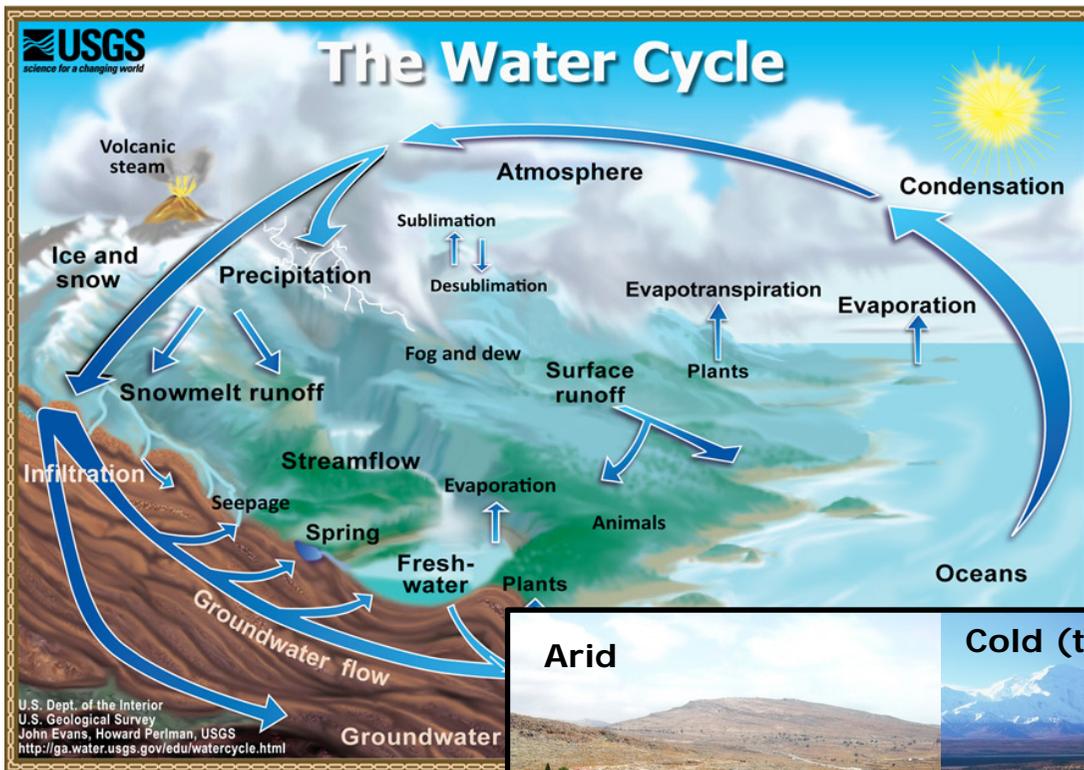# Integrated Climate and Hydrology Modelling

catchment scale coupling of a regional climate model and a hydrological model

Morten A. D. Larsen[#1], Martin Drews[#], Jens C. Refsgaard[*], Karsten H. Jensen[^], Michael B. Butts[+], Jens H. Christensen[x], Ole B. Christensen[x]
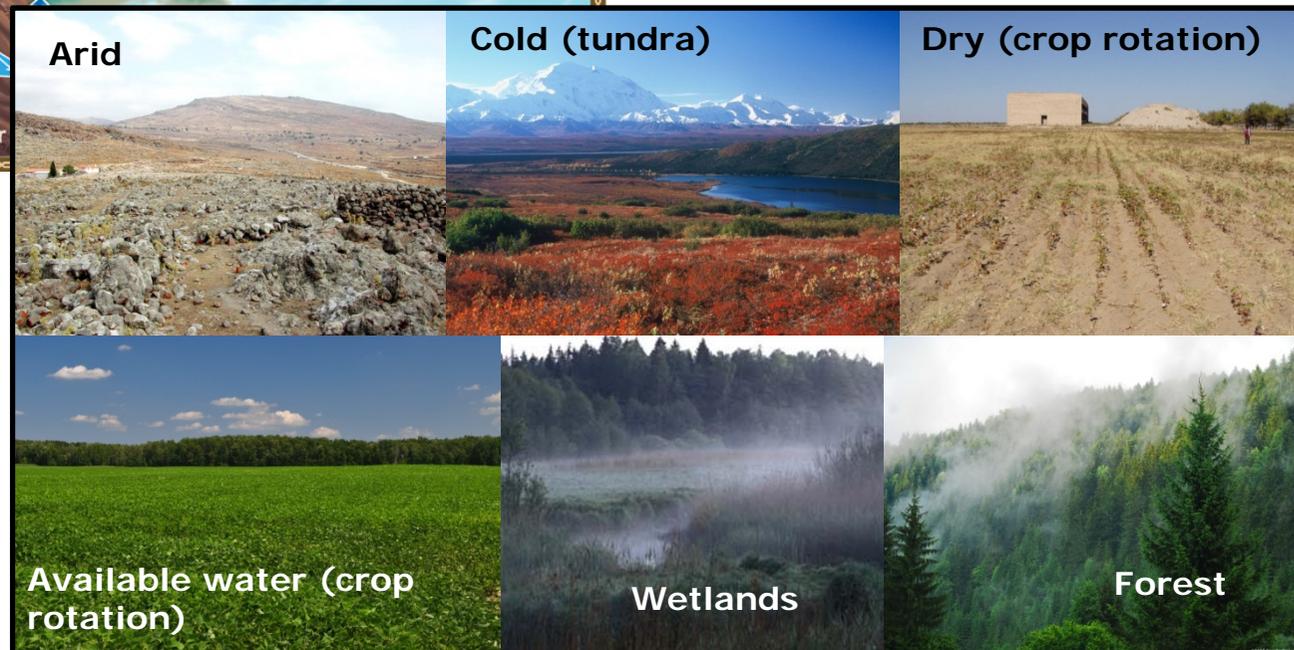
- [#] ***Technical University of Denmark***, *DTU Climate Centre* – [1] *Post Doc*
- [*] *Geological Survey of Denmark and Greenland*
- [^] *University of Copenhagen, Dep. of Geosciences and Natural Resource Management*
- [+] *DHI*
- [x] *Danish Meteorological Institute*
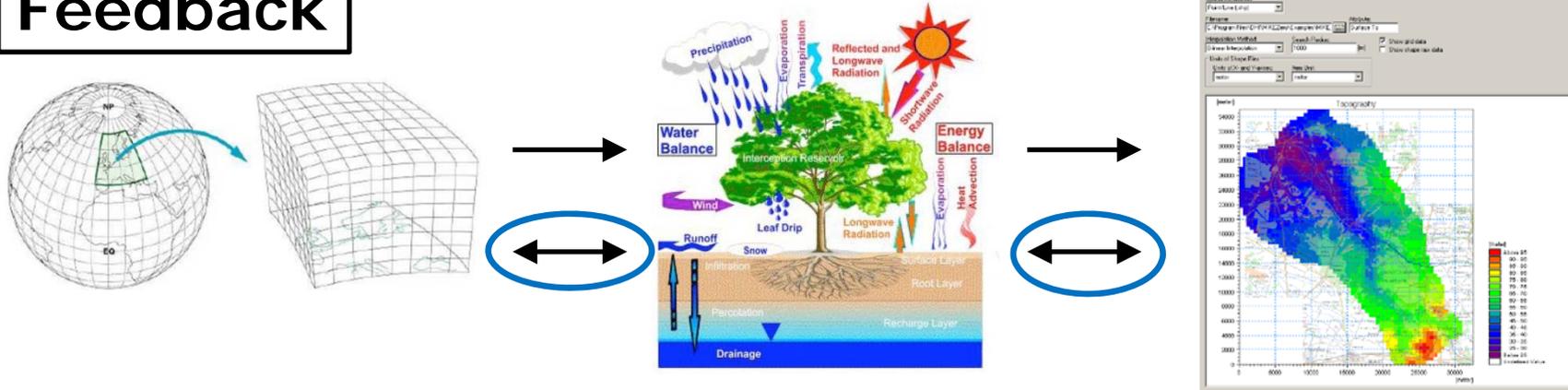
The Water Cycle

Processes;
complex,
interconnected in
time and space

Dynamics;
highly related to
land-surface

Arid

Cold (tundra)

Dry (crop rotation)

Available water (crop rotation)

Wetlands

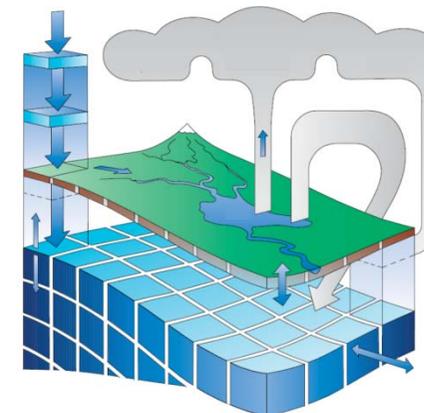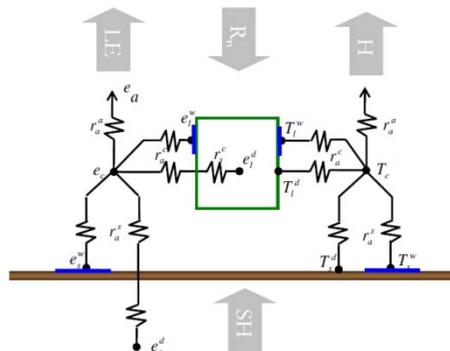Forest

Coupled / uncoupled

Simultaneous simulation – fully dynamic 2-way data exchange

Feedback

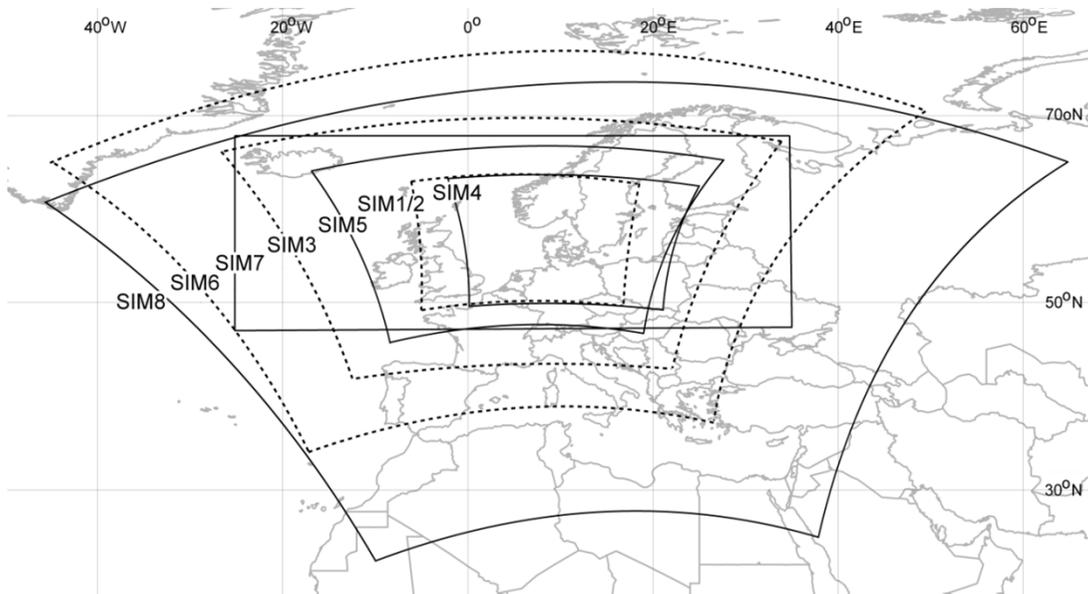**Regional climate model (HIRHAM) | Land surface model (SWET) | Hydrology model (MIKE SHE)**

Processes

HIRHAM – setup study - domains

1. Find the optimal HIRHAM domain characteristics for the coupled setup
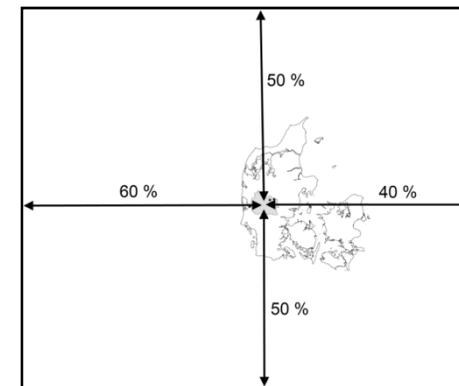2. No definite rules on domain size, location and resolution

Specifications
- DMI-HIRHAM (5)
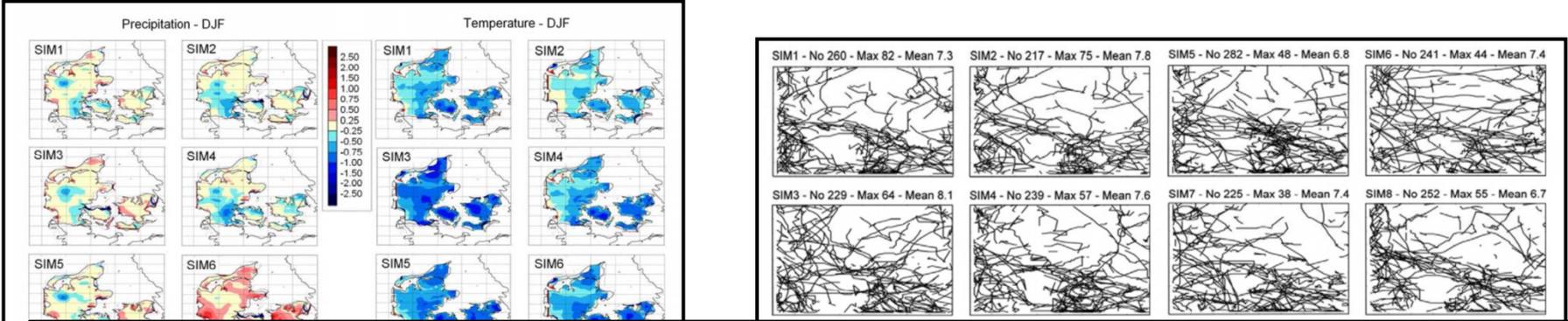- ERA-Interim
- 1 Jan 2008 – 30 Apr 2010

Assessment
- Seasonal precip. and temp.
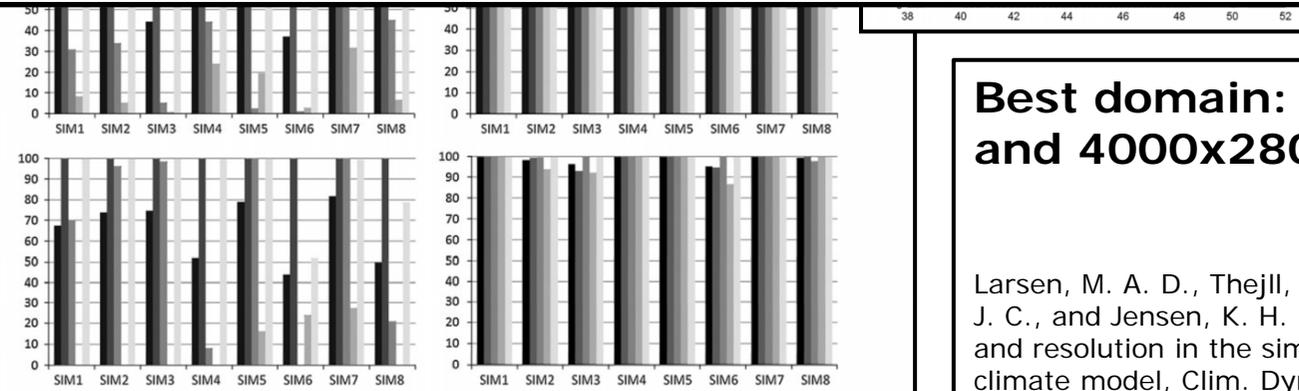- E-OBS and DMI observation data

Model run	Resolution (km)	Domain size (km - lon x lat)	Number of cells
SIM1	5.5	1400x1400	252
SIM2	11	1350x1350	122
SIM3	11	2800x2800	252
SIM4	5.5	1400x1400	252
SIM5	5.5	2000x2000	362
SIM6	11	4000x4000	362
SIM7	11	4000x2800	362
SIM8	12	5500x5200	452x432

Precipitation - DJF

Temperature - DJF

SIM1 SIM2 SIM3 SIM4 SIM5 SIM6

SIM1 - No 260 - Max 82 - Mean 7.3   SIM2 - No 217 - Max 75 - Mean 7.8   SIM5 - No 282 - Max 48 - Mean 6.8   SIM6 - No 241 - Max 44 - Mean 7.4

SIM3 - No 229 - Max 64 - Mean 8.1   SIM4 - No 239 - Max 57 - Mean 7.6   SIM7 - No 225 - Max 38 - Mean 7.4   SIM8 - No 252 - Max 55 - Mean 6.7

Earth observatory comment:

Also a high dependence on (good and vast) observation data even for studies at this scale (>1000 km)

Fig. 10 The significance levels of the bootstrap test. *Upper row* with random resampling in moving blocks, *lower row* with random resampling all over Denmark

**Best domain: 11 km resolution and 4000x2800 km size**

Larsen, M. A. D., Thejll, P., Christensen, J. H., Refsgaard, J. C., and Jensen, K. H. (2013). On the role of domain size and resolution in the simulations with the HIRHAM region climate model, Clim. Dynam., 40, 2903–2918, doi:10.1007/s00382-012-1513-y.

MIKE SHE/SWET – setup study

Calibrate MIKE SHE including SWET land surface model component
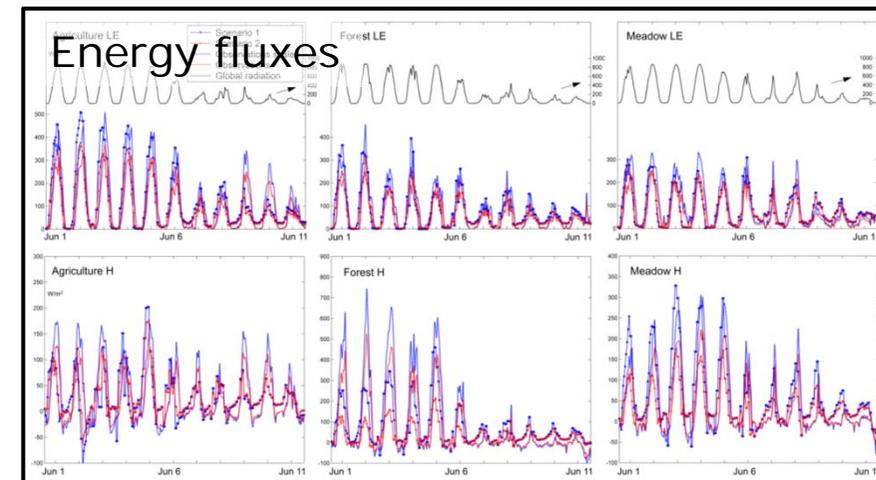
Site

Discharge
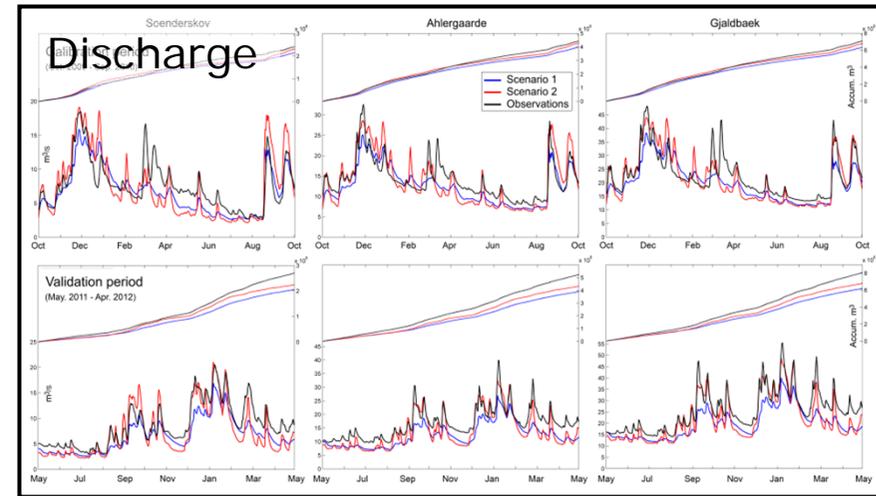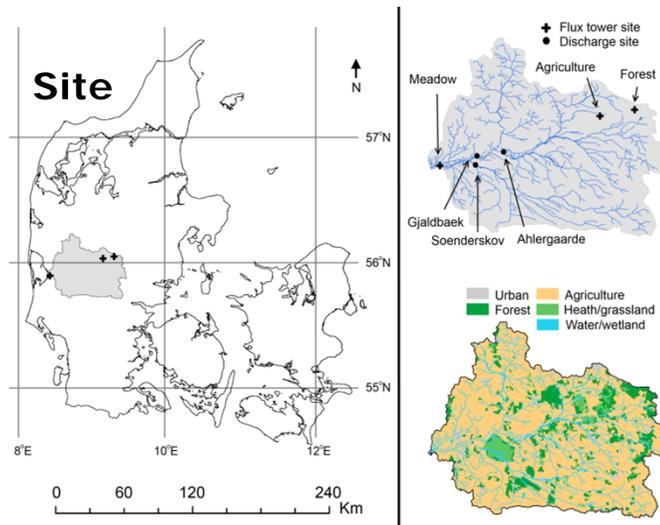
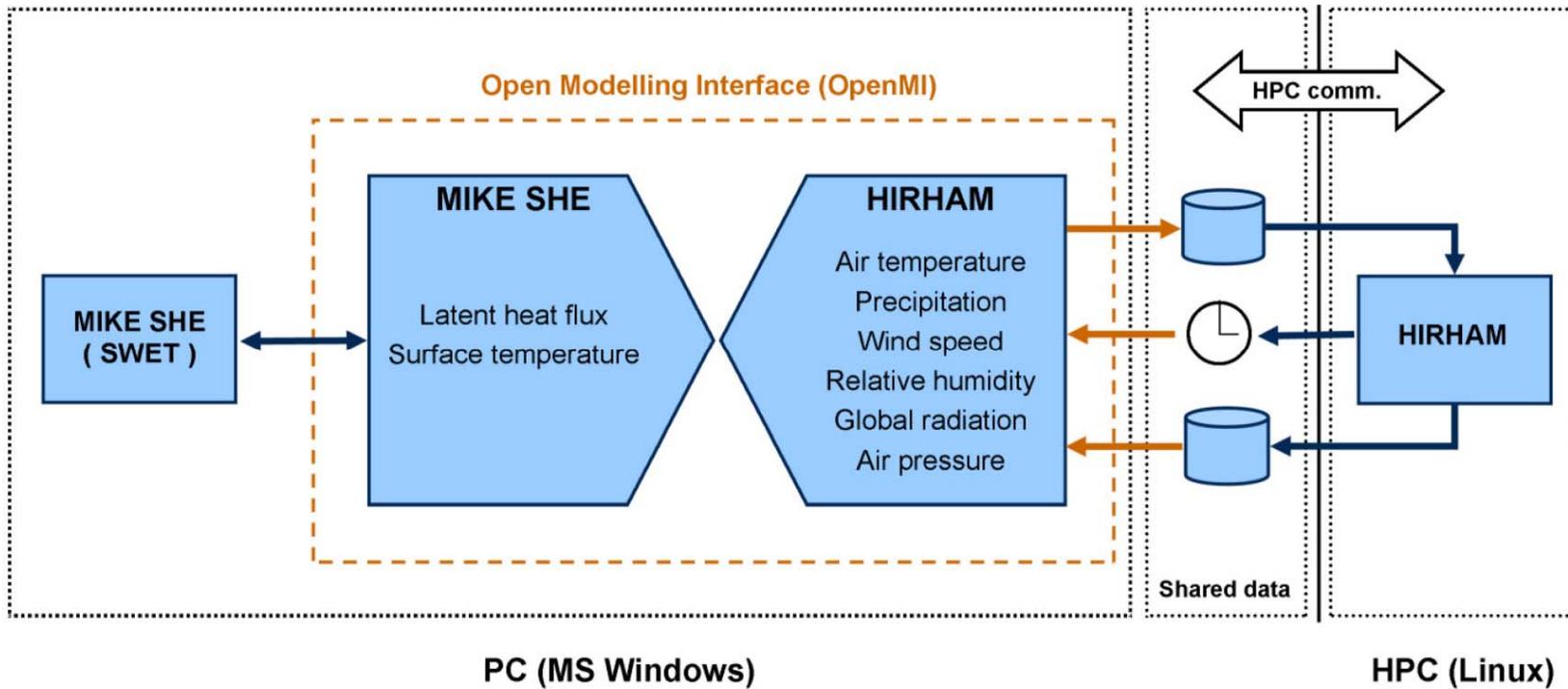**Energy fluxes**

Specifications
- MIKE SHE (2011)
- 500 m resolution
- Calibrated against observation data
- Calibration: 1 Oct 2009 – 30 Sep 2010
- Validation: 1 May 2011 – 30 Apr 2012

Assessment
- Energy fluxes (LE, H and G)
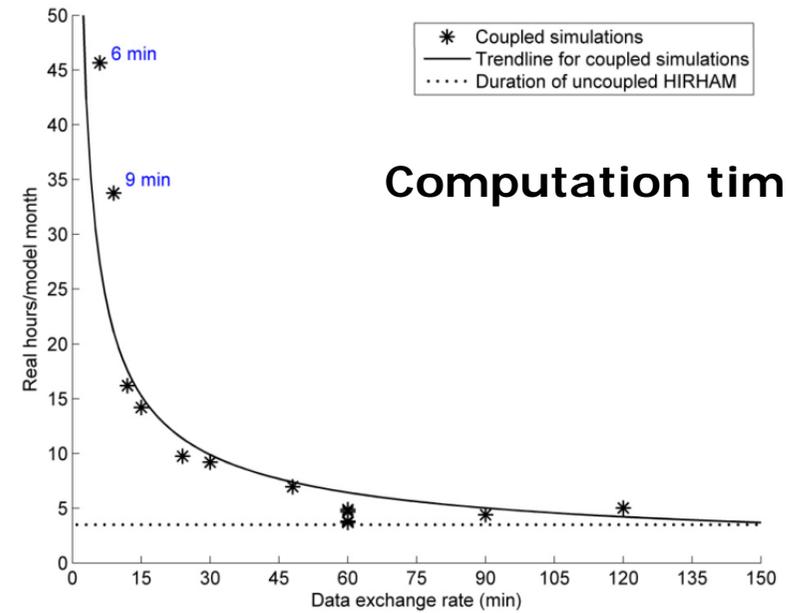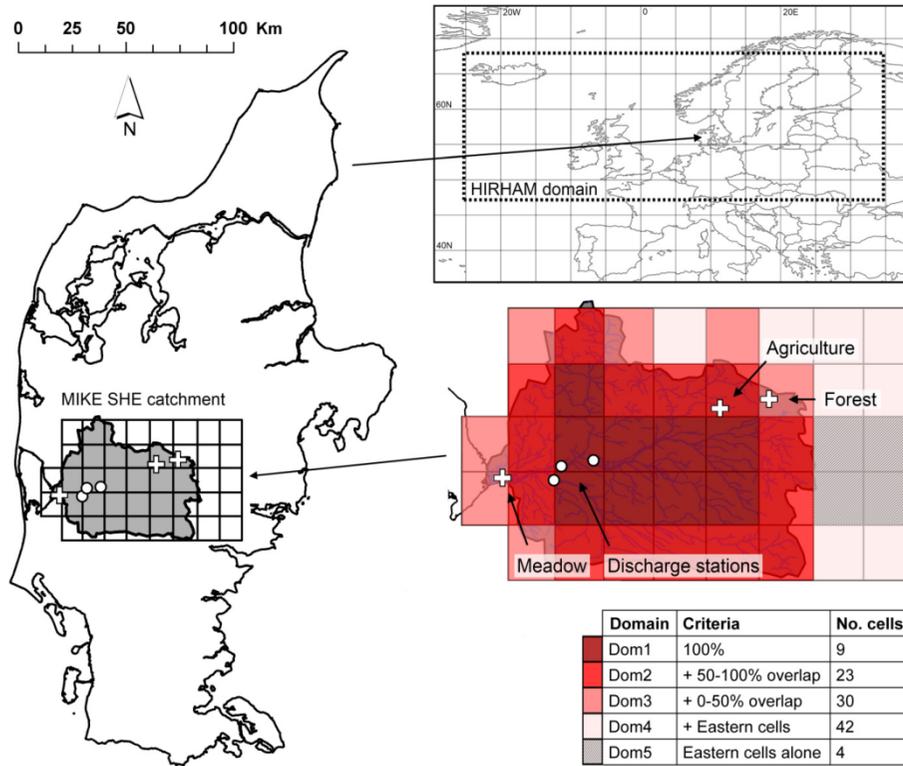- Discharge (water balance)
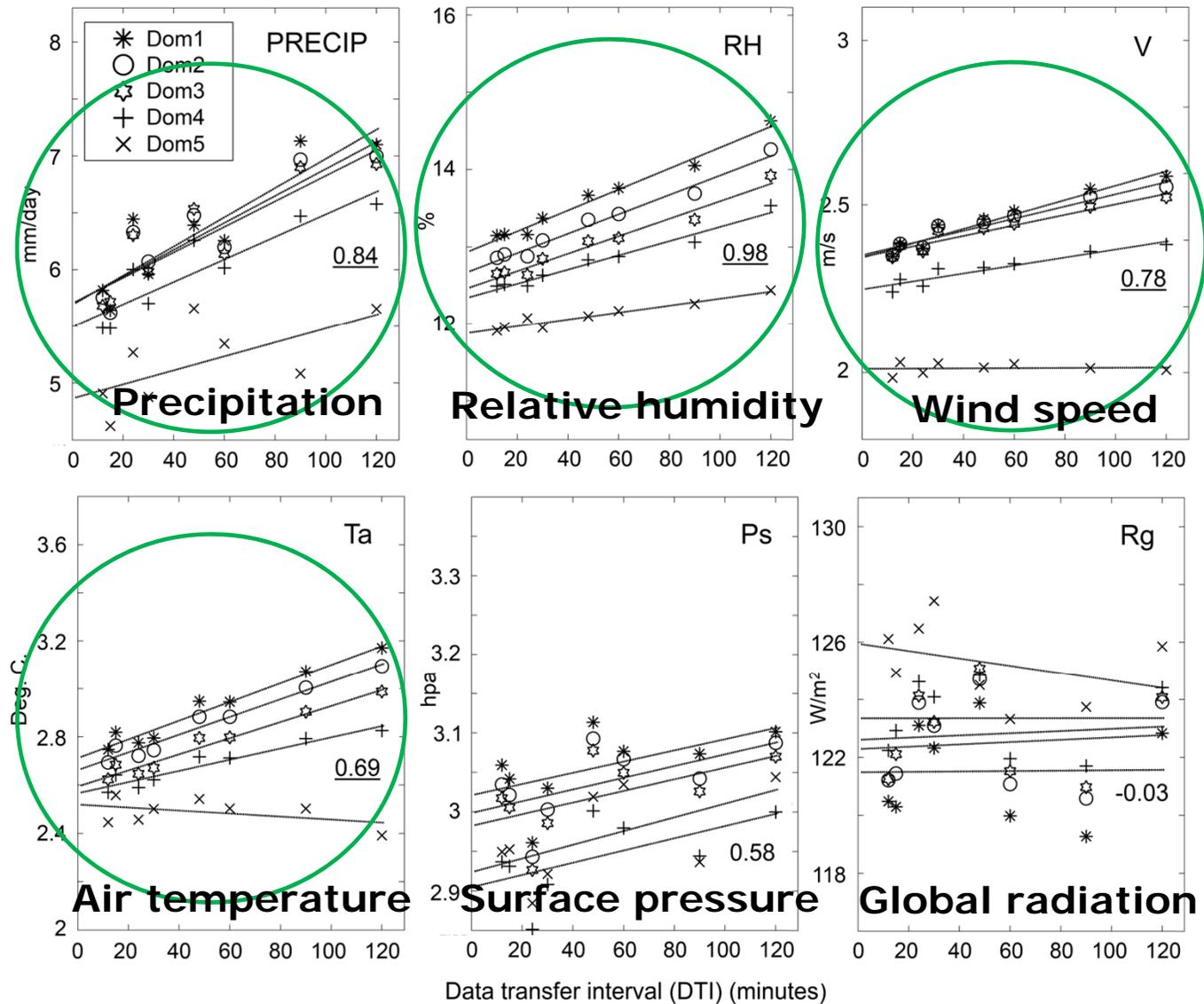- Spinup sensitivity

Coupled study

- Timing (wait/go)

- Mapping (interpolation)

- Temporal interpolation

- Unit conversion

Coupled study

Computation time
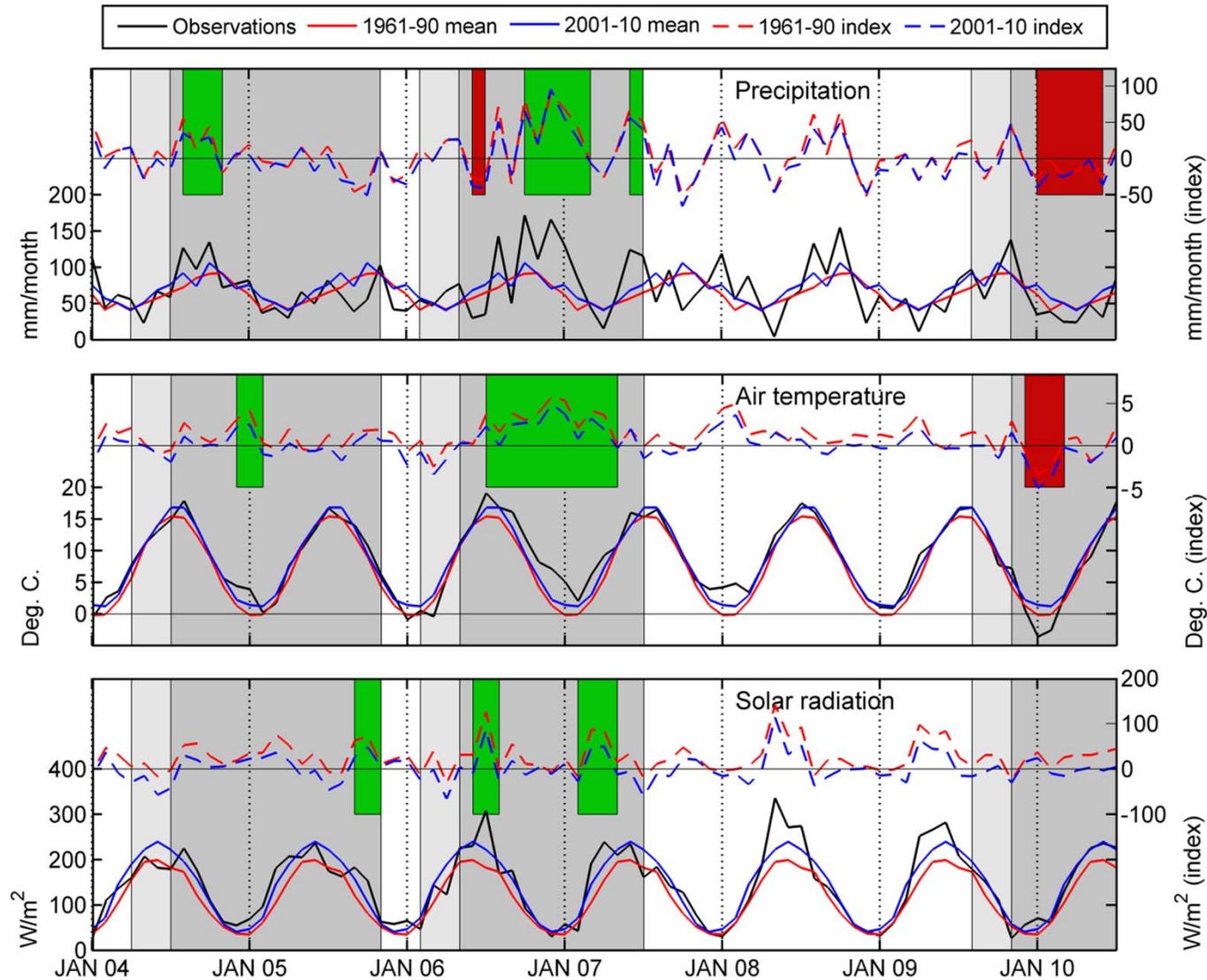
- **Data transfer interval**
- **Coupled/Uncoupled performance**

Evapotranspiration/data source/resolution

DTU Management Engineering, Technical University of Denmark
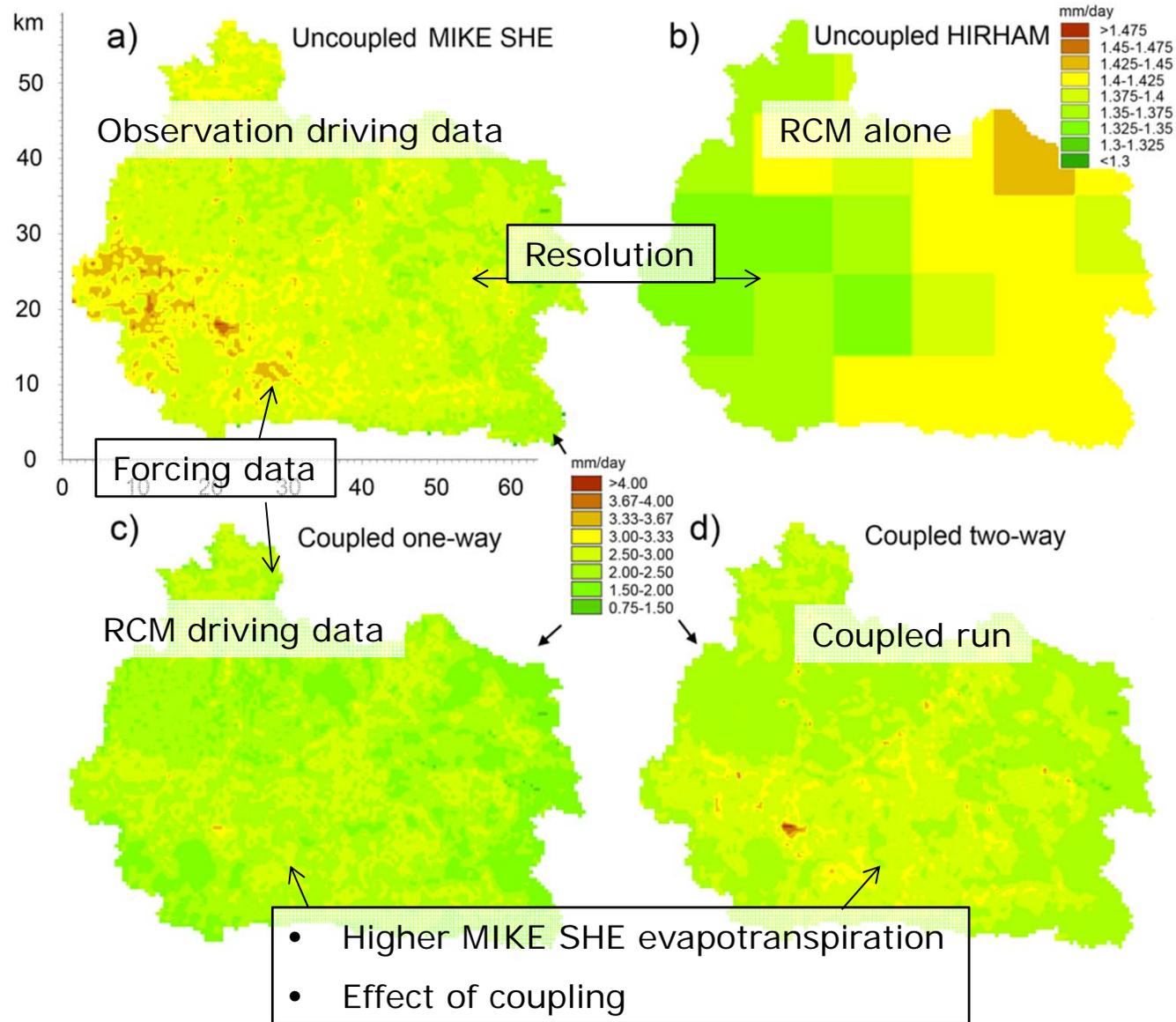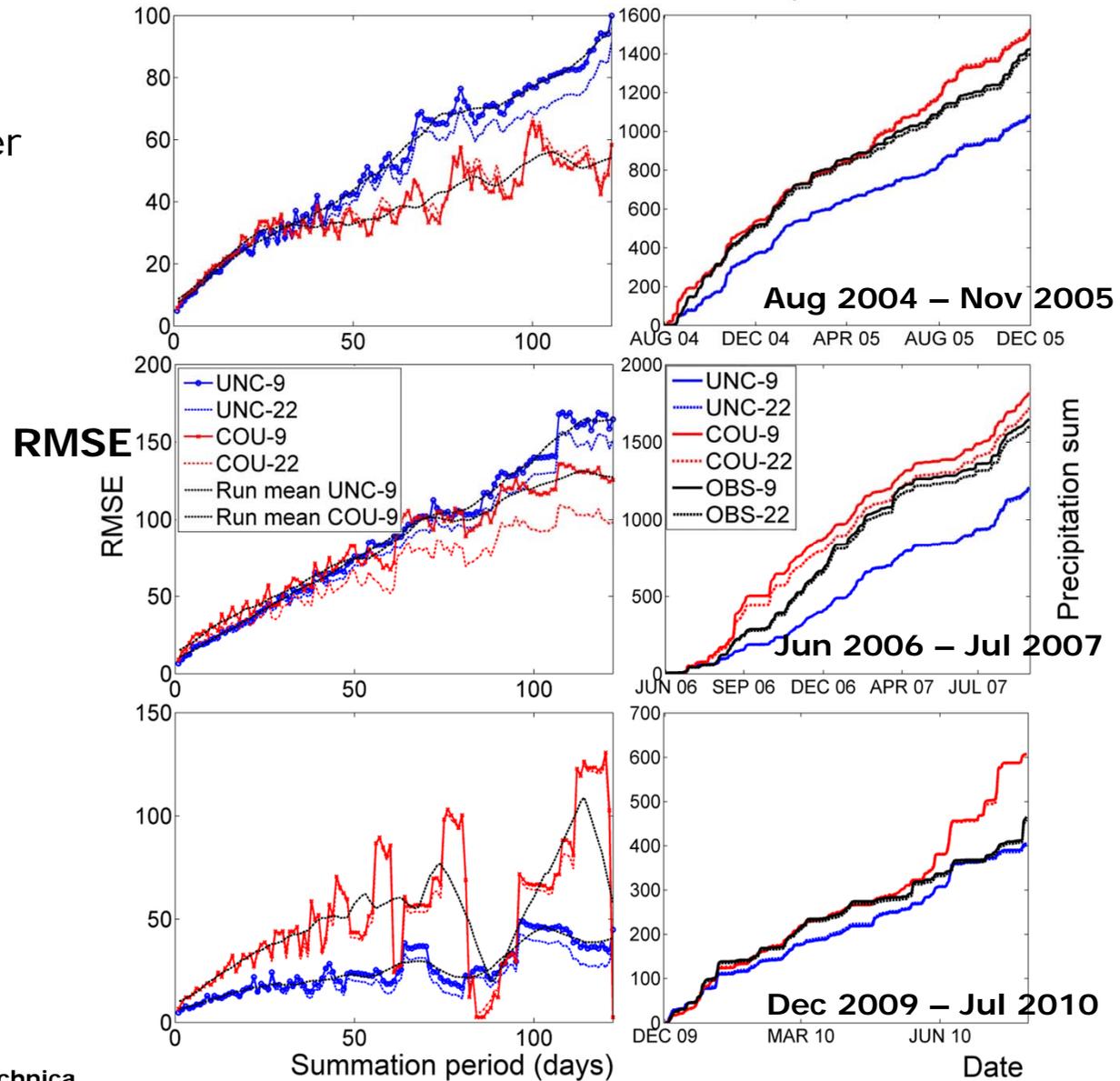
More extreme periods + long simulation

30 min. data transfer frequency

Model performance - precipitation

RMSE of observed and simulated precipitation after averaging in periods of 1-122 days (4 months). Running mean is are also shown.

RMSE

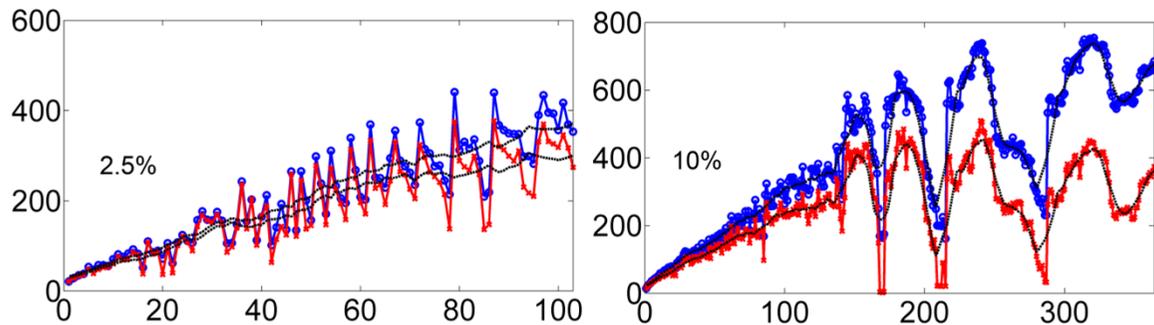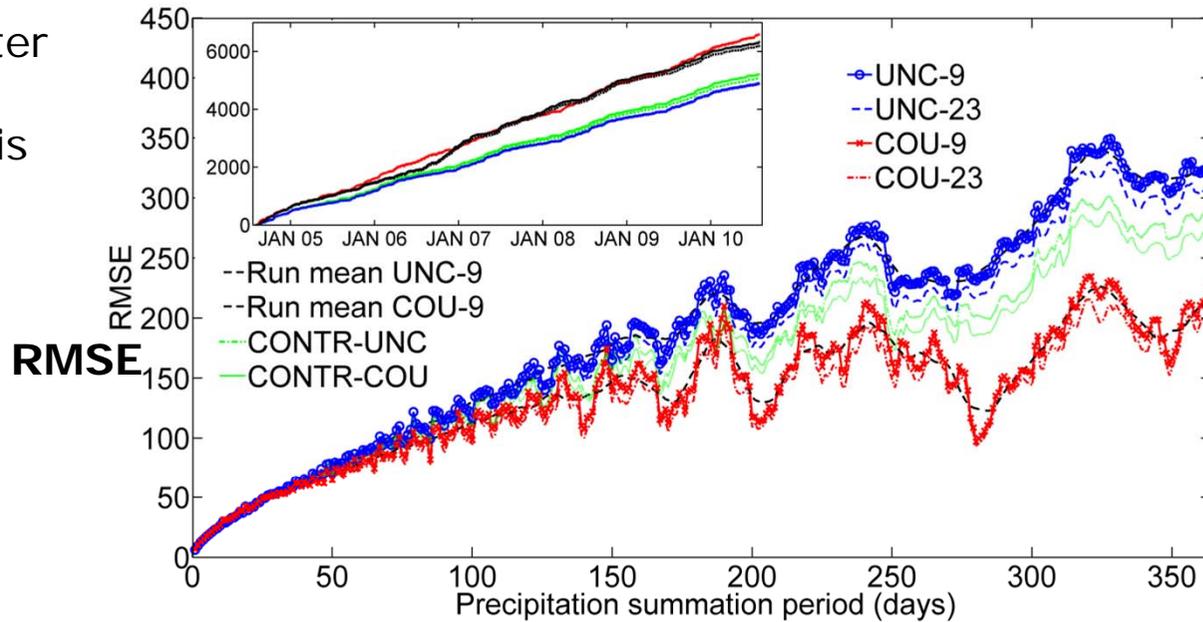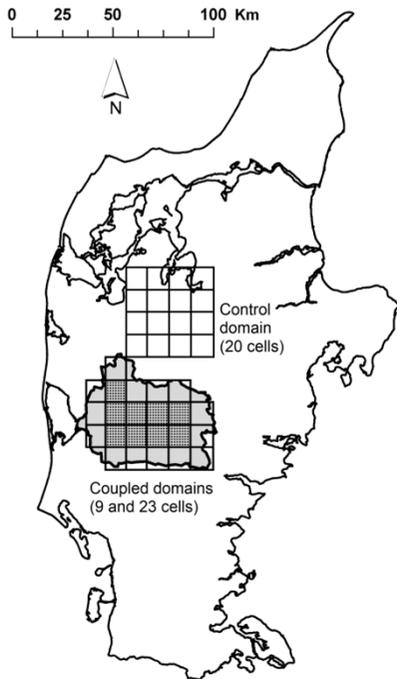**DTU Management Engineering, Technica**

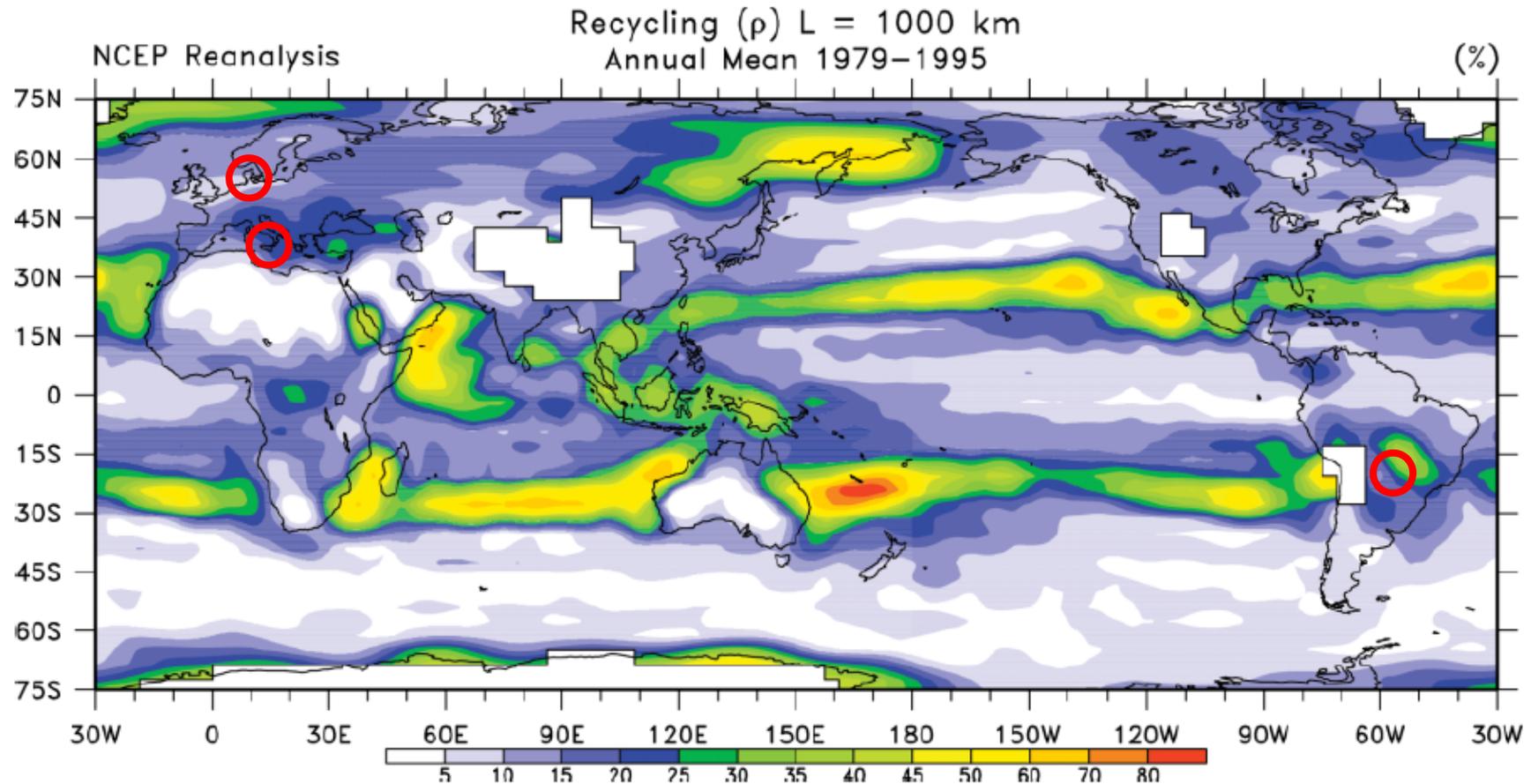# More extreme periods – precipitation

RMSE of observed and simulated precipitation after averaging in periods of 1-365 days. Running mean is are also shown.

Extreme rain (2.5%, 5%,10%, 33%)

, Technical University of Denmark

Location / moisture regime

Recycling (ρ) L = 1000 km
Annual Mean 1979−1995

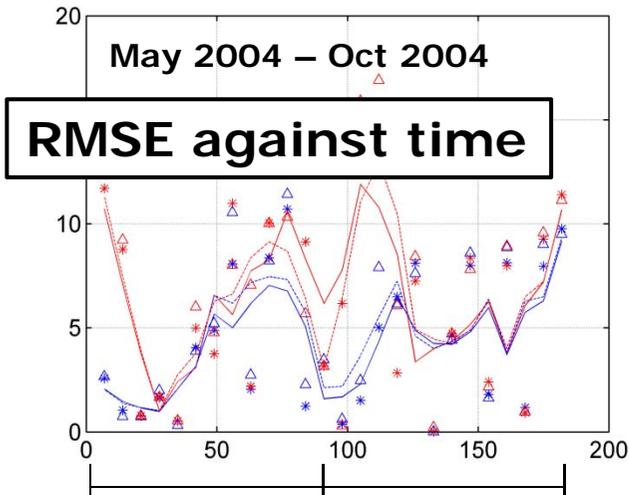Trenberth (1999)

DTU Management Engineering, Technical University of Denmark

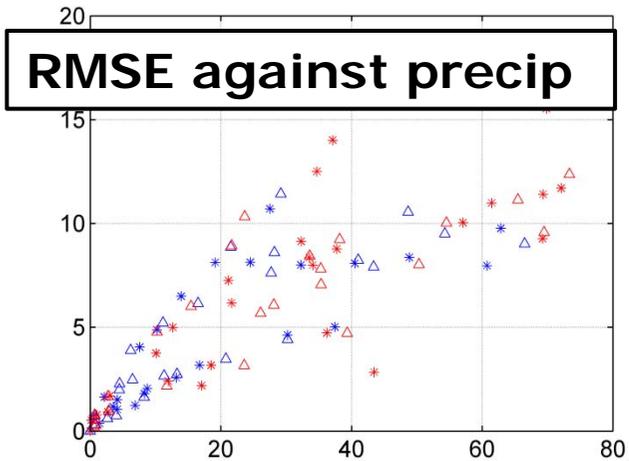# New study – Italian catchment

Crati River catchment (1300 km^2)

Thank you

DTU Management Engineering, Technical University of Denmark

Spin-up

RMSE against time

May 2004 – Oct 2004

Mar 2006 – Aug 2006

Sep 2009 – Feb 2010

days after model start

3 month spin-up   3 month eval. period

RMSE against precip

mm/day

DTU Management Engineering, Technical University of Denmark
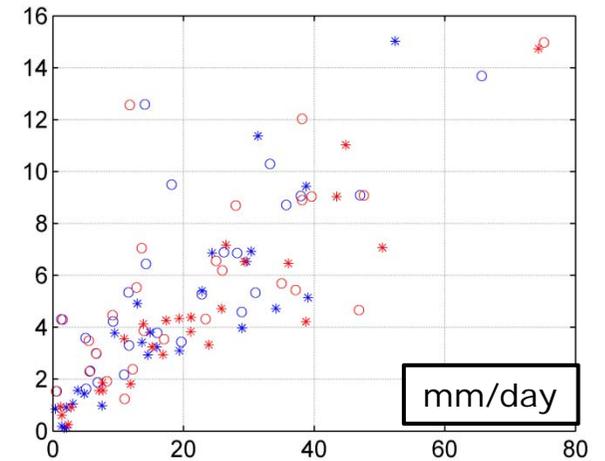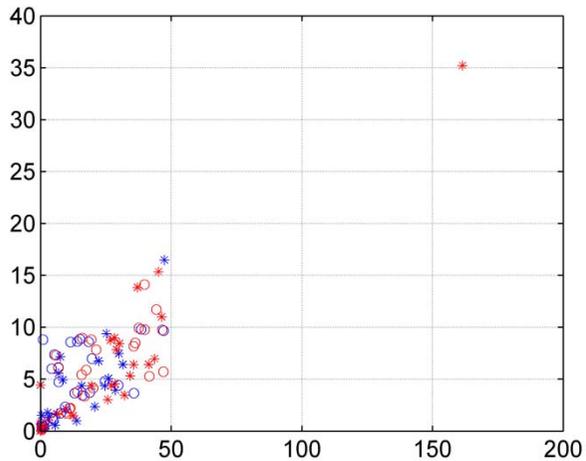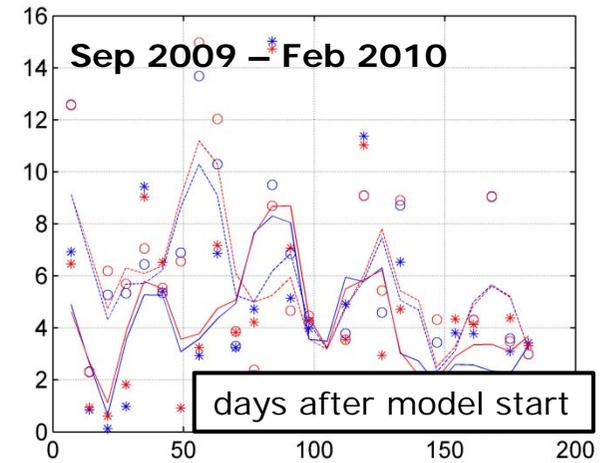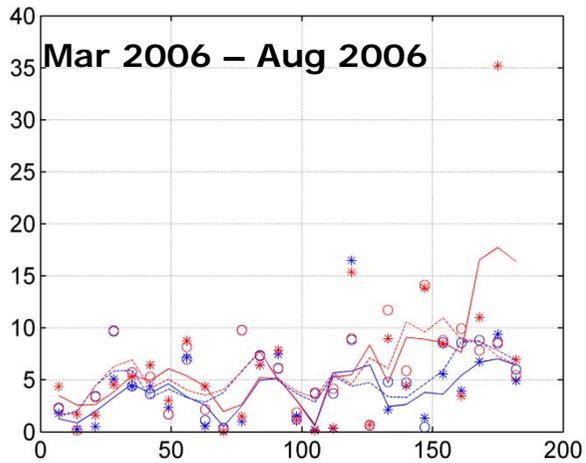
Perturbation – variability - precipitation
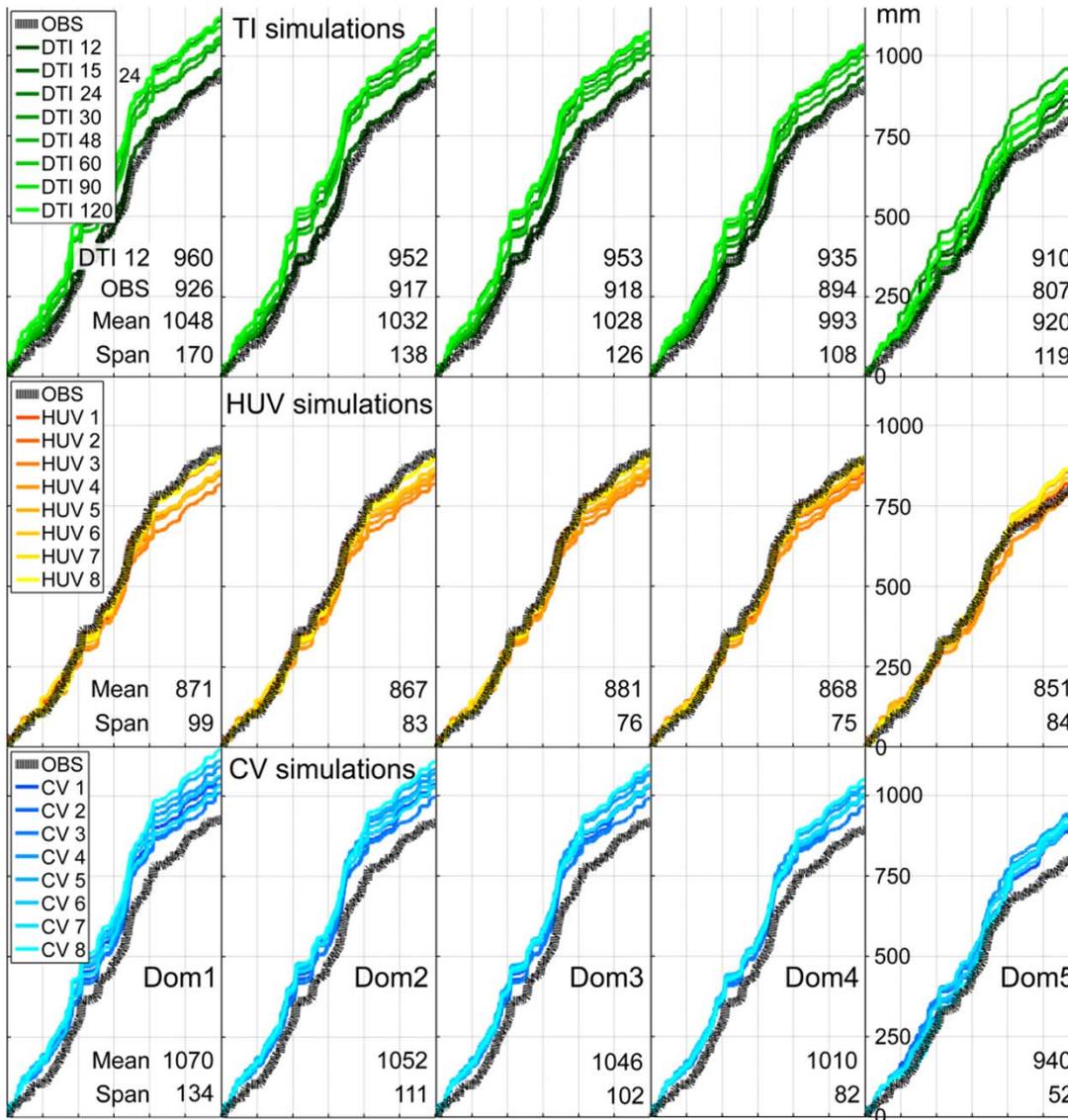
Coupled (12-120 min)

Mean: 1004 mm

Span: 132 mm

Uncoupled (perturbed):

Mean: 892 mm

Span: 83 mm

Coupled (60 min, perturbed):

Mean: 1027 mm

Span: 96 mm