NATURVIDENSKAB
KØBENHAVNS UNIVERSITET

HOBE

HOBE – Danish Hydrological Observatory

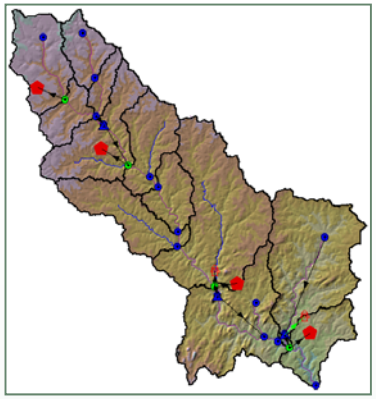
Center of Excellence in Catchment Hydrology

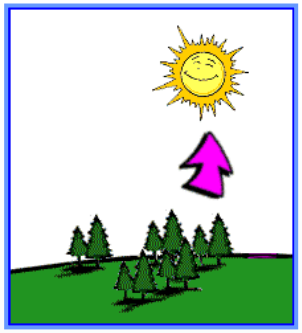
Karsten H. Jensen
University of Copenhagen

Financing

- Project period 2007-2017 (3 more years to go)
- 8.8 mill. € (65 mill. DKK) donation from the VILLUM FOUNDATION
- 3.4 mill. € (25 mill. DKK) from other sources

Overall motivation:
Problems with closure of water budget





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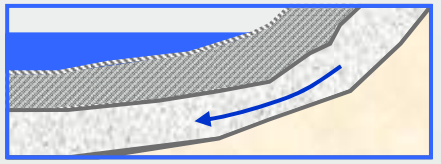
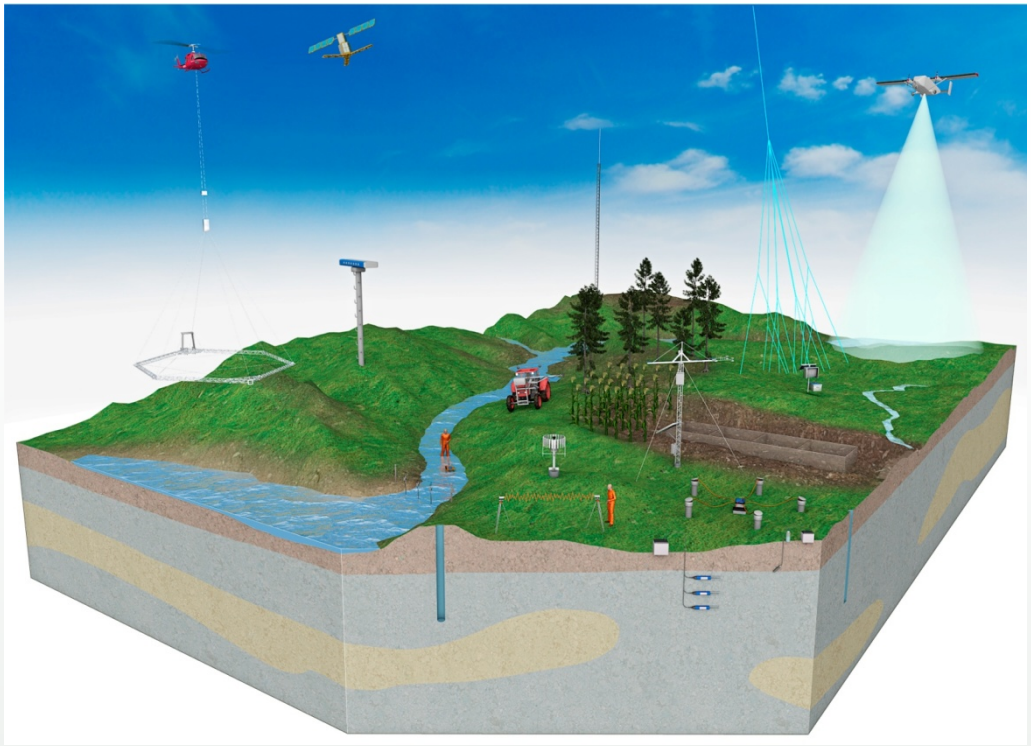


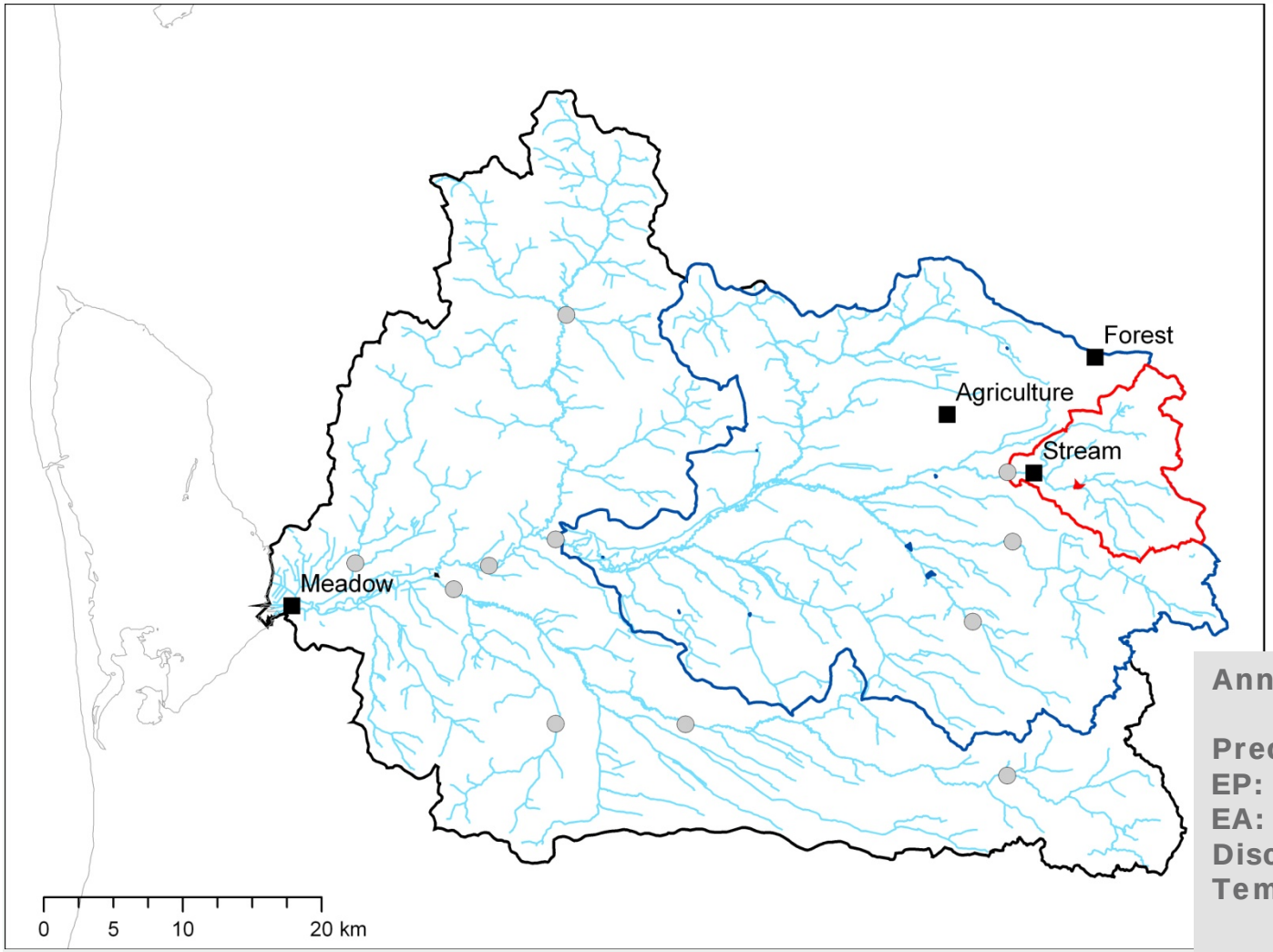
Precipitation = Evapotranspiration +
Stream flow +
Groundwater pumping +
Irrigation +
Submarine groundwater discharge

Key objectives of hydrological observatory

- To establish an observational and experimental inter-disciplinary 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



Study area - Skjern catchment and associated subcatchments – nested approach

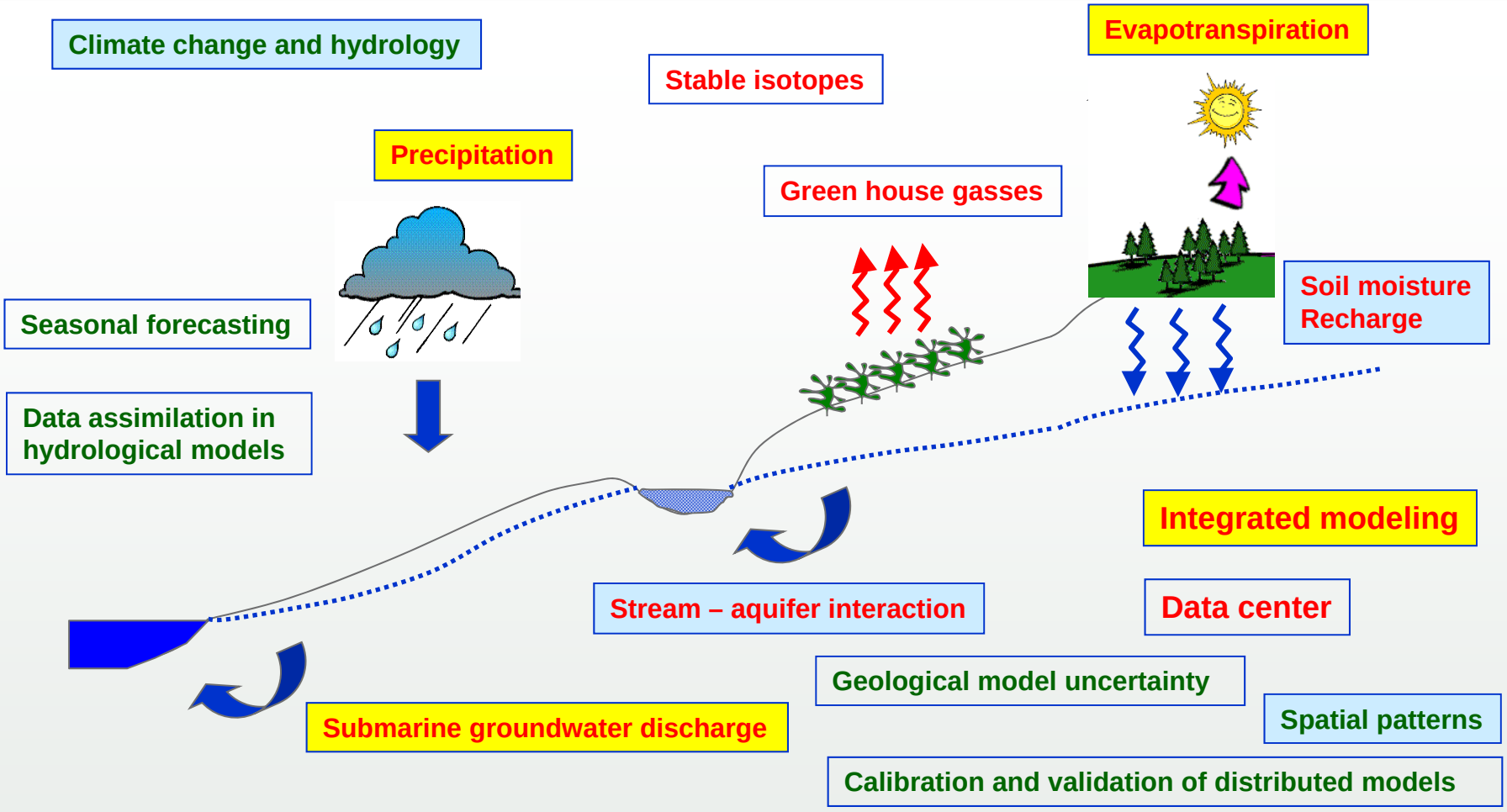


Skjern (2500 km^2)
Alergaarde (1050 km^2)
Holtum (80 km^2)
Stream network
Field sites
Discharge stations

Annual water balance metrics

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

Project components

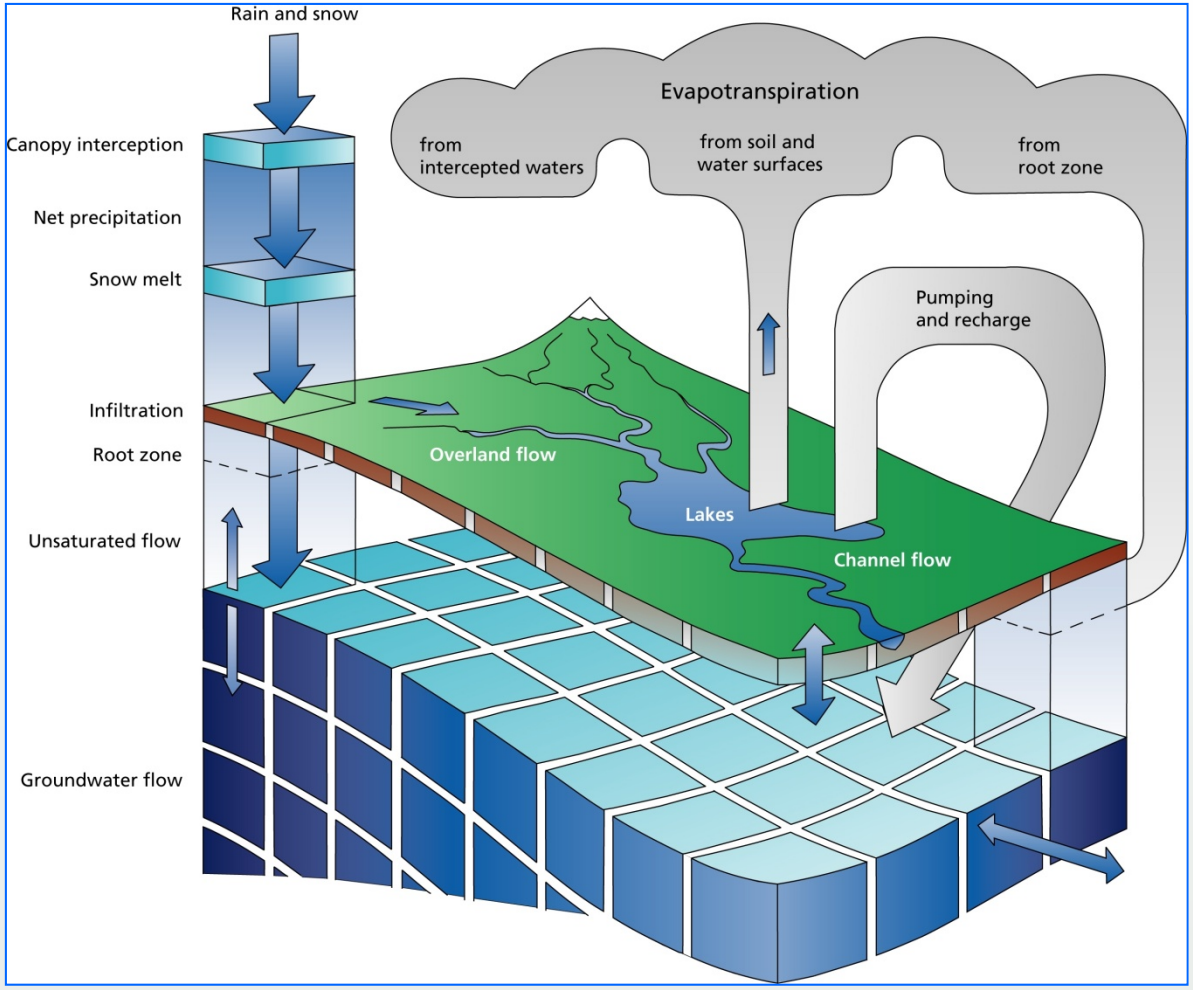


Research issues: Precipitation

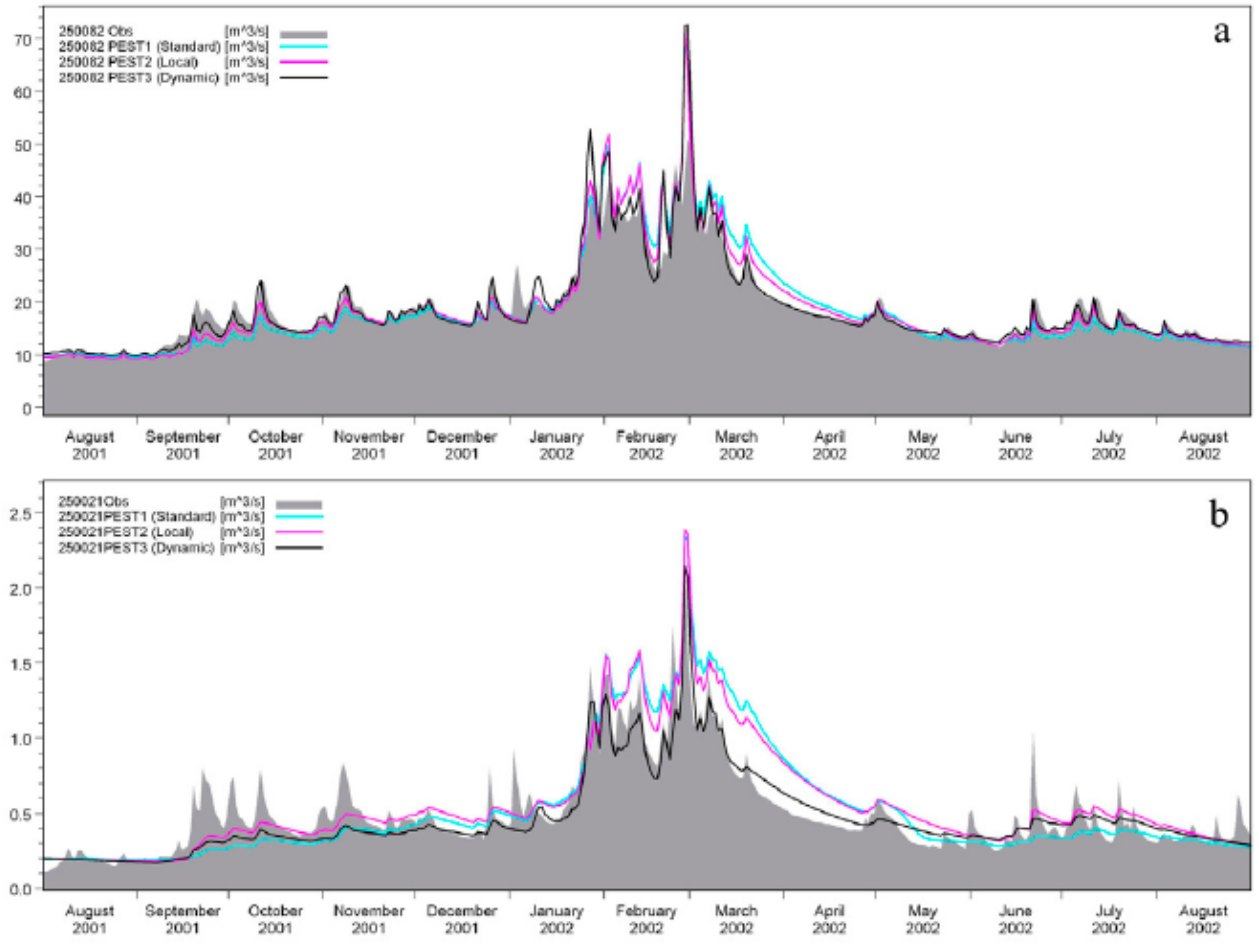
- Measurement and bias-correction of precipitation at local scale (rain gauges)
- Estimation of precipitation at catchment scale (weather radar)
- Quantification of uncertainty propagation in the hydrological system

Modeling platform for analysis

Integrated and distributed hydrological modeling (MIKE SHE)



Bias correction and impact on hydrology



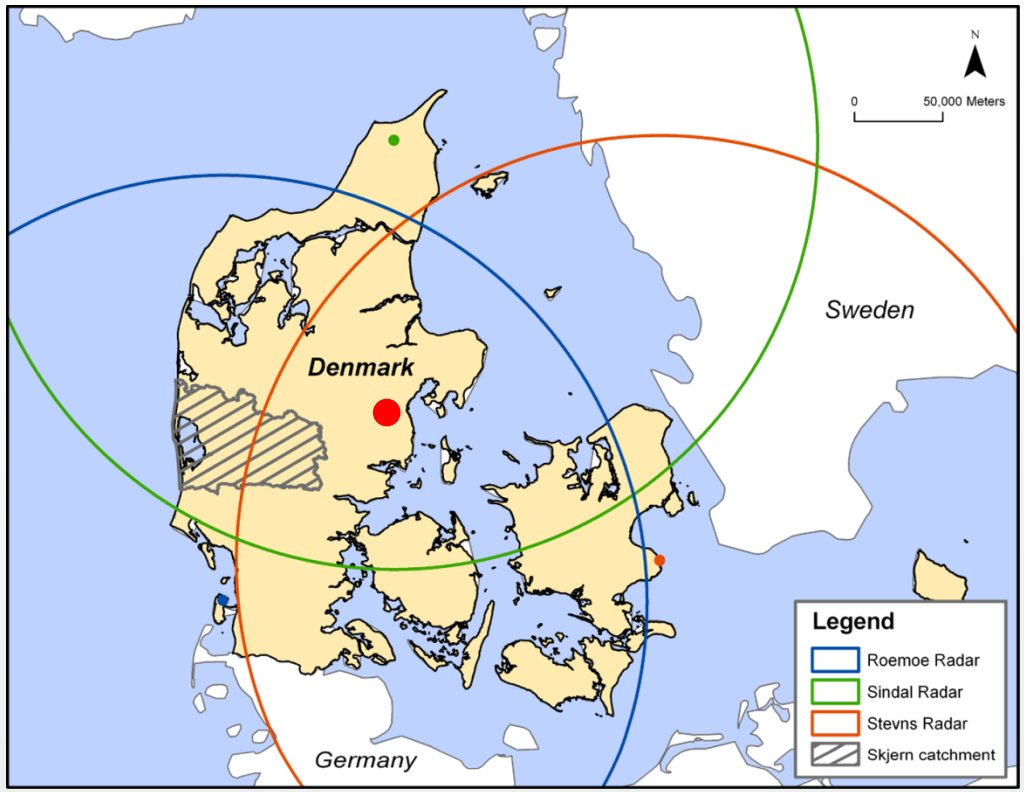
Downstream 1050 km²

Upstream 47 km²

Stisen et al., VZJ, 2011

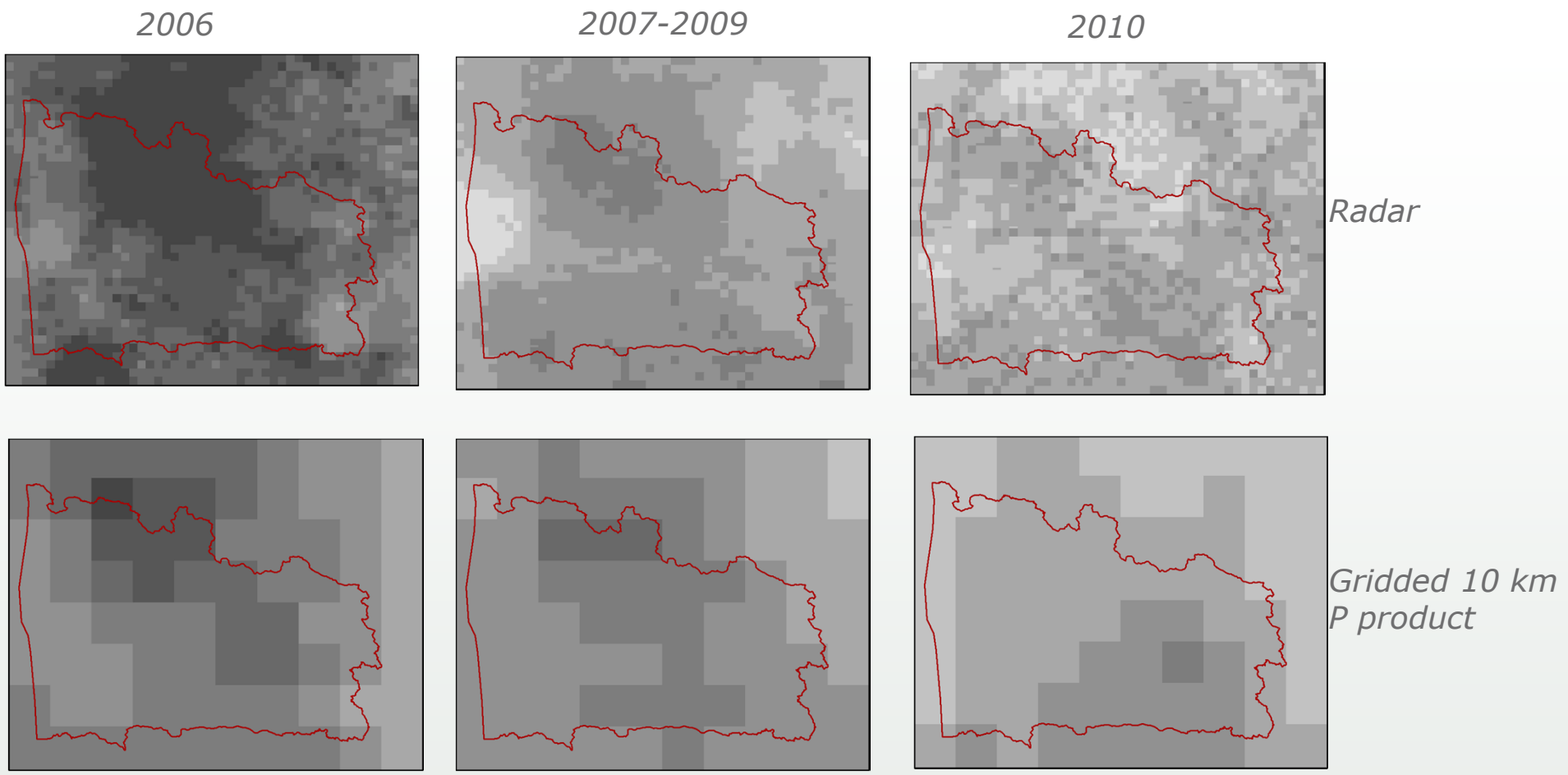
Fig. 6. Observed (Obs) and simulated (PEST1, PEST 2, and PEST 3) hydrographs for (A) a downstream station (250082) and (b) an upstream station (250021) for the hydrologic year 2002.

Precipitation estimate at catchment scale: weather radars



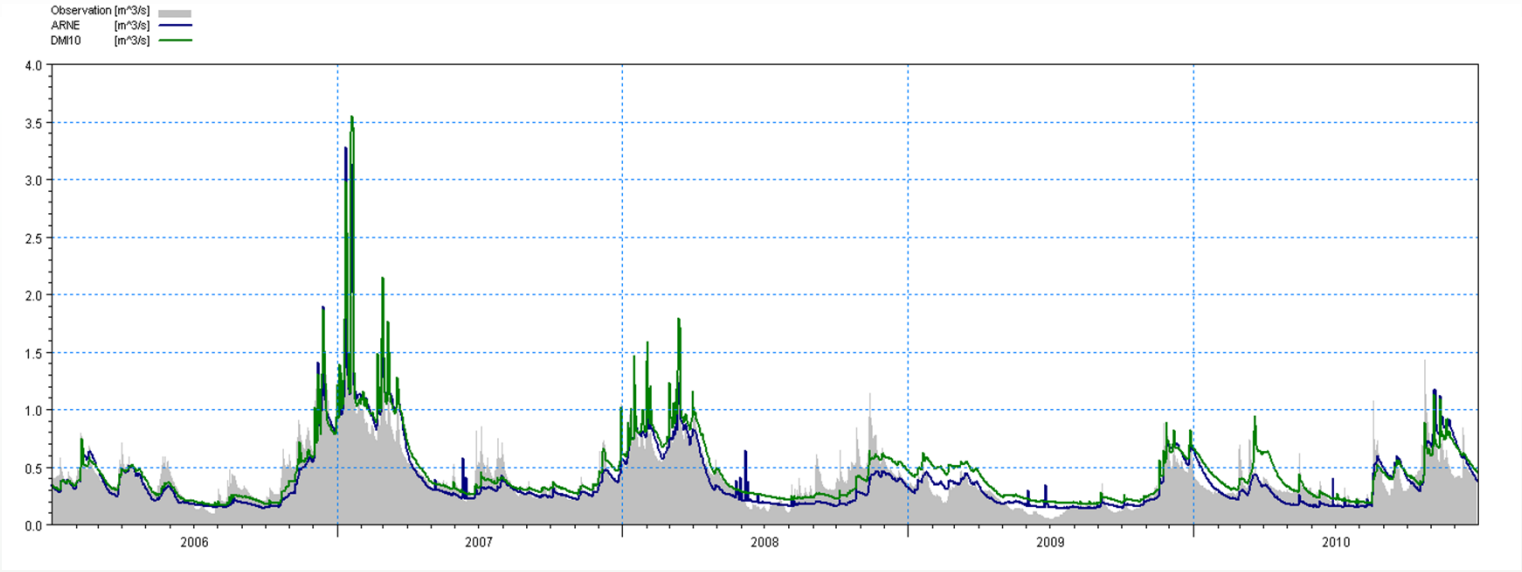
- Dual polarization radar

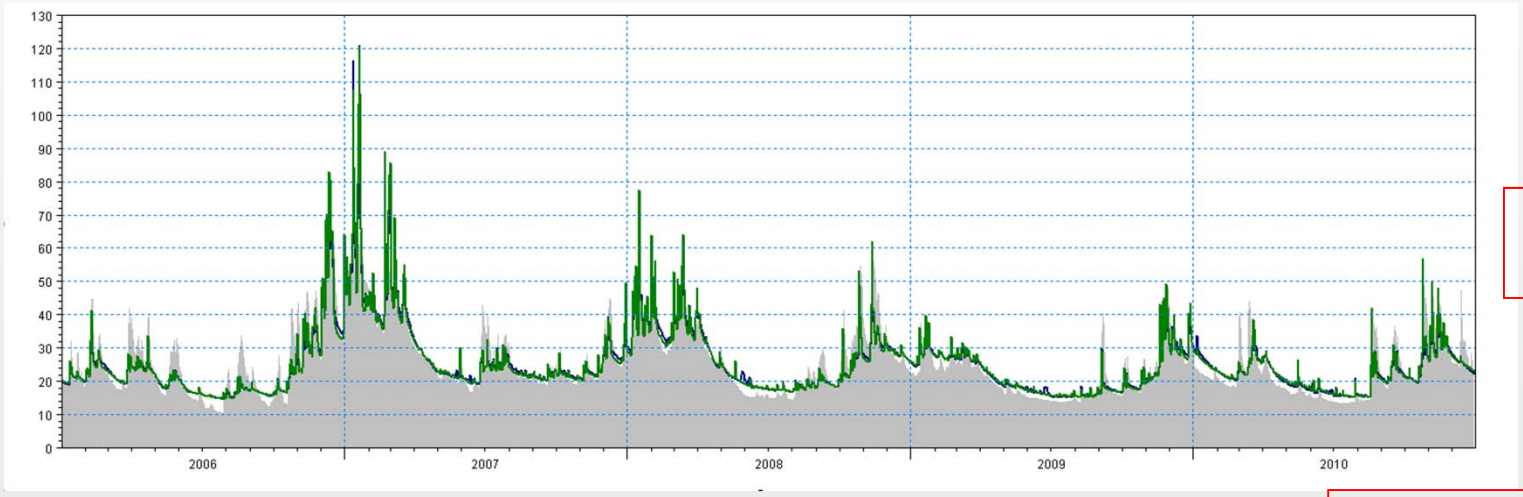
Radar and rain gauge based precipitation



He et al., WRR, 2013

Simulated discharge of upstream and downstream stations



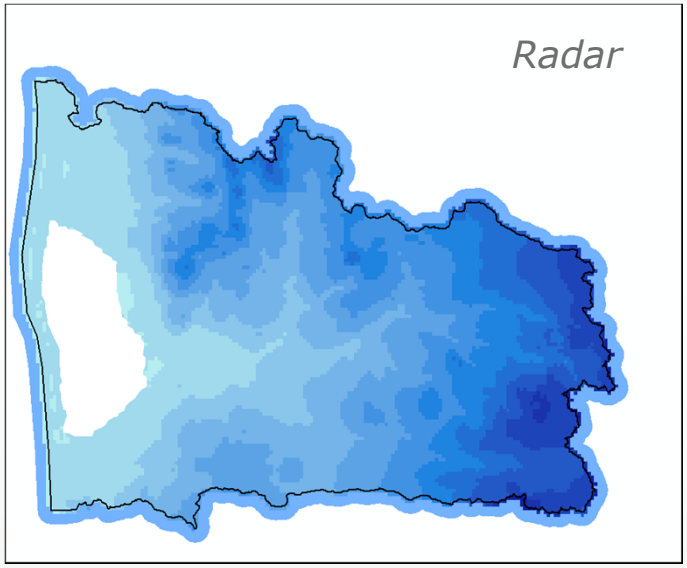


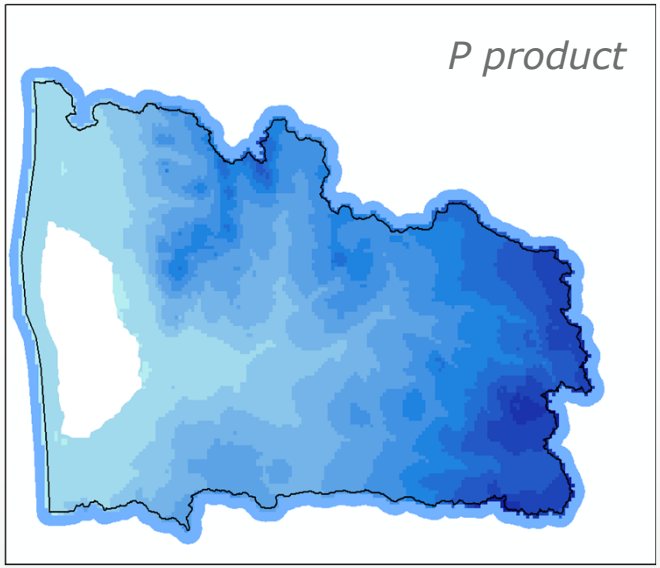
Upstream 47 km²

Downstream 1550 km²

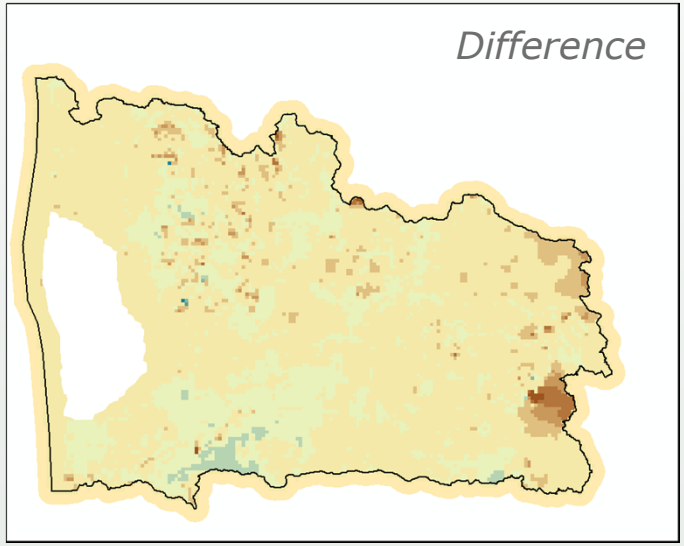
He et al., WRR, 2013

Average groundwater head (2006-2010)





Unit: m
-0.9 - 0
0.1 - 10
10.1 - 20
20.1 - 30
30.1 - 40
40.1 - 50
50.1 - 60
60.1 - 70
70.1 - 80
80.1 - 90
90.1 - 100
100.1 - 110
110.1 - 120



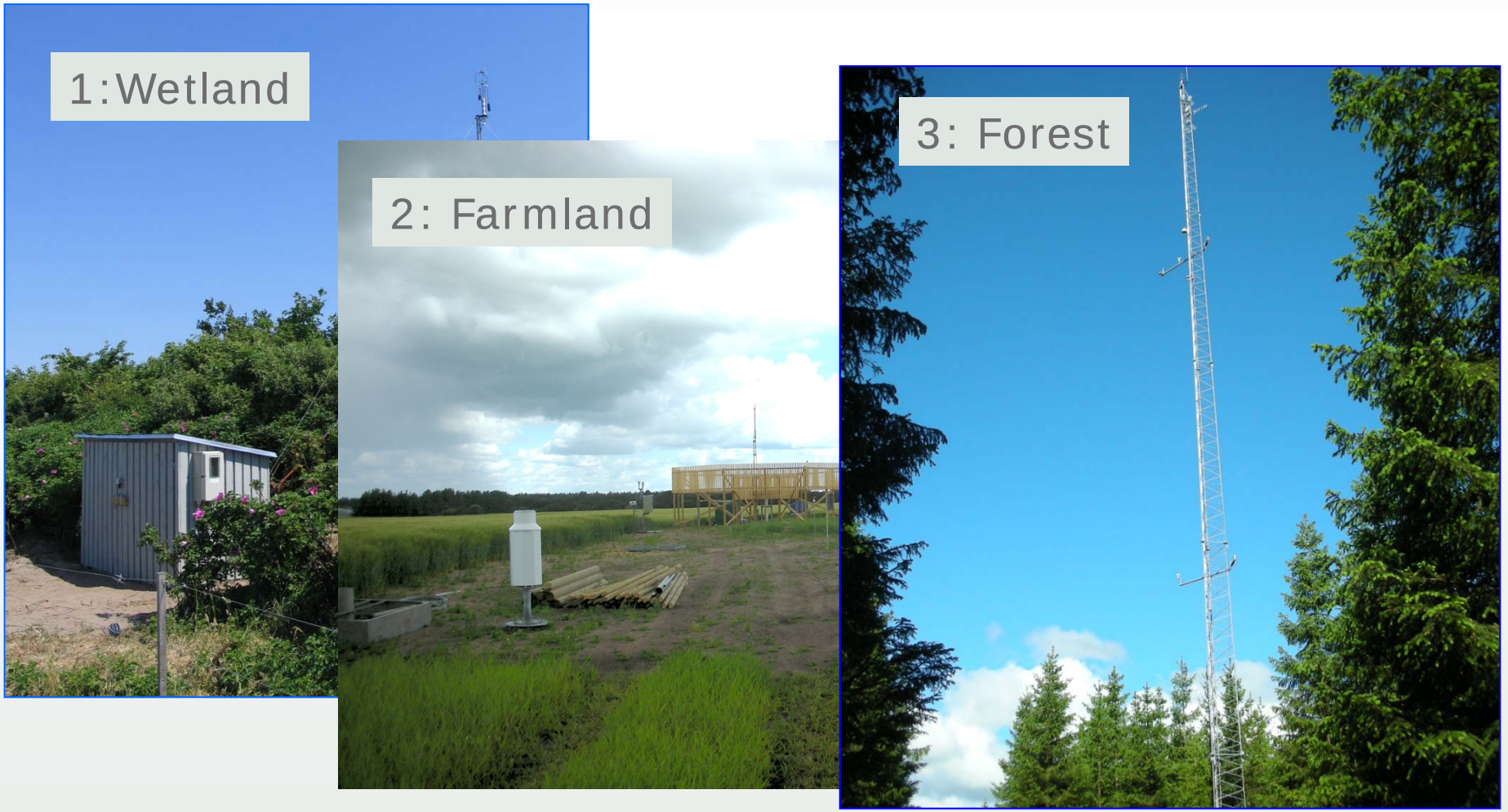
Unit: m
-2.5 - -2
-1.9 - -1.5
-1.4 - -1
-0.9 - -0.5
-0.4 - 0
0.1 - 0.5
0.6 - 1
1.1 - 1.5
1.6 - 2
2.1 - 2.5

He et al., WRR, 2013

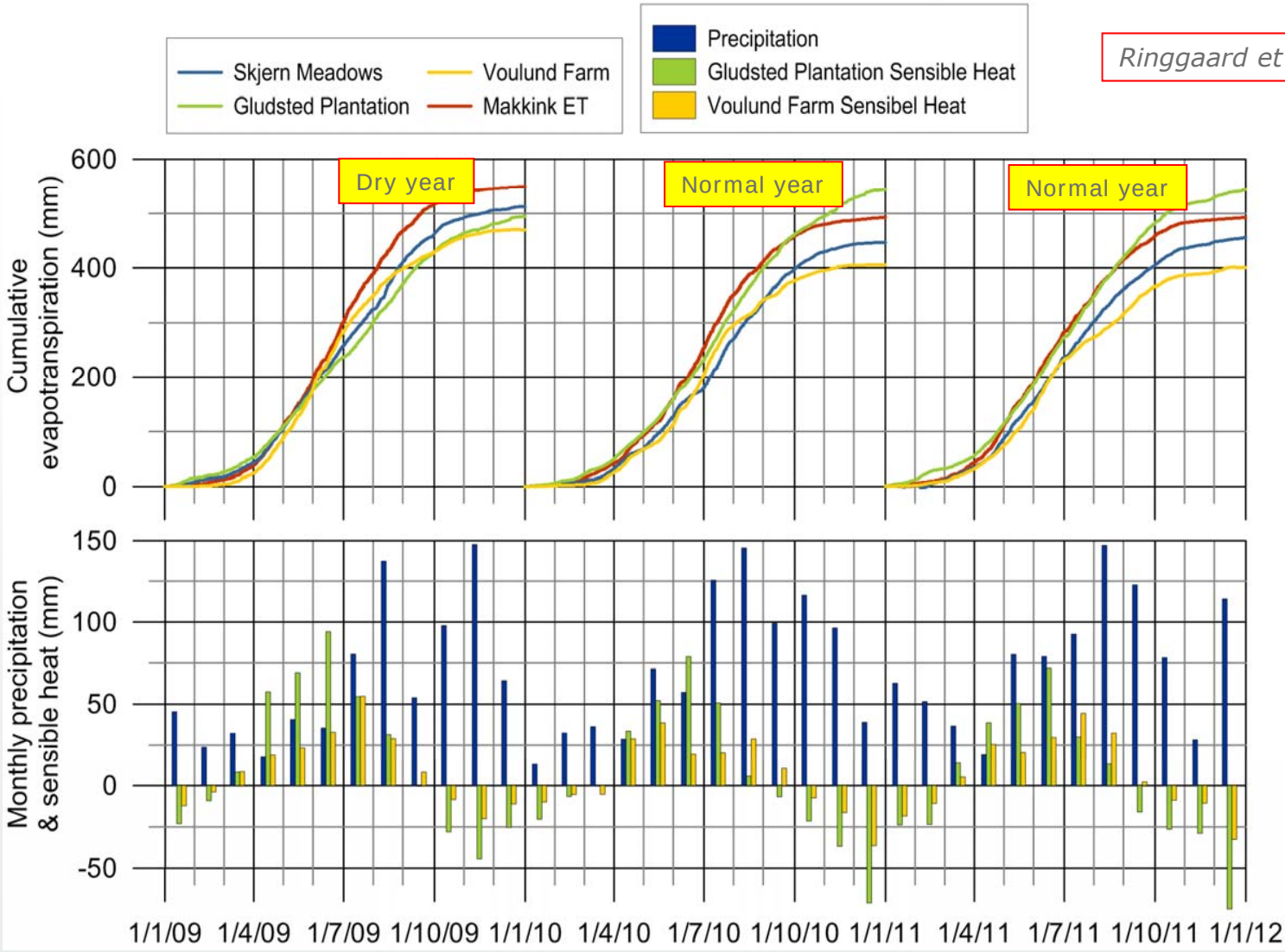
Research issues: Evapotranspiration

- 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

ET at local scale: three flux towers



ET for three land surfaces

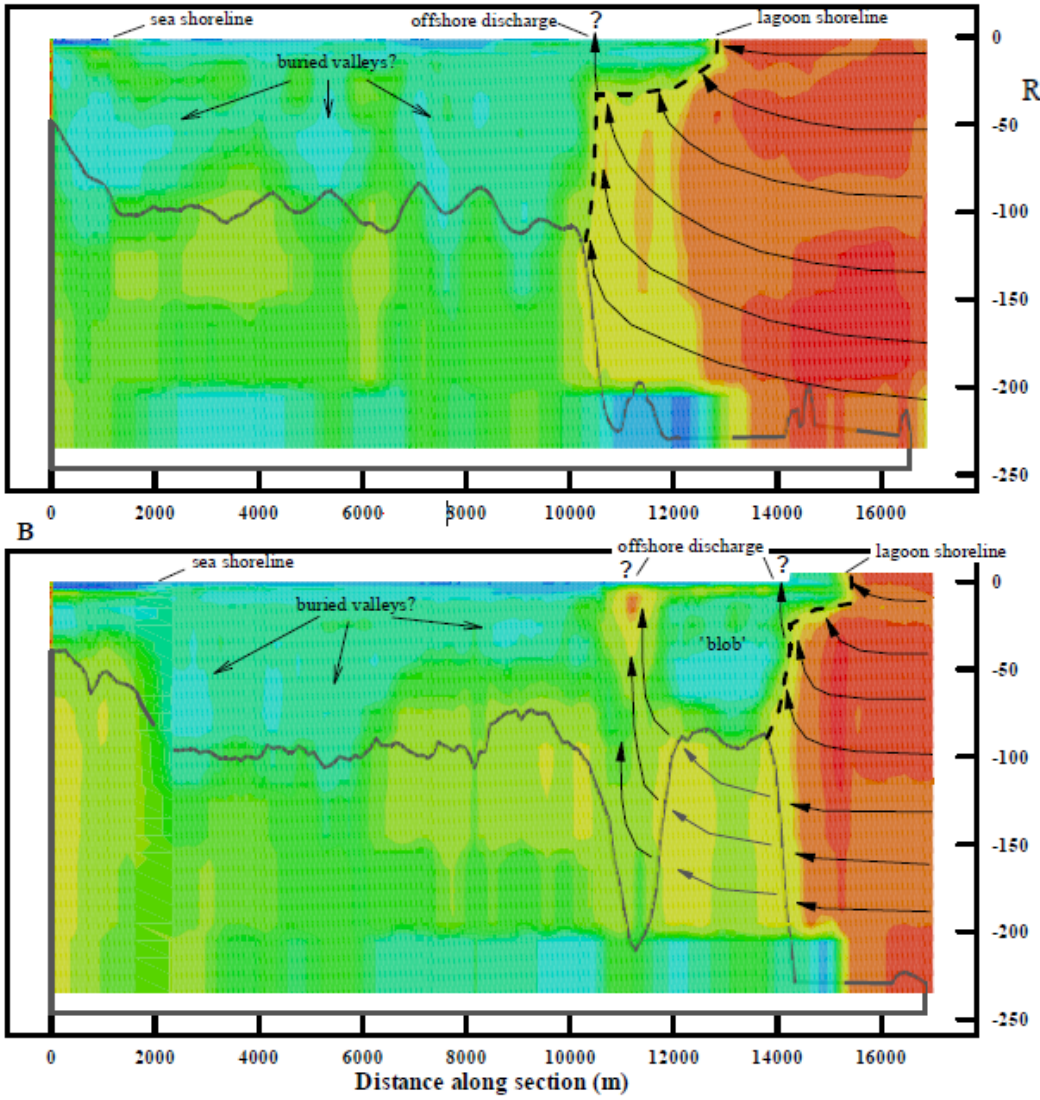


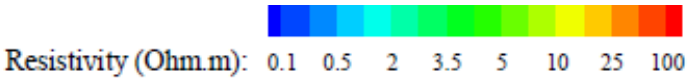
Ringgaard et al., WRR, 2013

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

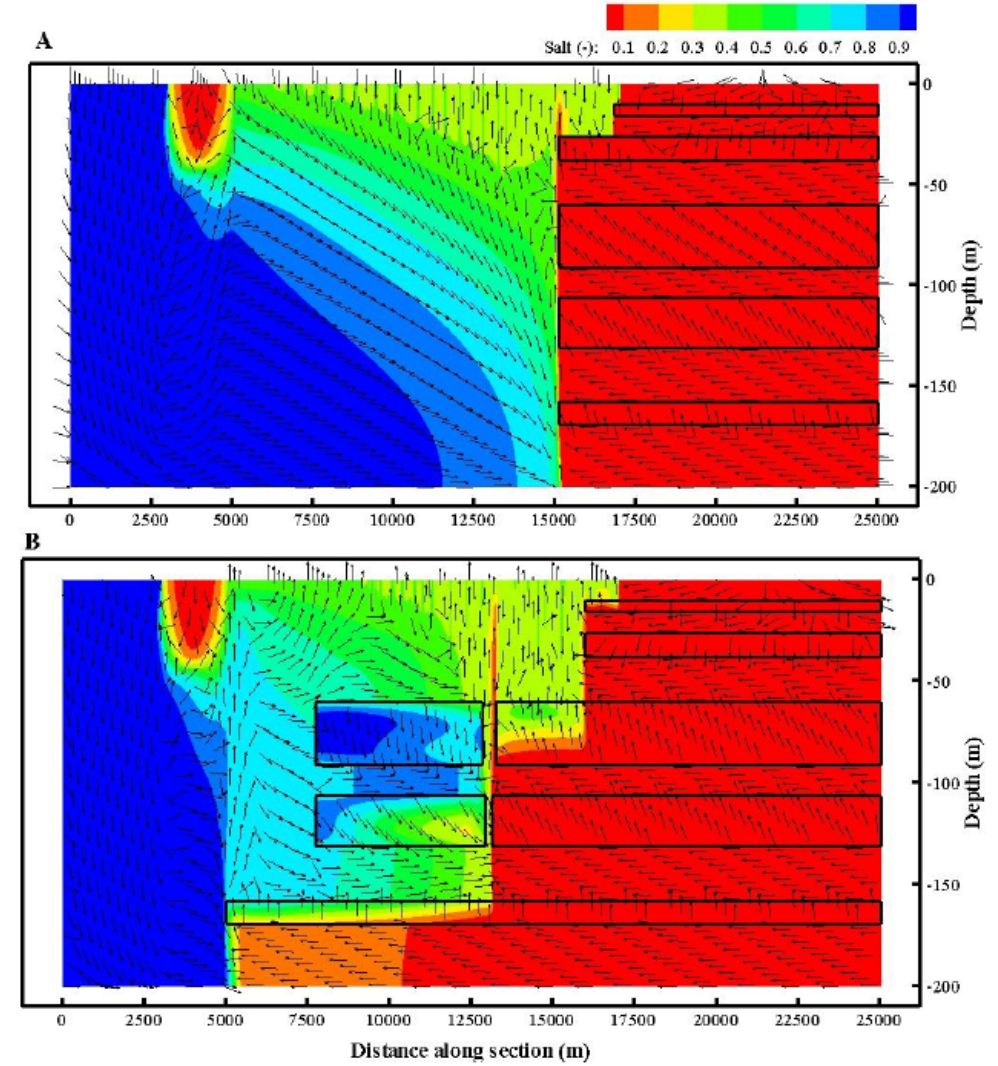
Submarine groundwater discharge





Haider, 2014

Numerical model analysis



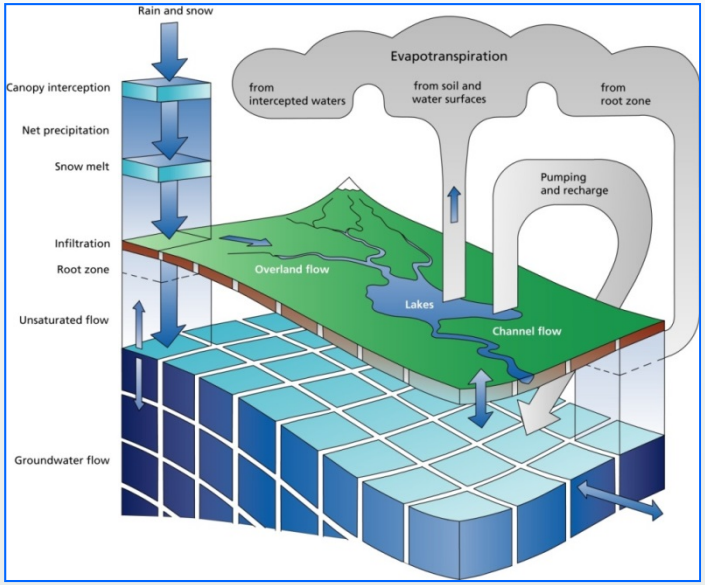
SGD amounts to 6%
of the river inflow to the lagoon

Haider, 2014

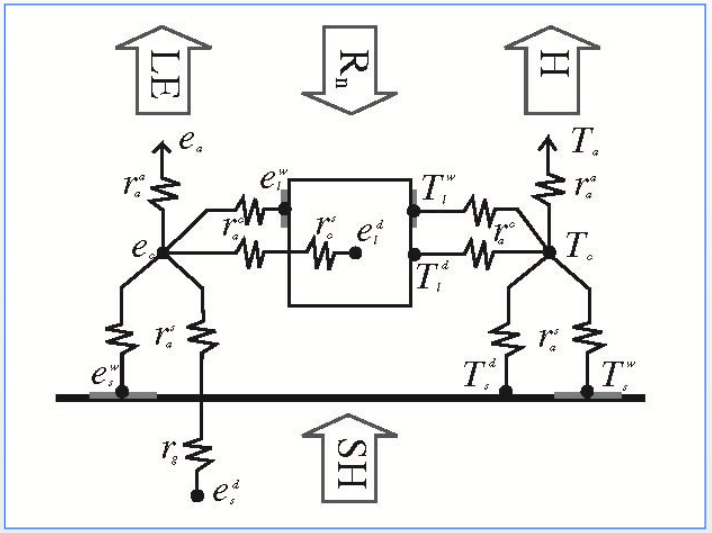
Research issues: Integrated modeling

- Integration of 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
- Spatial calibration and evaluation of distributed hydrological model

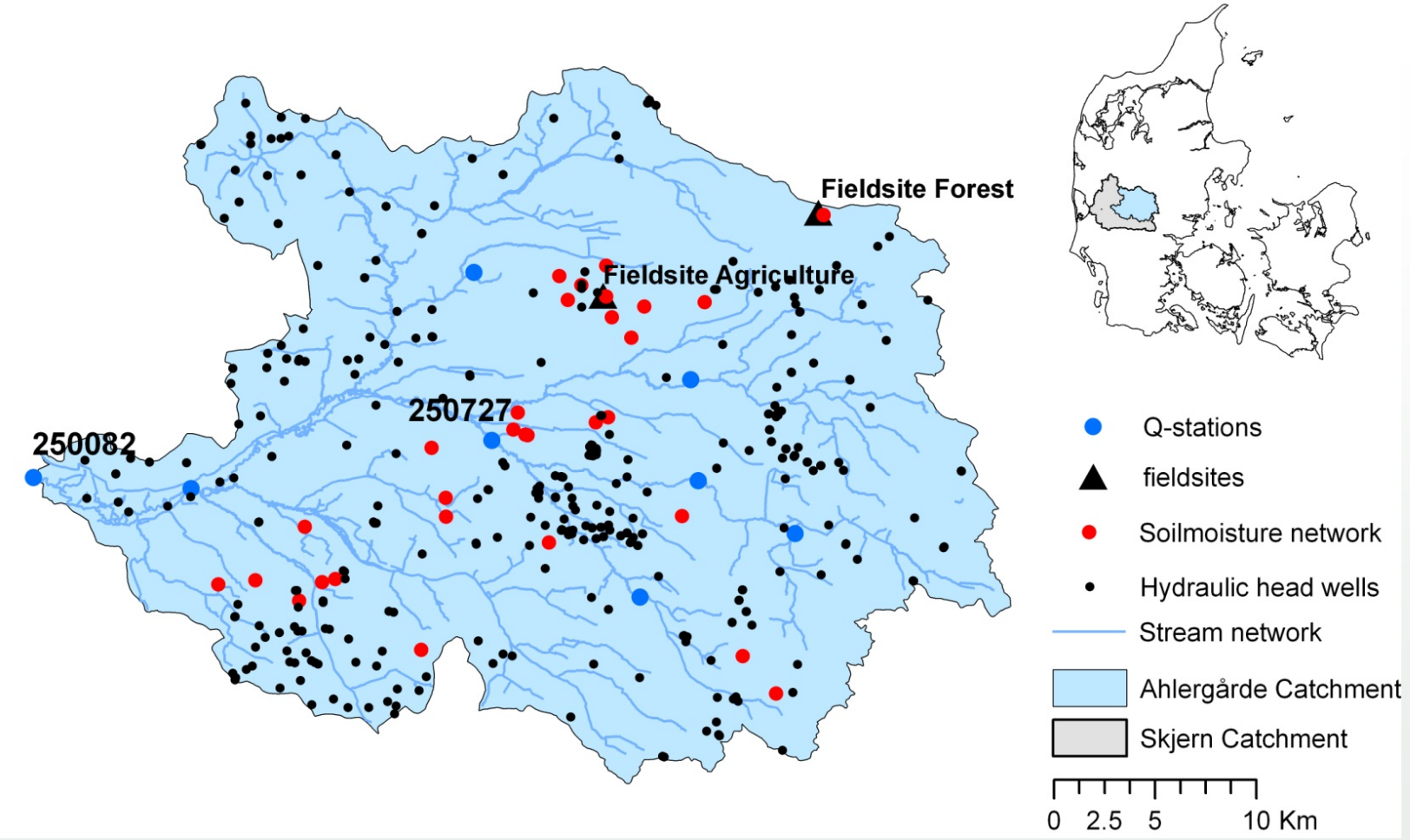
MIKE SHE



Land surface model (energy based)



Model area



Stisen et al., 2013

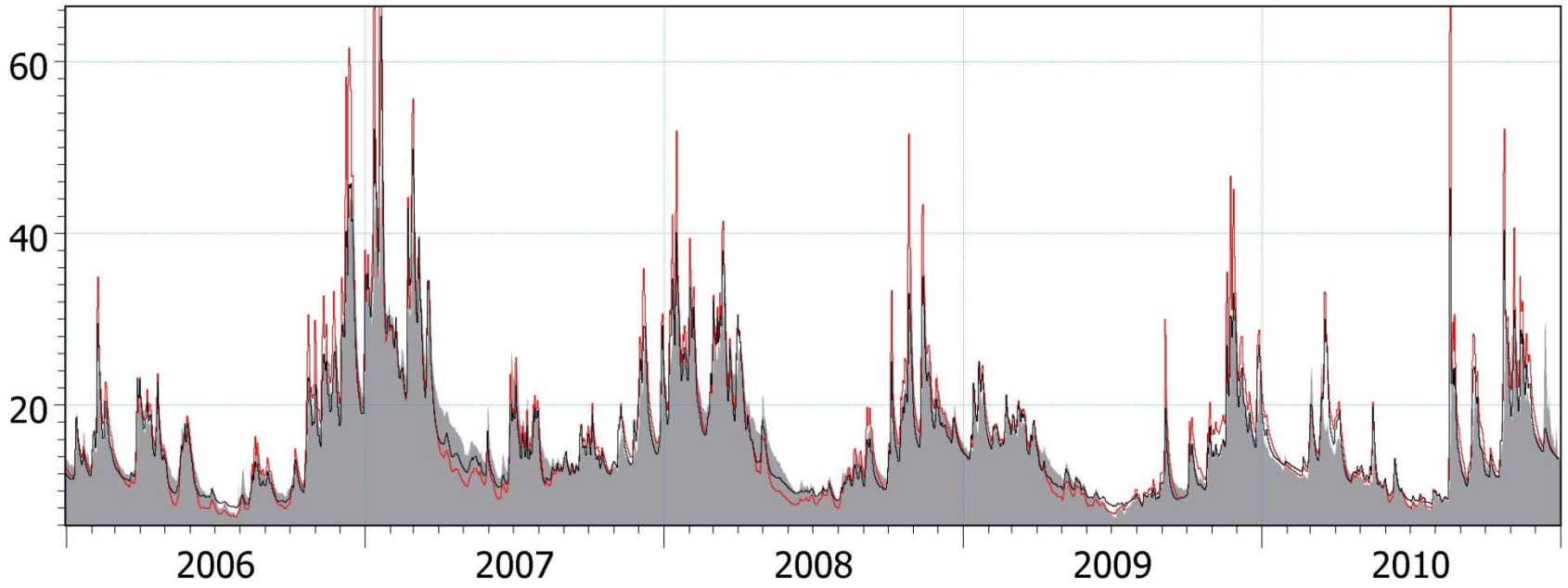
Multi-objective calibration approach to a complex hydrological model with multiple outputs

Data groups	Abr.	points	Obs/year	Objective functions
Stream Discharge	Q	8	365	Bias/RMSE
Hydraulic head	h	366	1-3	Bias/RMSE
Soil moisture	θ	30	365	Slope/RMSE
Latent heat flux	λET	2	365	Bias/RMSE
Surface temperature	T_s	1050	5	Bias/RMSE/R

Stisen et al., 2013

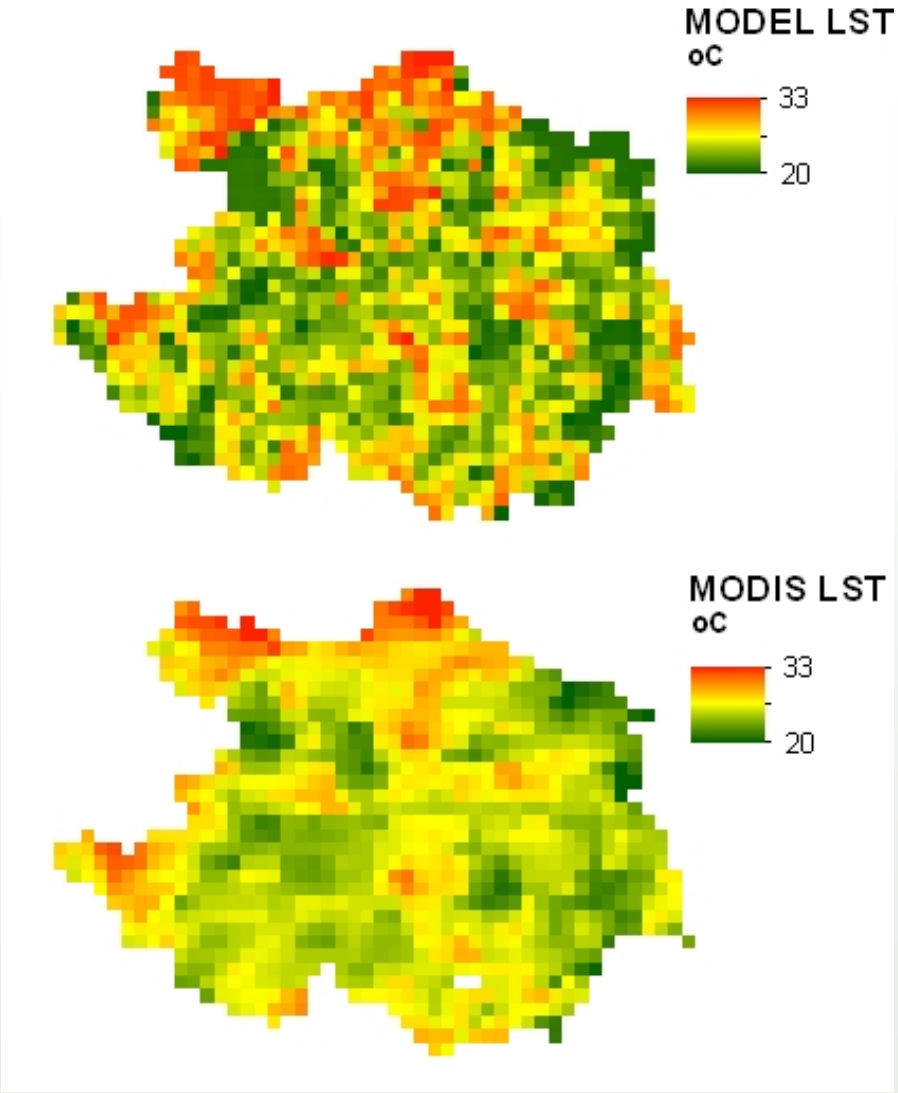
Calibration results

11 parameters selected for calibration



Stisen et al., 2013

Spatial pattern of surface temperature

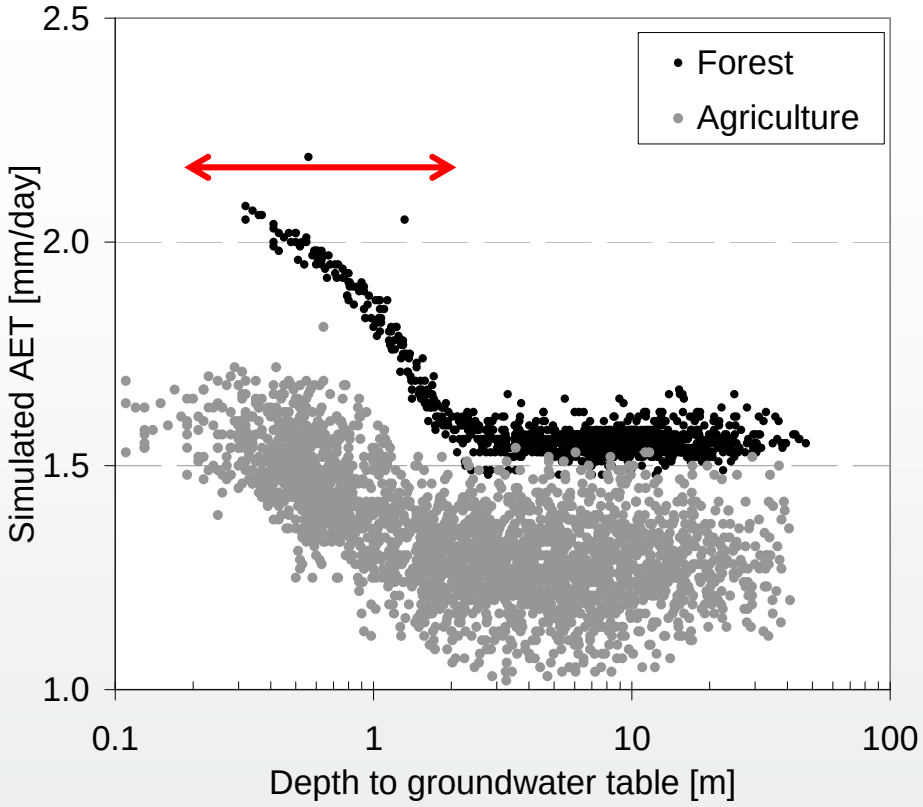


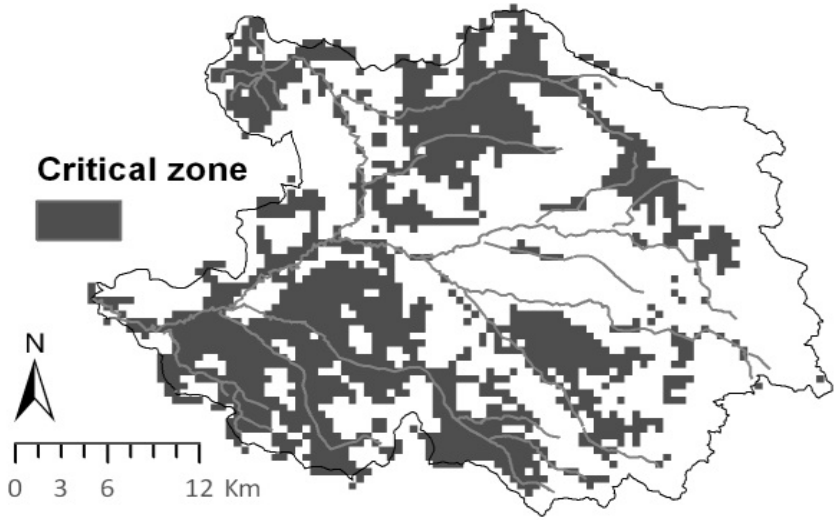
Simulated

Observed (MODIS)

Stisen et al., 2013

Groundwater controlled evapotranspiration





Critical zone 38%

Stisen et al., 2013

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