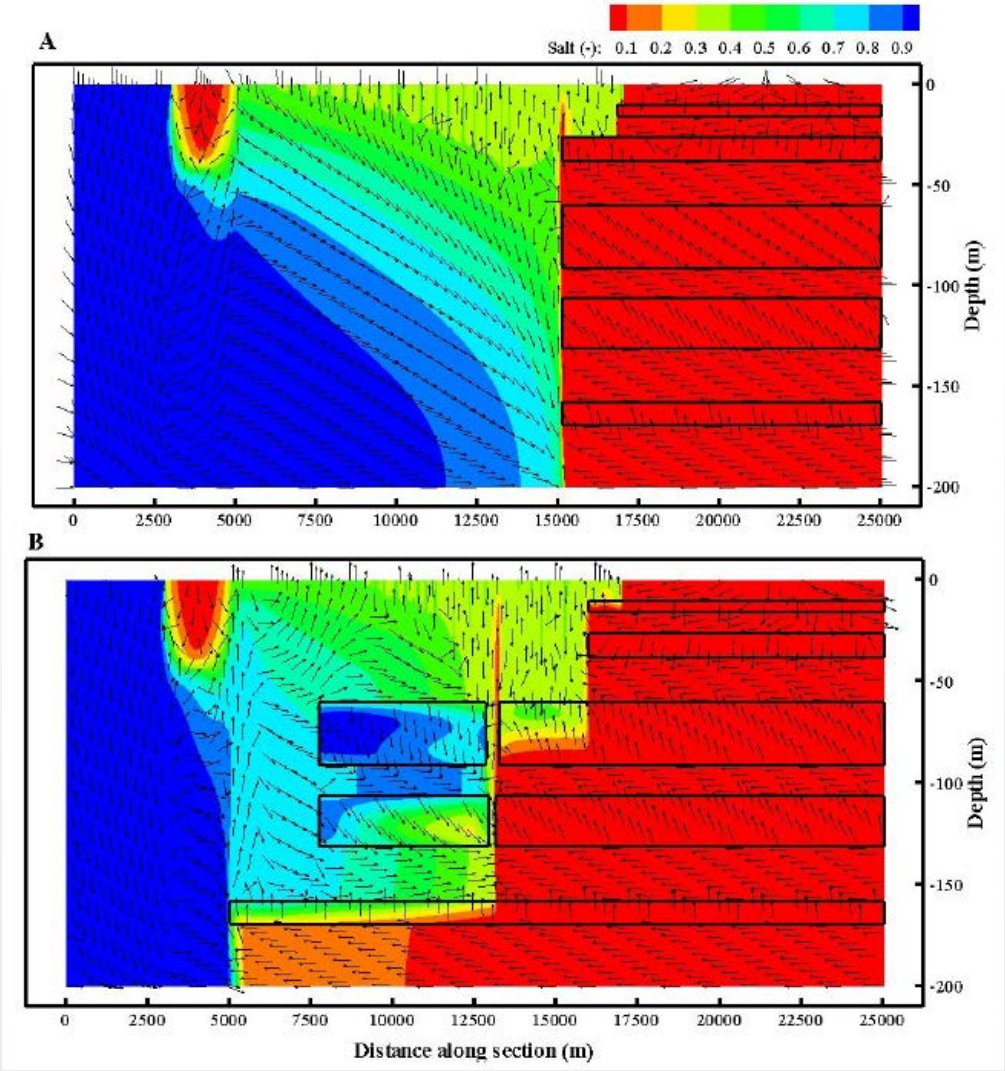






Haider, 2014

Numerical model analysis



SGD amounts to 6%
of the river inflow to the lagoon

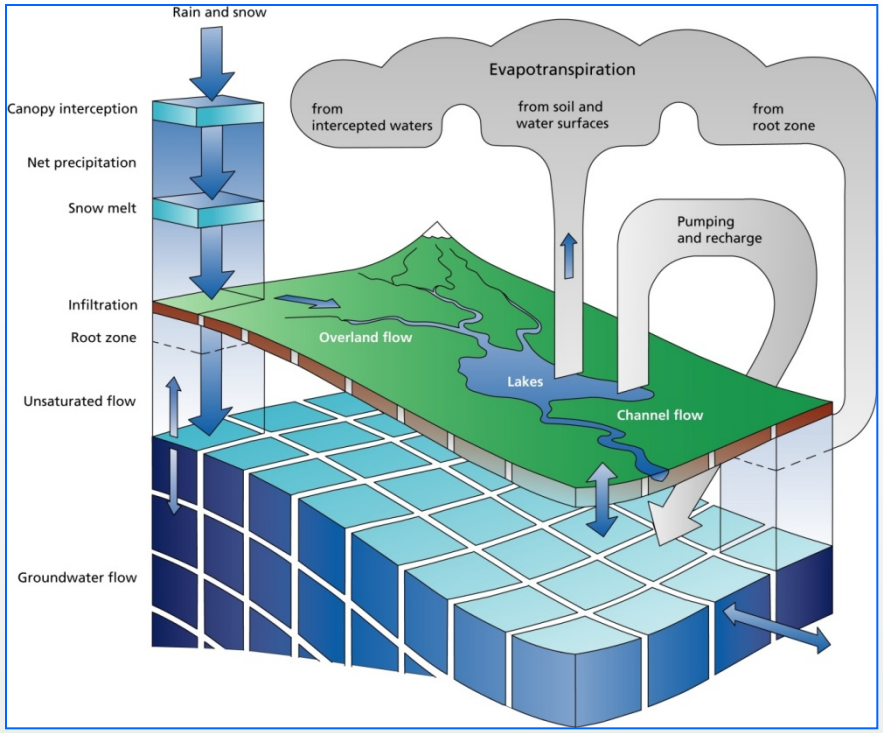
Haider, 2014

Research issues: Integrated modeling and analysis

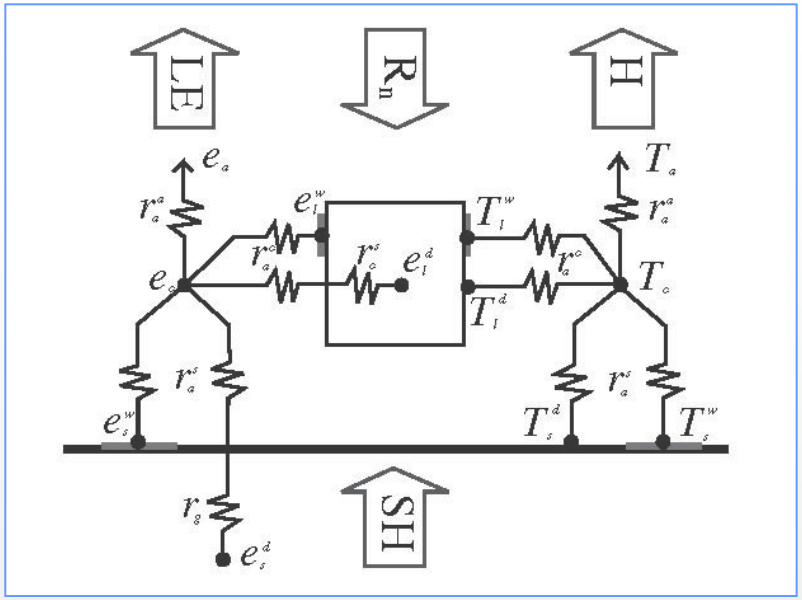
- Integrate monitoring data, measurements and experimental data representing various temporal and spatial scales
- Application of monitoring data, measurements and experimental data for multi-objective constraining of model
- Provide a coherent and integrated analysis of water resources states in and fluxes between hydrological compartments
- Uncertainty of water resources assessment due to uncertainty in forcing and calibration data
- Quantify uncertainty in water balance assessments

Modeling platform for integrated analysis

MIKE SHE

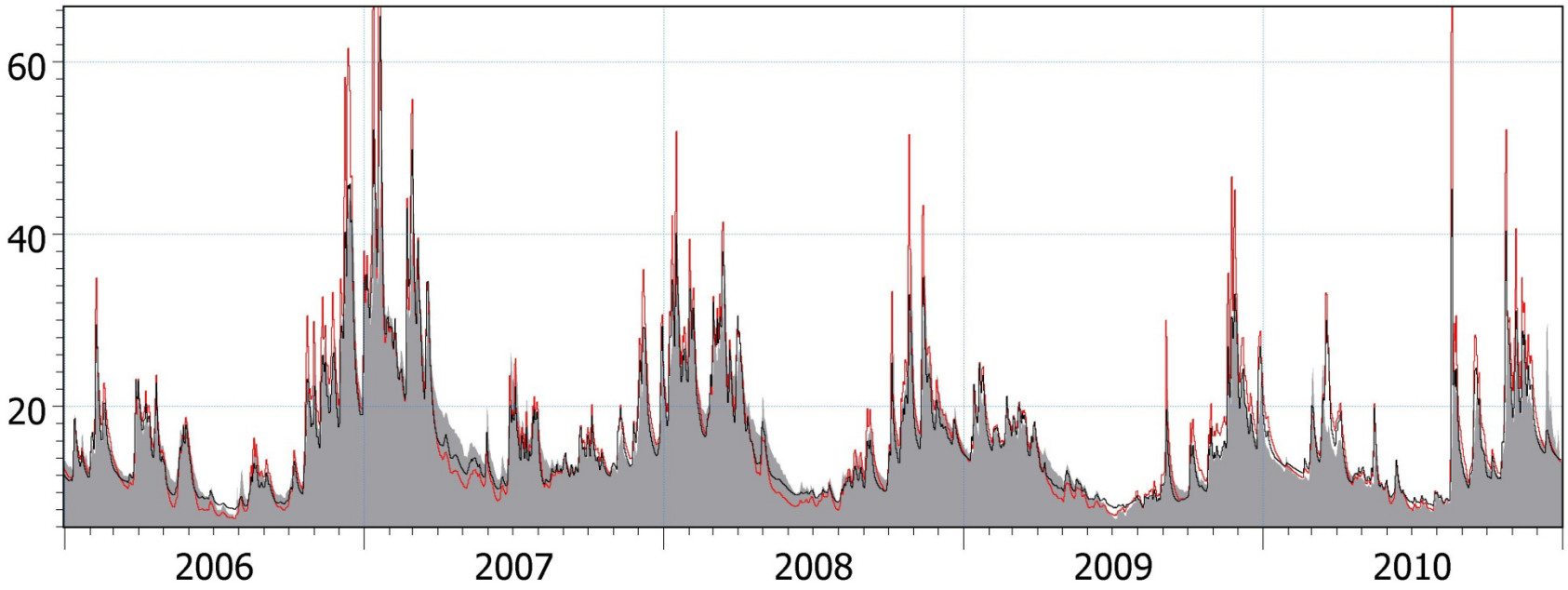


Land surface model (energy based)



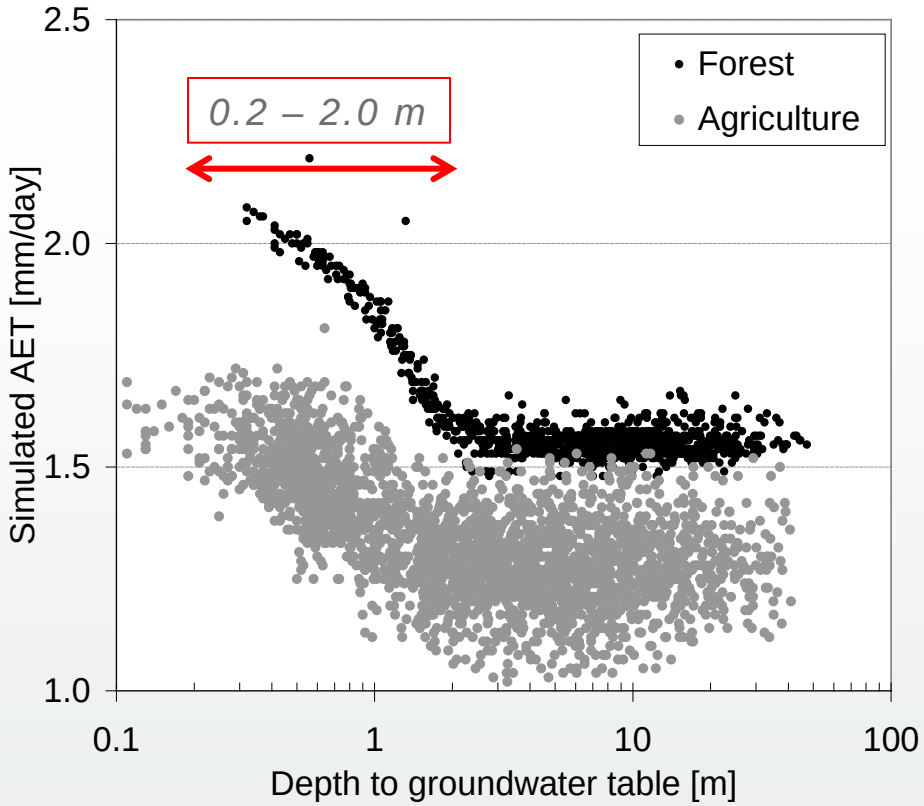
Multi-objective calibration results

11 parameters selected for calibration

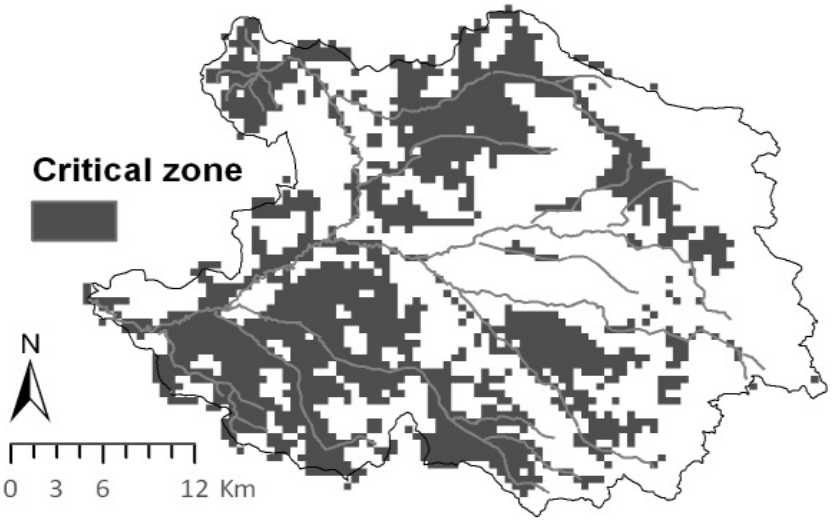


Stisen et al., 2013

Groundwater controlled evapotranspiration



Annual means 2010



Critical zone 38%

Stisen et al., 2013

Web site: http://www.hobecenter.dk/