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A crop-specific dynamic irrigation scheme in NOAH-HMS for improving human water-use estimation

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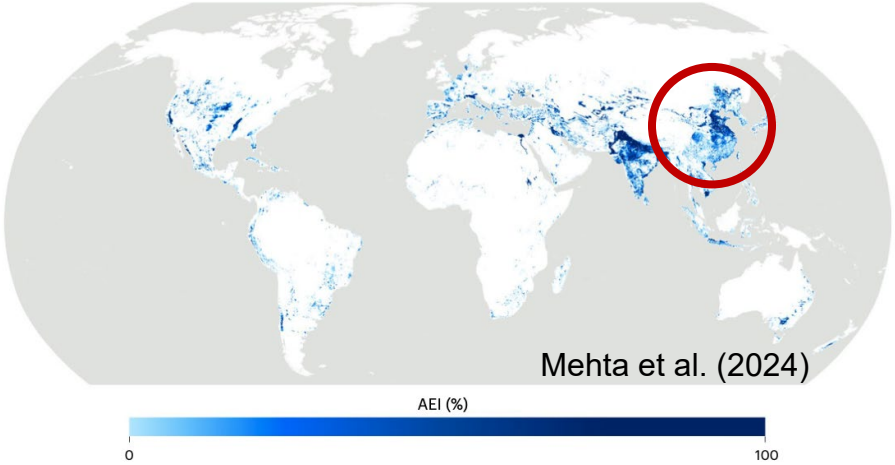
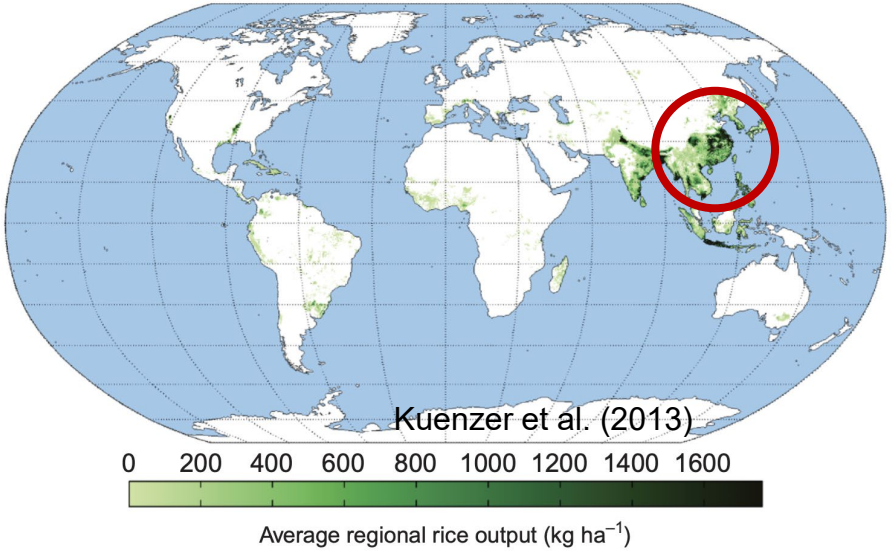
Introduction

Irrigation: area equipped with irrigation



Rice: rice growing area



- **Climate changes (extremes)** have direct impacts on water & food security.

Motivation – regional scales

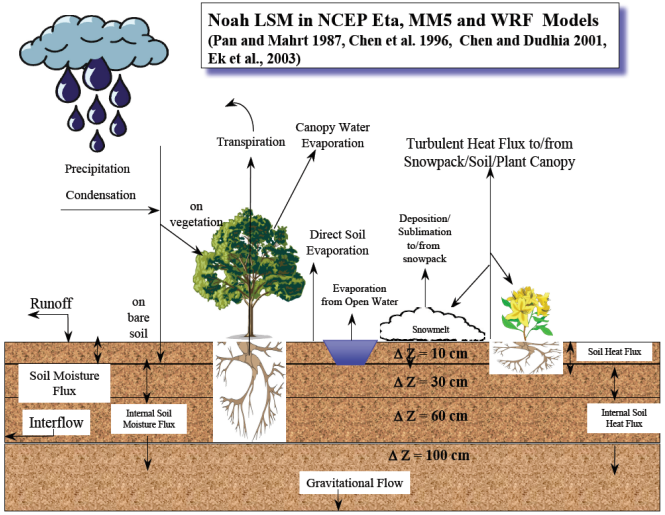
- **Droughts** frequently occur in humid regions especially in China.

- **Research gap** for an irrigation scheme, that is applicable for **multi-cropping, humid regions.**

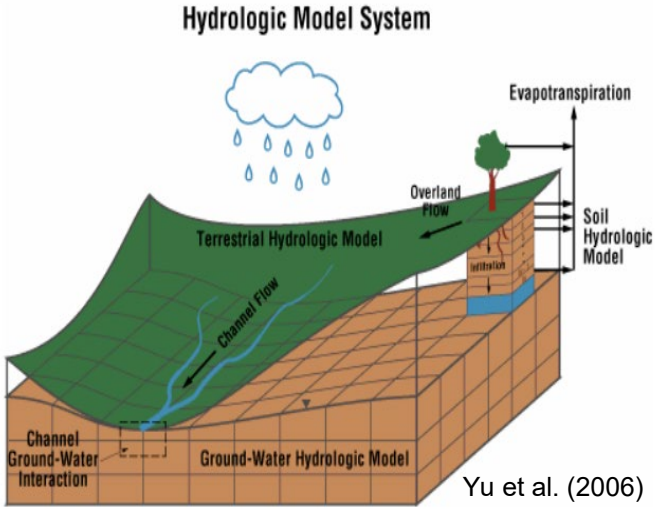
- **Objectives**
  - to introduce a crop-specific dynamic irrigation scheme into NOAH-HMS;
  - to apply the model to drought-prone, humid region;
  - to quantify the impacts of irrigation on the terrestrial water cycle.

Model: **NOAH-HMS** (WRF-NOAH-HMS)

- **NOAH**: land-surface model (vert. proc.)
- **HMS**: hydrologic model (hori. proc.)



Chen et al. (2001)



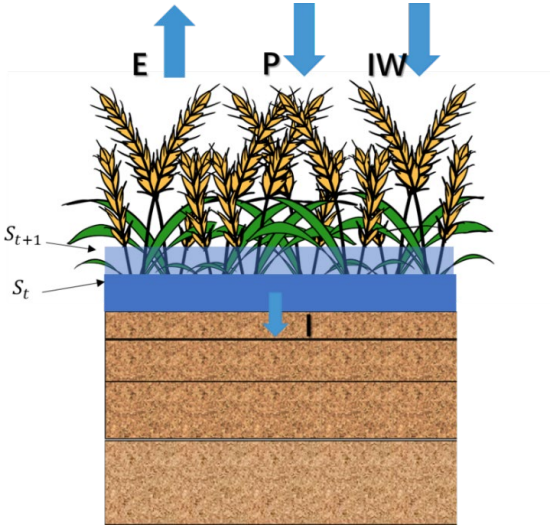
Yu et al. (2006)

- **WRF-NOAH-HMS**: fully-coupled with atmosphere at regional/long-term scales from atmosphere to groundwater

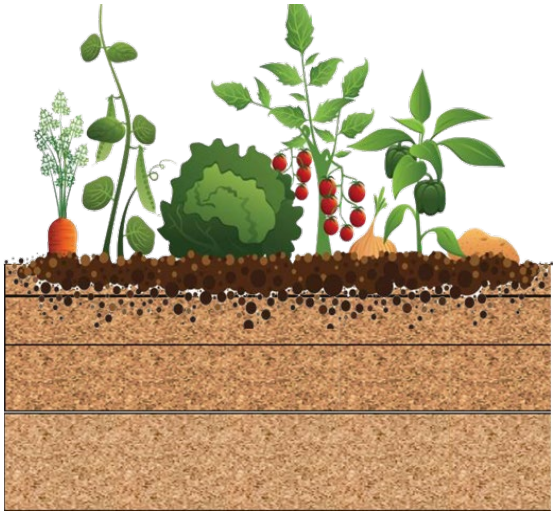
A crop-specific dynamic irrigation scheme

- **Concept**: different irrigation practices for different types of crops

Rice: surface-water balance method



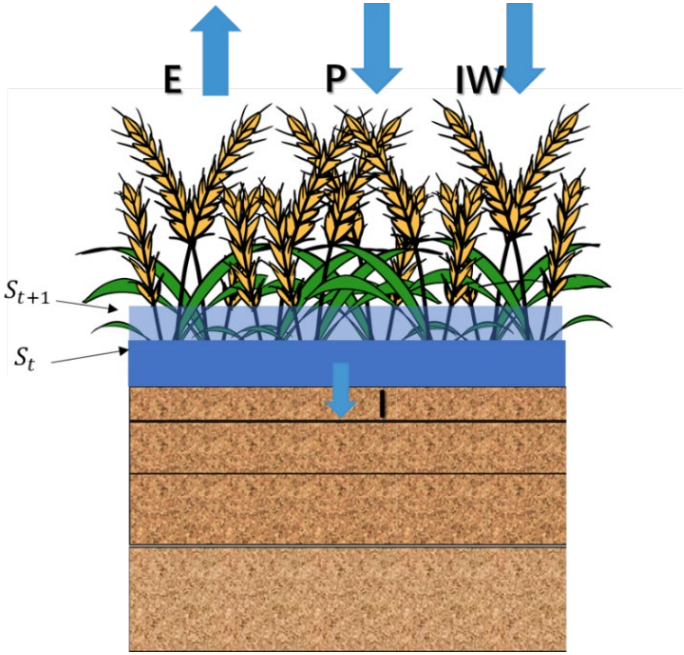
Non rice: soil-moisture deficit method



Irrigation scheme for rice

- **Method**:
  Paddy field water balance method (Wada et al., 2014)

- **Implementation**:
  - Extra surface water balance equation is added;
  - 50 mm is maintained during growing seasions;
  - Sub-grid evaporation due to irrigation is parameterized by considering irrigated area fraction;
  - Irrigation water demand is determined by ”surface water deficit”.



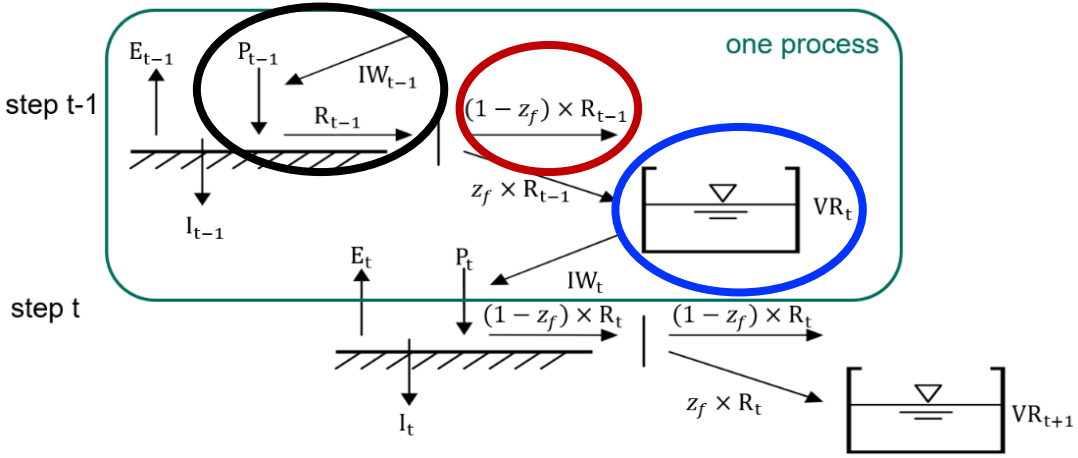
Irrigation scheme for non-rice crops

- **Method**:
  Soil moisture deficit method (Ozdogan et al., 2010)

- **Implementation**:
  - Irrigation period is determined by using a threshold of greenness fraction (> GF_{thresh});
  - Irrigation practice is trigged by the root-zone moisture availability (<60%);
  - Irrigation water demand is determined by ”soil water deficit” (field capacity).

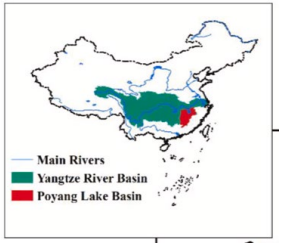
Coupling irrigation scheme to NOAH-HMS

- **Storage:**
  an virtual „reservoir“ (**VR**) stores and releases water for irrigation
- **Storing water:**
  from surface runoff according to Z_f ratios of irrigation water to total water
- **Releasing water:**
  estimated irrigated water (**IW**) is added into precipitation



Yang et al. (2010)

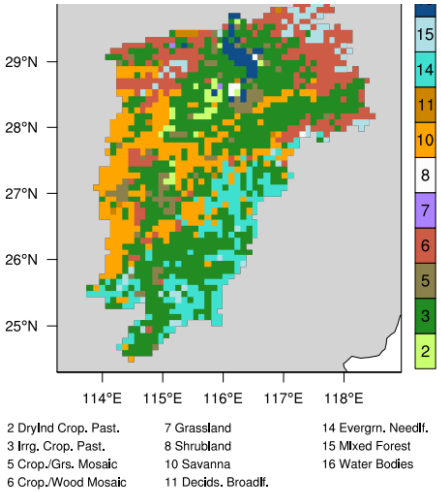
Case study – Poyang Lake basin in China



- **Setup**: 9 years: 2007-2015, 10 km
- **3 Runs**: **CTL** - no irrigation; **CDI** - crop-specified irrigation; **DI** – no crop-specified irrigation

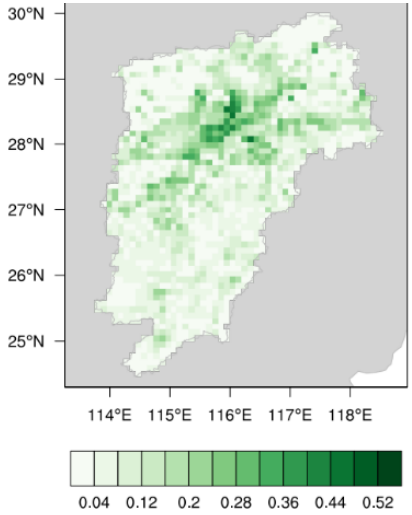
Landuse USGS

where to irrigate (3,5)



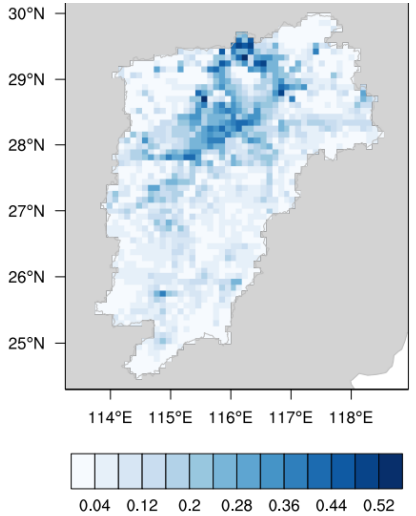
Rice fraction GHAYC

how to irrigate



Non-rice fraction GHAYC

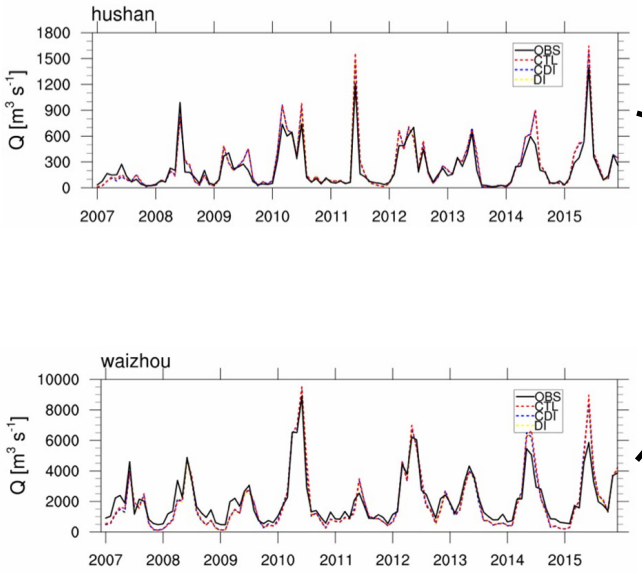
how to irrigate

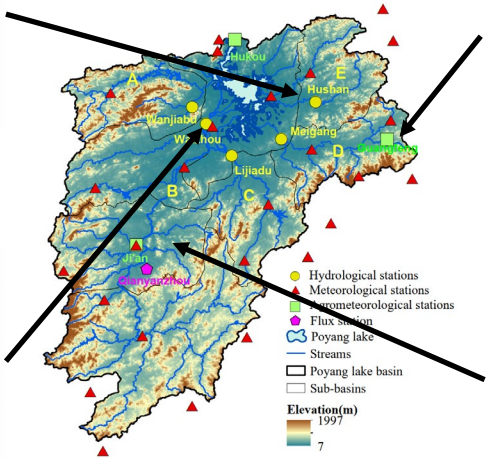


Monfreda et al. (2008)

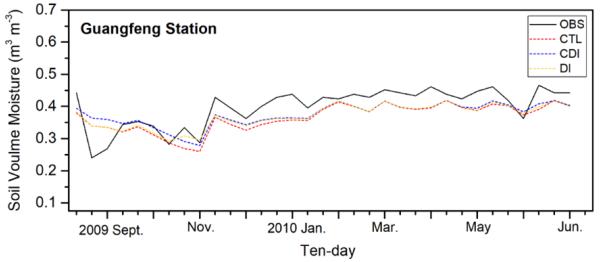
Validation @ hydrological. & agricultural stations

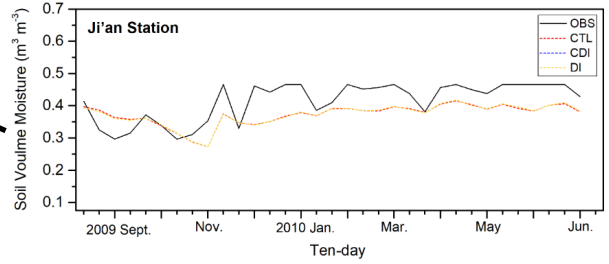
against **observed streamflow**



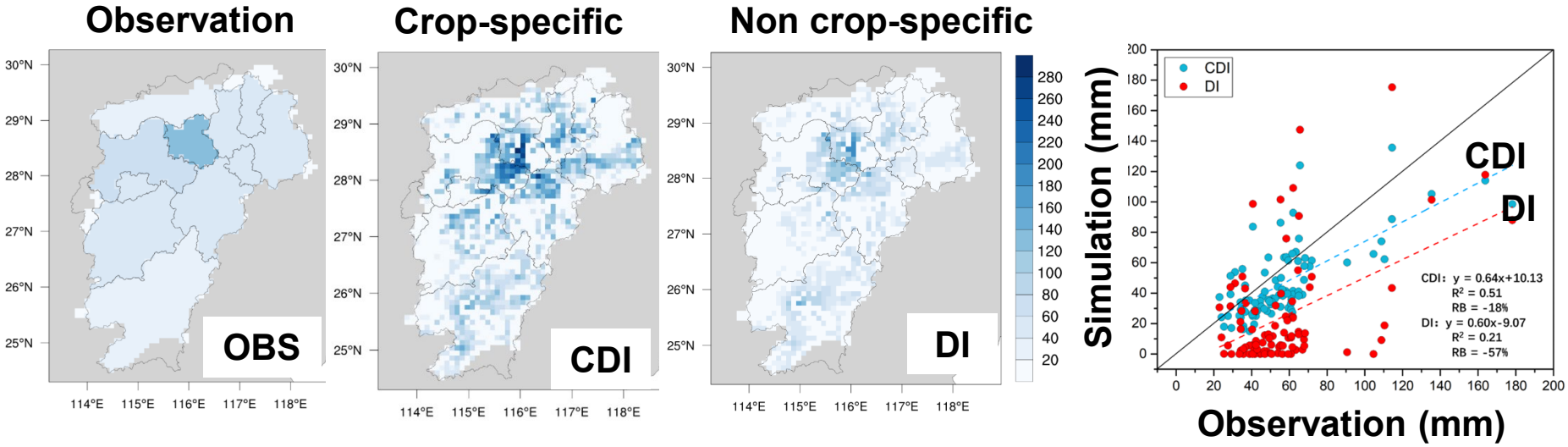


against **observed soil moisture**

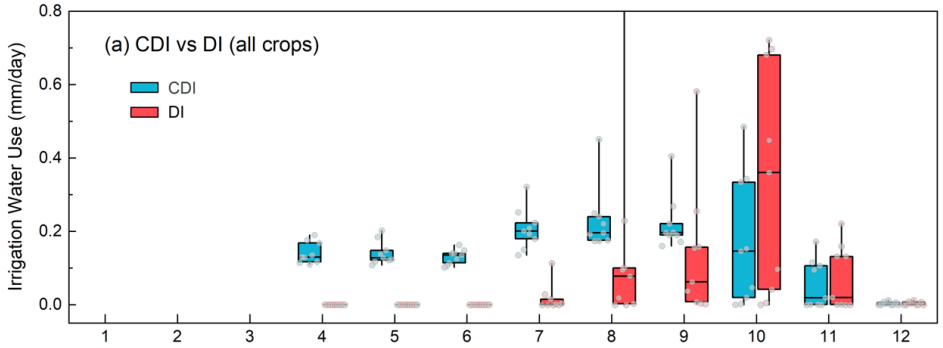




Evaluation of the estimated irrigation water use



Added values of crop-specified irrigation scheme



Spatial impacts of irrigation on soil and land surface

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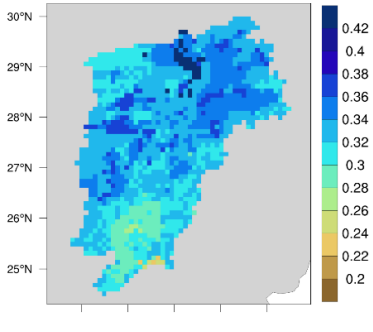
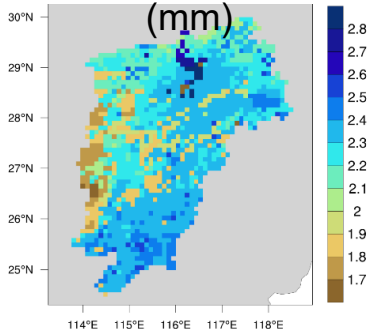
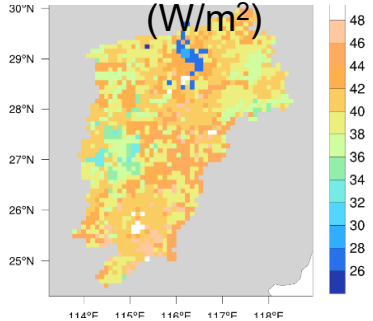
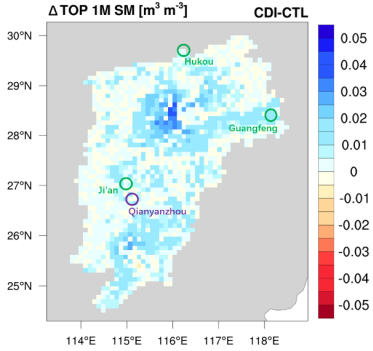
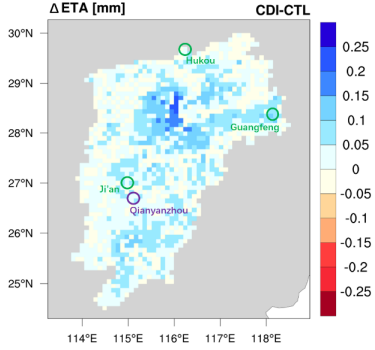
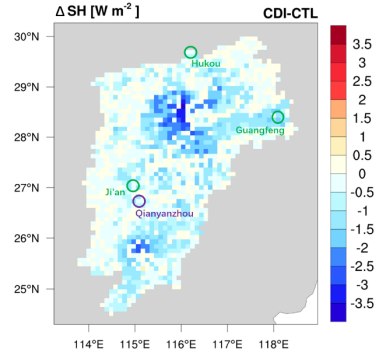
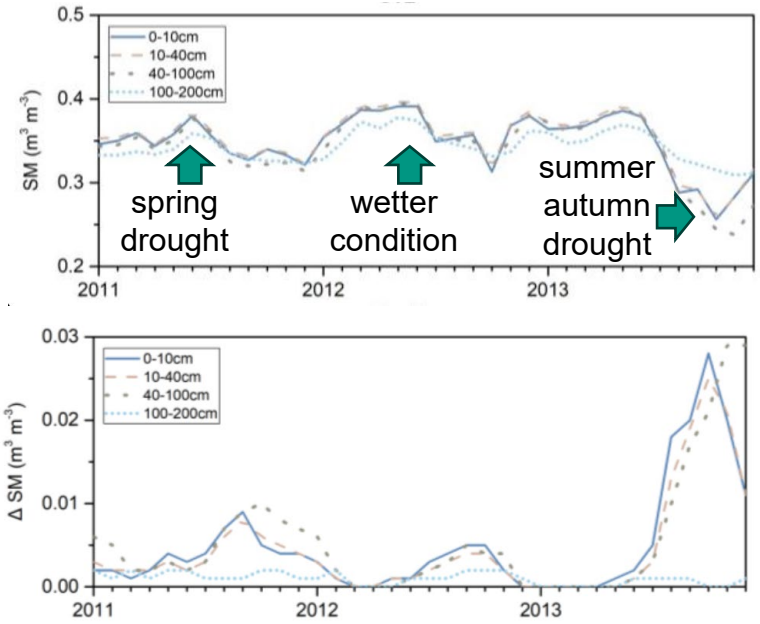
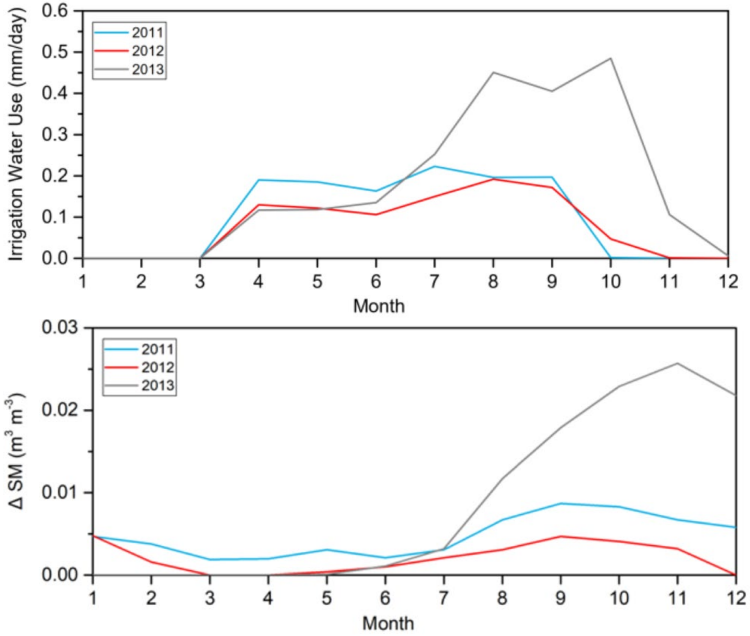
	Soil moisture (-)	Latent heat (mm)	Sensible heat (W/m²)
no irrigation			
with irrigation			

Temporal impacts of irrigation under diff. conditions





Summary & Conclusion

- We have developed **an crop-specific dynamic irrigation scheme** in a regional land surface-hydrologic modeling framework.
- We have applied the irrigation-enabled model to an important cropping region in **humid, Poyang Lake region** in Southeast China.
- Compared with the soil moisture deficit method, the enhanced model **has better performance** in simulating irrigation water amount over the basin (MRE -39% and R +0.26).
- The newly developed scheme is highly advantageous for **multi-cropping humid region**, and has the potential for expansion into the **fully-coupled modeling**.

References

❑ WRF-NOAH-HMS

Water Resources Research

Research Article | Open Access

Fully coupled atmospheric-hydrological modeling at regional and long-term scales: Development, application, and analysis of WRF-HMS

Sven Wagner, Benjamin Fersch, Fei Yuan, Zhongbo Yu, Harald Kunstmann

❑ NOAH-HMS-irrigation

manuscript submitted to *Journal of Hydrology*

A crop-specific dynamic irrigation scheme in a regional land surface-hydrologic modeling framework for improving human water-use estimation and irrigation impact assessment

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❑ NOAH-HMS-reservoir

Hydrological Processes

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Role of reservoir regulation and groundwater feedback in a simulated ground-soil-vegetation continuum: A long-term regional scale analysis

Jianhui Wei, Ningpeng Dong, Benjamin Fersch, Joël Arnault, Sven Wagner, Patrick Laux, Zhenyu Zhang, Qianya Yang, Chuanguo Yang, Shasha Shang, Lu Gao, Zhongbo Yu, Harald Kunstmann