



HOBE – Danish Hydrological Observatory

Center of Excellence in Catchment Hydrology

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University of Copenhagen



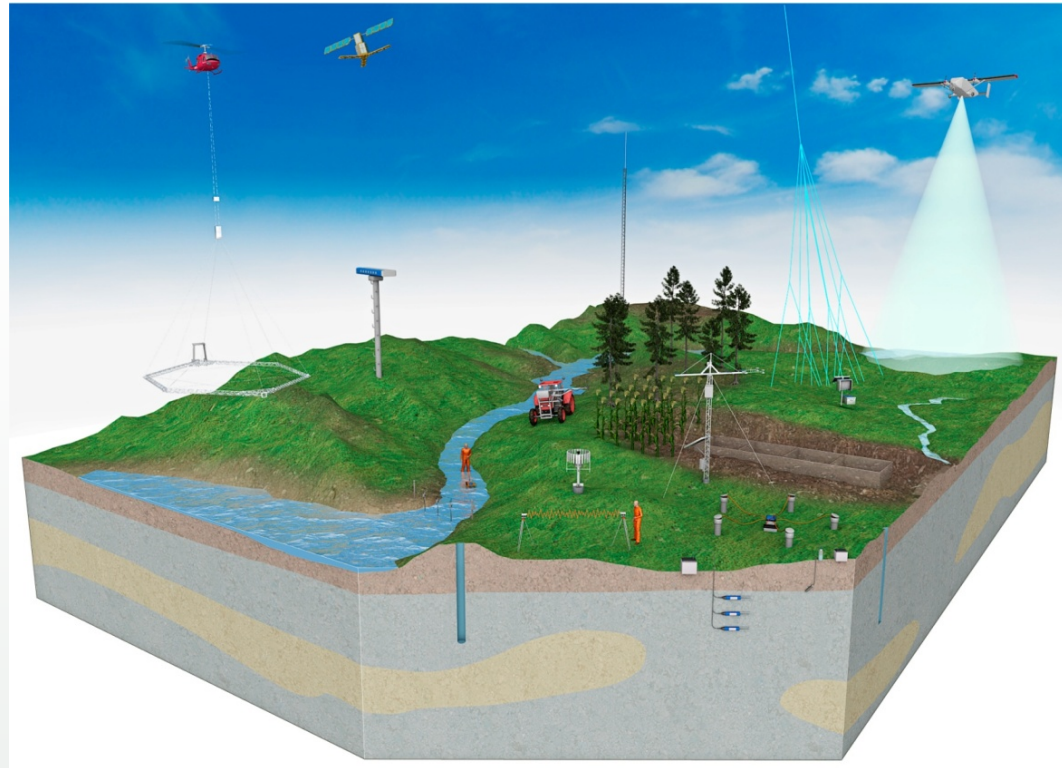
HOBE: Program context

- ▶ 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

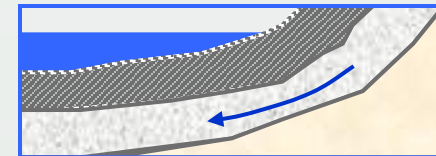
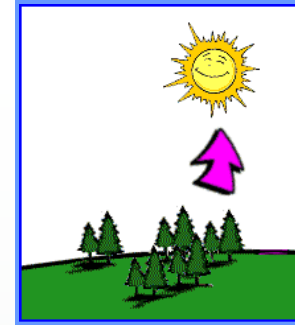
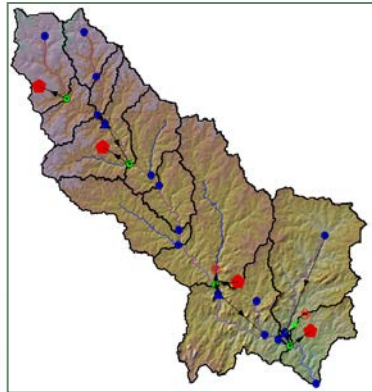


Hydrological observatory: Key objectives

- ▶ 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

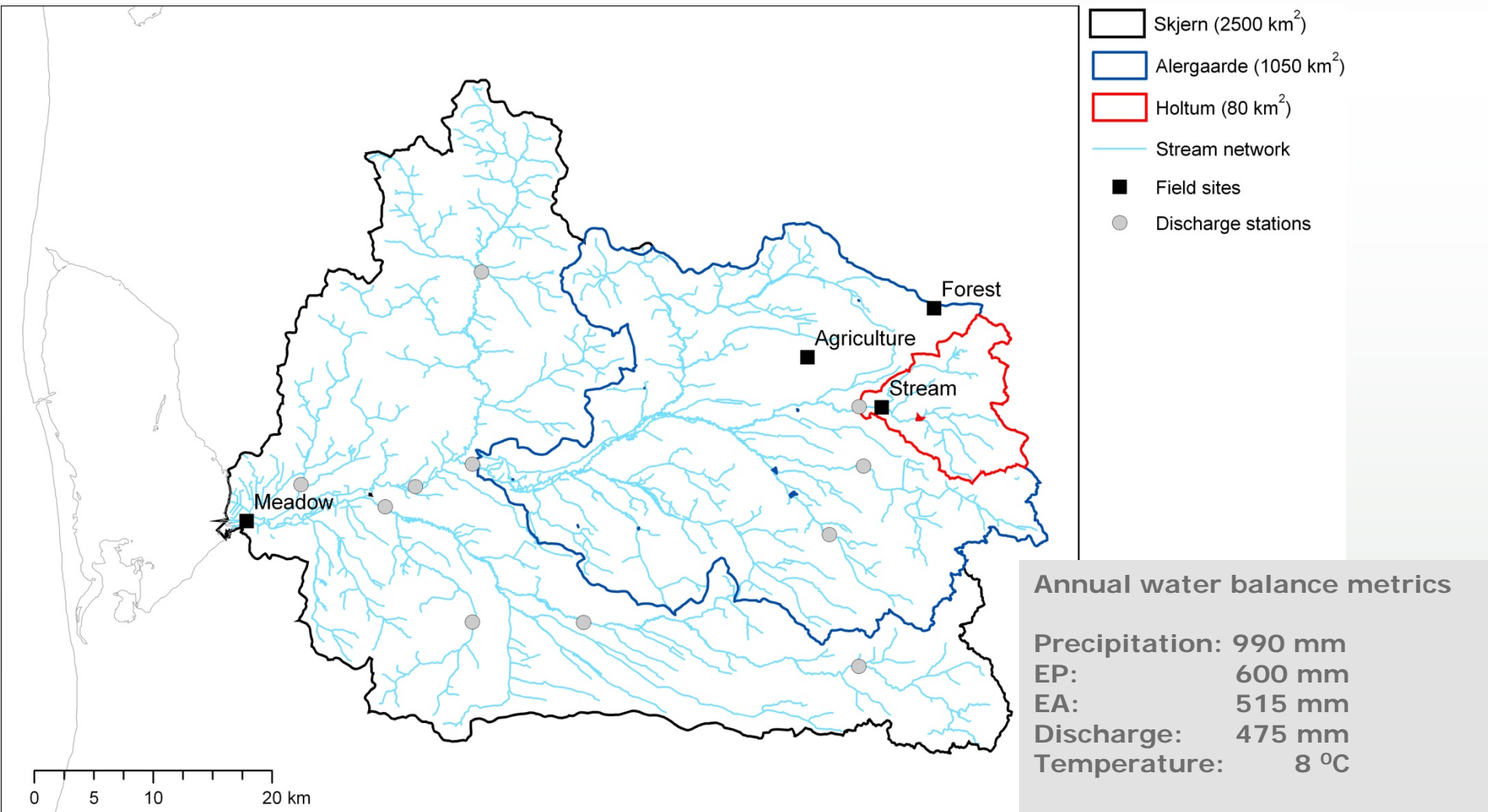


Problems with closure of water budget

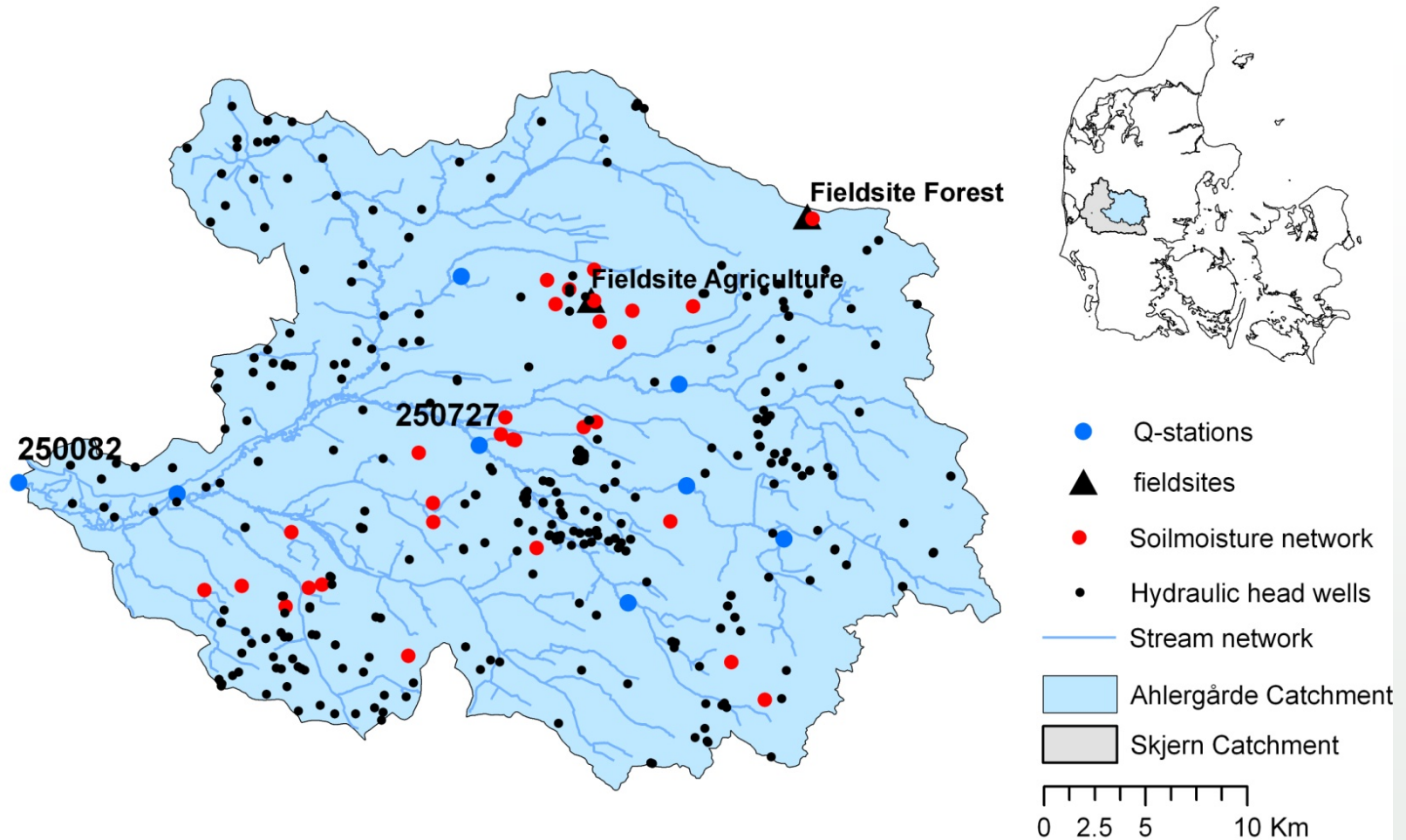


Precipitation = Evapotranspiration +
 Stream flow +
 Groundwater pumping +
 Irrigation +
 Submarine groundwater discharge

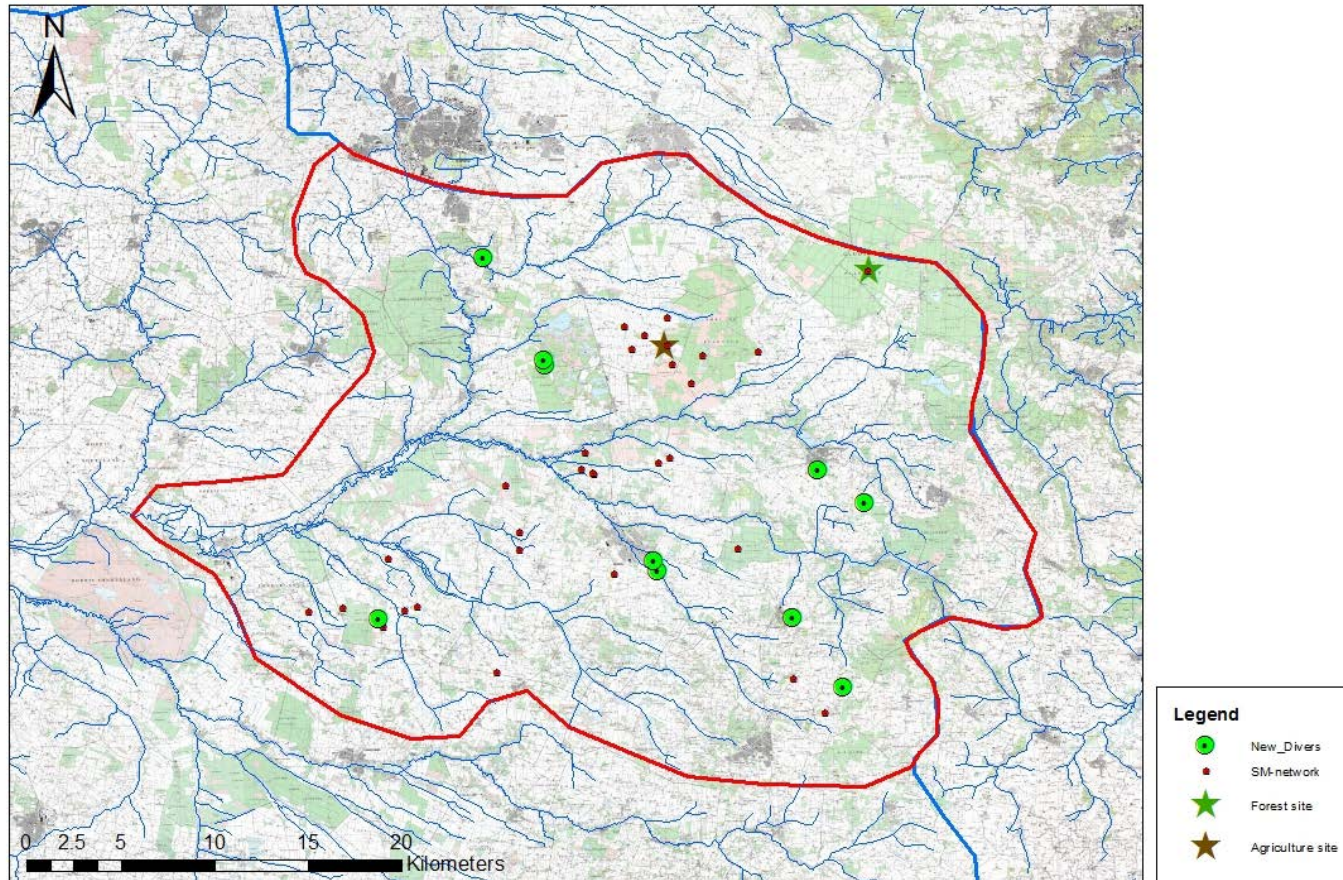
Study area - Skjern catchment and associated subcatchments – nested approach



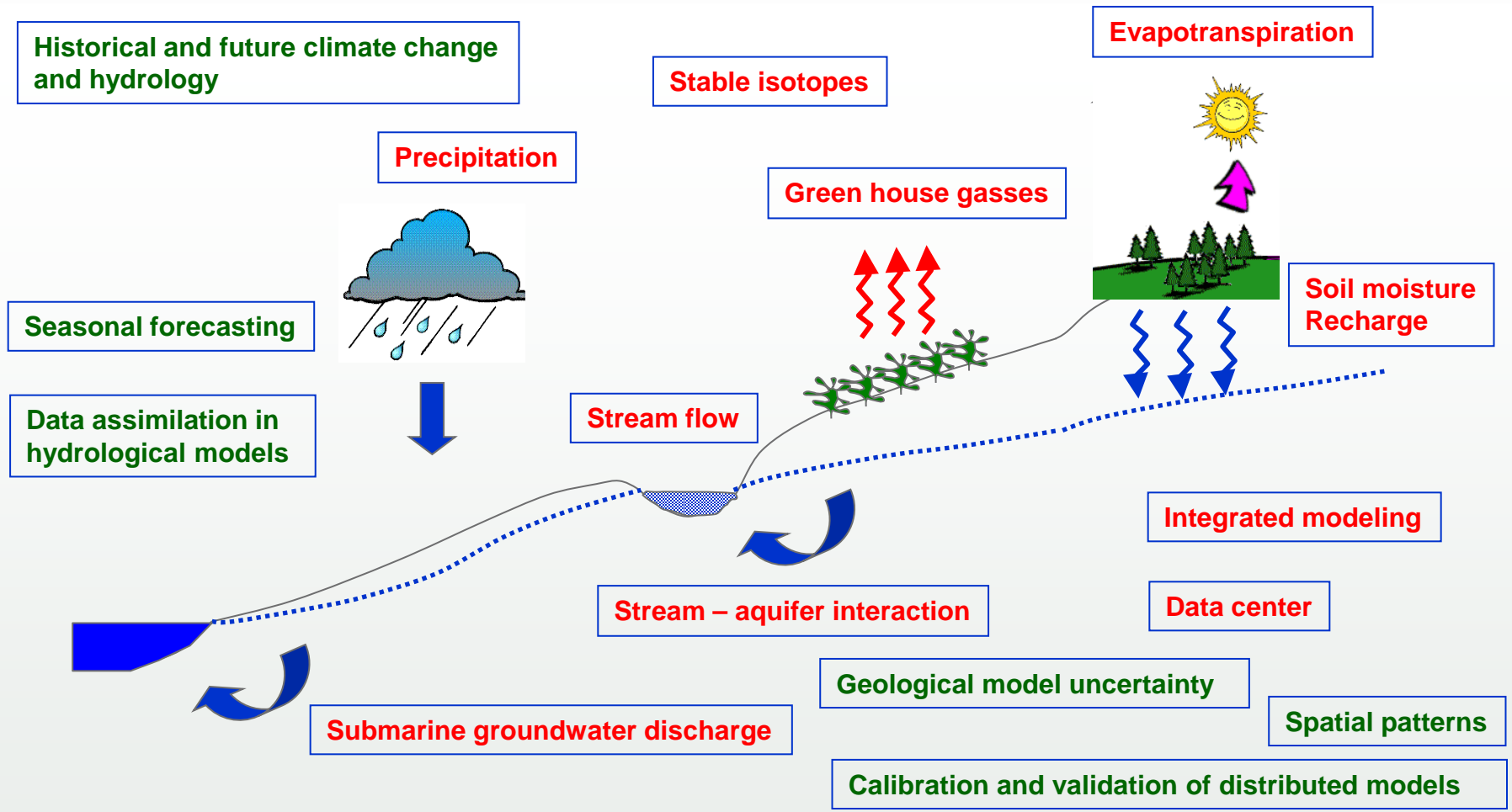
Flux stations, stream flow, soil moisture and groundwater



Groundwater divers



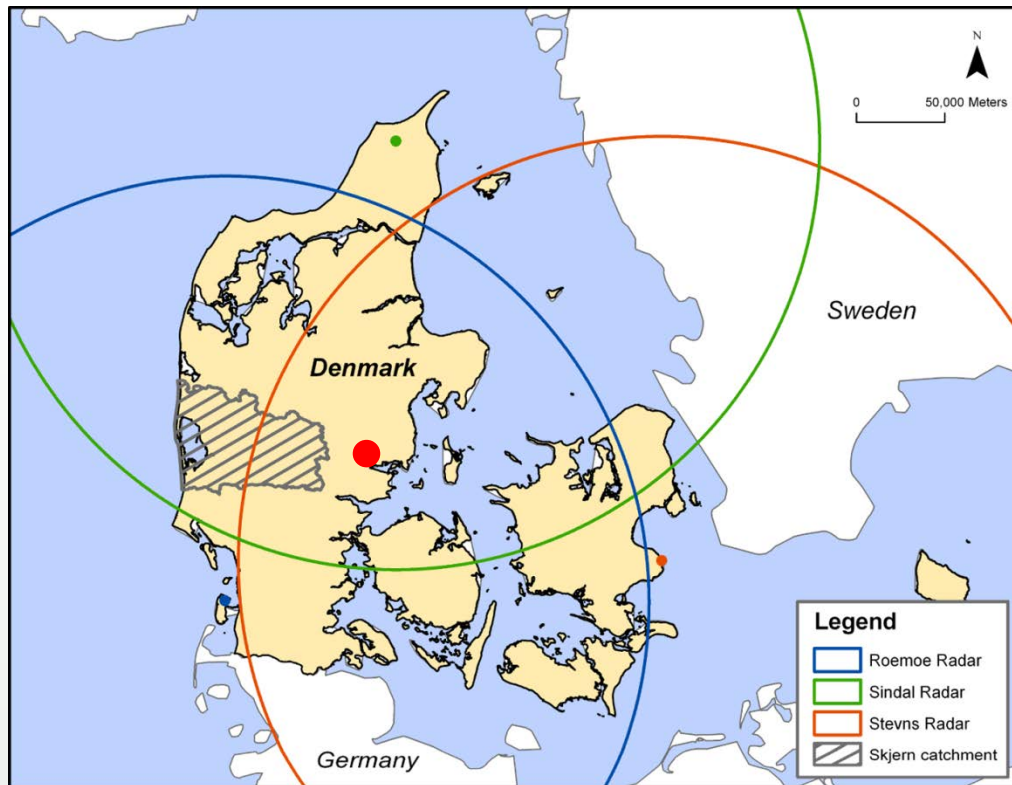
Project components



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

2006

2007-2009

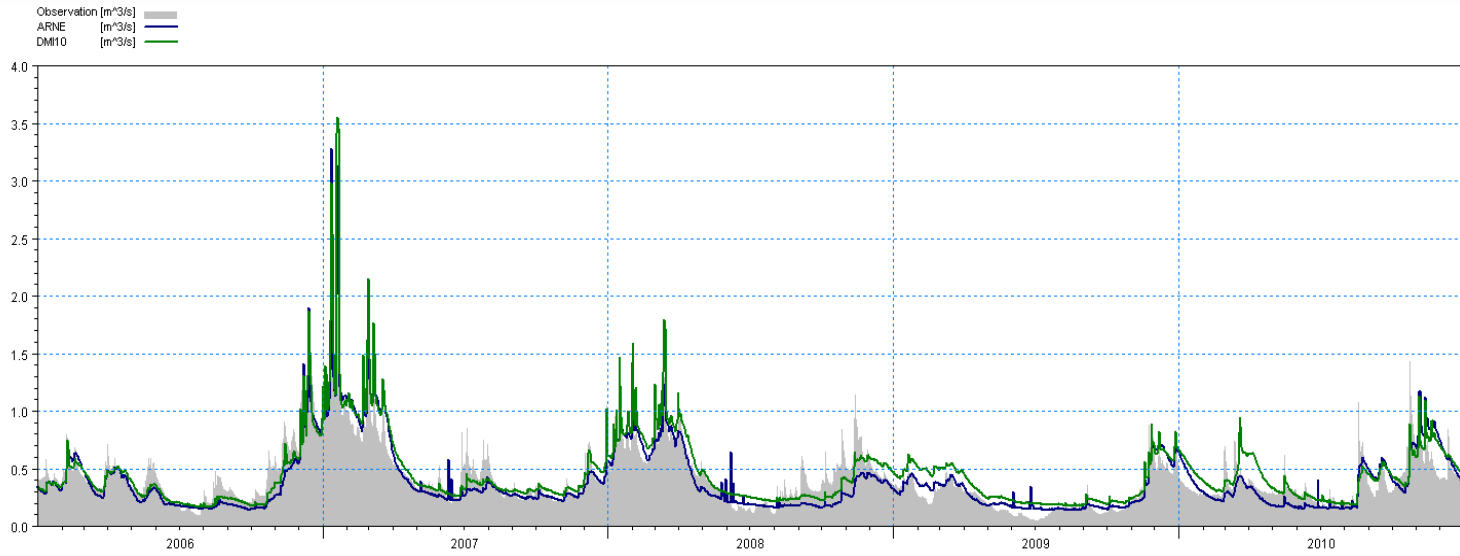
2010

Radar

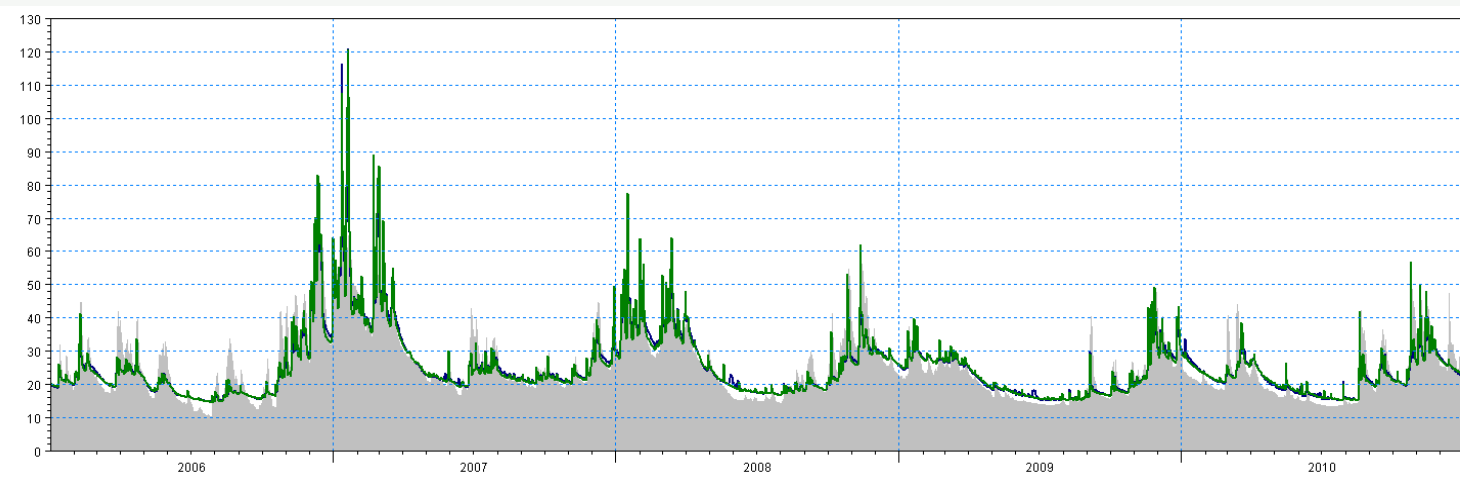
*Gridded 10 km
P product*

He et al., WRR, 2013

Simulated discharge of upstream and downstream stations

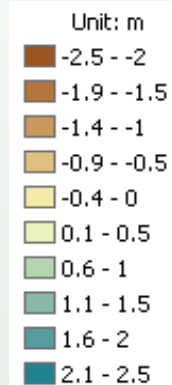
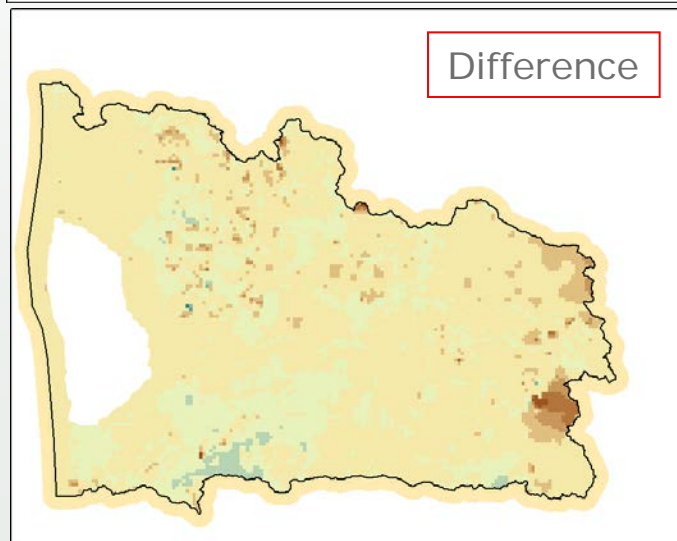
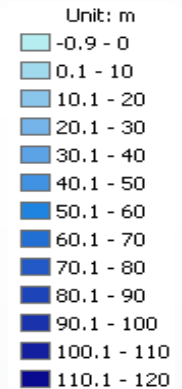
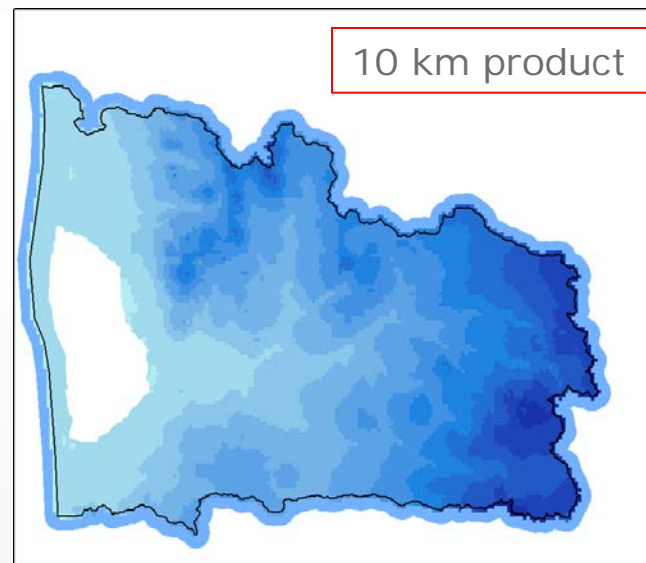
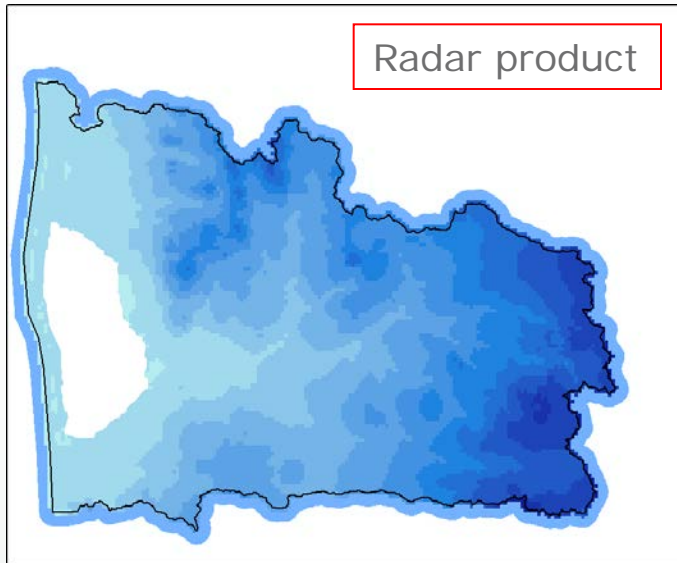


*Upstream
47 km²*



*Downstream
1550 km²*

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

1: Wetland



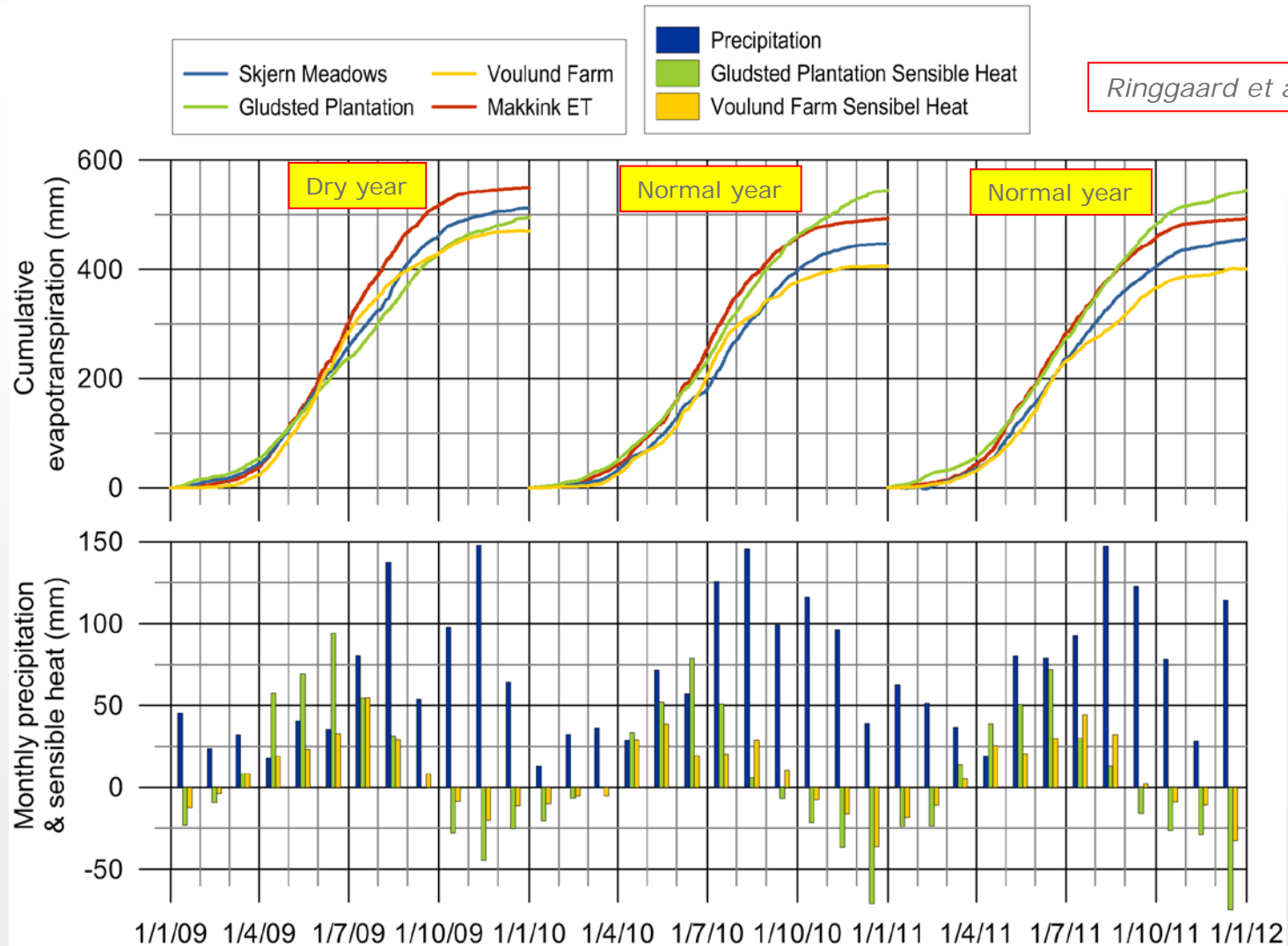
2: Farmland



3: Forest



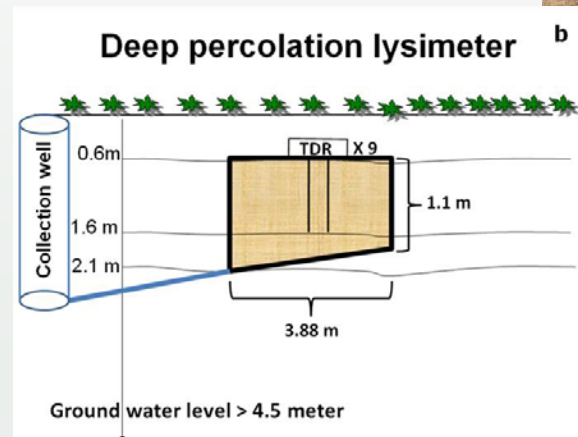
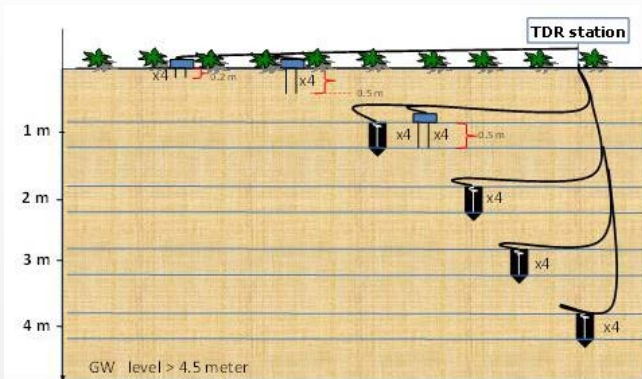
ET for three land surfaces



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

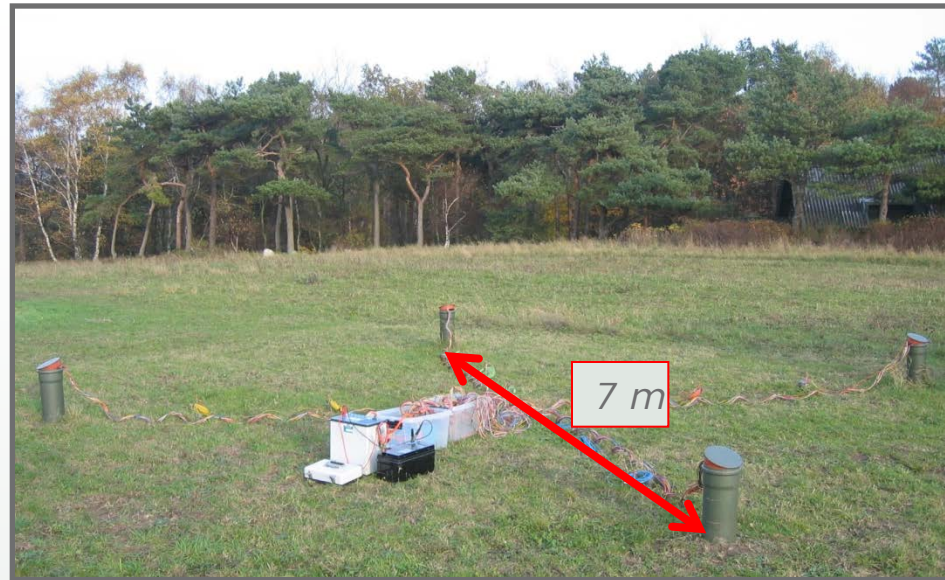
Soil moisture: Field observatories



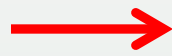


Cross-borehole geophysics

GPR (ground penetrating radar)


ERT (electrical resistance tomography)



Measure travelttime of EM wave

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

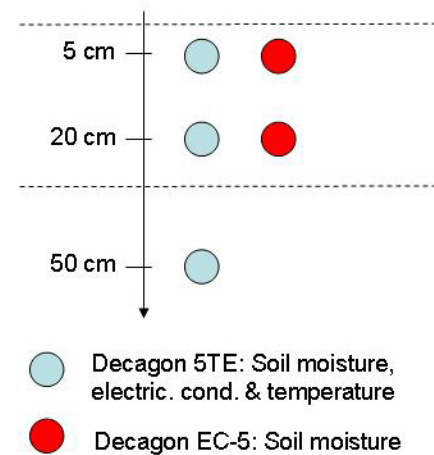
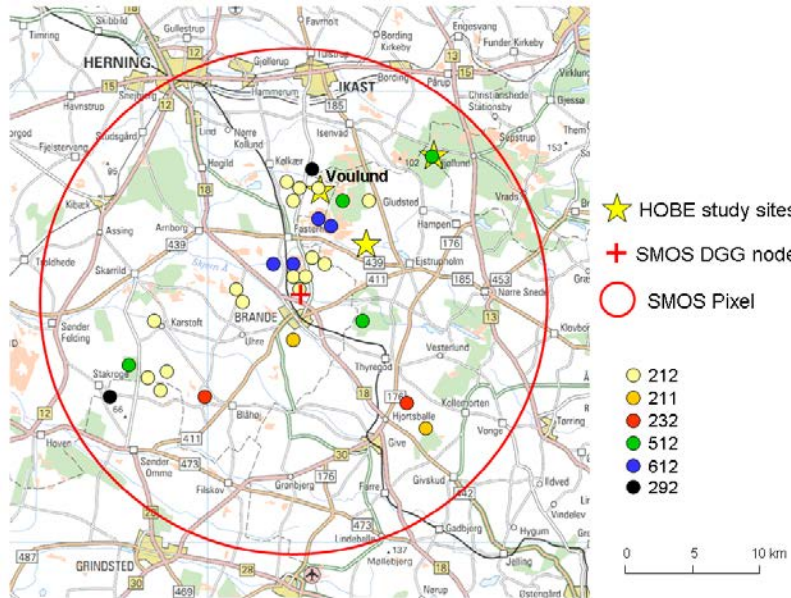
Measure resistance

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

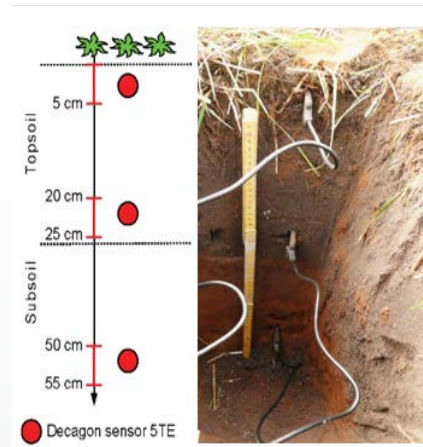
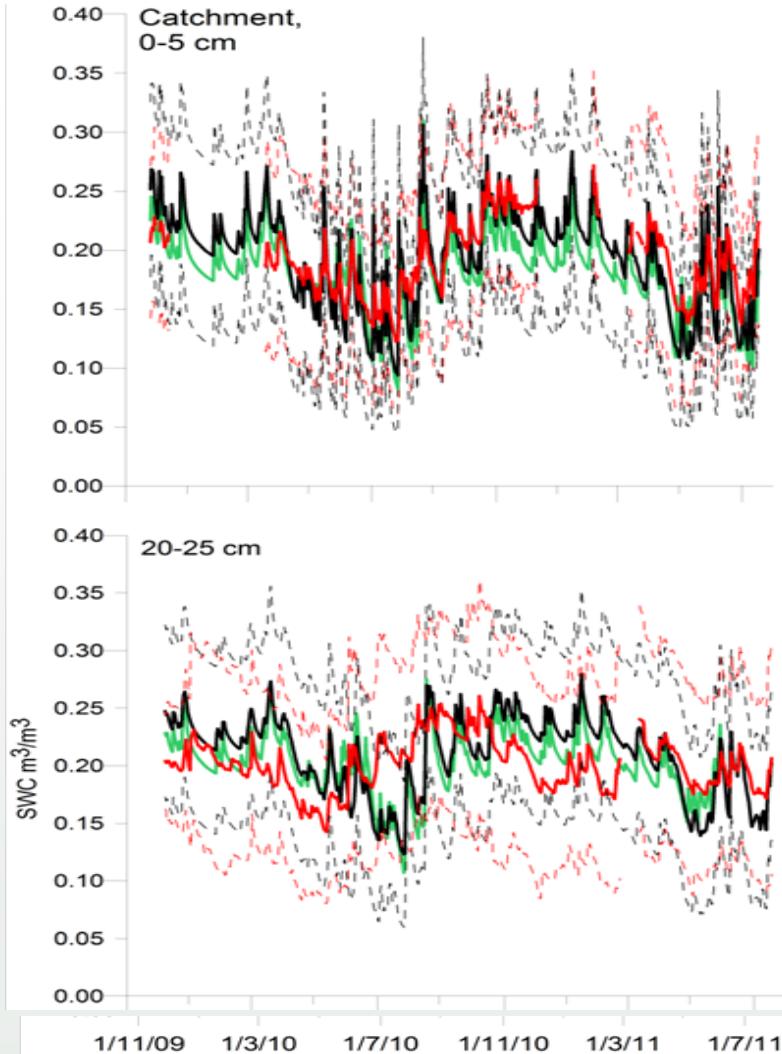
1D profiles, 2D images, psudo 3D images

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

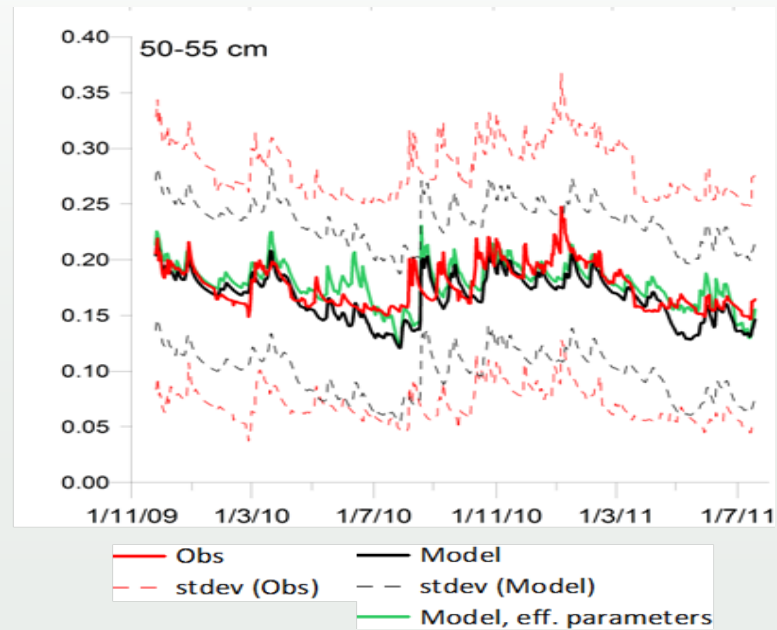
Soil moisture: Distributed soil moisture, electric conductivity and temperature network



Soil moisture: Results from soil moisture network

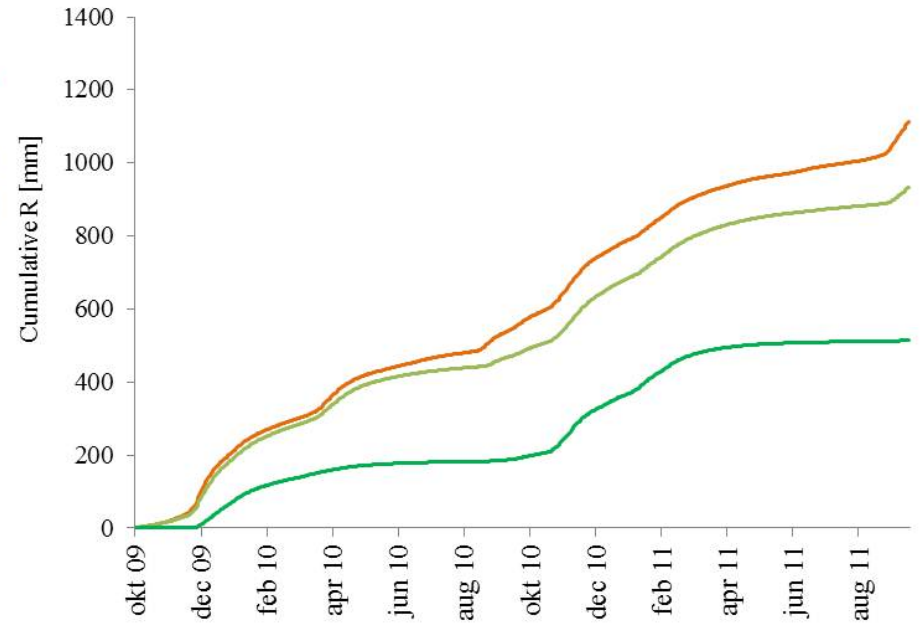
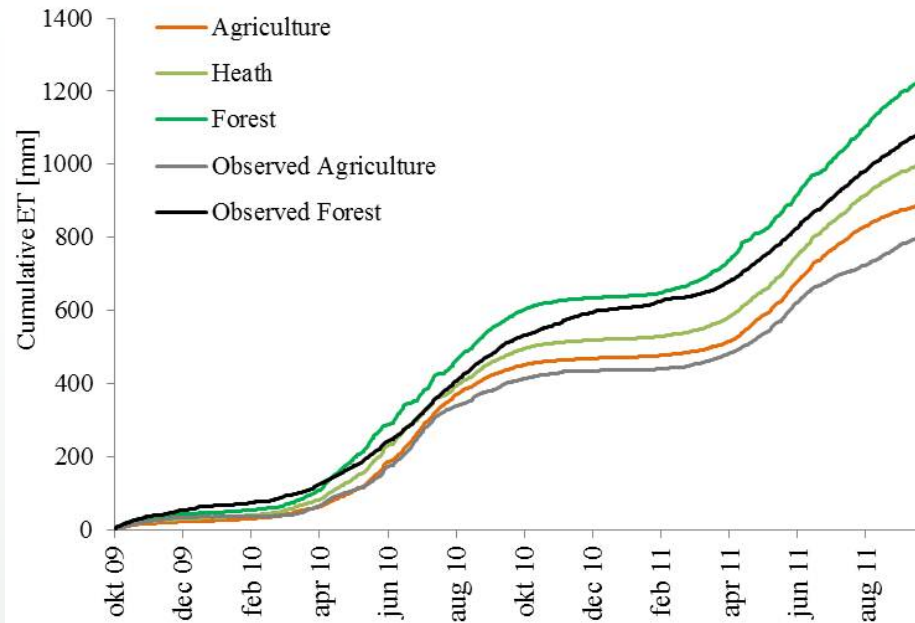


Andreasen et al., VZJ, 2013



— Obs — Model
 - - - stdev (Obs) - - - stdev (Model)
 — Model, eff. parameters

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, $\lambda = 21.4$ cm)

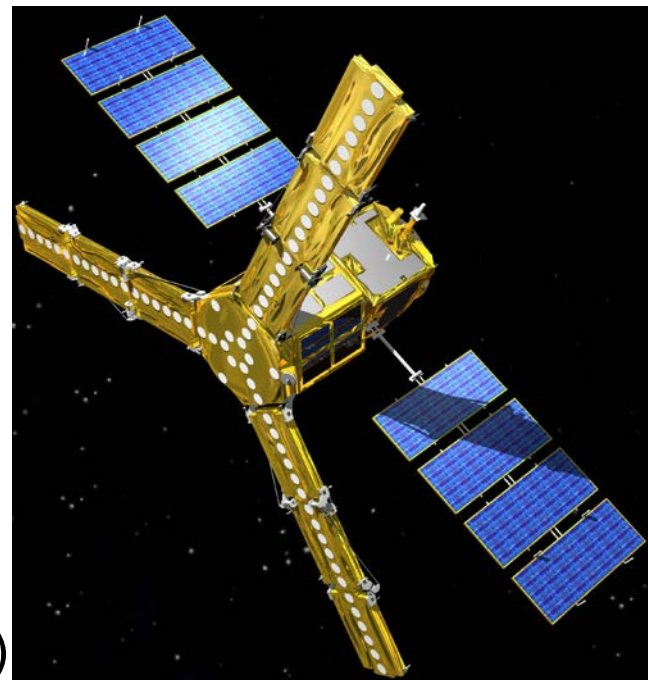
Global fields of surface soil moisture
every 3rd day

Goal: 4 % accuracy

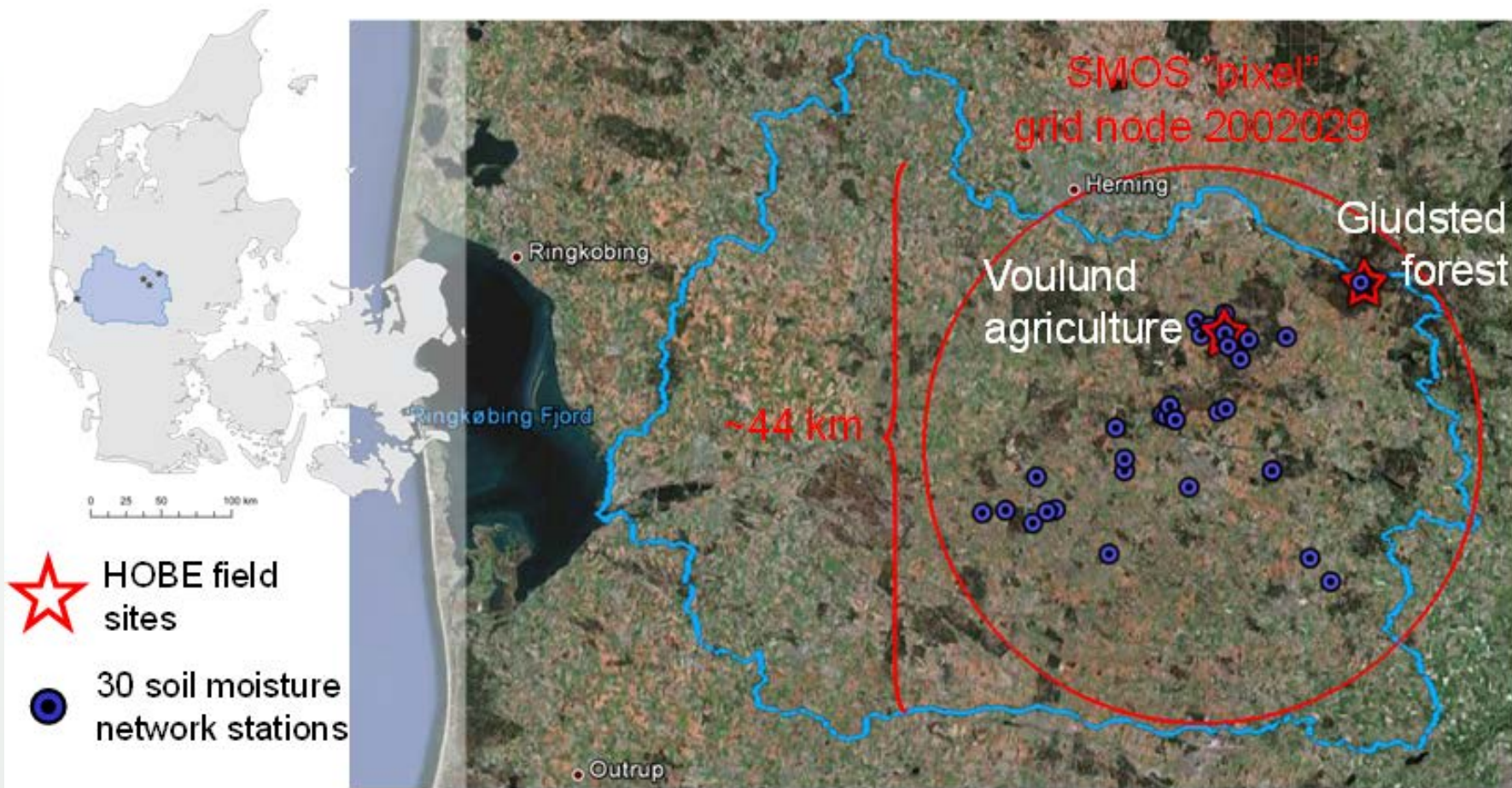
Limitations:

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

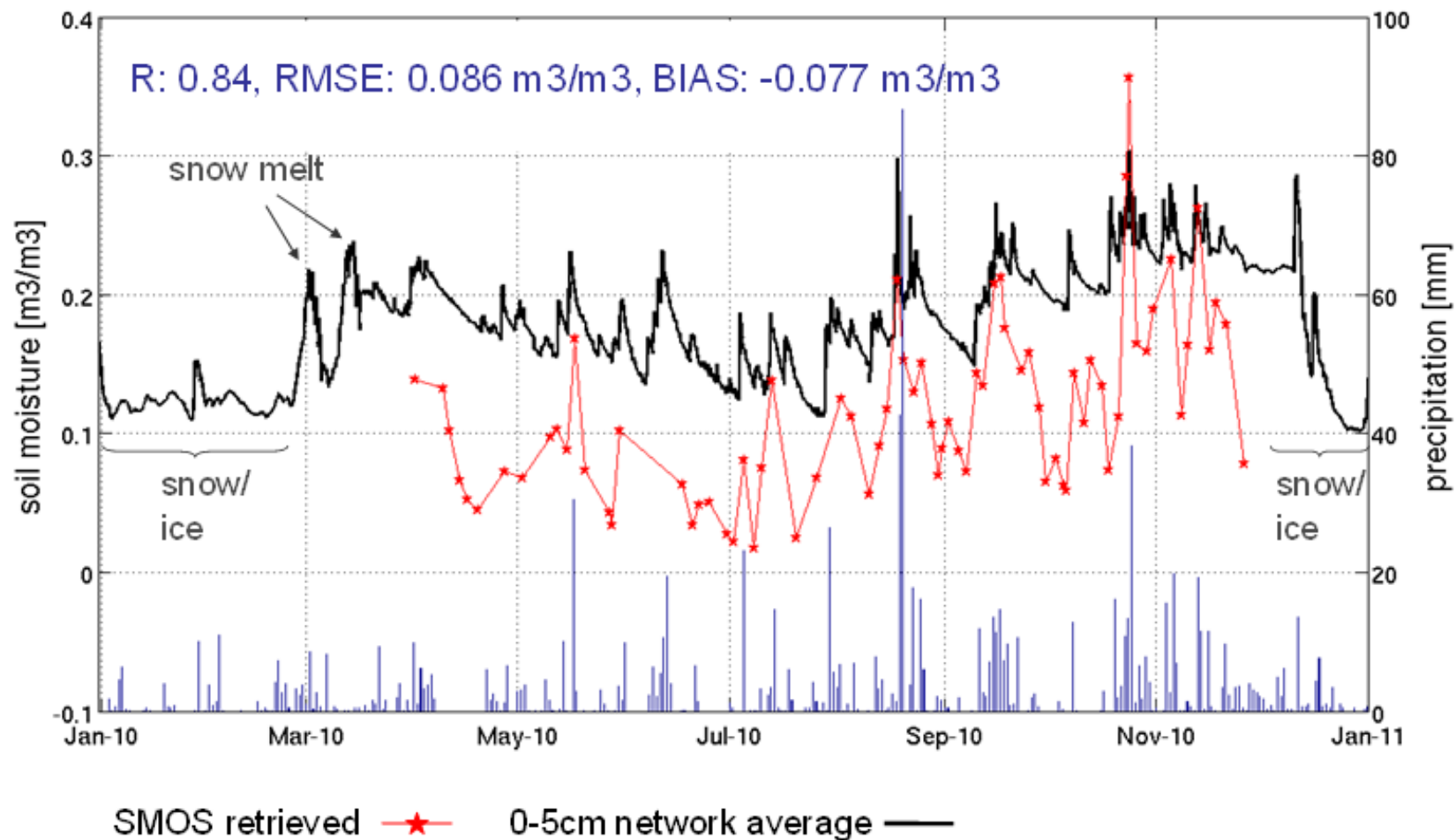
Launched: November 2009



Soil moisture: SMOS spatial scale



Soil moisture: SMOS retrieved soil moisture and measurements

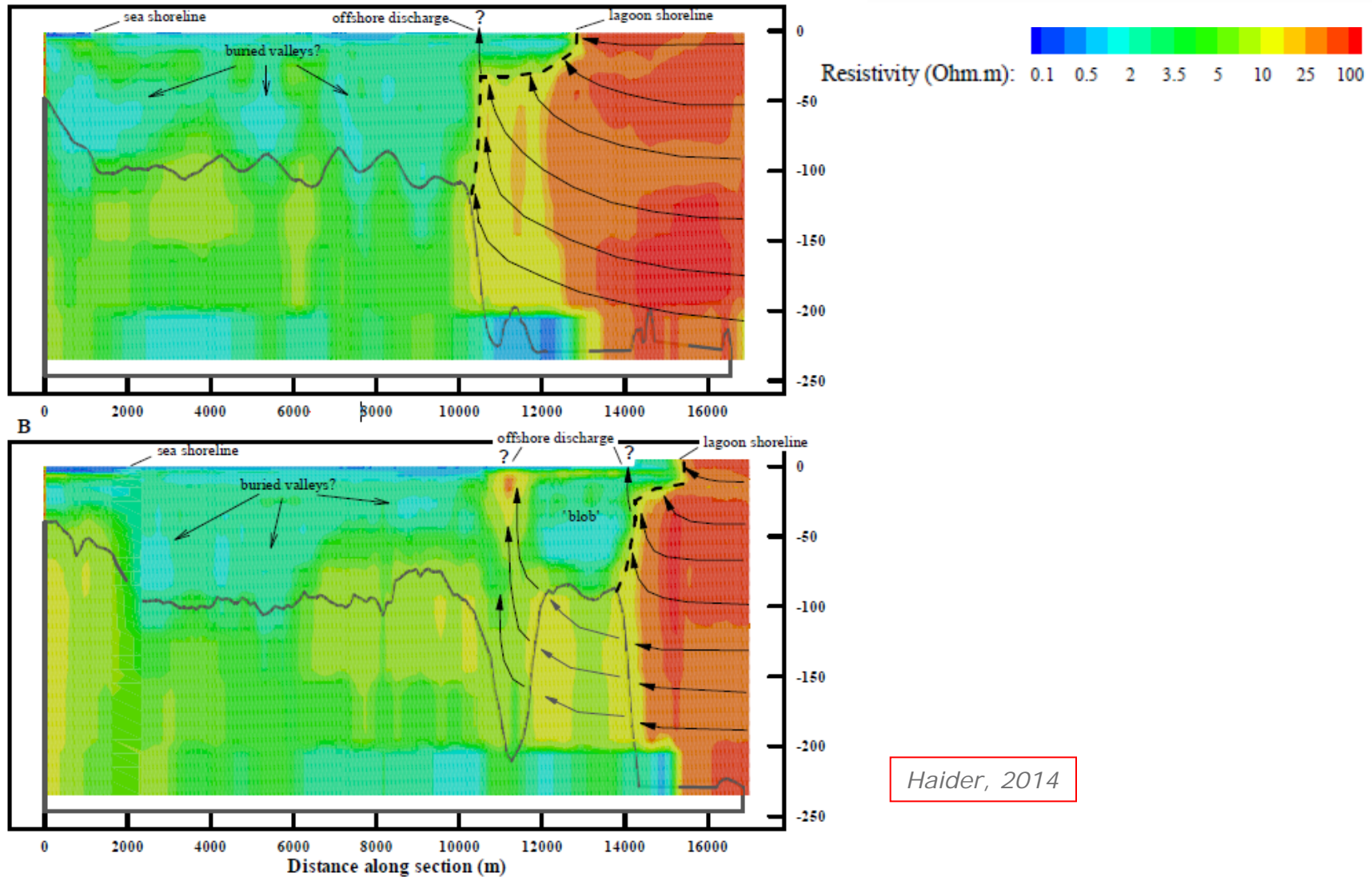


Bircher et al., HESS, 2012

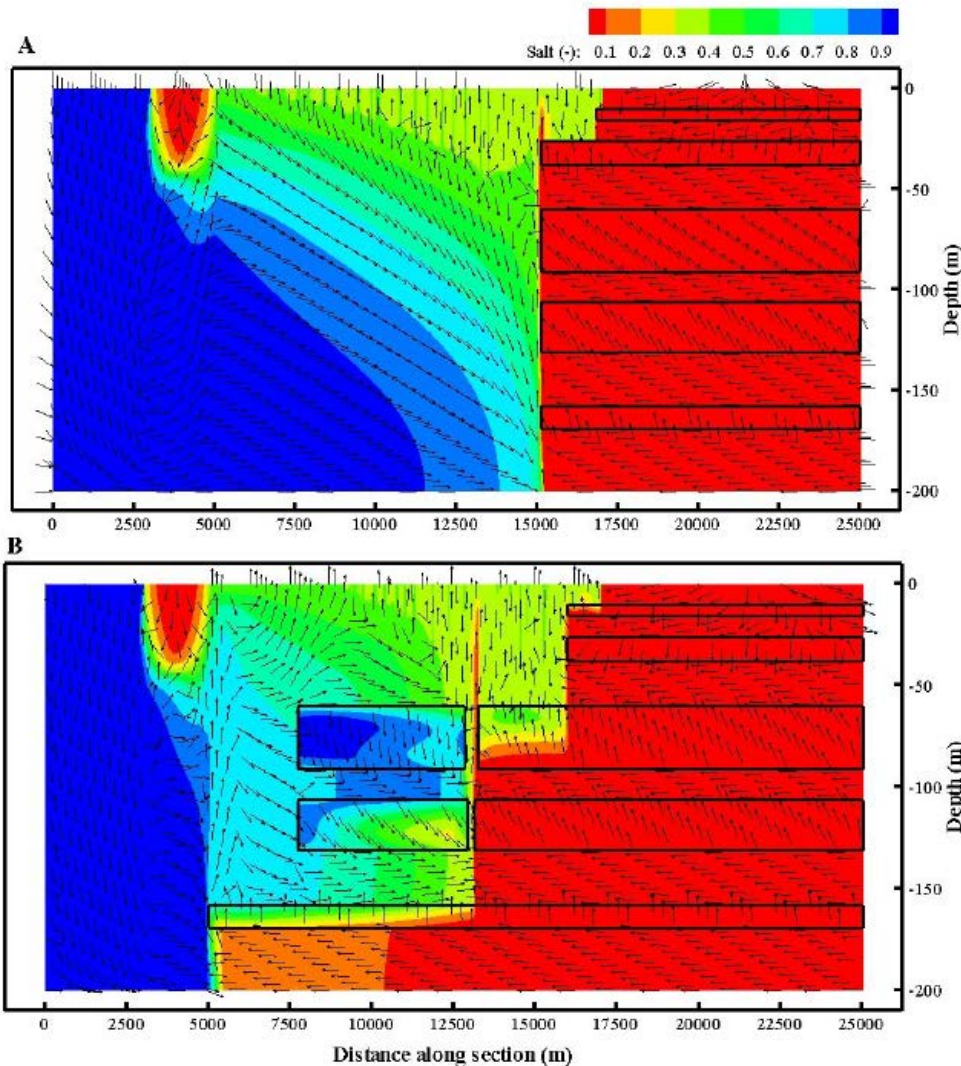
Research issues: Submarine groundwater discharge

- ▶ 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



Numerical model analysis



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

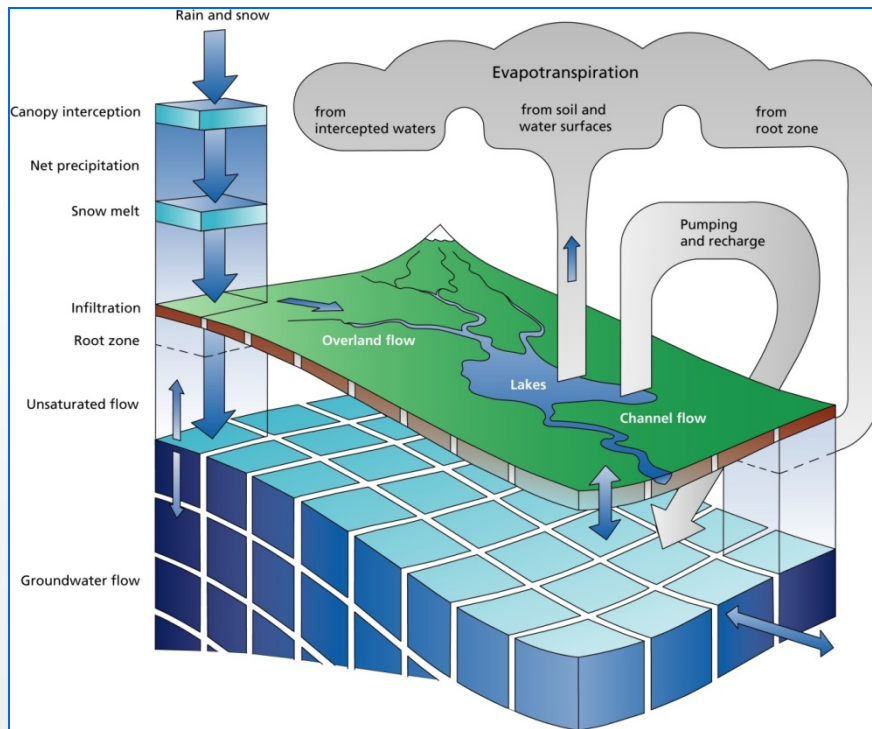
Haider, 2014

Research issues: Integrated modeling and analysis

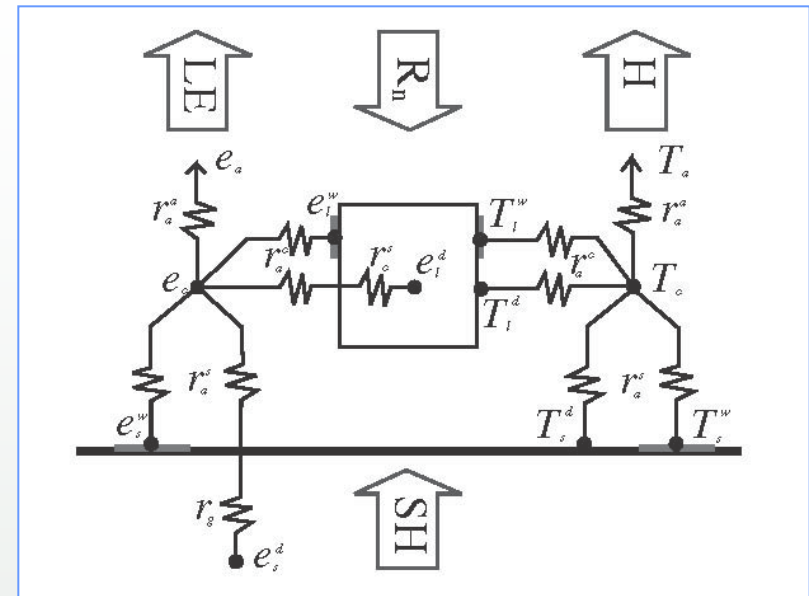
- ▶ Integrate monitoring data, measurements and experimental data representing various temporal and spatial scales
- ▶ Application of monitoring data, measurements and experimental data for multi-objective constraining of model
- ▶ Provide a coherent and integrated analysis of water resources states 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

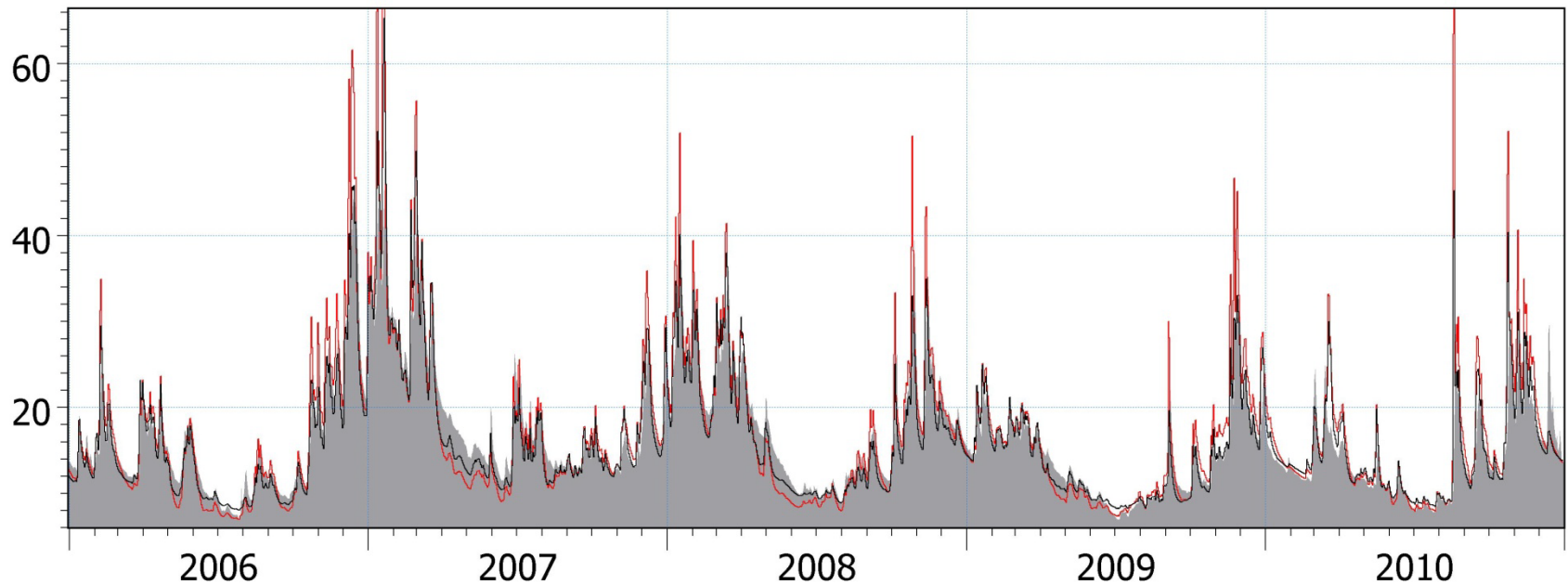


Land surface model (energy based)

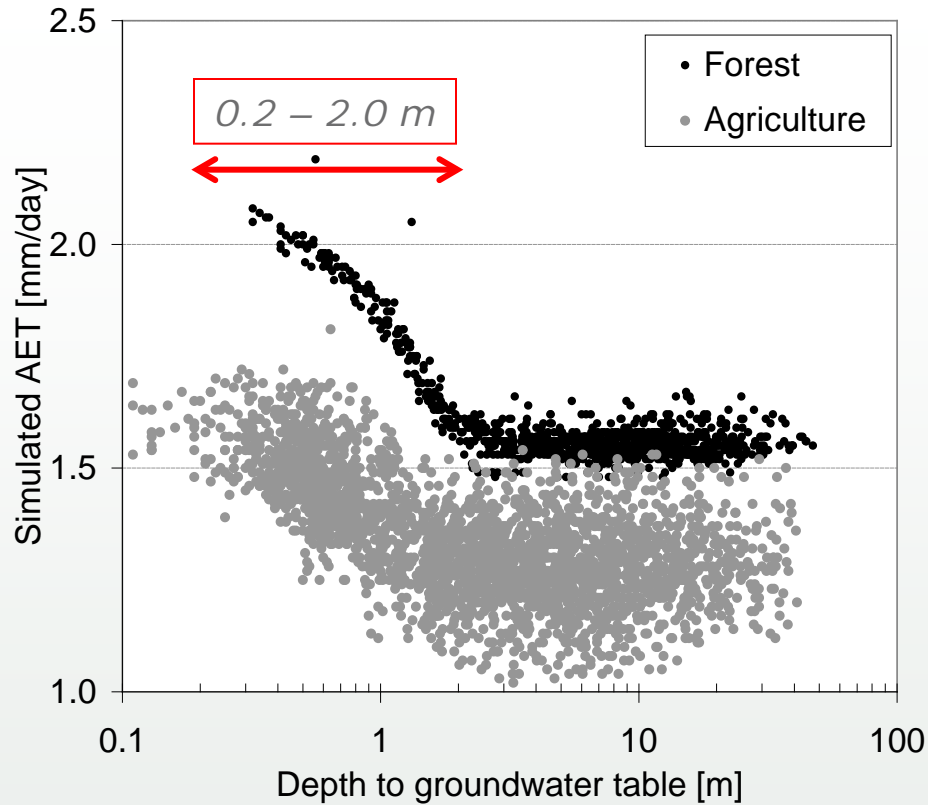


Multi-objective calibration results

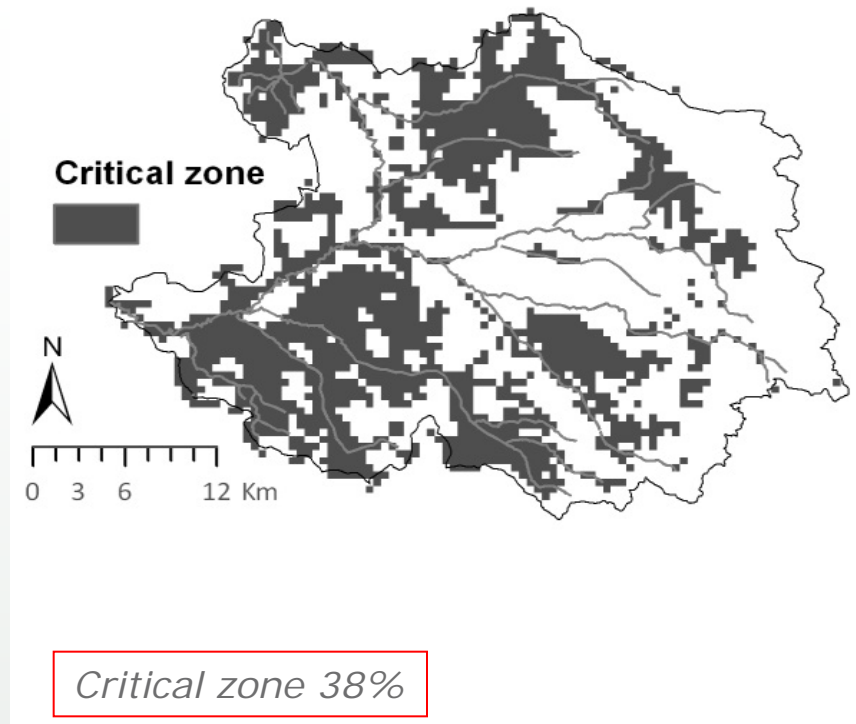
11 parameters selected for calibration



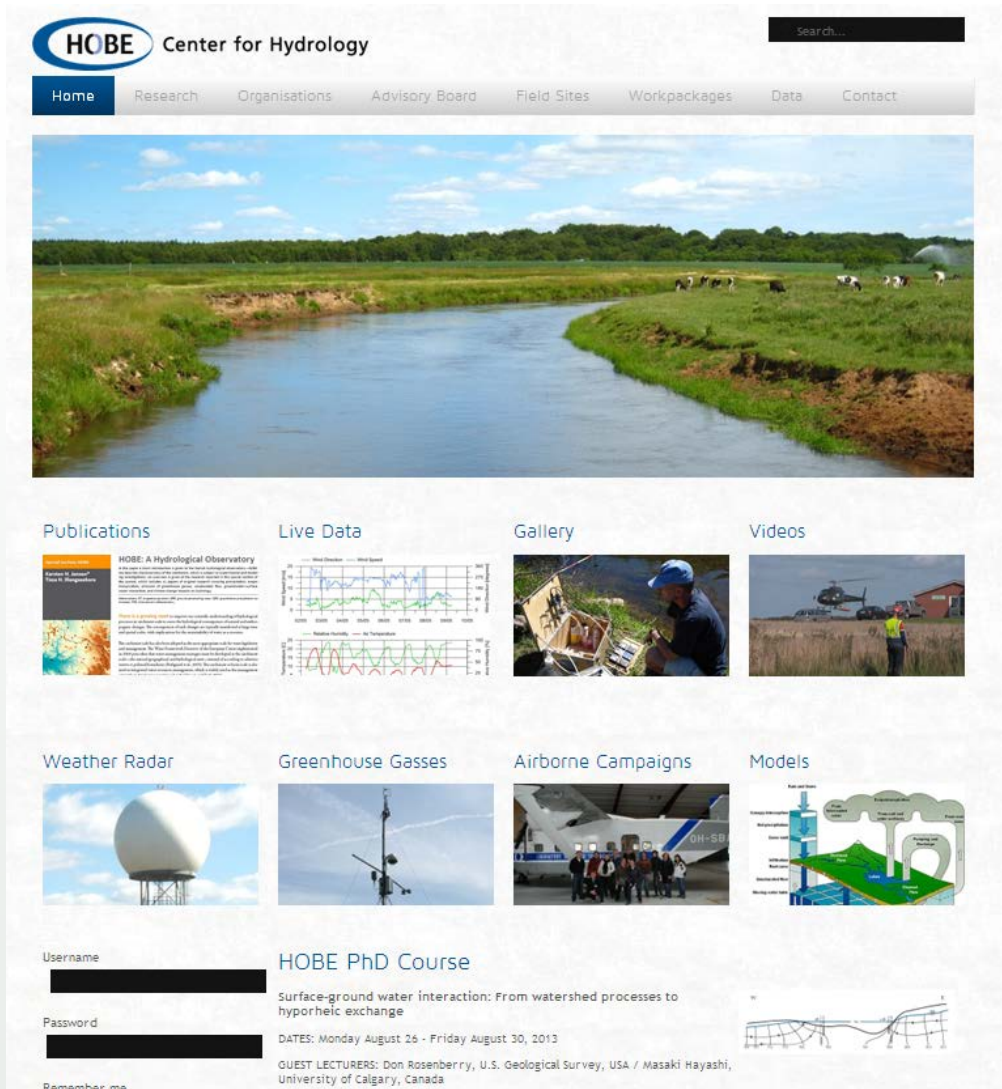
Groundwater controlled evapotranspiration



Annual means 2010



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



The screenshot shows the homepage of the HOBE Center for Hydrology. At the top left is the HOBE logo and the text "Center for Hydrology". To the right is a search bar. Below this is a navigation menu with links for Home, Research, Organisations, Advisory Board, Field Sites, Workpackages, Data, and Contact. The main content area features a large landscape photograph of a river in a rural setting. Below the photo are several sections: "Publications" with a thumbnail of a paper titled "HOBE: A Hydrological Observatory"; "Live Data" with two line graphs showing hydrological data over time; "Gallery" with a photo of a person in a field; "Videos" with a photo of a helicopter; "Weather Radar" with a photo of a radar dome; "Greenhouse Gasses" with a photo of a measurement tower; "Airborne Campaigns" with a photo of an aircraft labeled "GH-SB"; and "Models" with a 3D diagram of a watershed model. At the bottom left is a login form with fields for "Username" and "Password", and a "Remember me" checkbox. At the bottom right is a section for the "HOBE PhD Course" with the title "Surface-ground water interaction: From watershed processes to hyperheic exchange", dates "Monday August 26 - Friday August 30, 2013", and lecturers "Don Rosenberry, U.S. Geological Survey, USA / Masaki Hayashi, University of Calgary, Canada". A small diagram of a cross-section of the ground is also present.