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

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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
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 (microphysical, 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

Temperature [K]:
- CRU3
- GPCC
- ACM2
- CAM
- Grell
- KF
- MRF
- MRF42
- MYJ
- WSM5
- WSM5_42

Precipitation [mm]:
- CRU3
- GPCC
- ACM2
- CAM
- Grell
- KF
- MRF
- MRF42
- MYJ
- WSM5
- WSM5_42
WRF simulation results: Poyang
Seasonal & Annual Validation @ 30km

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

Poyang:

\[\text{WRF 0.5deg agg.} \quad \text{CRU3 @ 0.5deg} \quad \text{Difference}\]

\[\text{AVG: -1K}\]

\[\text{WRF 0.5deg agg.} \quad \text{GPCC @ 0.5deg} \quad \text{Difference [\%]}\]

\[\text{AVG: -25\%}\]
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

MIN: -4  AVG: 0  MAX: 4
MIN: 11.5  AVG: 17.5  MAX: 20.5
MIN: -2.7  AVG: 0  MAX: 2.7
First WRF- NoahLSM - HMS simulation results:
Poyang @ 10km: Annual Precipitation [mm], 2003-2004

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

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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]**

<table>
<thead>
<tr>
<th>Uncoupled model</th>
<th>Coupled model</th>
<th>Difference</th>
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MIN: 0 AVG: 2011 MAX: 3694
MIN: 0 AVG: 2348 MAX: 3725
MIN: -105 AVG: -47 MAX: 0
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

Annual mean Temperature [K]
- WRF 0.5deg agg.
- CRU3 @ 0.5deg
- Difference
  - AVG: -1 K

Validation data: GPCC & CRU3

Annual Precipitation [mm/year]
- WRF 0.5deg agg.
- GPCC @ 0.5deg
- Difference [%]
  - AVG: 0 %
GPCC precipitation percentage of normals