Hydro-Meteorological Simulations for the Poyang Lake Region using WRF and HMS

Sven Wagner, Benjamin Fersch, Harald Kunstmann

Institute for Meteorology and Climate Research (IMK-IFU)

Precipitation Feedbacks in the Haihe River and Poyang Lake Regions (*PreFeed)*

Chinese partner:

- Prof. Zhongbo Yu; Assoc. Prof. Fei Yuan; Dr. Chuanguo Yang
- State Key Lab of Hydrology-Water Resources and Hydraulic Engineering, Hohai University, Nanjing

Objectives

- Investigate feedback mechanisms between land surface conditions, subsurface conditions & the atmosphere for the two target regions
- Joint landuse- & climate change impact on regional water cycle

This is achieved by …

- Developing and applying a suited **fully two way coupled model system**
- which consist of regional atmospheric- & distributed hydrological model

Outline

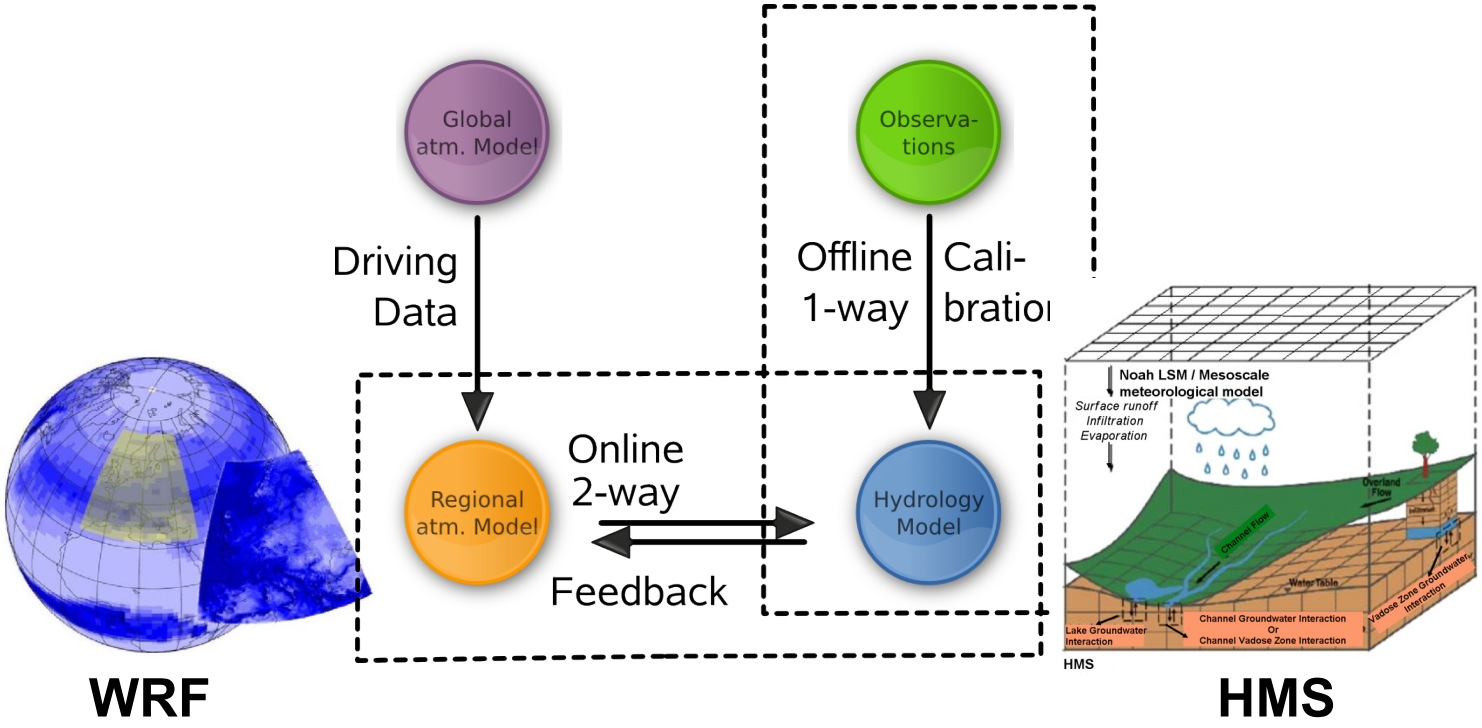
- Model approach

- WRF setup and procedure
- WRF validation for Haihe & Poyang regions

- WRF – NoahLSM - HMS
- State of development
- First results

- Summary & Outlook

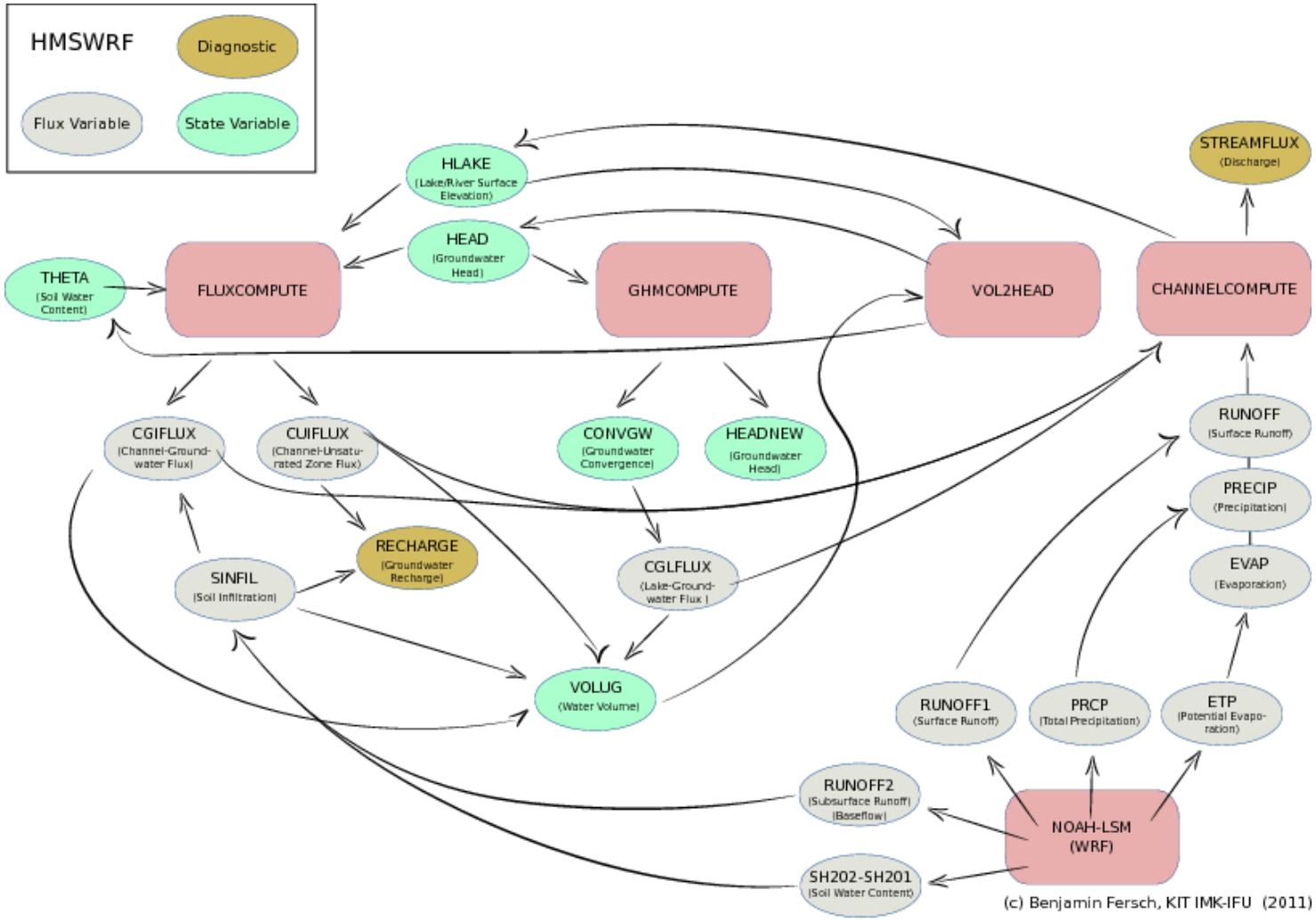
Overview Model Approach



- Both models use the same land surface model (Noah-LSM), sharing compatible water & energy flux formulations
- Both models communicate at the same scale

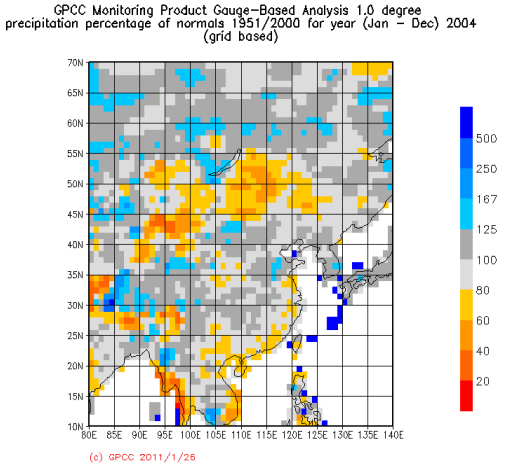
- Allows **long-term simulations** for the investigation of the impact of joint land-use and climate changes on the regional water cycle

Overview Model Approach: Schematic of Noah-LSM & HMS fluxes

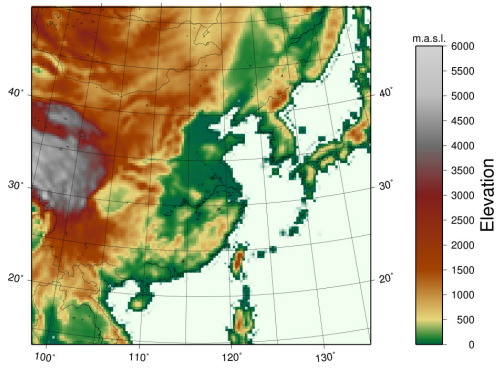


WRF setup and procedure

- Reanalysis simulations to find appropriate setup
- Reanalysis driving data: ECMWF‘s ERA interim
- Simulation period: 2003 – 2005
- Validation data: CRU3, GPCC, APHRODITE



- Several configurations of WRF with respect to model physics (microphysic, PBL, cumulus parameterization, radiation) and vertical resolution



- Double nesting approach:

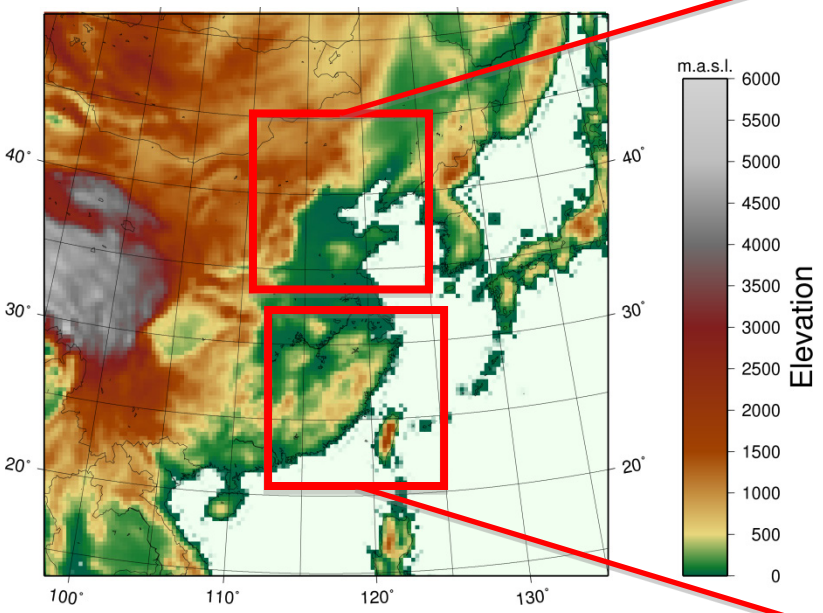
  coarse domain: 30 km

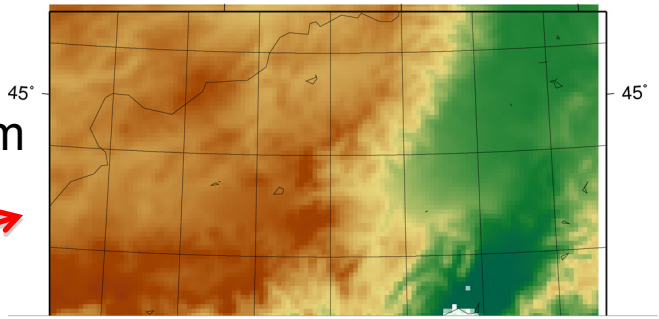
  fine domain: 10 km

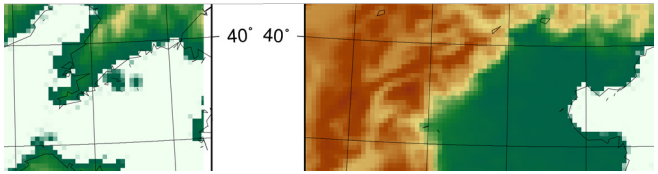
WRF setup: Domains

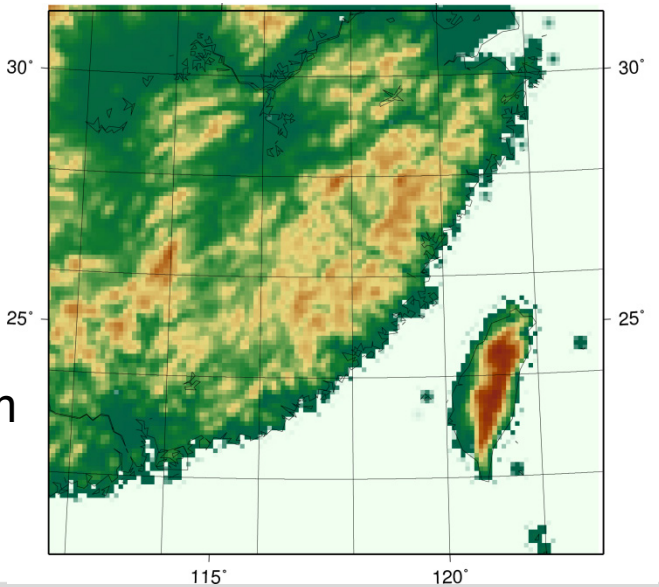
Haihe @ 10 km

Coarse domain @ 30km





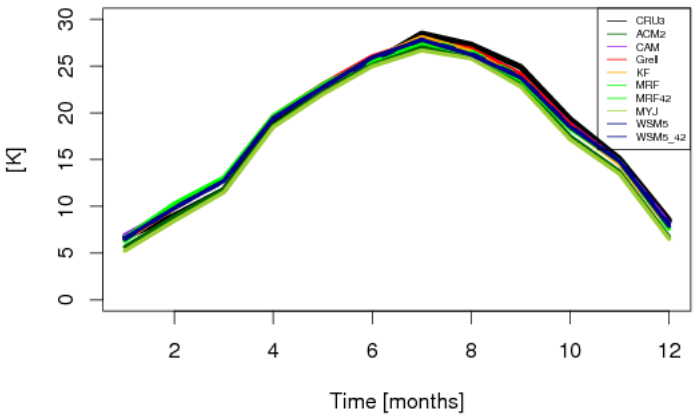




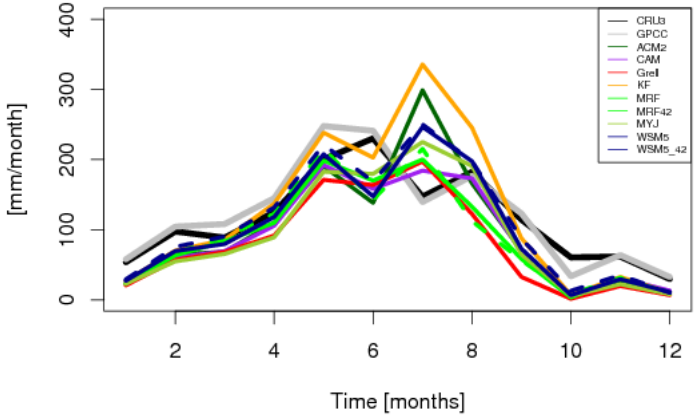
Poyang @ 10 km

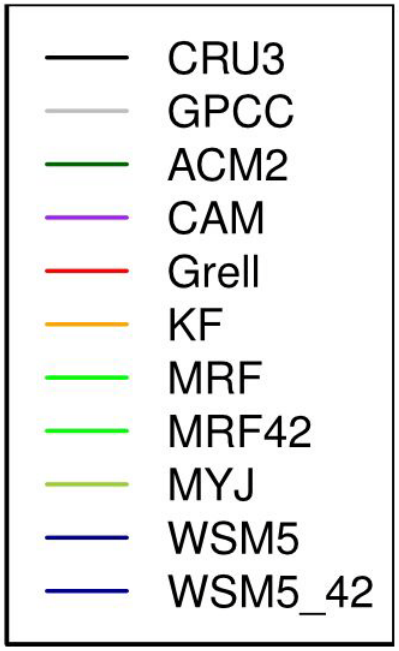
WRF simulation results:
Poyang @ 30km: T2 and TOT_PREC, 2003-2005

Temperature [K]: monthly mean



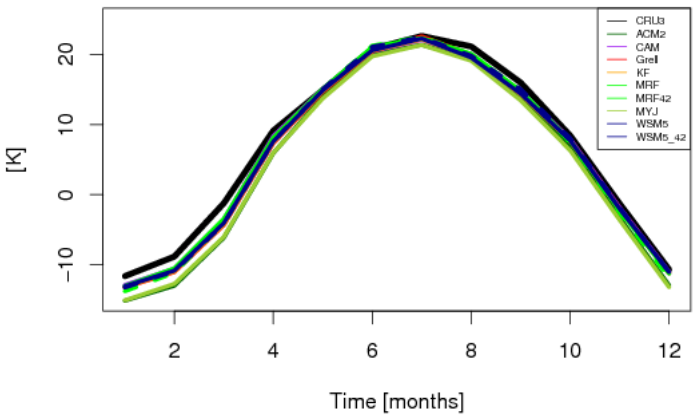
Precipitation [mm]: monthly sum



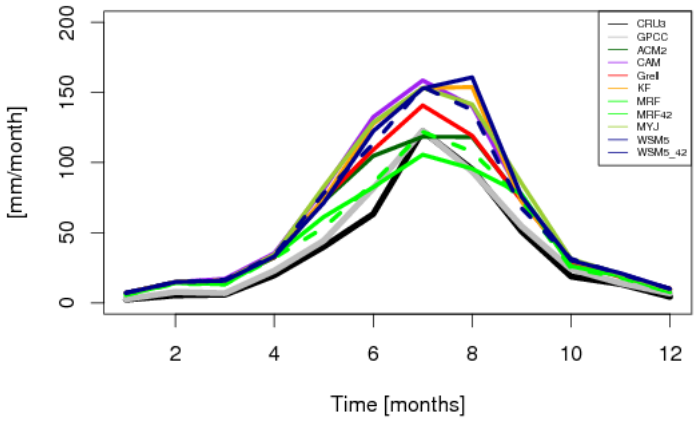


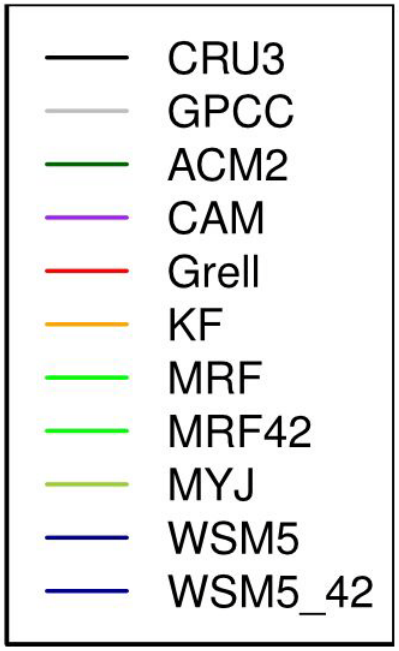
WRF simulation results:
Haihe @ 30km: T2 and TOT_PREC, 2003-2005

Temperature [K]: monthly mean



Precipitation [mm]: monthly sum

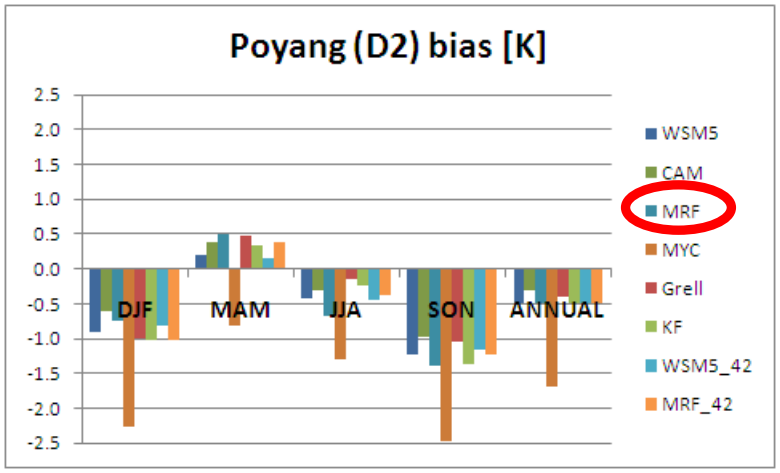


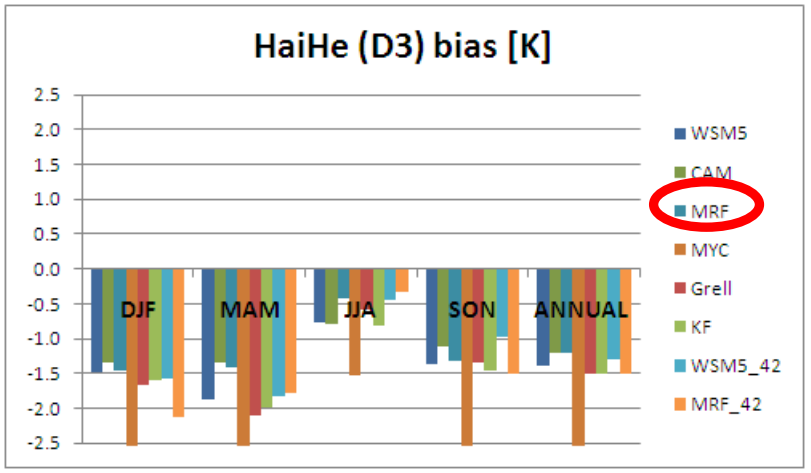


WRF simulation results: Poyang and Haihe Seasonal & Annual Validation @ 30km

Karlsruhe Institute of Technology

Temperature [K]: Bias





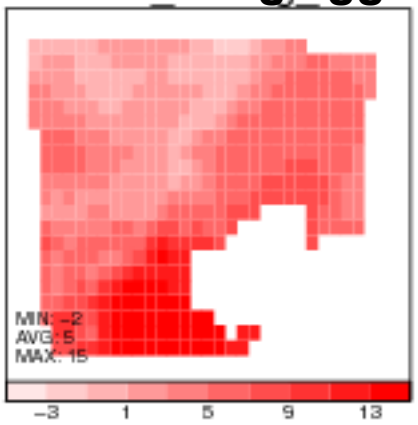
Precipitation [mm]: Bias

Selected suited WRF configuration

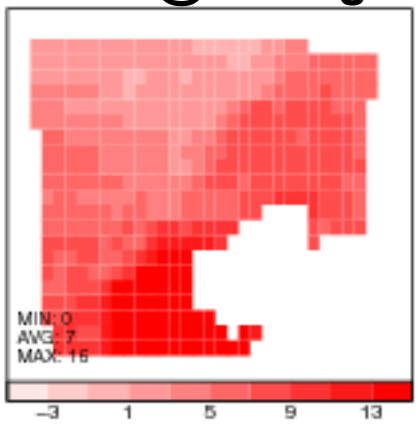
WRF simulation results: Poyang and Haihe
Annual mean Temperature [K] @ 30km

Haihe:

WRF 0.5deg agg.



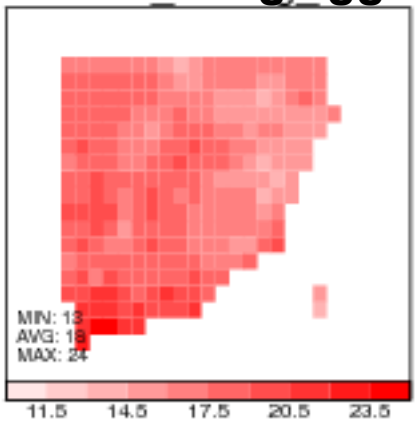
CRU3 @ 0.5deg



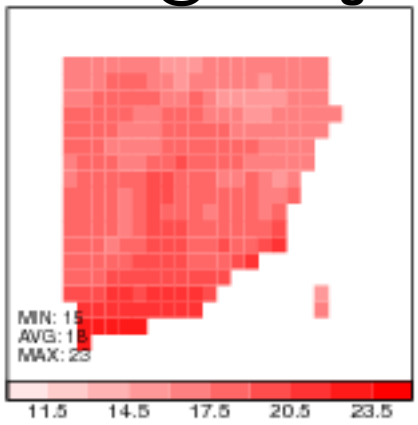
AVG: -1K

Poyang:

WRF 0.5deg agg.



CRU3 @ 0.5deg

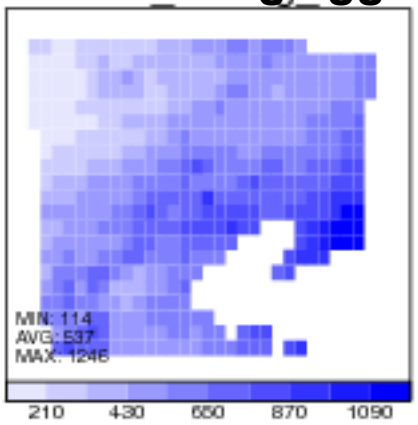


AVG: -1K

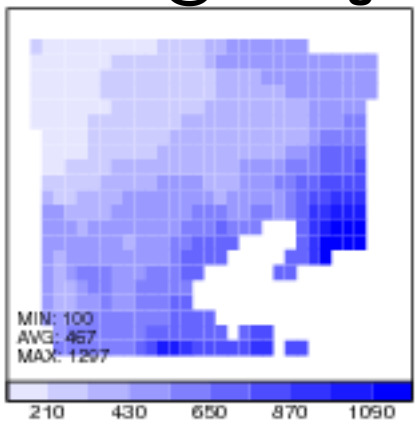
WRF simulation results: Poyang and Haihe
Annual Precipitation [mm/year] @ 30km

Haihe:

WRF 0.5deg agg.



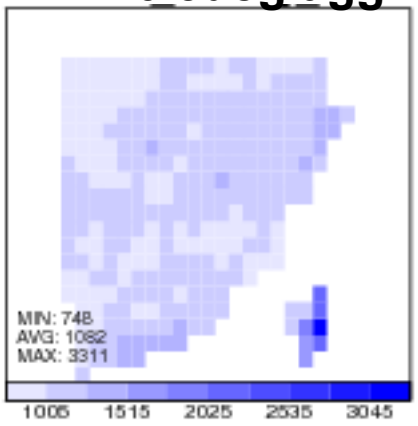
GPCC @ 0.5deg



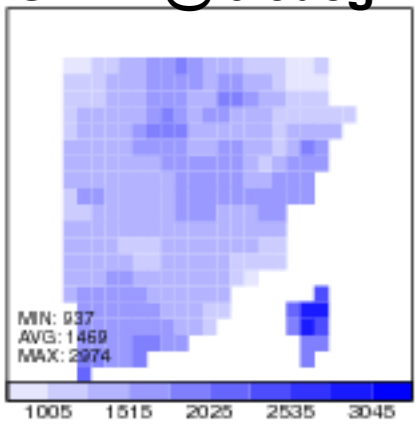
AVG:
21%

Poyang:

WRF 0.5deg agg.



GPCC @ 0.5deg



AVG:
-25%

WRF – NOAH-LSM – HMS

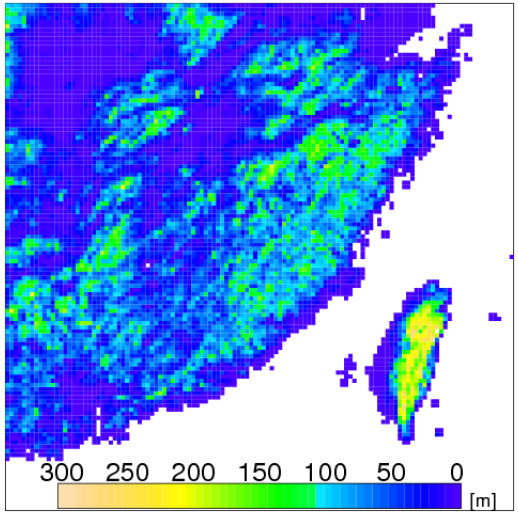
WRF-NoahLSM-HMS: state of development

- ✓ Integration of preprocessors (static surface and sub-surface hydrological parameters)
- ✓ netCDF compliance (IO)
- ✓ HMS model in the WRF code structure (hydrology driver routine) allowing flexible time step application
- ✗ Parallelization (simulation time of 32 hour for 1 month)

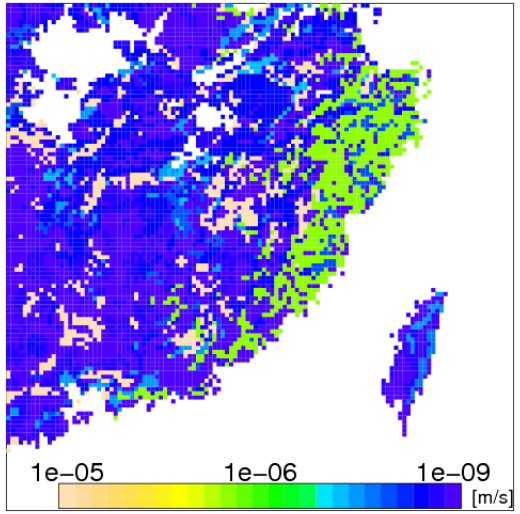
- ➢ Current model setup enables coupled atmospheric-hydrological simulations (water- & energy budget)
- ✗ upward moisture transport (capillary rise or shallow groundwater head) is under implementation → Chuanguo Yang's presentation

WRF-NoahLSM-HMS – PREPROCESSING: Additional hydrological input parameters

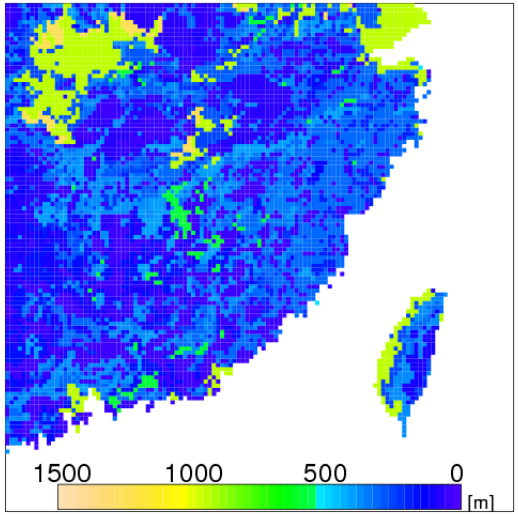
DEM (sd): USGS HYDRO1K (GTOPO30)



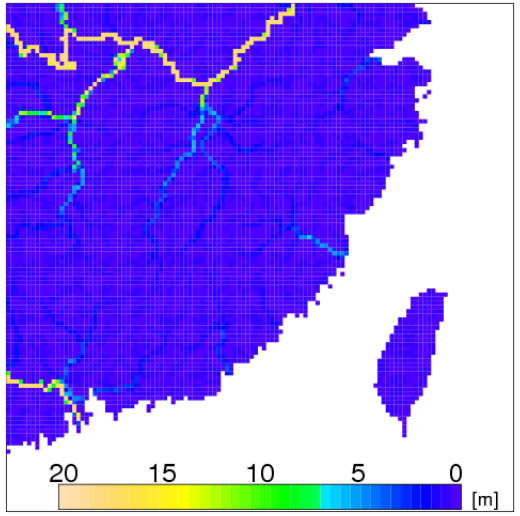
Hydraulic conductivity: Chinese Geological data set



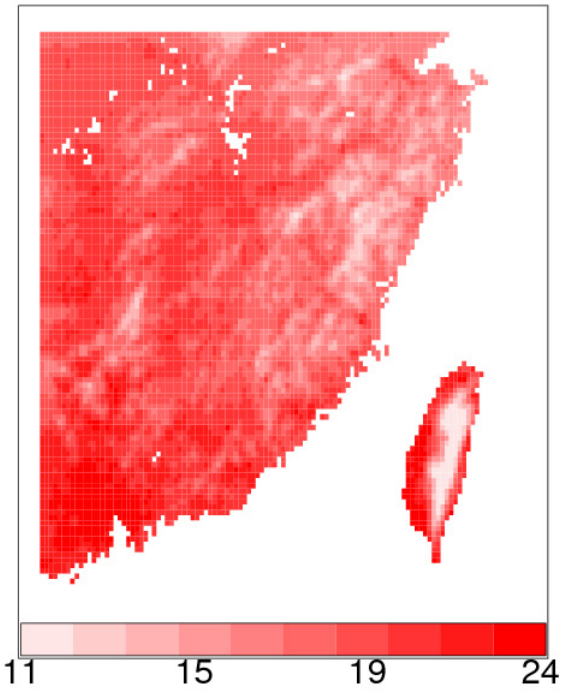
Aquifer thickness: Chinese Geological data set



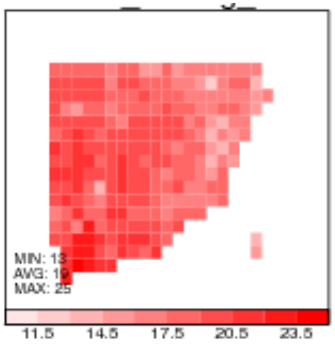
Streambed depth: USGS HYDRO1K



First WRF- NoahLSM - HMS simulation results: Poyang @ 10km: Temperature [K], 2003-2005

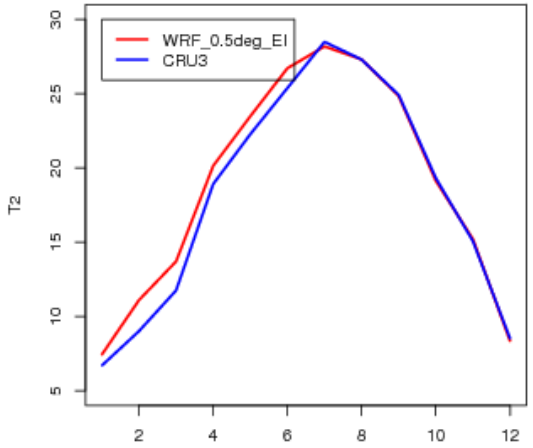


WRF 0.5deg agg.

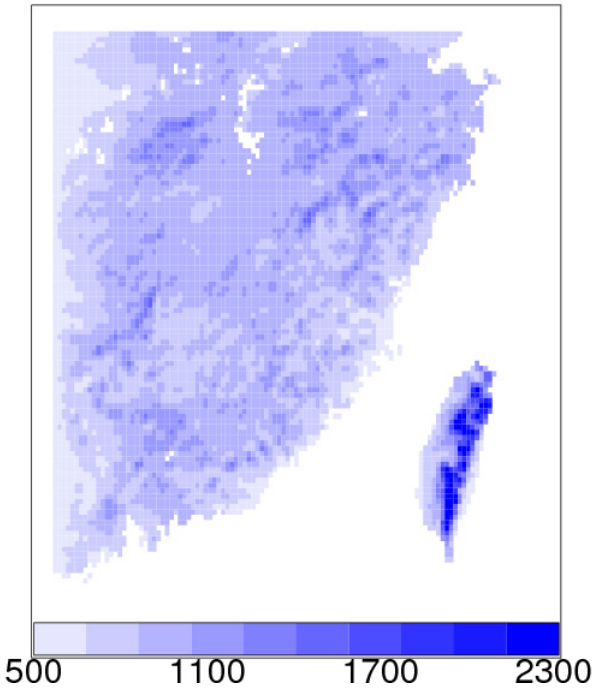


CRU3 @ 0.5deg

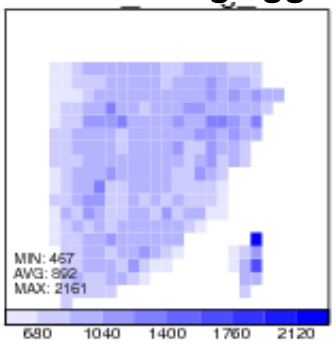
Difference



First WRF- NoahLSM - HMS simulation results: Poyang @ 10km: Annual Precipitation [mm], 2003-2005

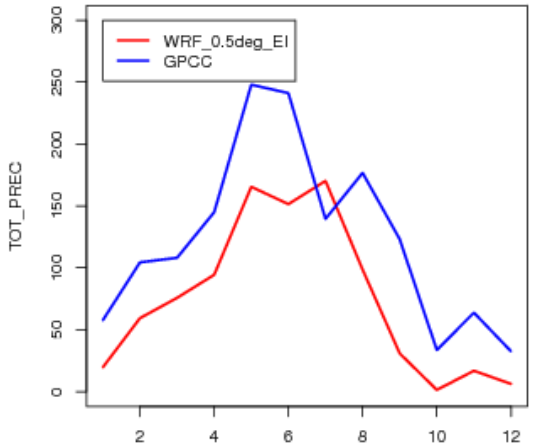


WRF 0.5deg agg.



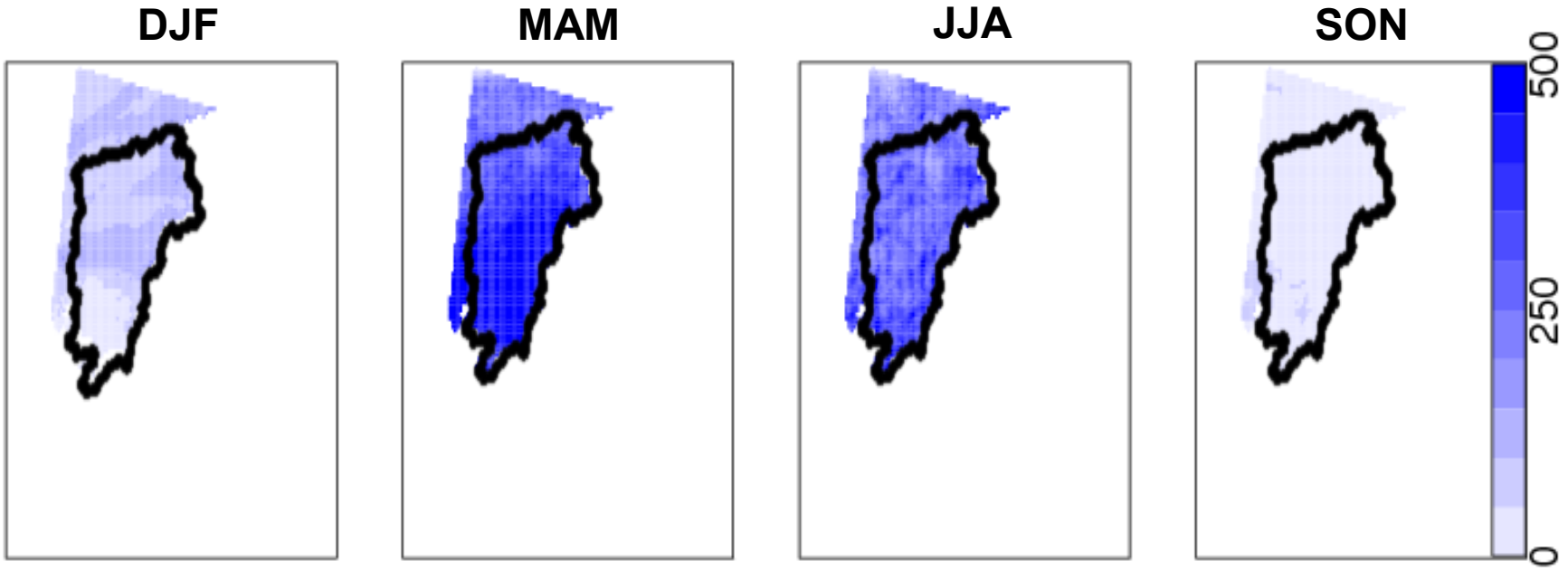
GPCC @ 0.5deg

Difference [%]



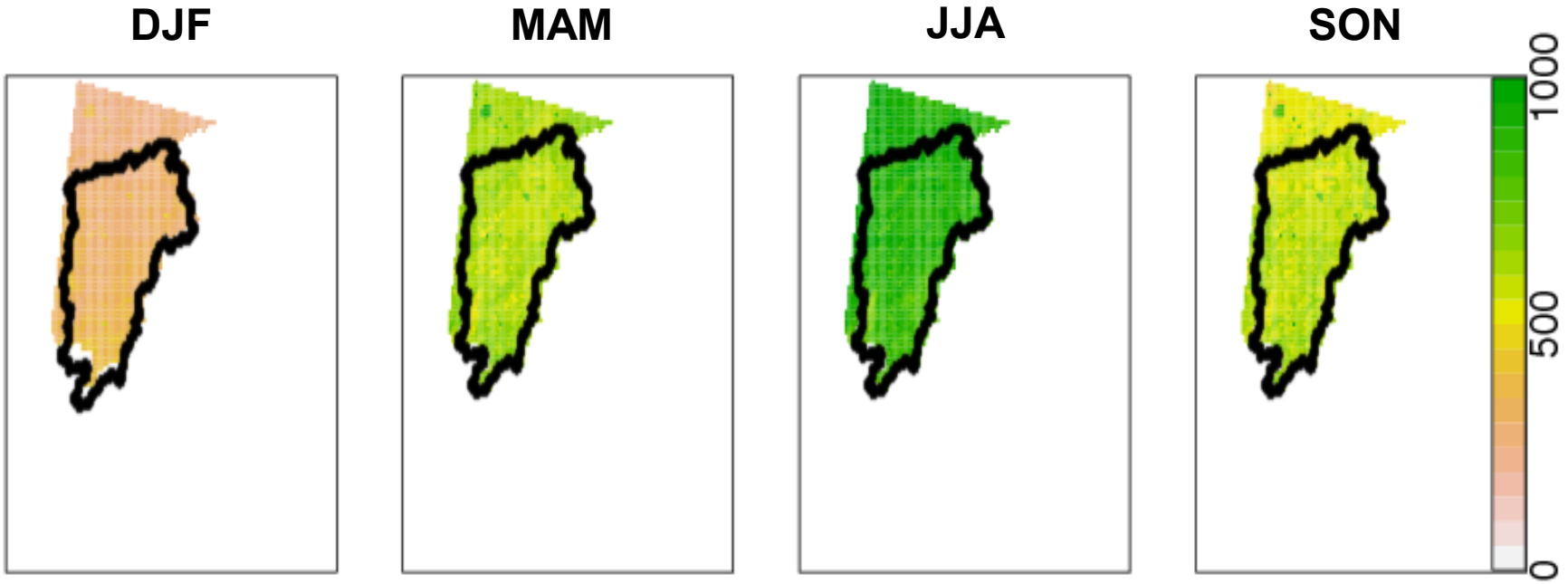
First WRF- NoahLSM - HMS simulation results: Poyang @ 10km: PRECIP, 2004-2005

[mm/seas]



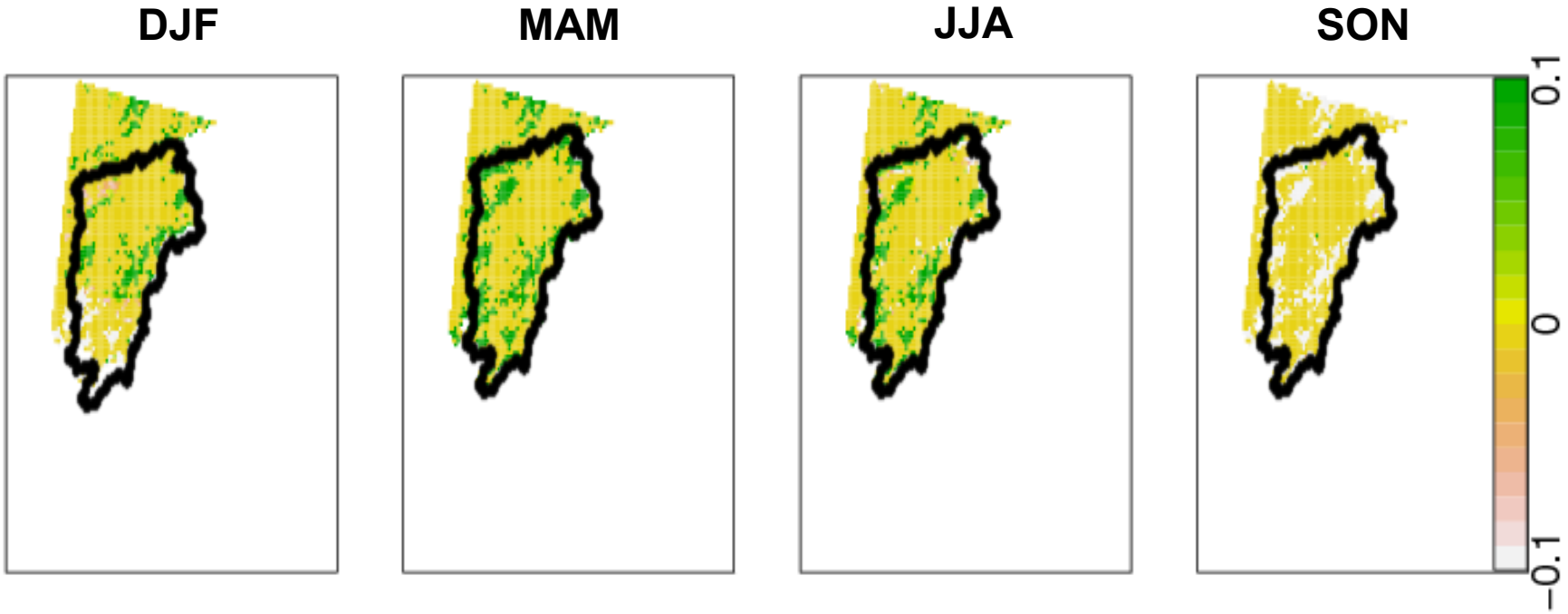
First WRF- NoahLSM - HMS simulation results: Poyang @ 10km: POT. EVAP, 2004-2005

[mm/seas]



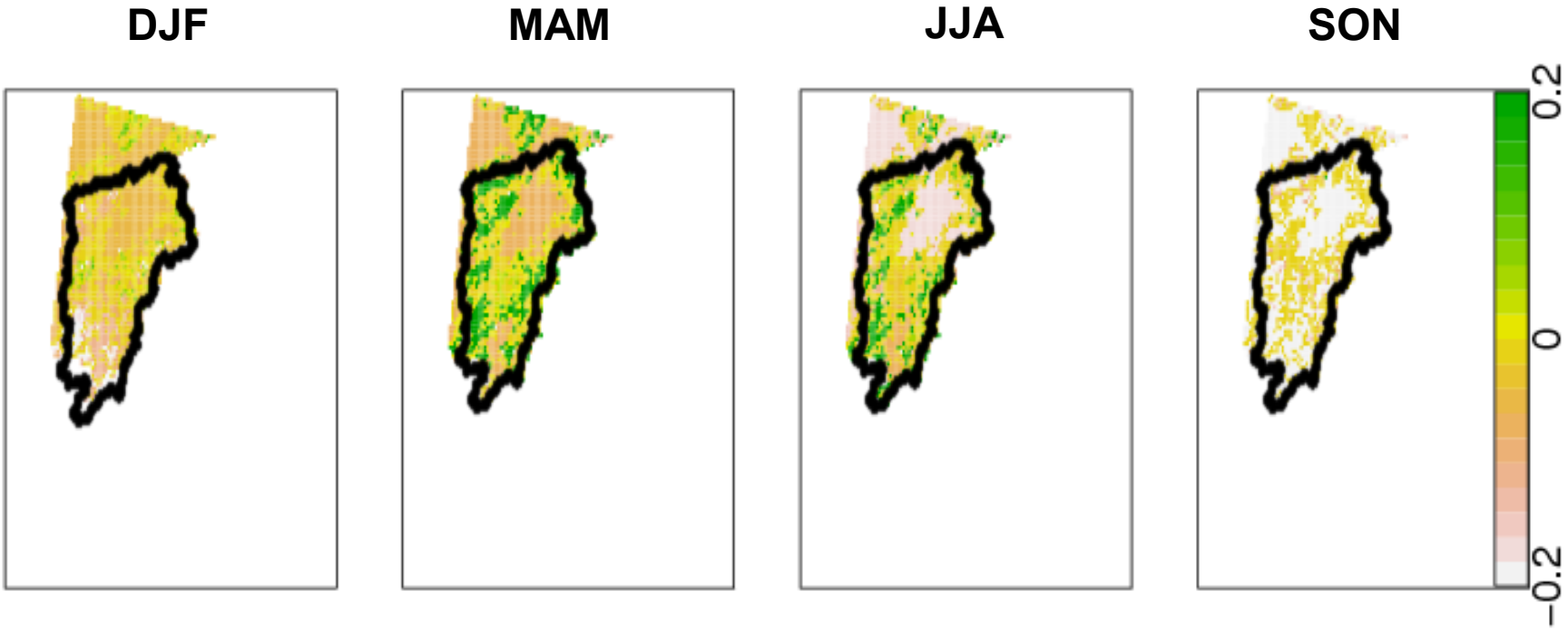
First WRF- NoahLSM - HMS simulation results: Poyang @ 10km: RECHARGE, 2004-2005

[mm/day]



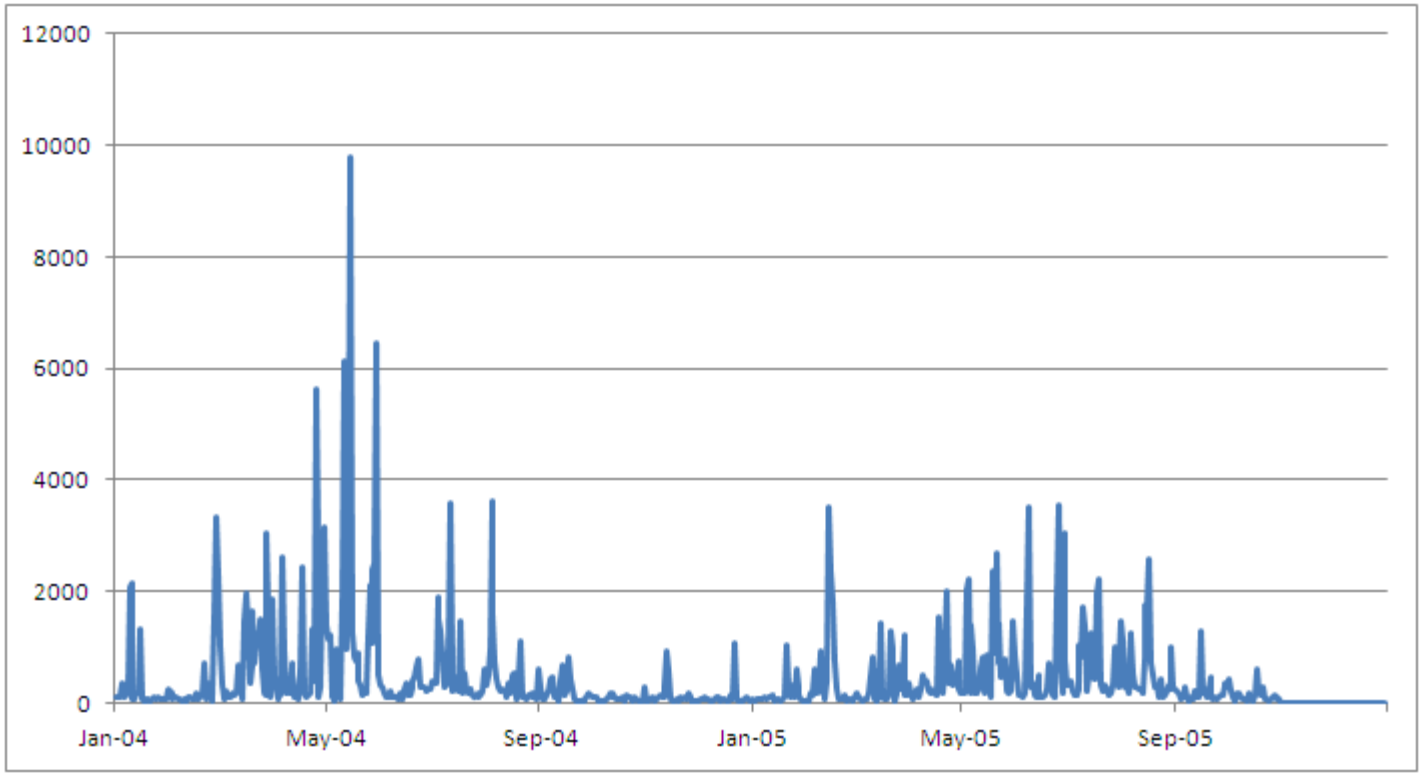
First WRF- NoahLSM - HMS simulation results: Poyang @ 10km: GW HEAD, 2004-2005

GW head change [m/month]



First WRF- NoahLSM - HMS simulation results: Poyang @ 10km: STREAMFLOW, 2004-2005

[m³/s]



Summary and Outlook

- Performance and Validation of several WRF configurations
- Identification of suited WRF setup for Poyang and Haihe region

- **WRF-NoahLSM-HMS:**
- Integration of HMS preprocessors & code in WRF model structure
- First integrated WRF - NoahLSM - HSM simulations are performed

Next steps in 2012

- Finalization of technical coupling, parallelization & validation
- Investigation of land-surface feedbacks at different time scales
- Joint regional climate & land use change simulations

Thank you for your attention