

# Assessing the hydrological impacts of climate change at the local scale: Dynamical coupling of a regional climate model to a hydrological model

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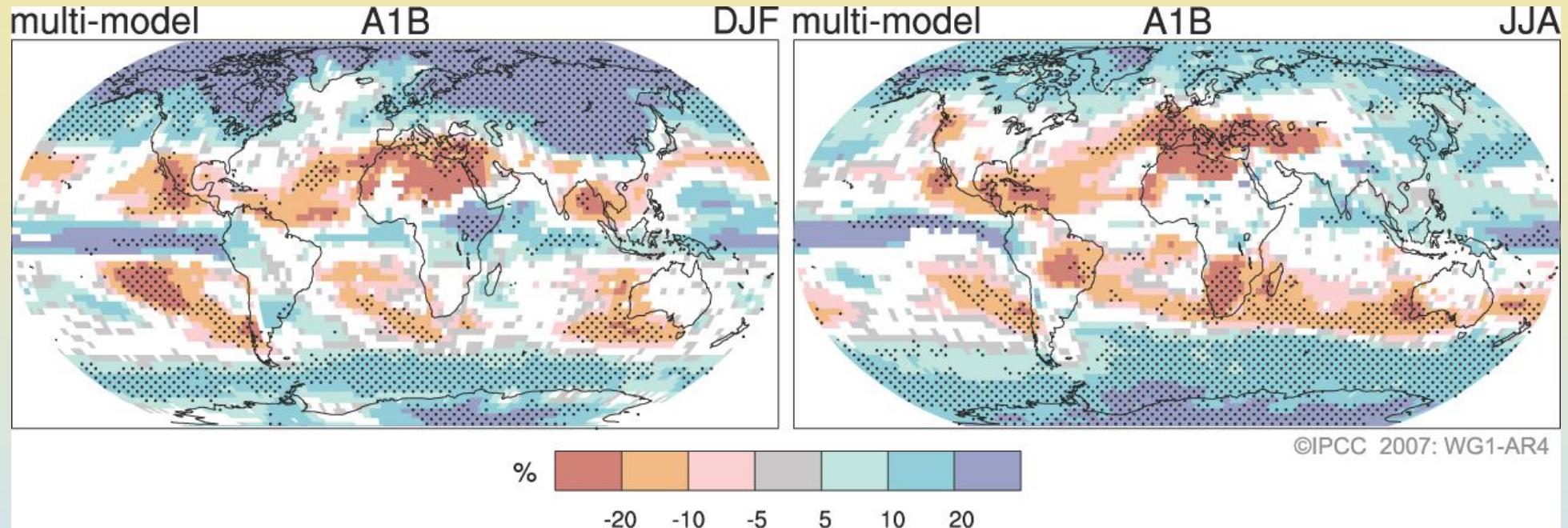
<sup>4</sup>Geological Survey of Denmark and Greenland

# Overview

- ◆ Motivation
- ◆ Hydrological modelling and climate change
- ◆ Dynamical coupling of a RCM to a hydrological model
- ◆ Conclusions



# Mean global precipitation changes



 **From IPCC WG1-AR4 (2007):** Relative changes in precipitation (in percent) for the period 2090–2099 vs. 1980–1999

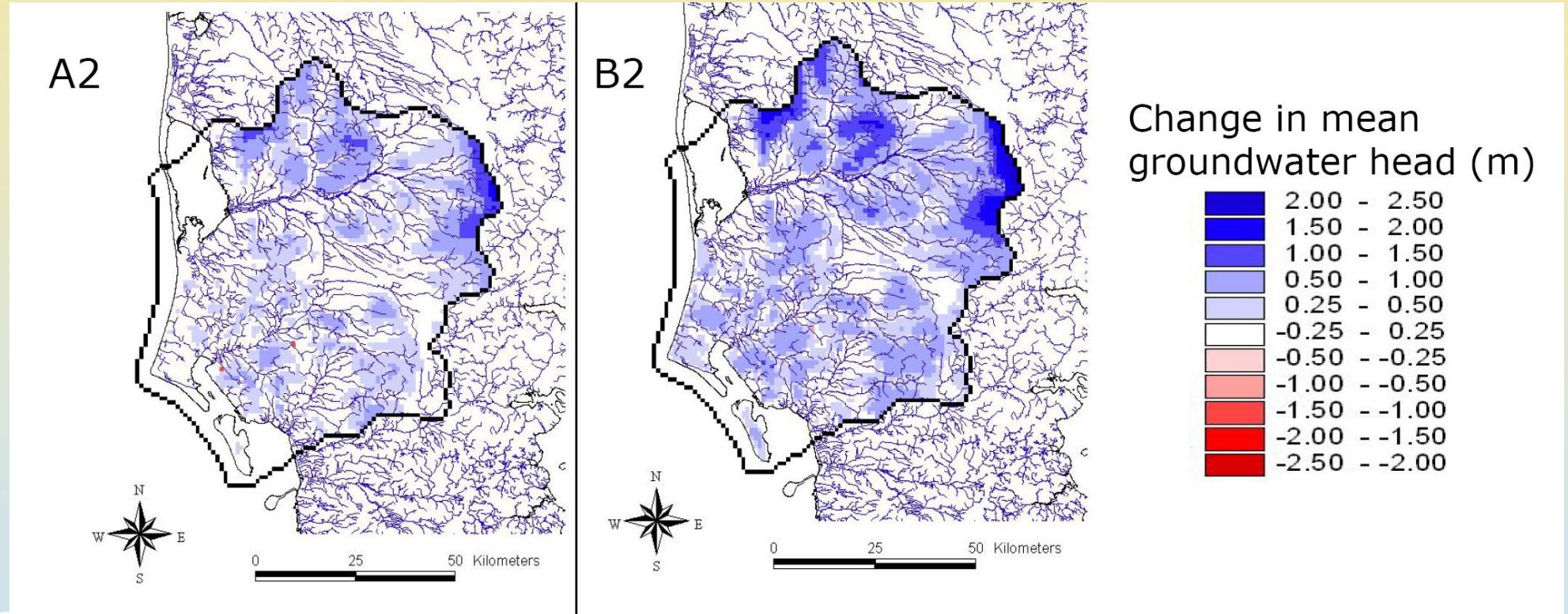


- ◆ Increased/reduced availability of freshwater (e.g. precipitation)
- ◆ Extreme precipitation
- ◆ Draughts
- ◆ Evapotranspiration

## Examples of hydrological impacts of climate change:

- ◆ Water availability (irrigation, hydropower, etc.)
- ◆ Changes in groundwater head
- ◆ Changes in surface water, e.g. river runoff
- ◆ Increased risk of floods
- ◆ Transport of pollutants

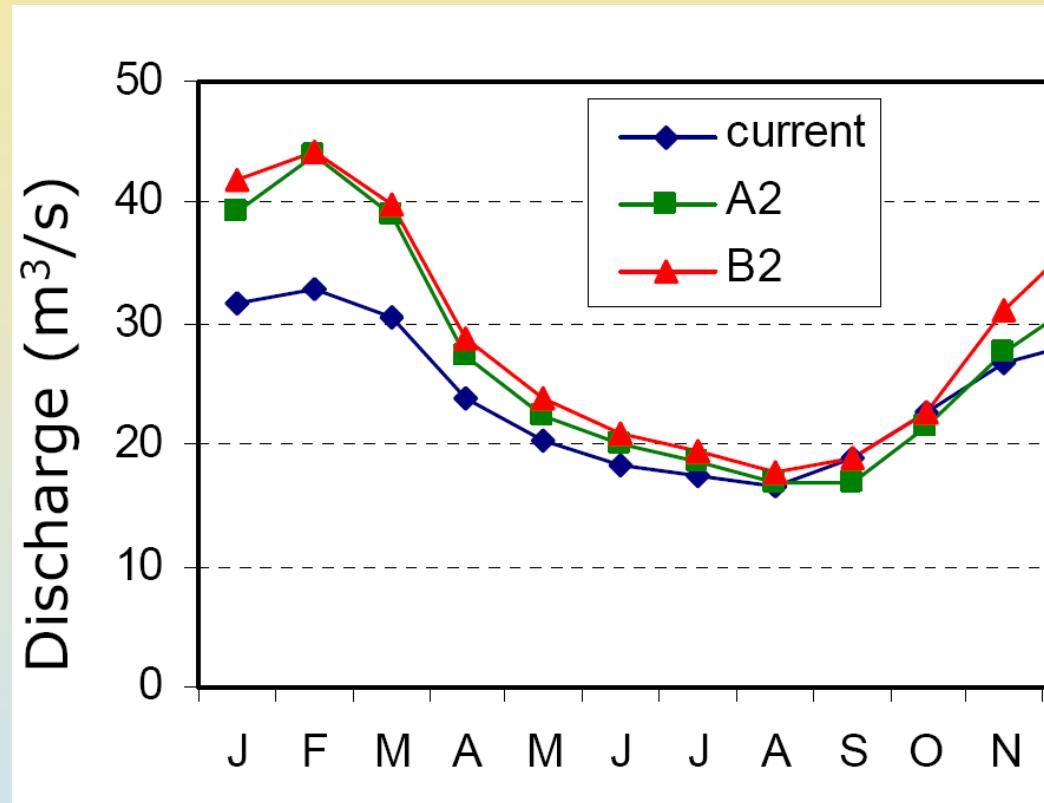
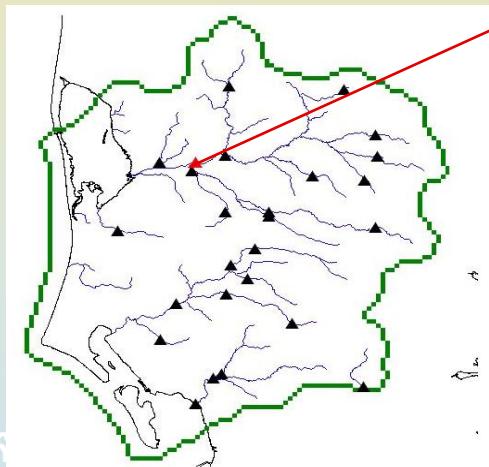
## Example: Groundwater head



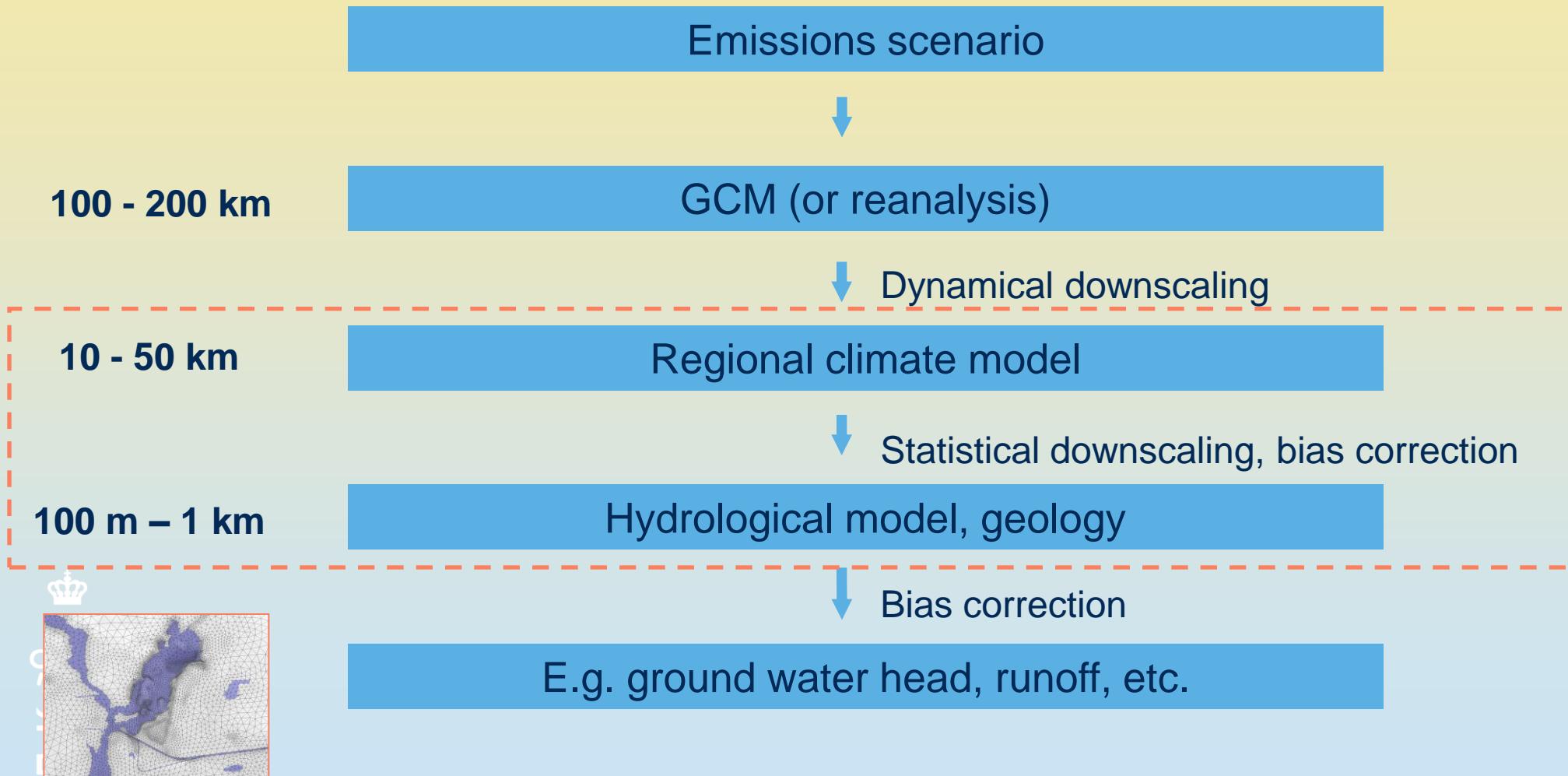
**Dmi**

Courtesy of: Geological Survey of Denmark and Greenland; Roosmalen et al.

## Example: Mean annual discharge

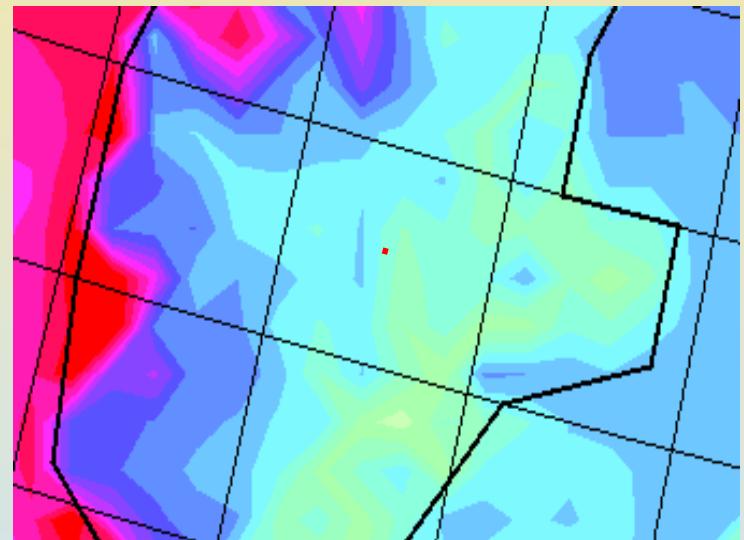


# Modelling hydrological change



# Coupling an RCM to hydrological models

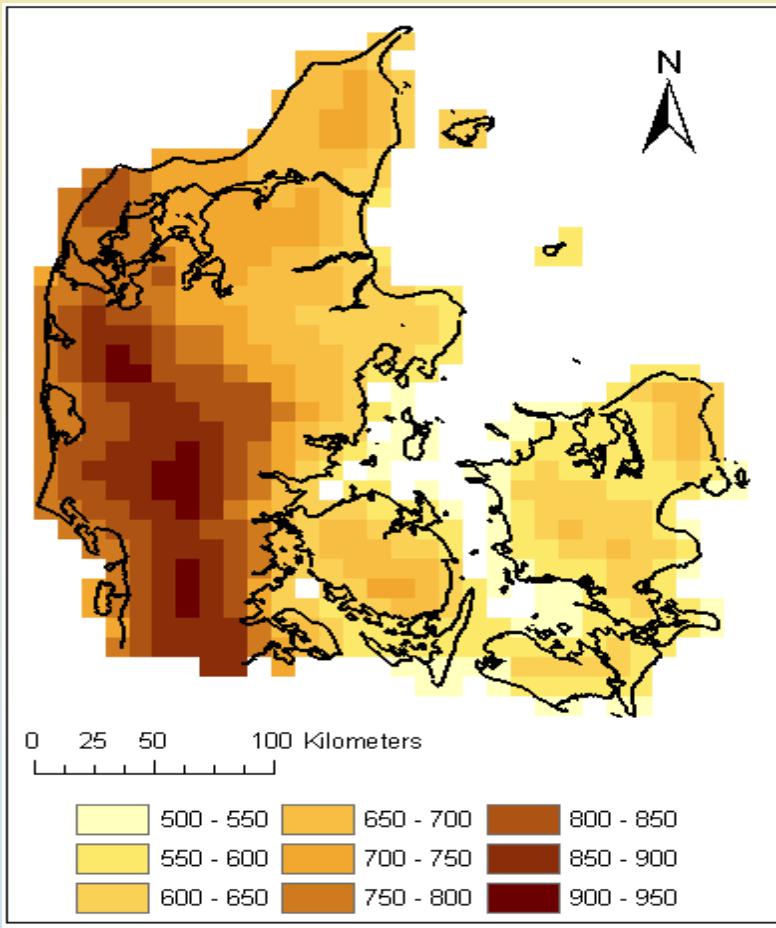
- ◆ Further downscaling is (often) needed
- ◆ Bias correction
- ◆ Different temporal resolution
- ◆ Propagation of uncertainties (!)



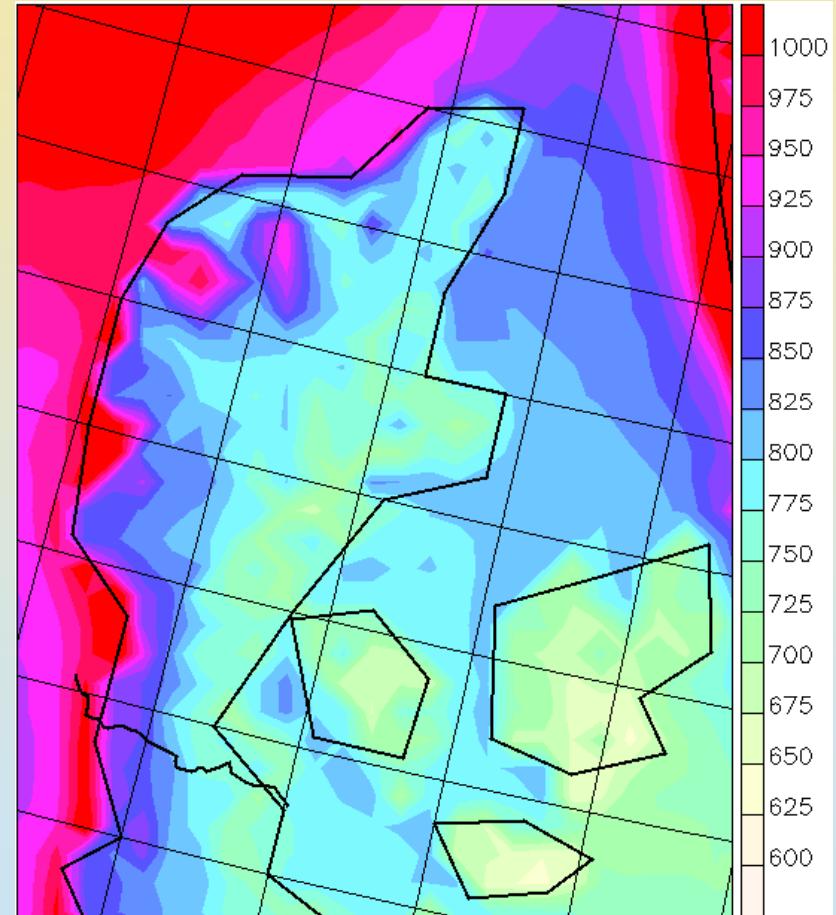
- ◆ In traditional hydrological modelling, feedbacks from the surface to the atmosphere are typically neglected!

# Need for bias correction

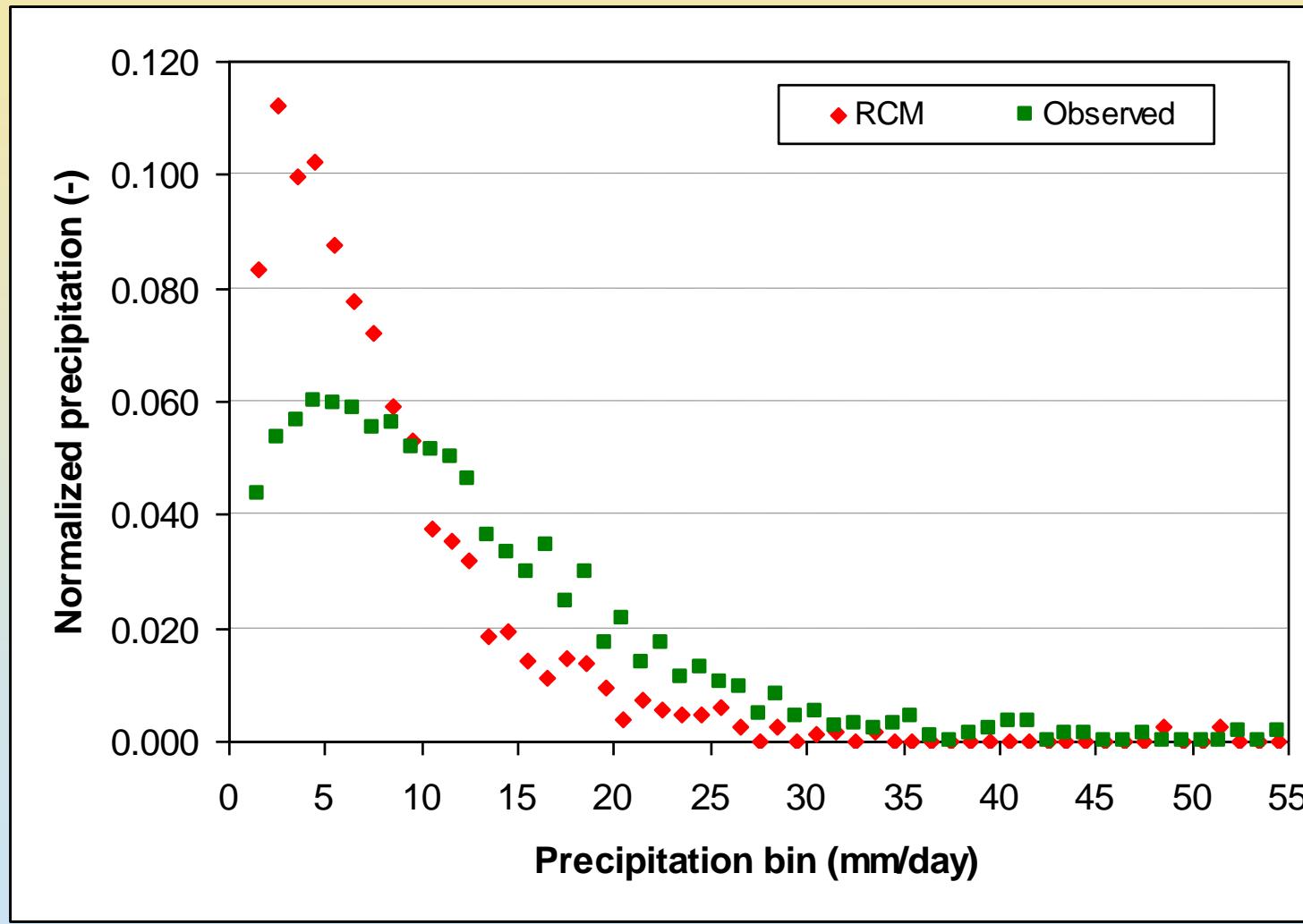
**Observed (1961-1990)**



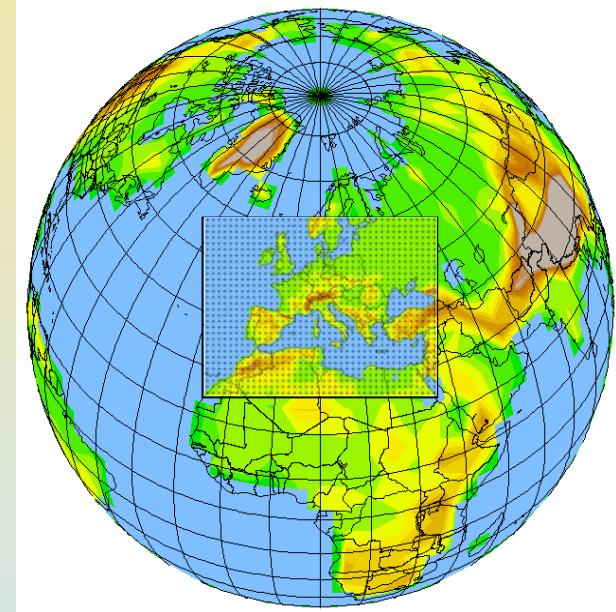
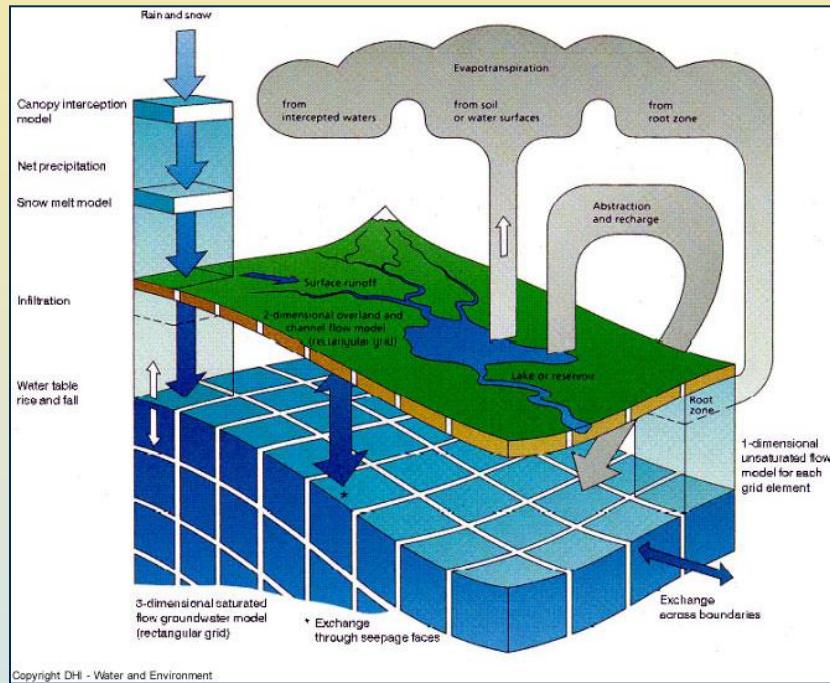
**HIRHAM4 RCM (12 km)**



# "Drizzle" problem



# HYACINTS coupled modelling system



## MIKE SHE (DHI)

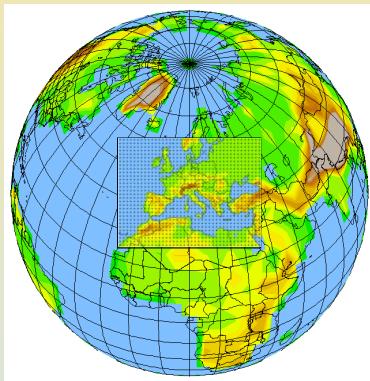
Physically based, commercial,  
hydrological model (SVAT module)



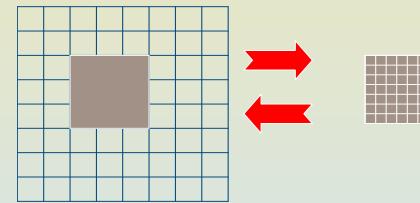
## HIRHAM5 (DMI)

Regional climate model

# Two-way dynamical coupling



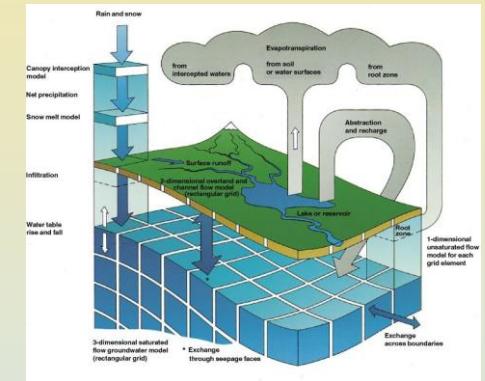
Air temperature  
Precipitation  
Wind speed  
Relative humidity  
Global radiation  
Air pressure



**HIRHAM5**

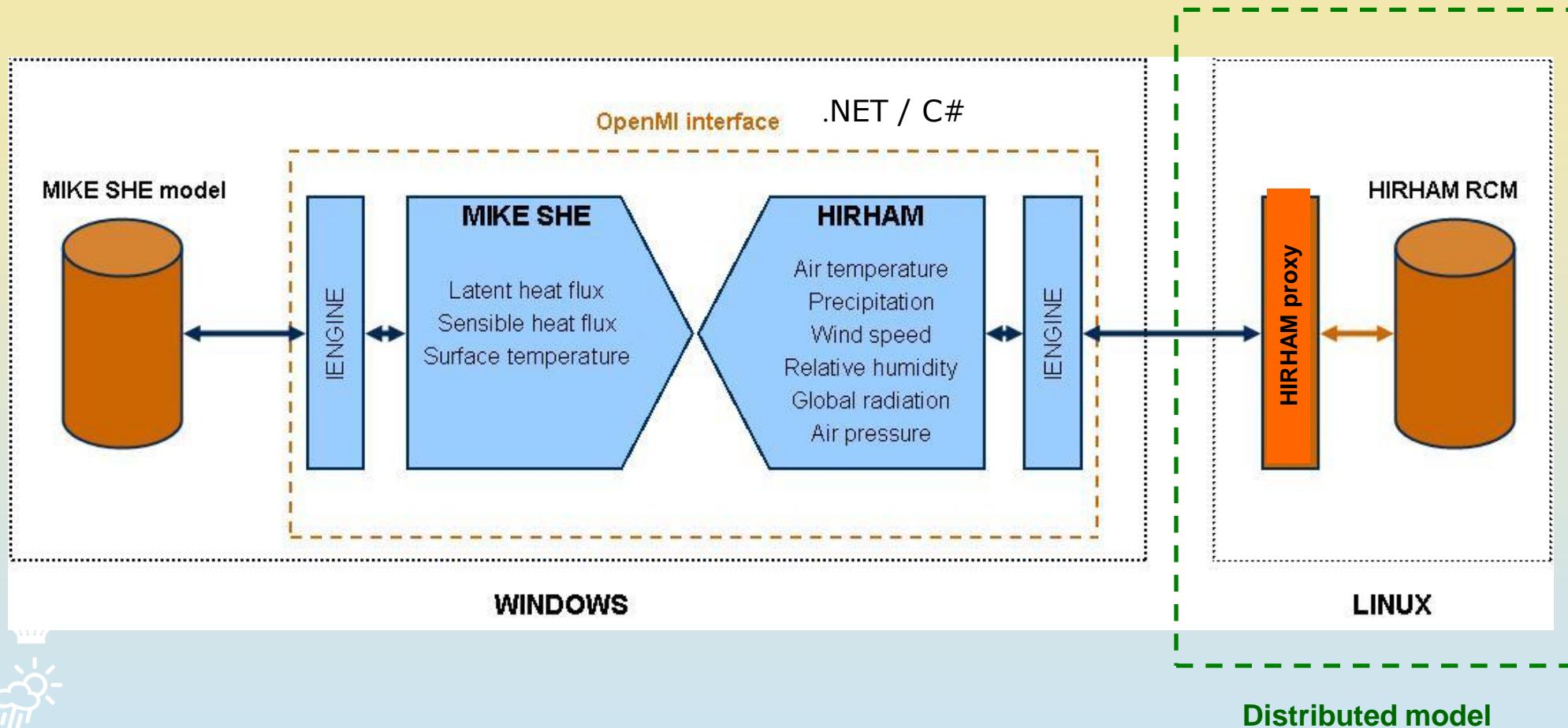


Latent heat flux  
Sensible heat flux  
Surface temperature



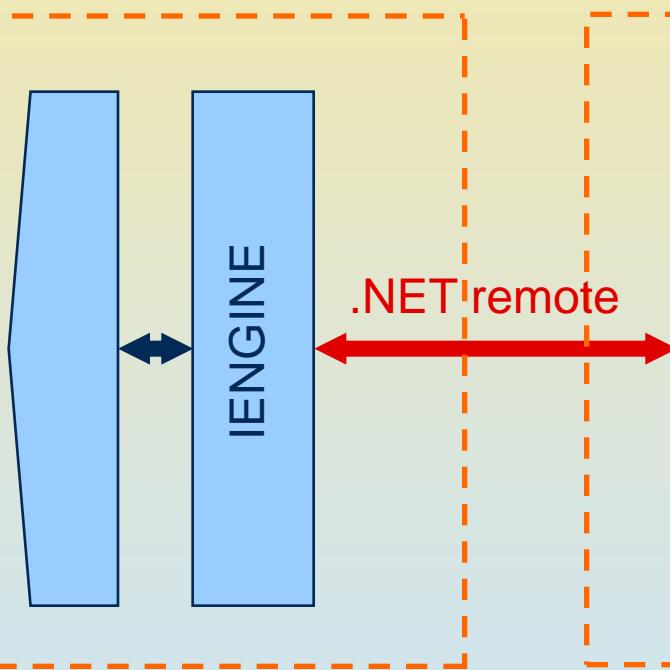
**MIKE SHE**

# Model coupling - outline

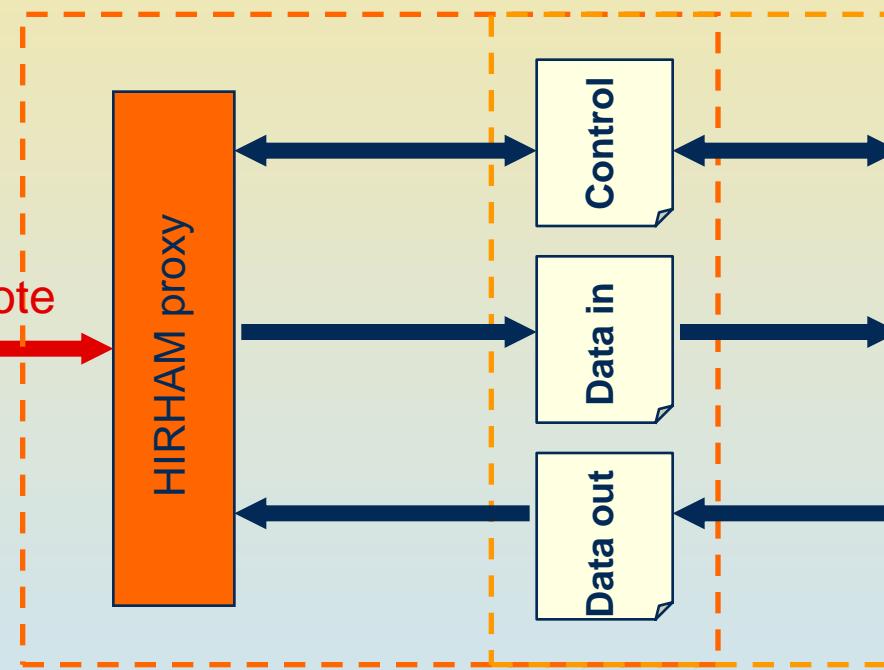


# Model coupling - outline

High performance PC



LINUX PC



LINUX PC (or HPC)



OpenMI front-end  
(Windows .NET)

OpenMI back-end  
(Linux Mono)

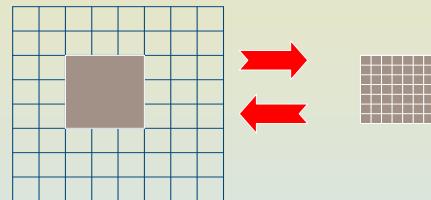
Binaries or  
text

Linux Fortran

\*HIRHAM5 + extensions

## Linking model grids

- ◆ HIRHAM: rotated latitude-longitude, 10-50 km
- ◆ MIKE SHE: UTM, 500-1000 m
- ◆ MIKE SHE domain is a subset of the HIRHAM domain



- HIRHAM to MIKE SHE is handled by OpenMI (interpolation)
- MIKE SHE to HIRHAM is handled by HIRHAM

## A simple 1-column test case: FIFE

- ◆ FIFE area, 15 x 15 km<sup>2</sup>, Kansas, USA
- ◆ 10 meteorological stations
- ◆ 22 flux stations
- ◆ 32 soil moisture stations

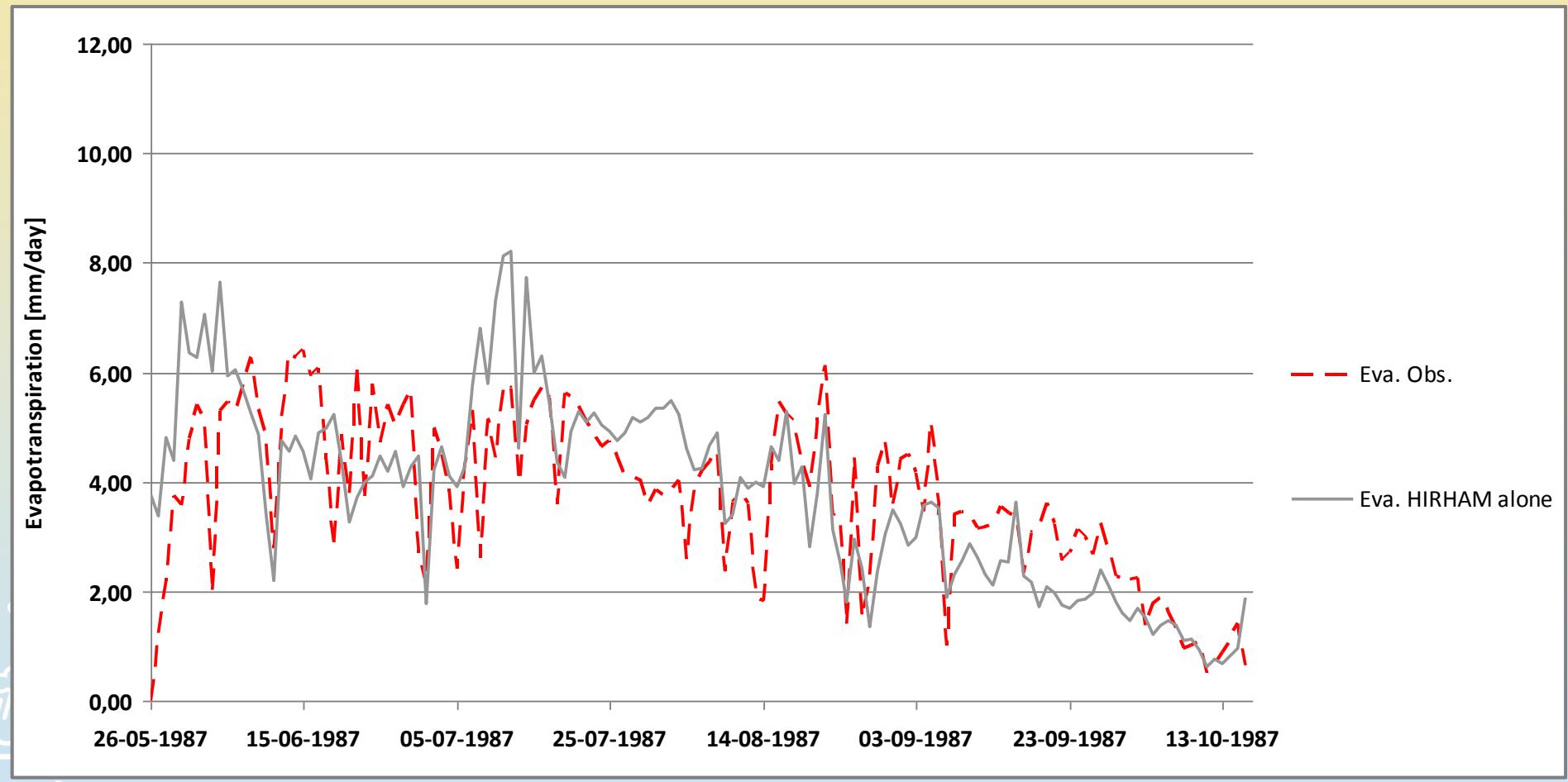


- ◆ MIKE SHE model calculations (2 km grid)
  - Forced by observations
  - Forced by HIRHAM (one-way coupling)
  - Forced by HIRHAM (two-way coupling)
- ◆ HIRHAM calculations



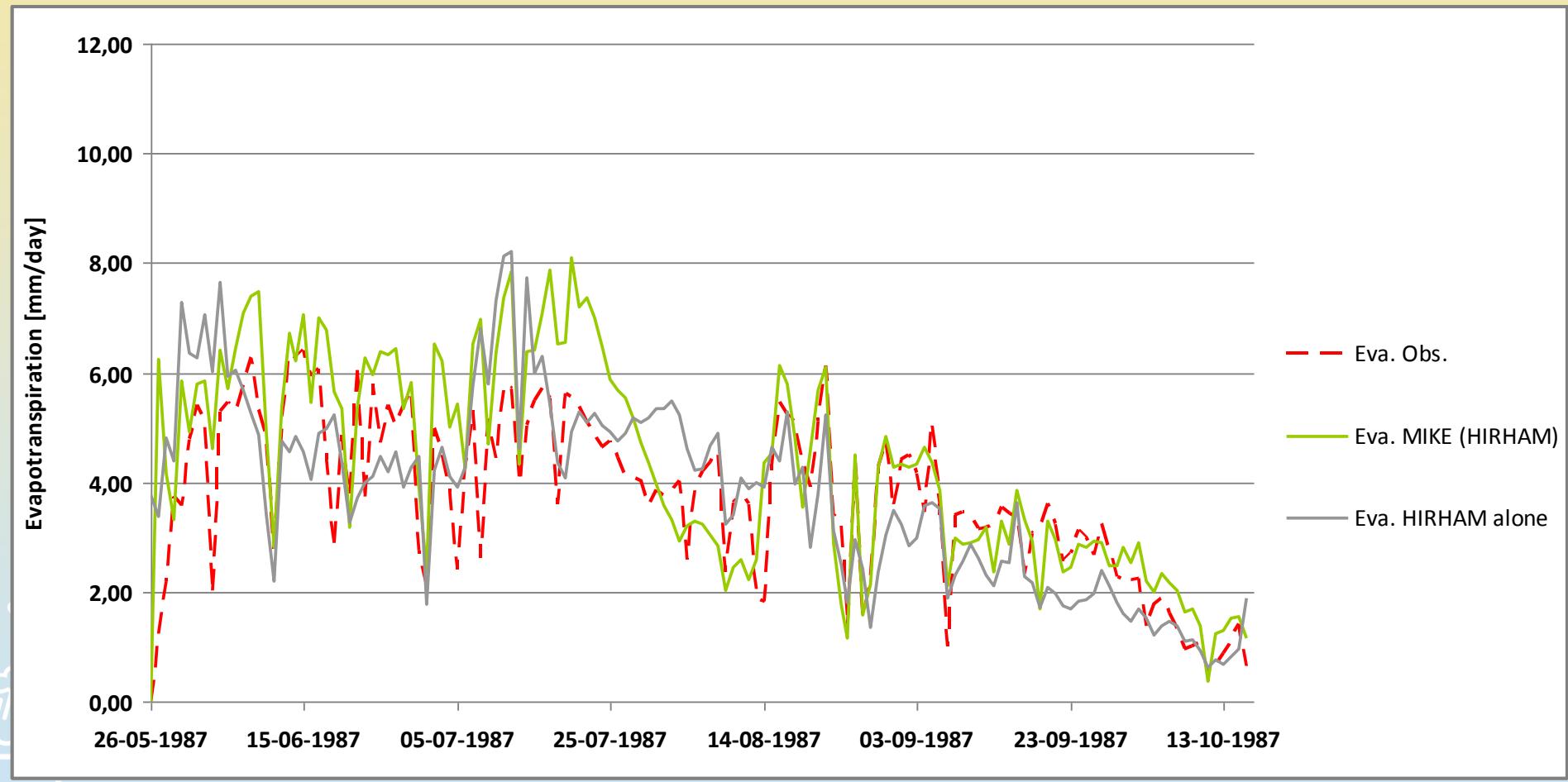
From: Søren H. Rasmussen, DMI

# Test: Evapotranspiration



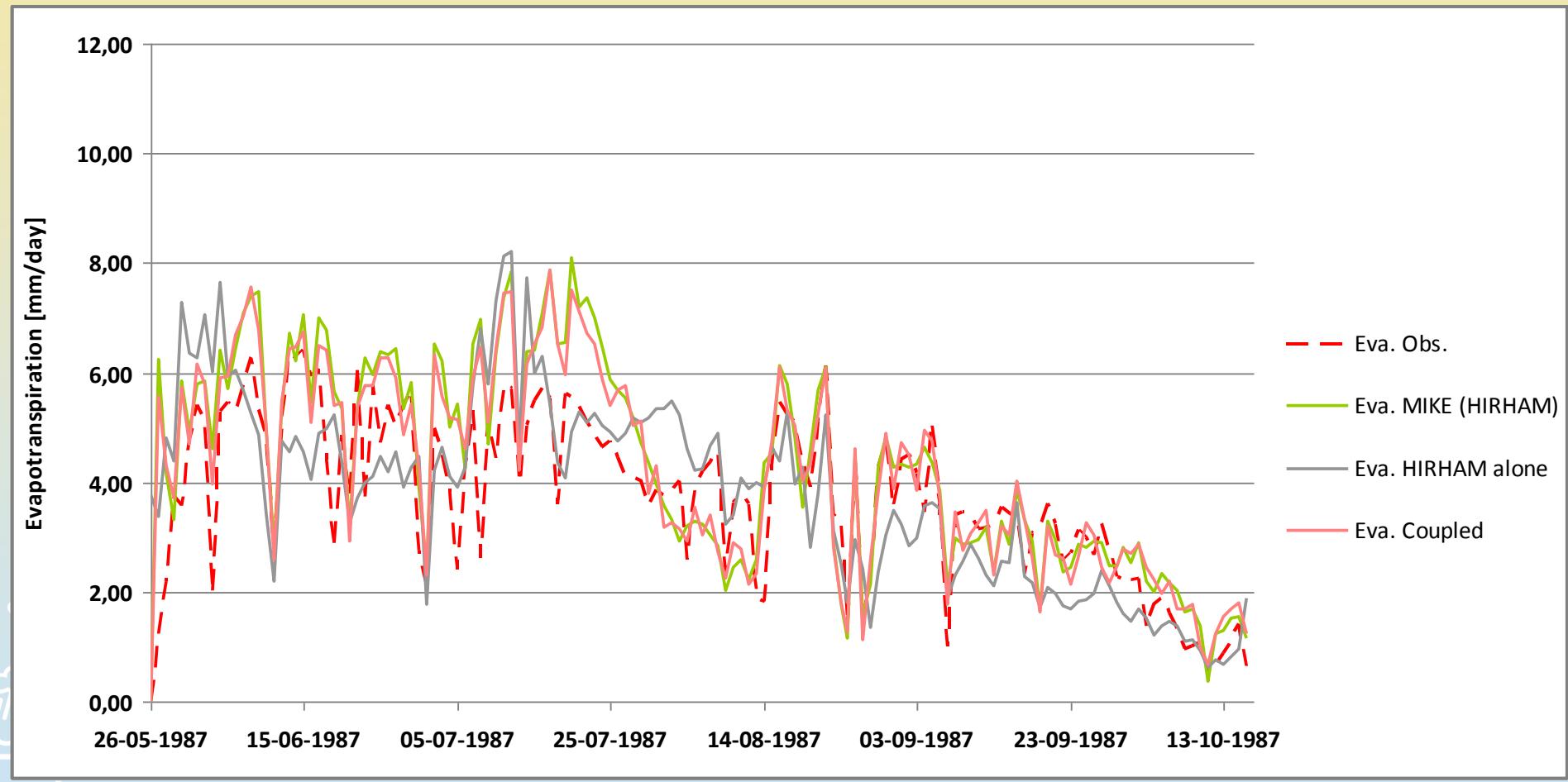
Dmi  
Dm

# Test: Evapotranspiration



Dmi  
Dm

# Test: Evapotranspiration



Dmi  
19

## Conclusions

- ◆ One-way RCM-hydrological model coupling
  - Preliminary results are very encouraging – **added value** for hydrological modelling
- ◆ Dynamic RCM-hydrological model coupling
  - Technically quite challenging
  - Different scales
  - Direct coupling has been implemented
  - Need for further downscaling and/or bias correction **will be investigated**
  - Importance of feedback to the atmosphere **will be investigated**



**Thank you for your kind attention**