Coupled hydro-meteorological simulations for the Poyang lake region, China

Institute for Meteorology and Climate Research (IMK-IFU)

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Objectives

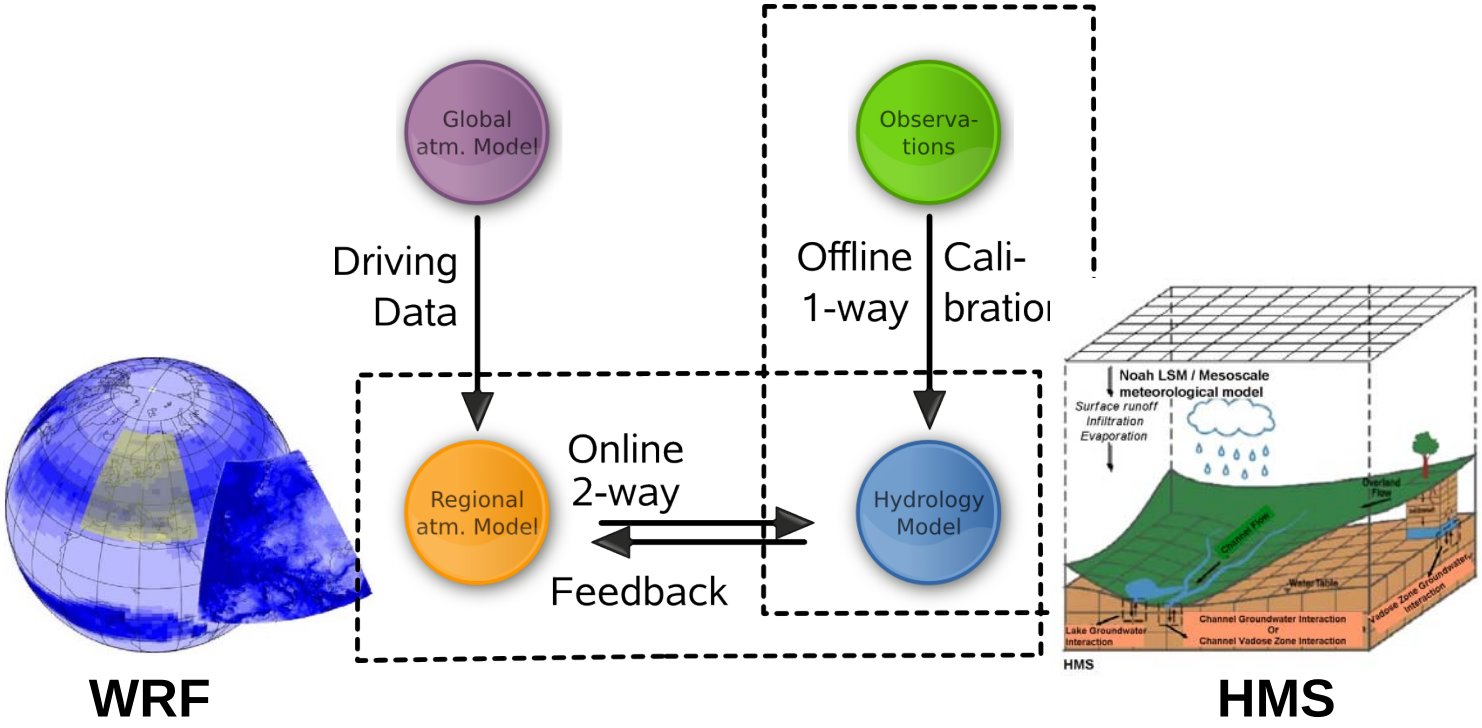
- Investigate feedback mechanisms between land surface conditions, subsurface conditions & the atmosphere for the Poyang lake region
- Joint landuse- & climate change impact on regional water cycle

This is achieved by …

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

- Precipitation Feedbacks in the Haihe River and Poyang Lake Regions, China (***PreFeed***)
- Joint DFG-NSFC project

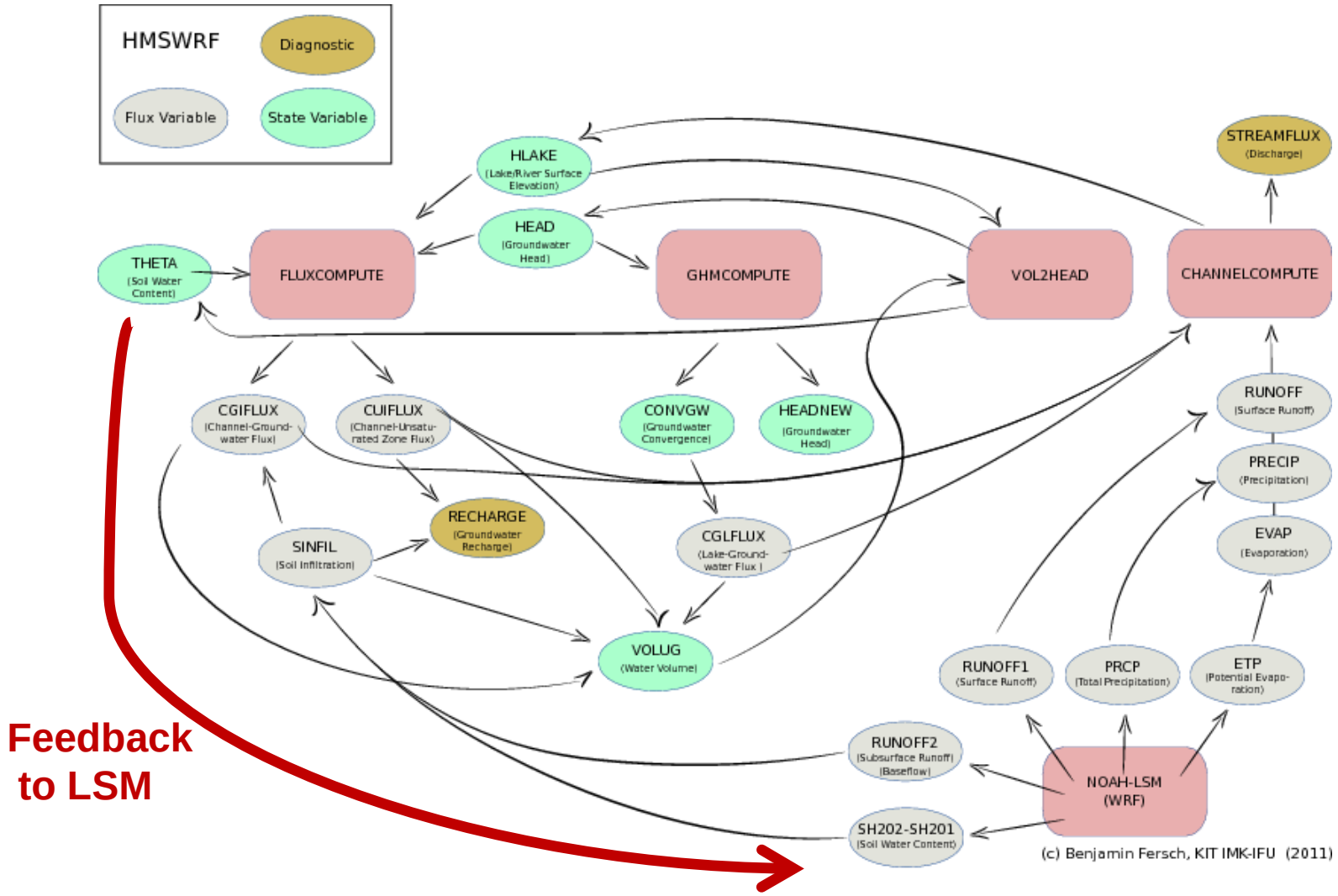
Overview Model Approach



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

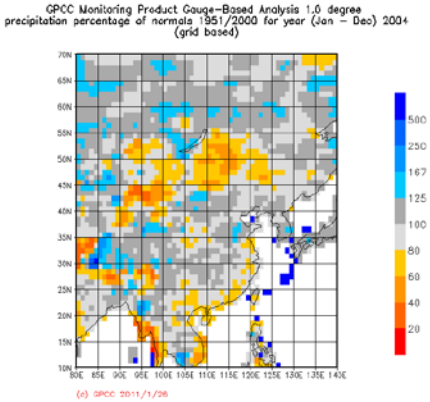
- Allows **long-term simulations** for the investigation of the impact of joint land-use and climate changes on the regional water cycle

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

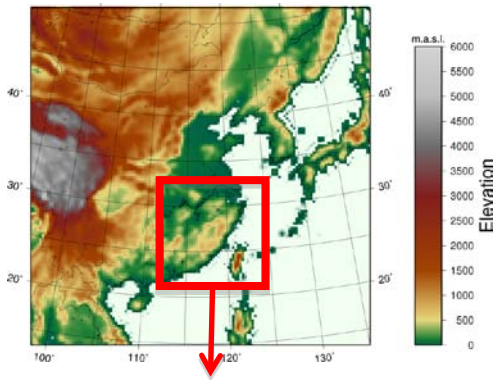


- Several configurations of WRF with respect to model physics (microphysic, PBL, cumulus parameterization, radiation) and vertical resolution

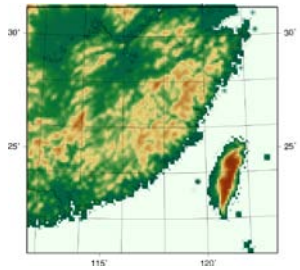
- Double nesting approach:

  coarse domain: 30 km

  fine domain: 10 km

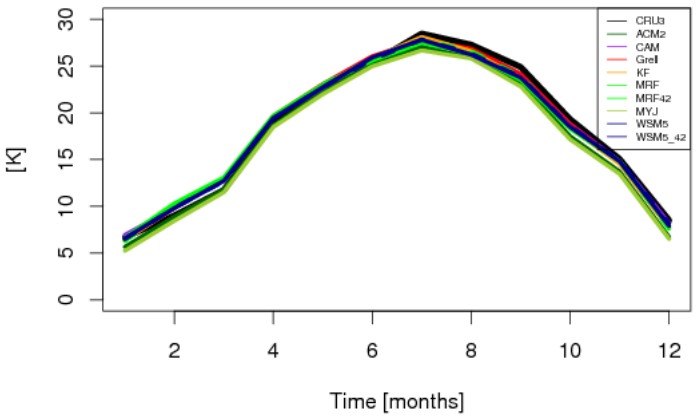


Poyang @ 10 km:

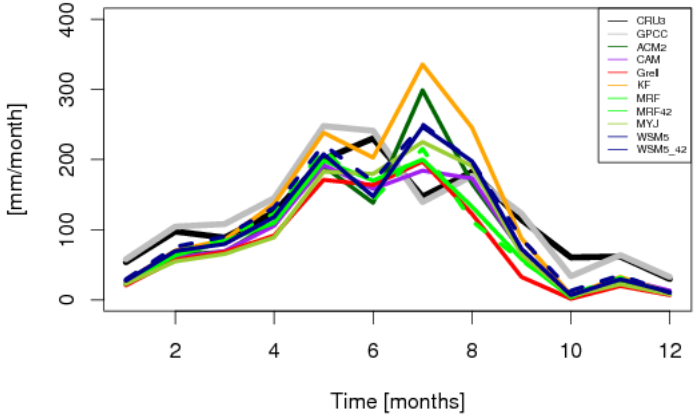


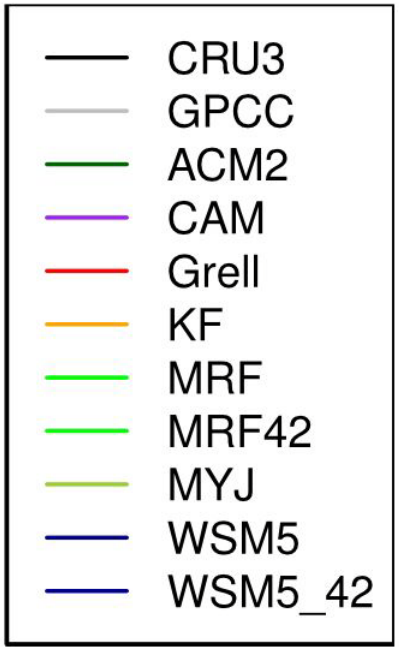
WRF simulation results:
Poyang @ 30km: T2 and TOT_PREC, 2003-2005

Temperature [K]: monthly mean



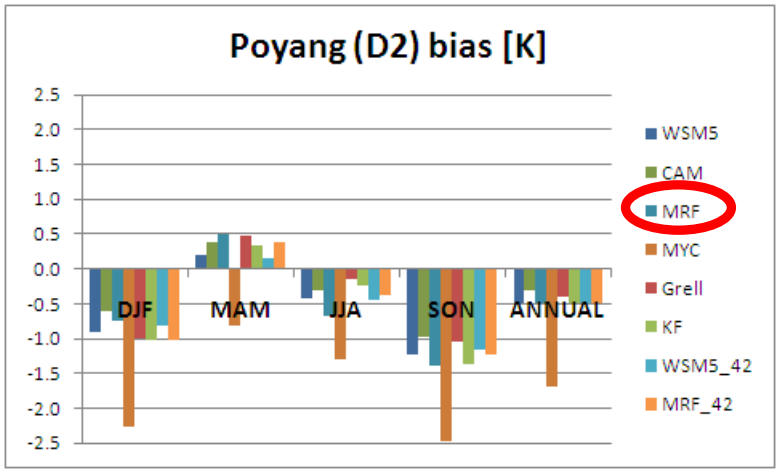
Precipitation [mm]: monthly sum



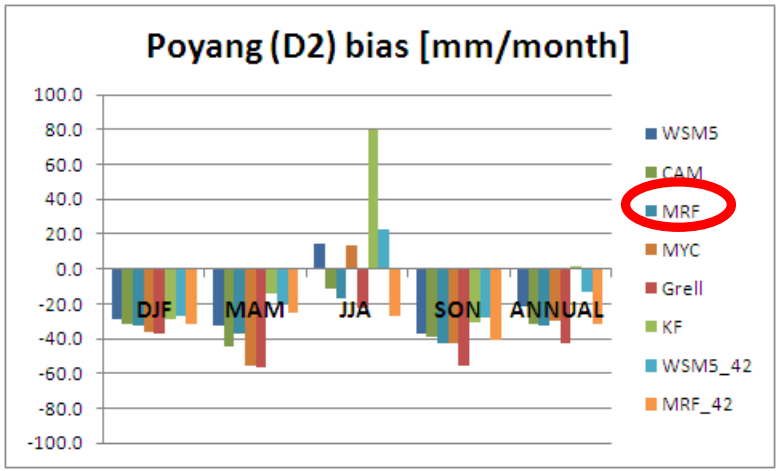


WRF simulation results: Poyang
Seasonal & Annual Validation @ 30km

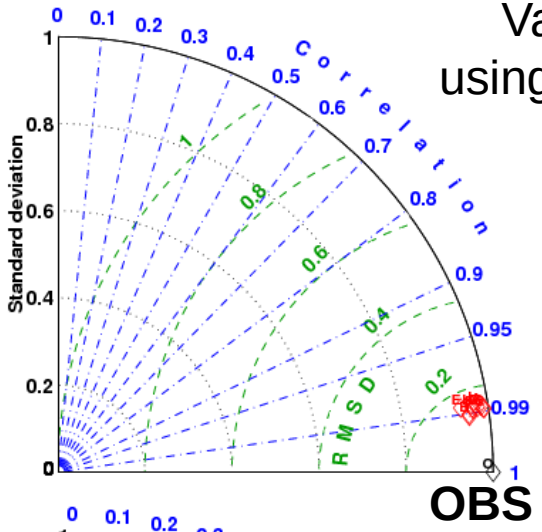
Temperature [K]: Bias

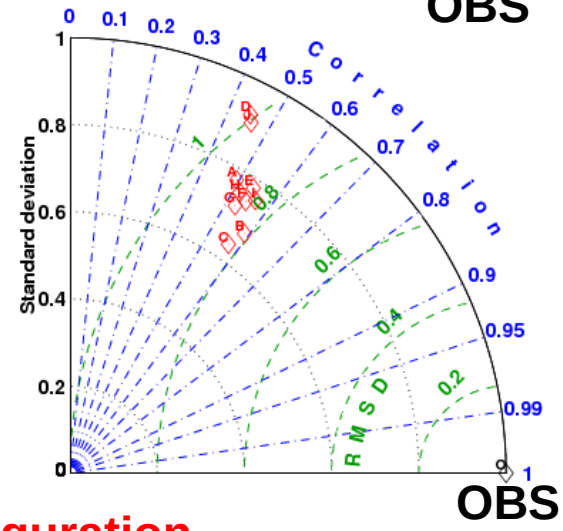


Precipitation [mm]: Bias



Validation using station data





Selected suited WRF configuration

WRF simulation results @ 30km : Poyang
Annual Temperature [K] & Precipitation [mm]

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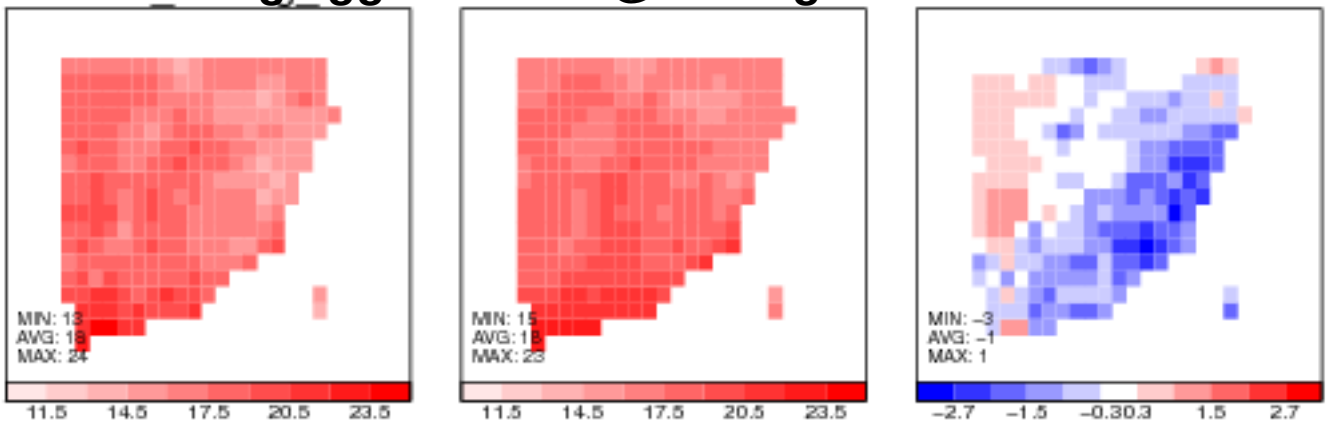
Poyang:

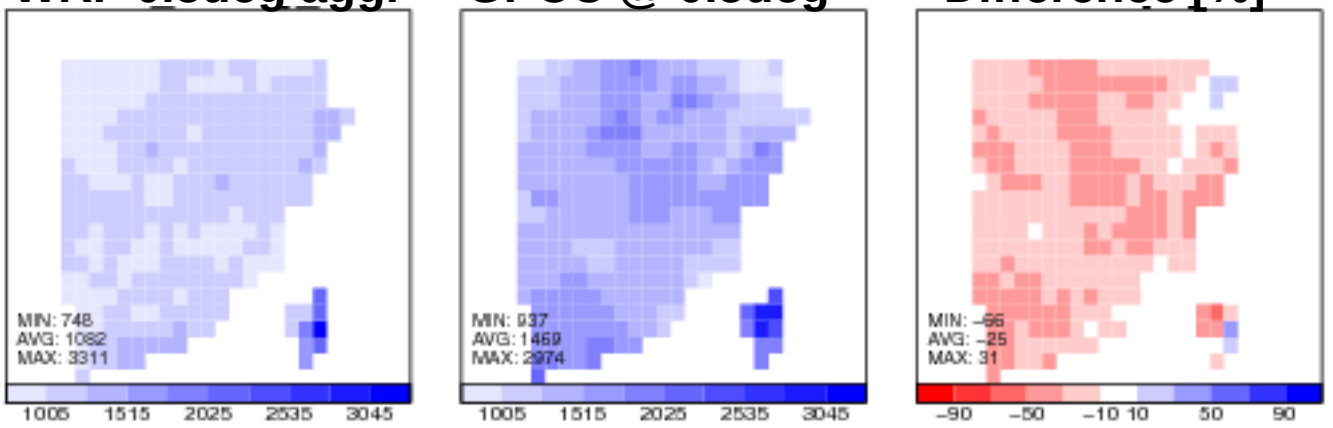
WRF 0.5deg agg. | **CRU3 @ 0.5deg** | **Difference**



AVG: -1K

Poyang:

WRF 0.5deg agg. | **GPCC @ 0.5deg** | **Difference [%]**



AVG: -25%

WRF – NOAH-LSM – HMS

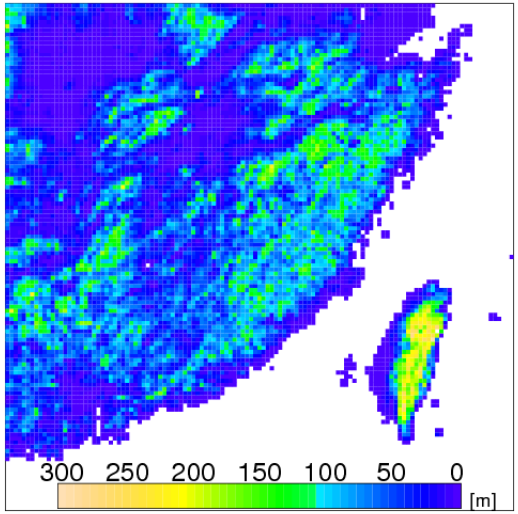
WRF-NoahLSM-HMS: state of development

- Implementation of HMS model in the WRF code structure (hydrology driver routine) allowing flexible time step application
- Integration of preprocessors (static surface and sub-surface hydrological parameters)
- netCDF compliance (IO)

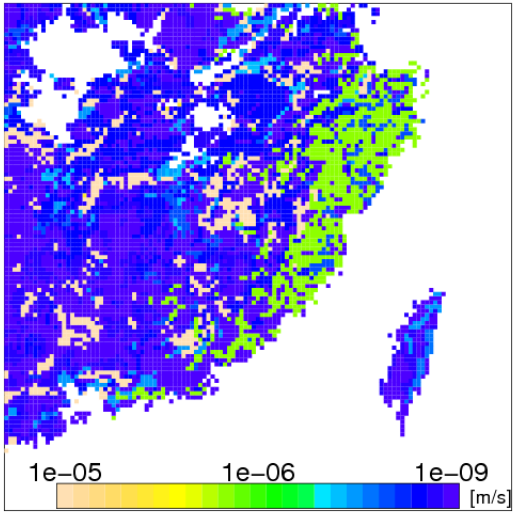
- Current model setup enables coupled atmospheric-hydrological simulations (water- & energy budget)
- upward moisture transport (capillary rise or shallow groundwater head) is under implementation → poster by Yang et al. in this session: A75

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

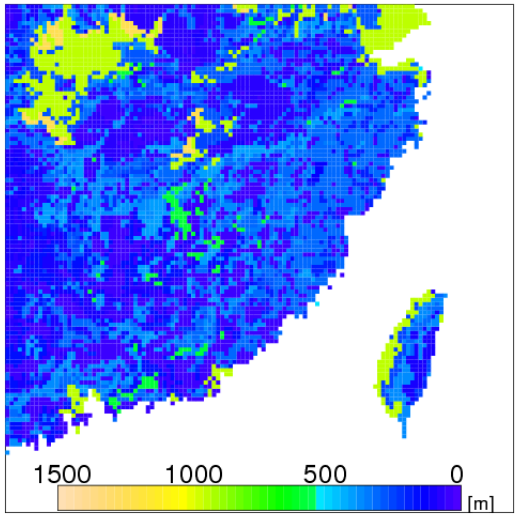
DEM (sd): USGS HYDRO1K (GTOPO30)



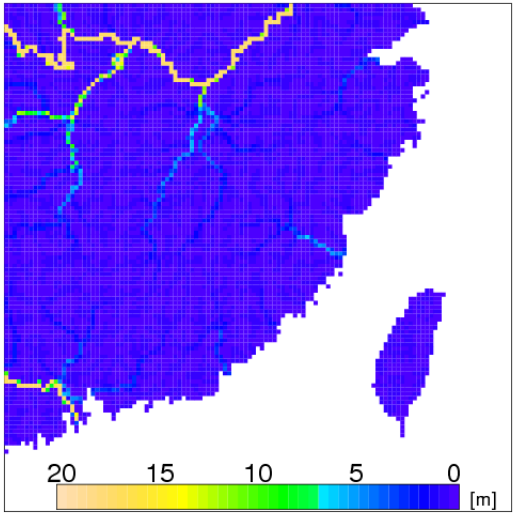
Hydraulic conductivity: Chinese Geological data set



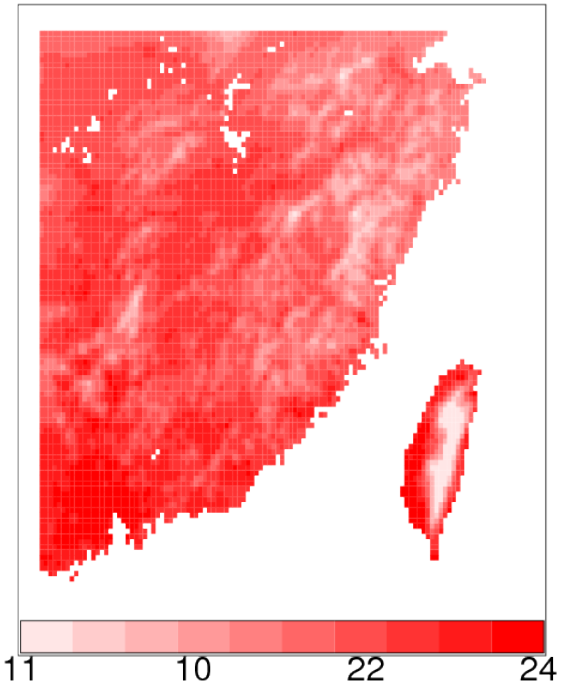
Aquifer thickness: Chinese Geological data set



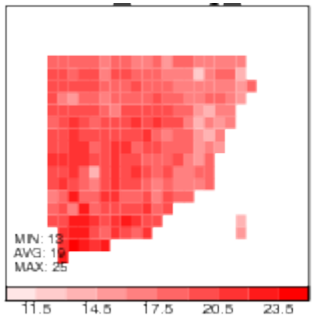
Streambed depth: USGS HYDRO1K



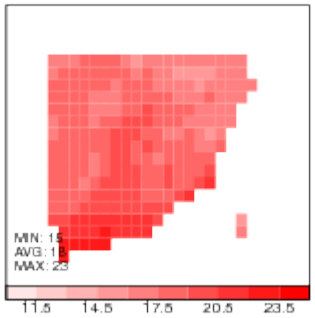
First WRF- NoahLSM - HMS simulation results: Poyang @ 10km: Temperature [K], 2003-2004



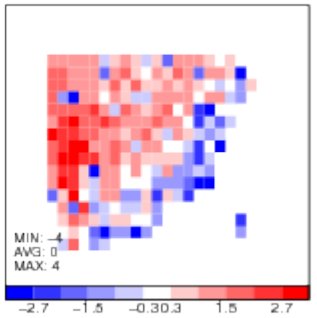
WRF 0.5deg agg.

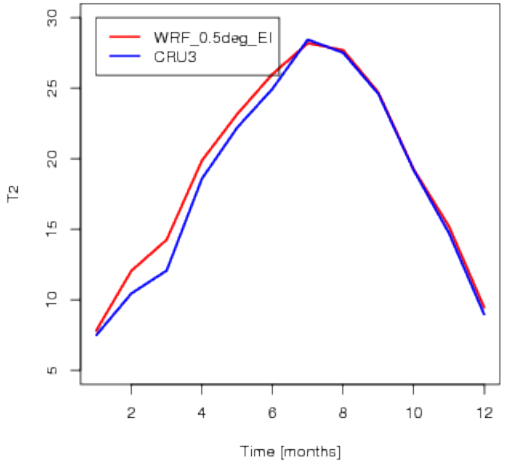


CRU3 @ 0.5deg

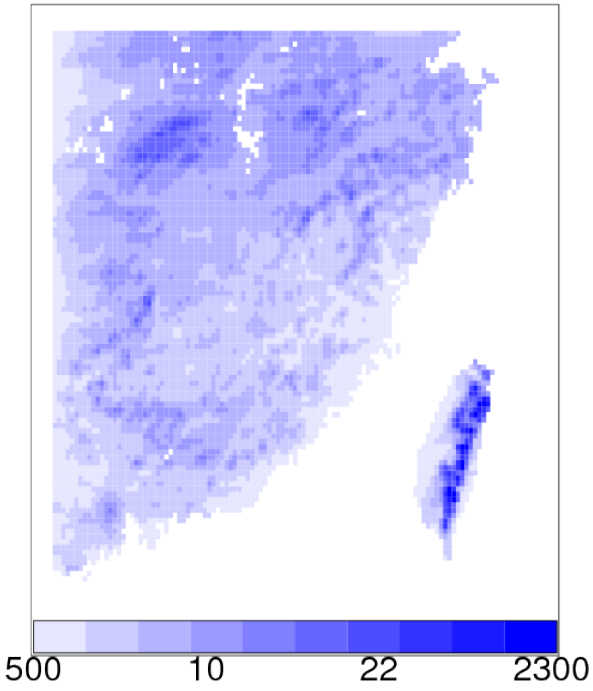


Difference

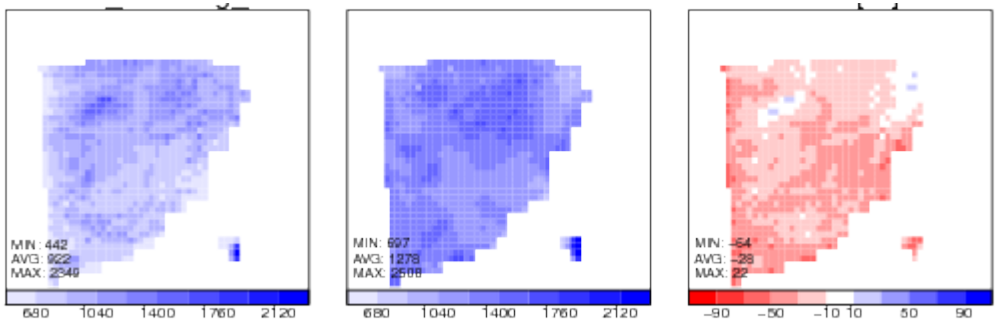


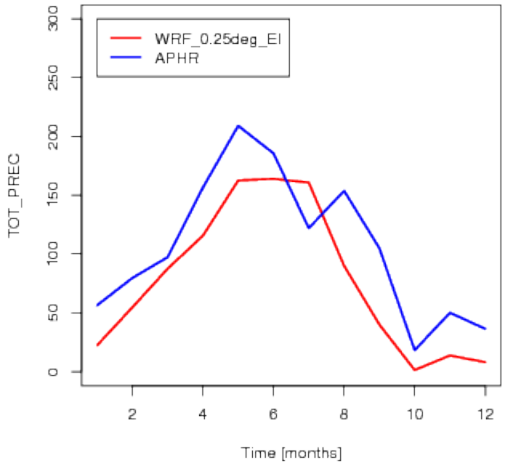


First WRF- NoahLSM - HMS simulation results: Poyang @ 10km: Annual Precipitation [mm], 2003-2004



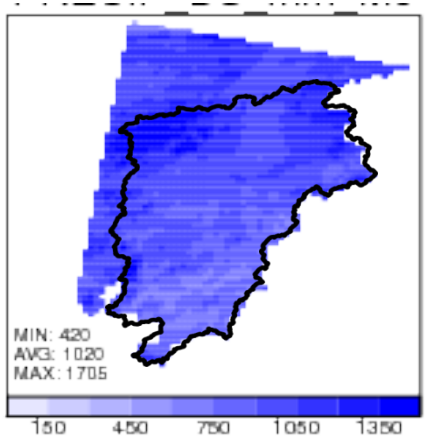
WRF 0.25deg agg. APHR @ 0.25deg Difference [%]

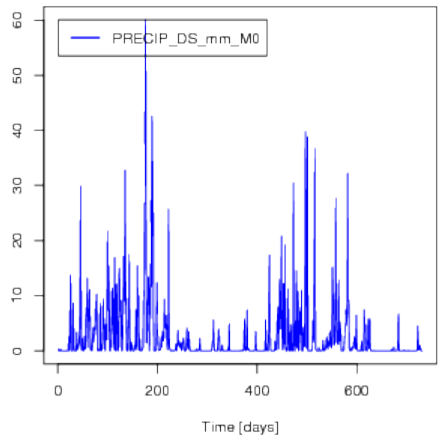




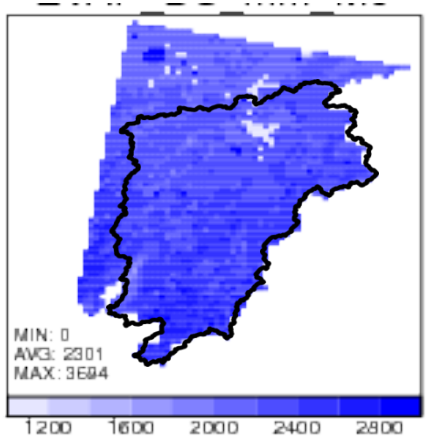
First WRF- NoahLSM - HMS simulation results: Poyang @ 10km: 2003-2004

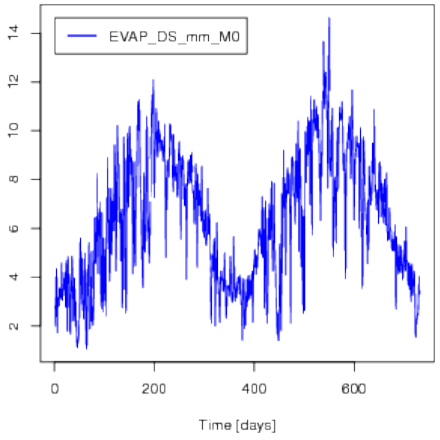
PRECIP [mm]



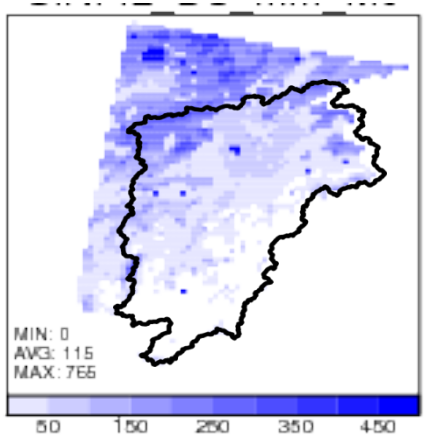


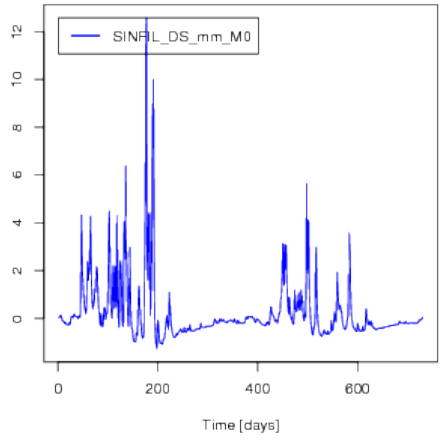
pot. EVAP [mm]



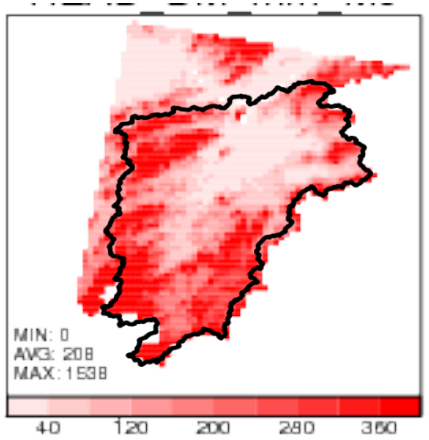


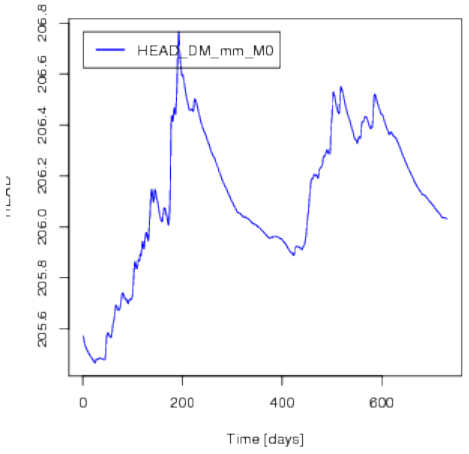
Infiltration [mm]





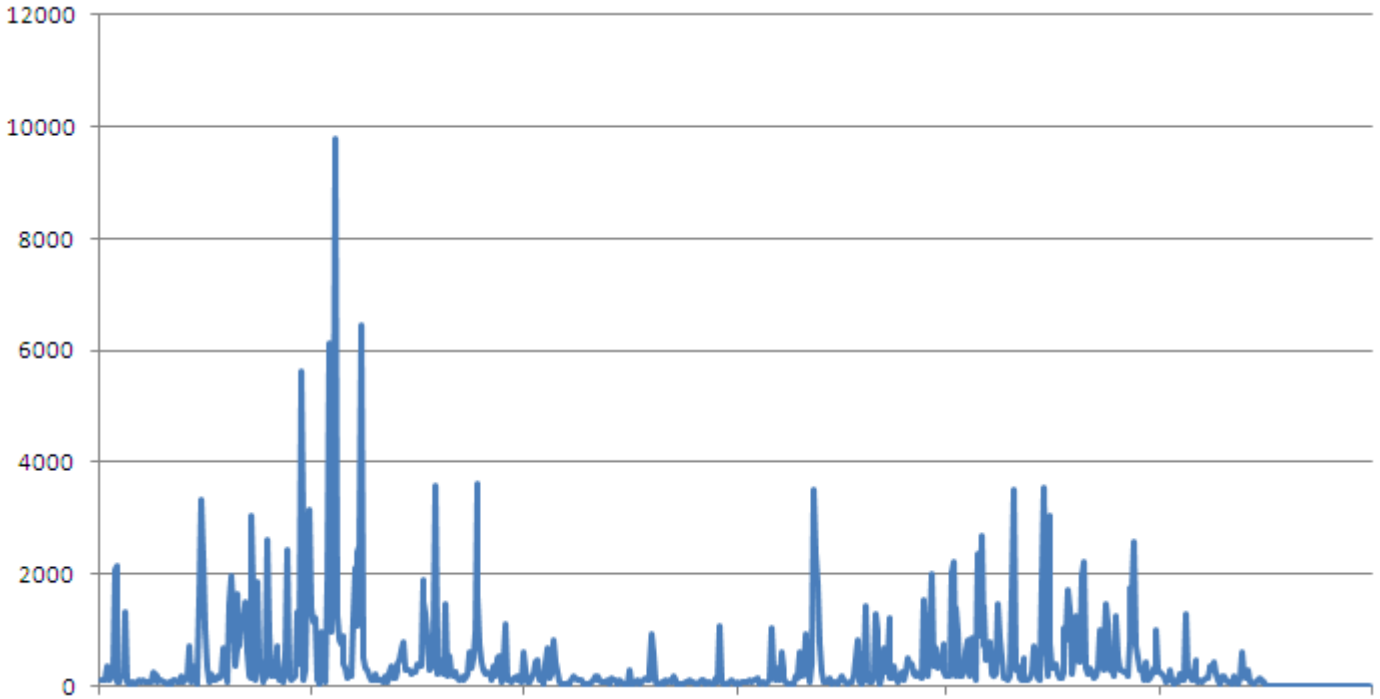
GW head [mm]





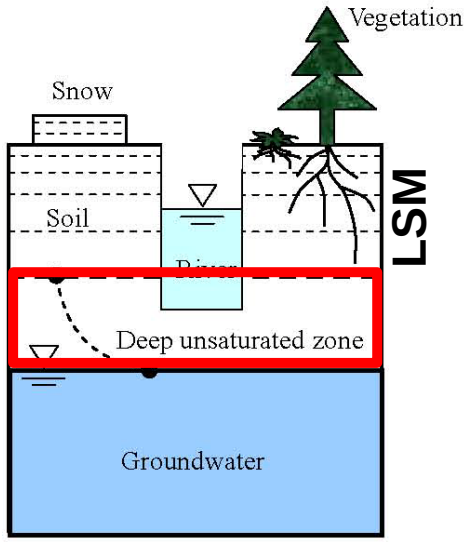
First WRF- NoahLSM - HMS simulation results: Poyang @ 10km: STREAMFLOW

[m³/s]



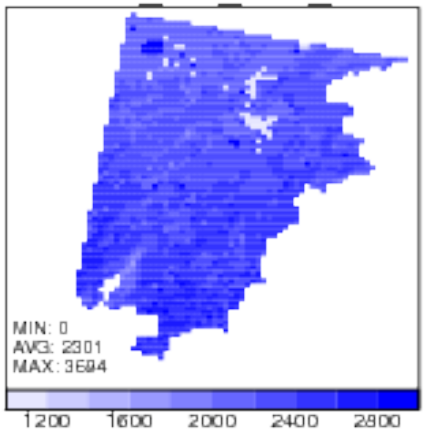
Outlook: Concept of Closed Regional Water Balance Modeling

- Introduce a deep unsaturated zone at the bottom of soil layers of LSM and groundwater
- link LSM and groundwater using drainage flux at bottom of deepest soil layer
- assume linear changing trend of matrix potential in deep unsaturated zone
- more details: poster by Yang et al. in this session: A75

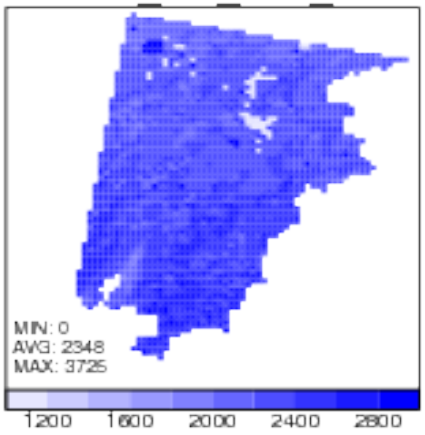


pot. EVAP [mm]

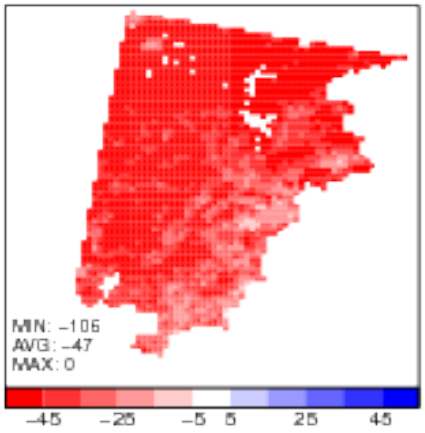
Uncoupled model



Coupled model



Difference



Summary

- Performance and validation of several WRF configurations
- Identification of suited WRF setup for coupled WRF-NoahLSM-HMS simulations for Poyang region

- **WRF-NoahLSM-HMS:**
- Integration of HMS preprocessors & code in WRF model structure
- First one-way (top-down) WRF - NoahLSM - HSM simulations are performed

Outlook: with the feedback mechanisms

- Investigation of land-surface feedbacks at different time scales
- Joint regional climate & land use change simulations

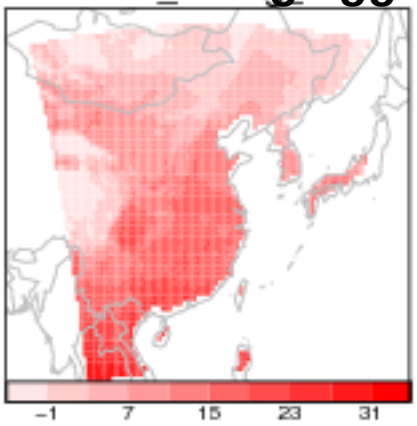
Thank you for your attention

WRF simulation results: complete domain
Annual Temperature & Precipitation @ 30km

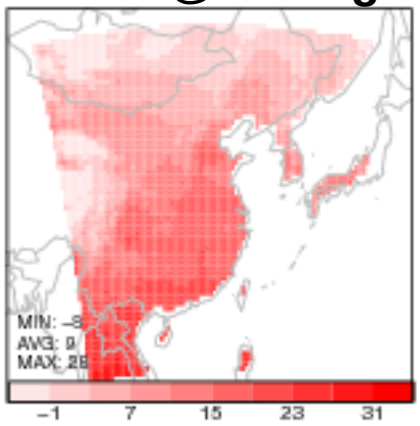
Karlsruhe Institute of Technology

Annual mean Temperature [K]

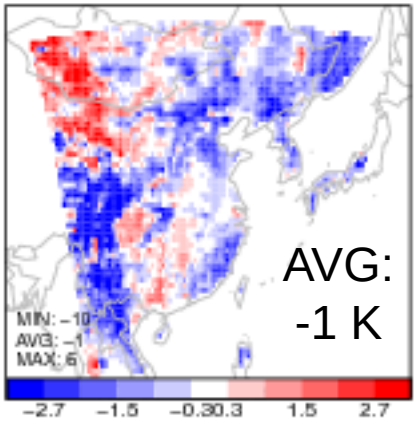
WRF 0.5deg agg.



CRU3 @ 0.5deg

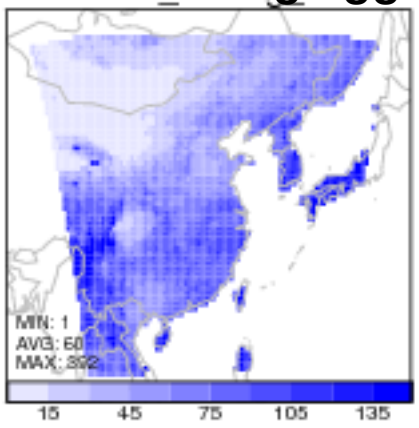


Difference

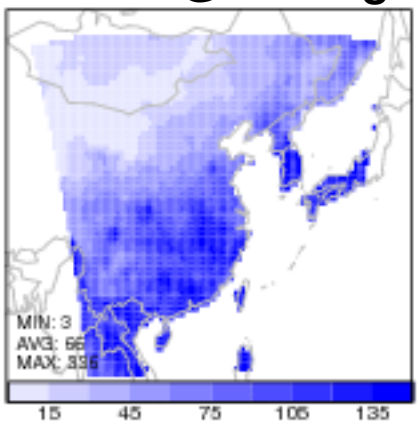


Annual Precipitation [mm/year]

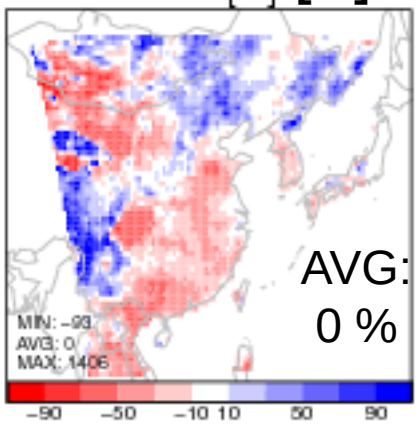
WRF 0.5deg agg.



GPCC @ 0.5deg

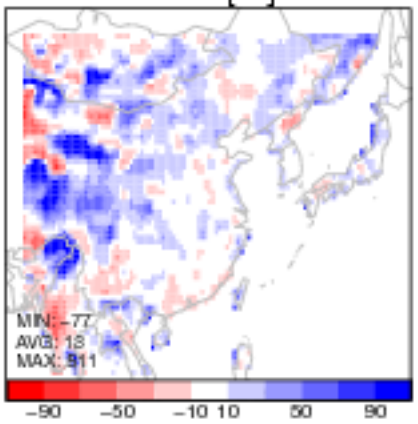


Difference [%]



Validation data:
GPCC & CRU3

DIFF [%]



GPCC precipitation percentage of normals