Modeling irrigation activities in North China Plain: from a realistic perspective

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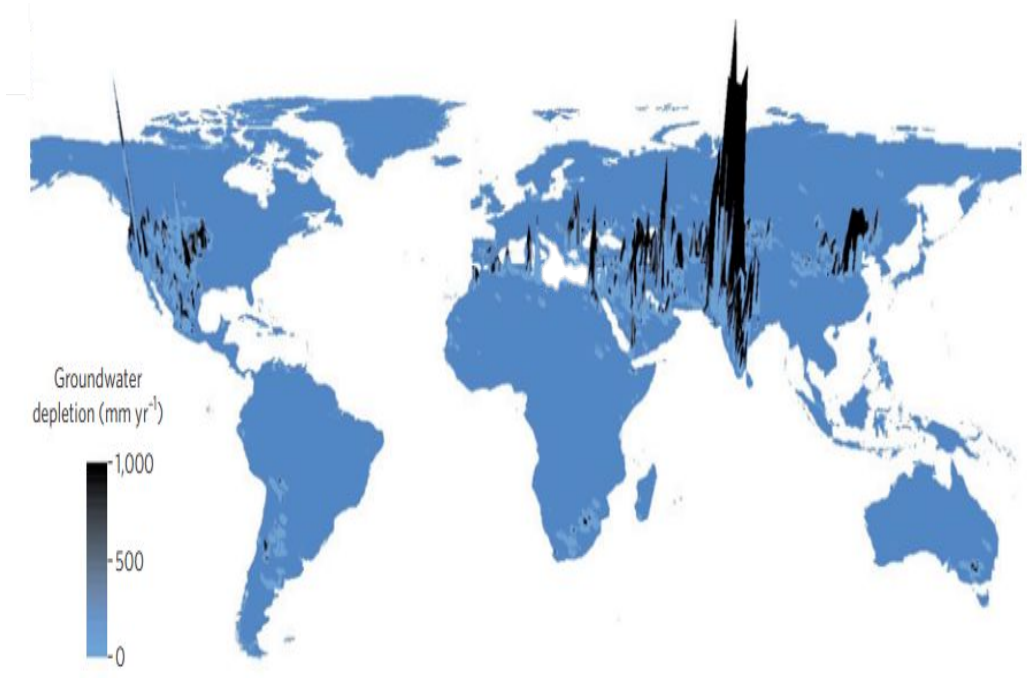
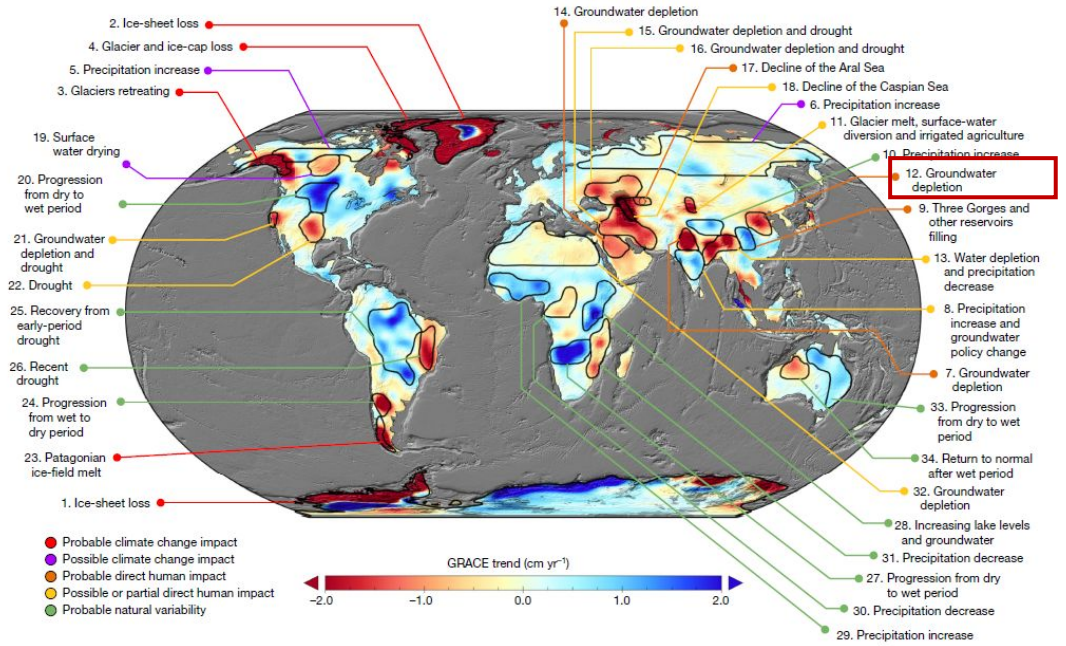
Research motivation

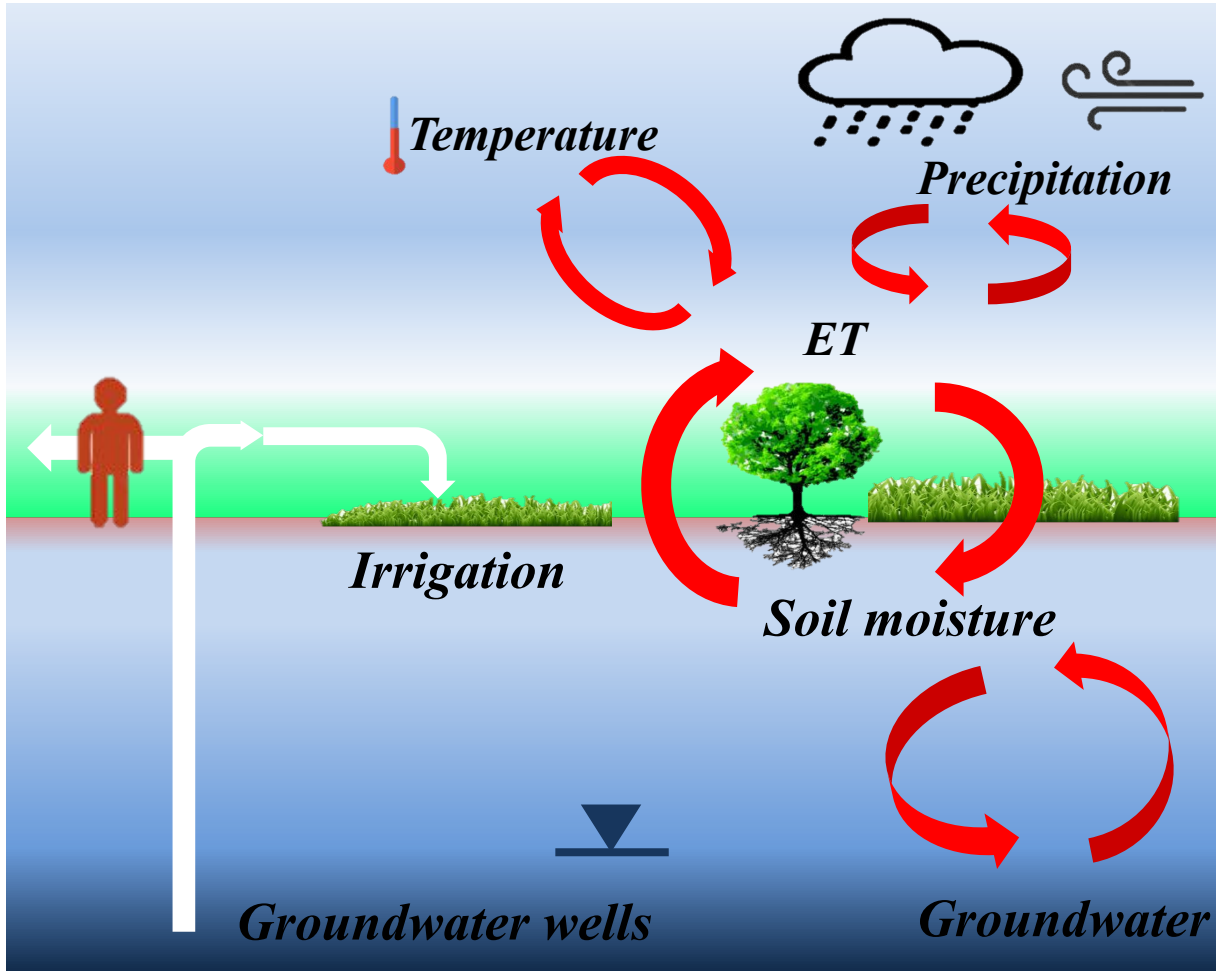




Global GRACE trend of terrestrial water storage changes

- More than half of the world's major aquifers are being depleted, some of them at an alarming pace.
- Human activities (i.e., irrigation) are the major driver for groundwater depletion in North China Plain.

Research motivation



Challenges and Shortcomings:

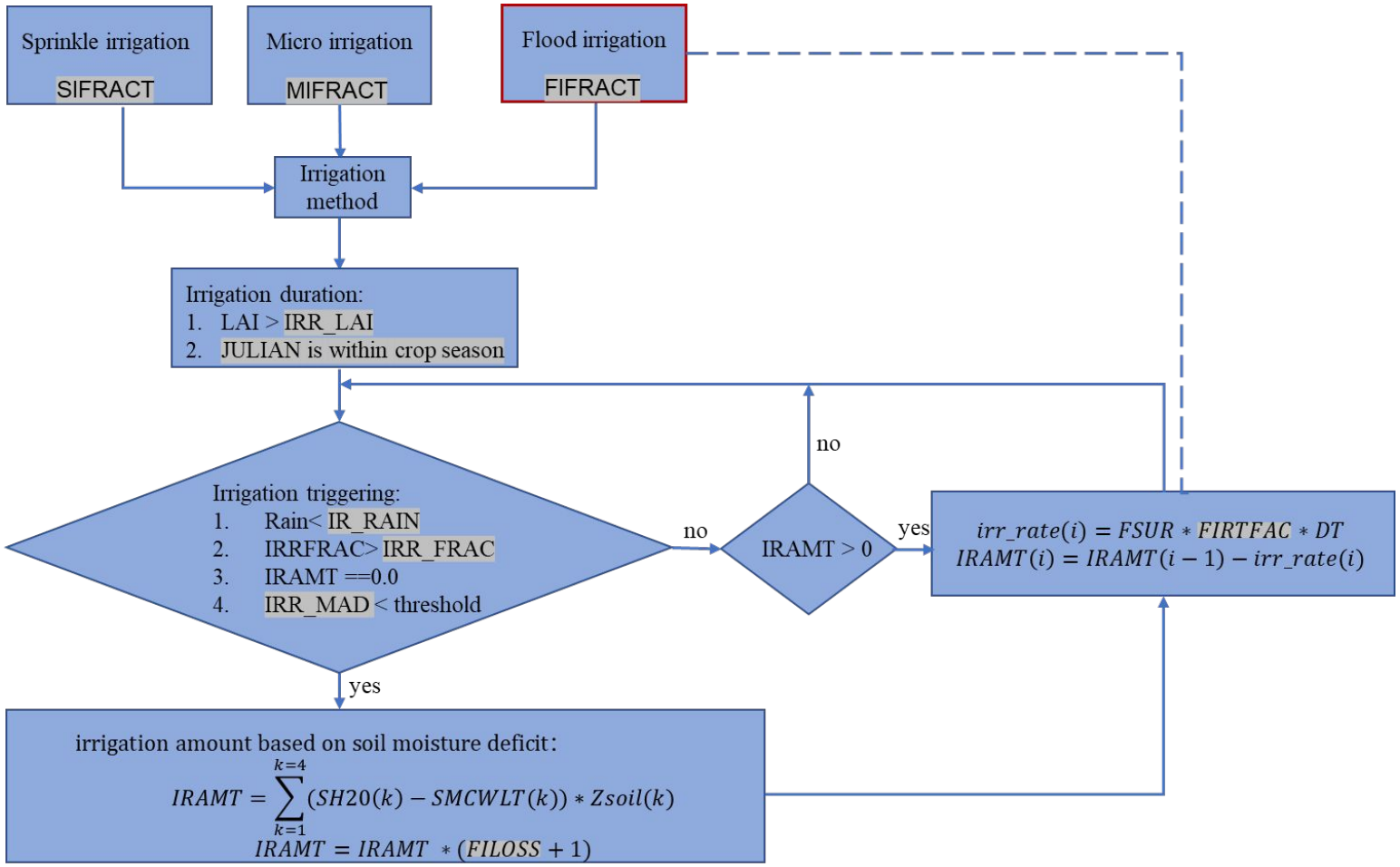
1. Not many observations in China
2. Irrigation is highly variable in space and time
3. Focus on sensitivity tests, not a reality in China

Research question

1. How much irrigation water use is in North China Plain?

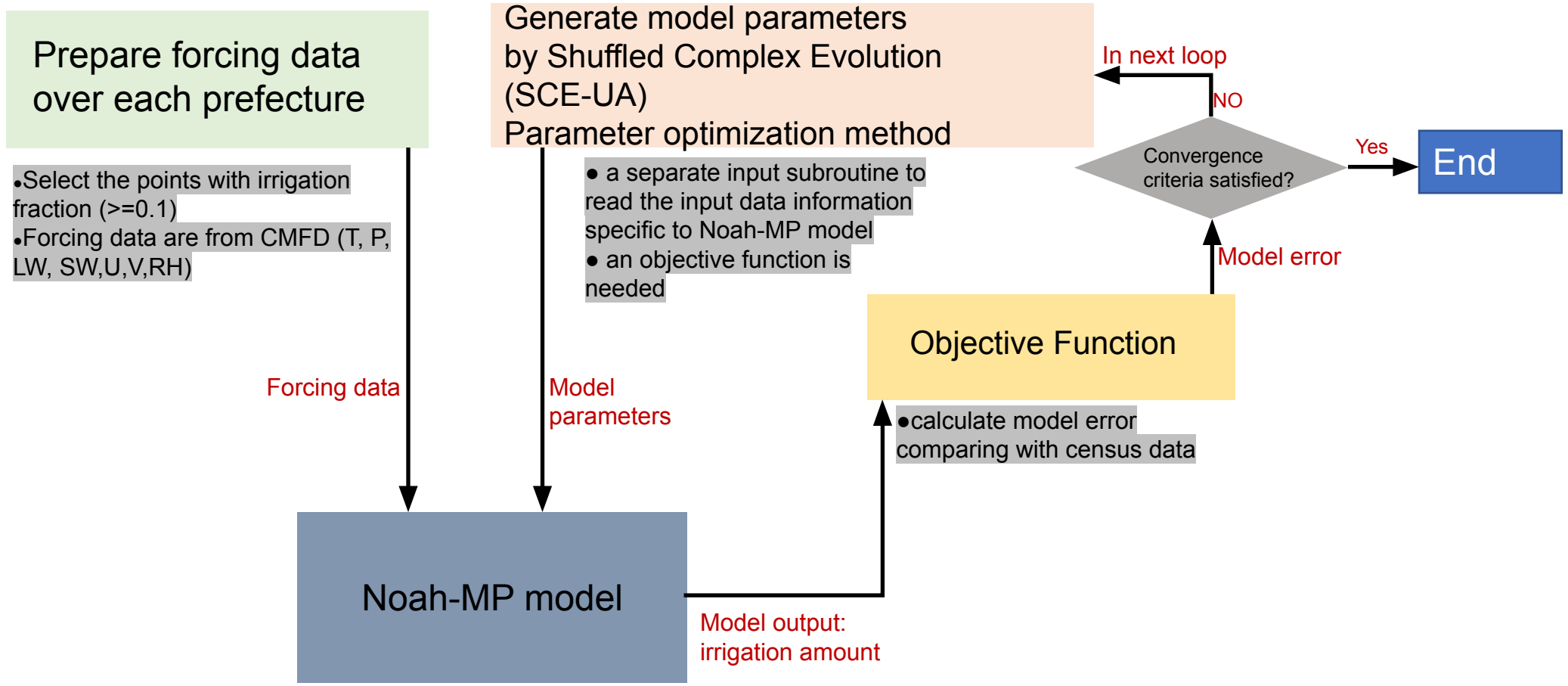
2. How does groundwater-fed irrigation impact on water storage?

Application one: irrigation water use estimation in North China Plain



- Previous studies focused on sprinkler irrigation technique, which is commonly applied in the USA but not conforms with the actual situation in China.
- All three major irrigation methods (Sprinkler irrigation, Micro irrigation, Flood irrigation) have been incorporated into Noah-MP for applications all over the world

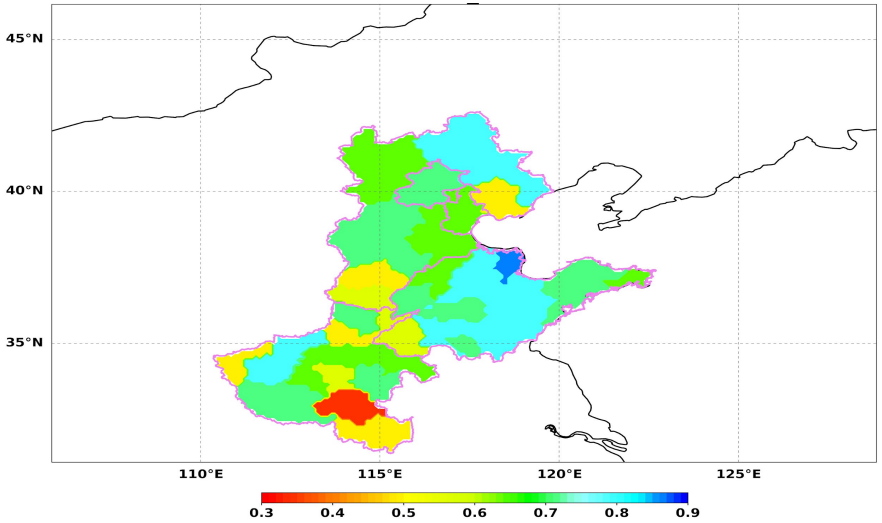
Automatic calibration framework in Noah-MP model



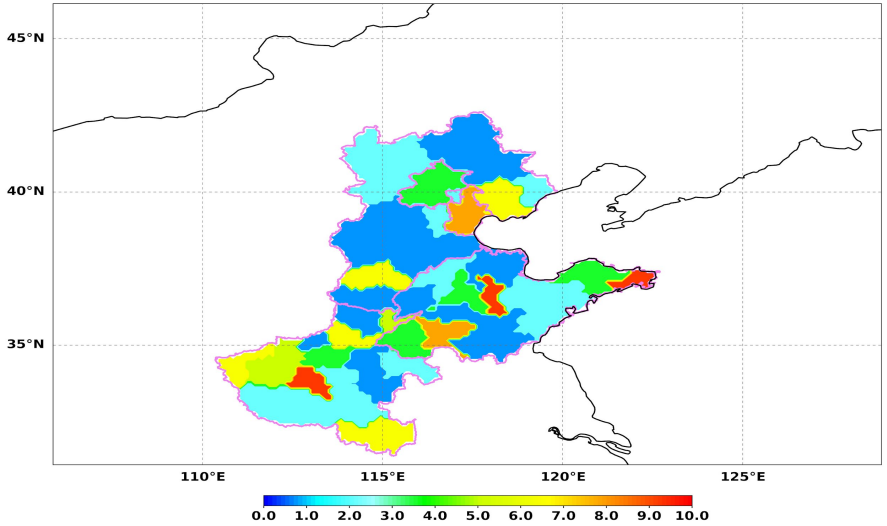
- The framework of automatic calibrated parameters is based on SCE-UA method in Noah-MP model.

Irrigation parameters calibration results

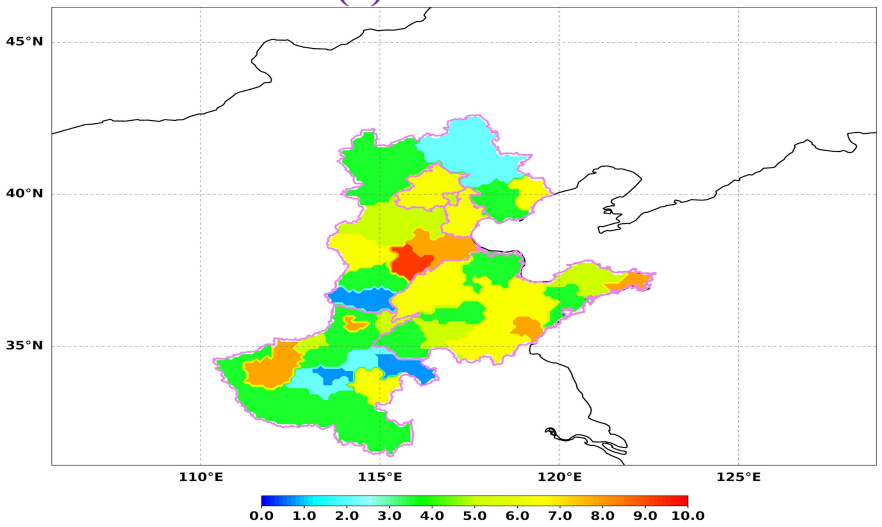
(a) IRR_MAD



(b) FILOSS



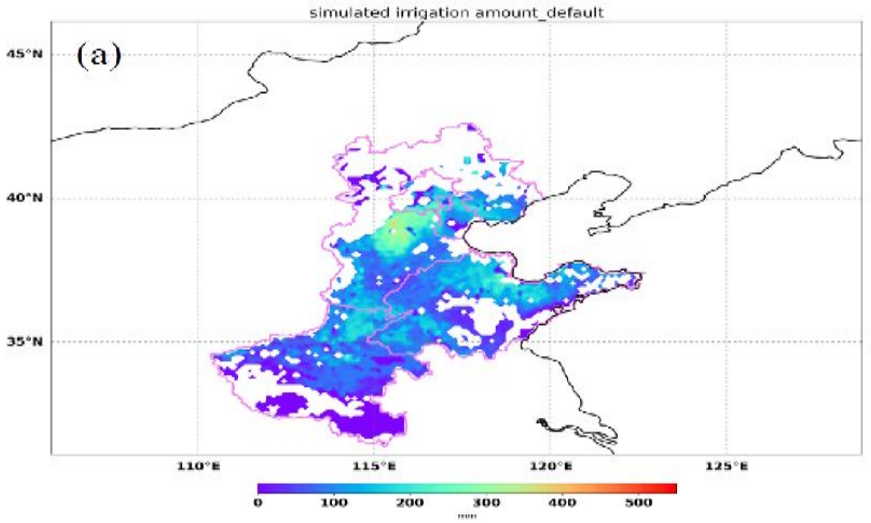
(c) FIRTFAC



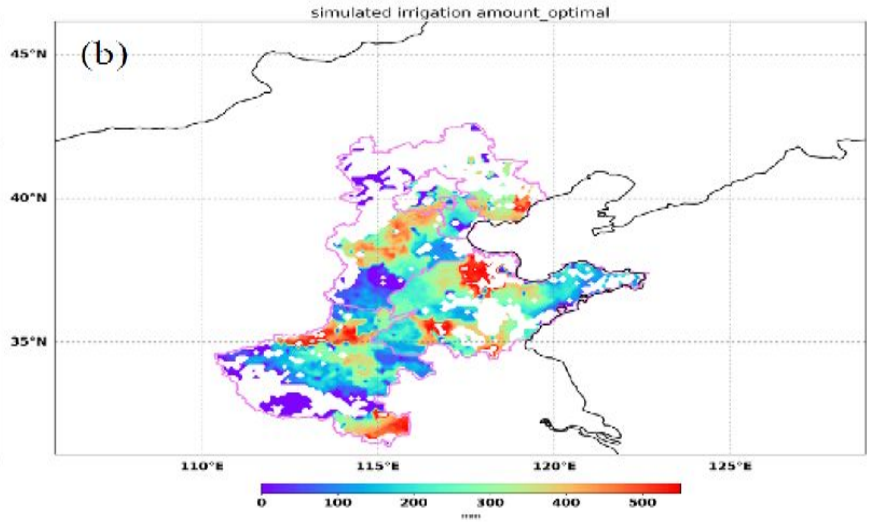
- Irrigation parameter calibration work is carried out in 48 prefectures over NCP.

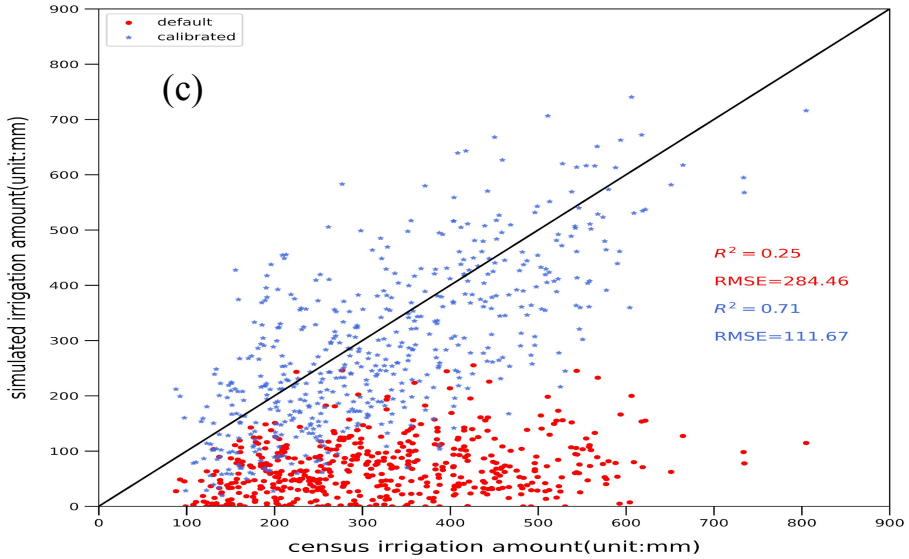
Irrigation water use simulation results

Default simulation



Calibrated simulation

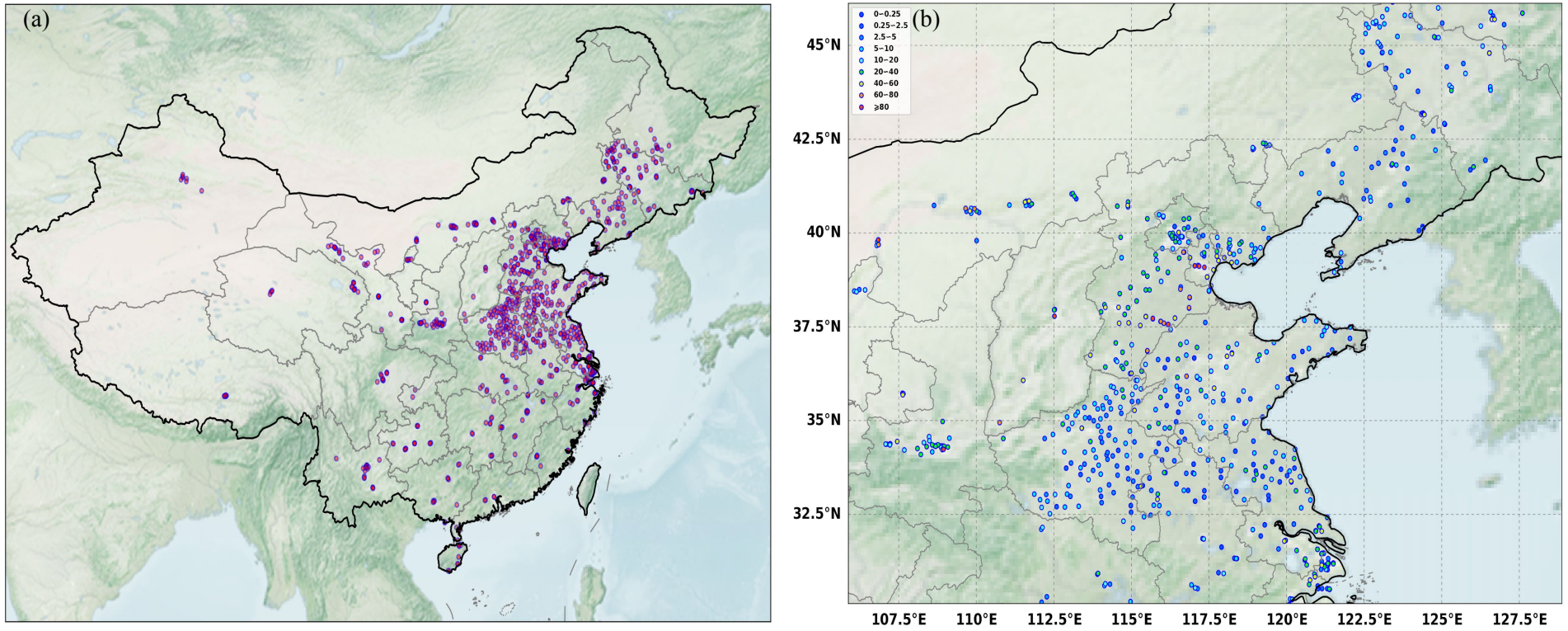




- The calibrated irrigation parameters improves the simulated irrigation water use in agreement with census data at prefecture level

Application two: groundwater-fed irrigation impacts on water storage

data preparations

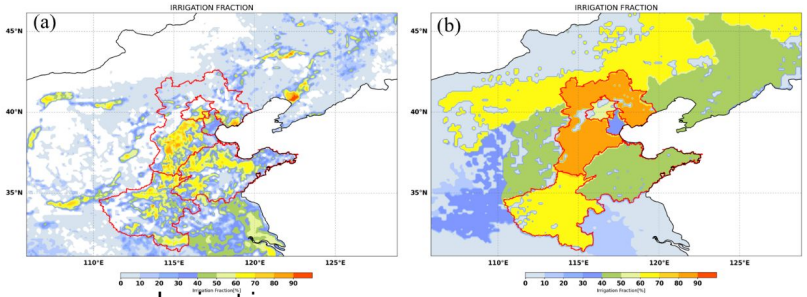


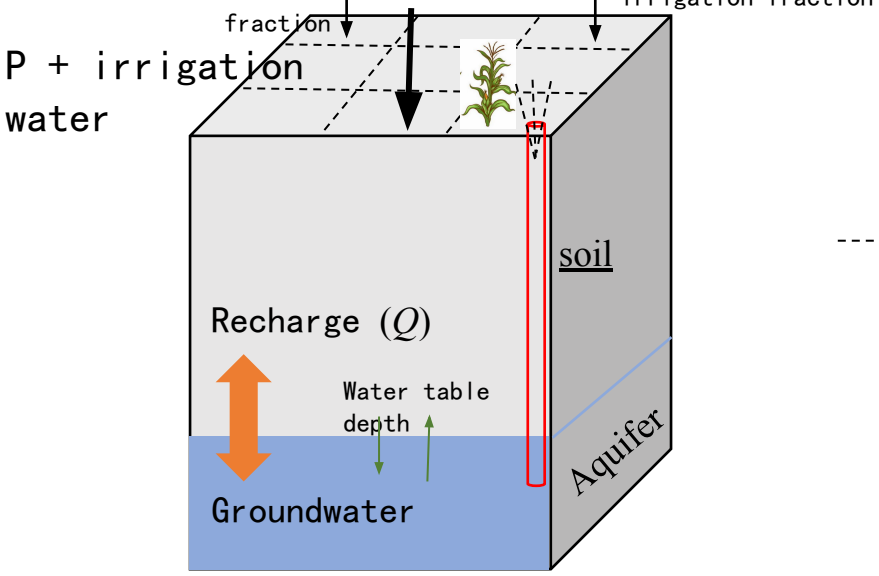
- Spatial distribution map of groundwater level monitoring wells. (a) China (b) research domain

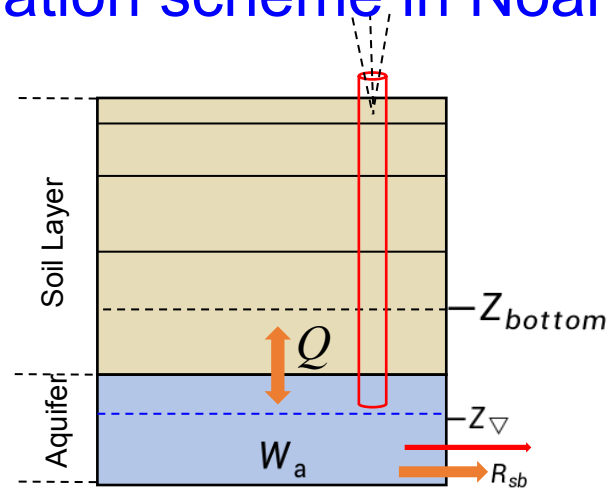
◆ `water table depth` data source: Geological environmental monitoring of groundwater level yearbooks of China

◆ The monthly observed groundwater level data from 2005 to 2016.

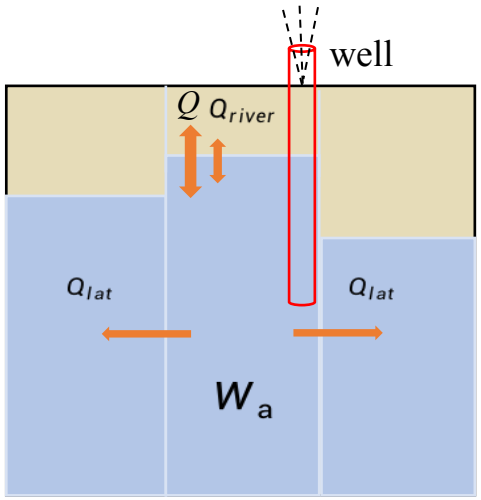
Incorporate groundwater-fed irrigation scheme in Noah-MP model



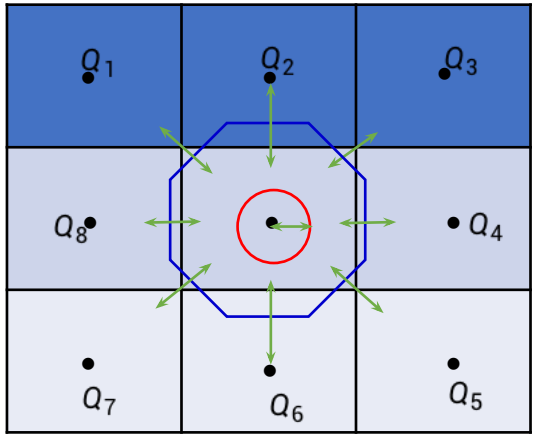




SIMGW Scheme
Niu et al.2007



MMF Scheme
Fan et al.2007



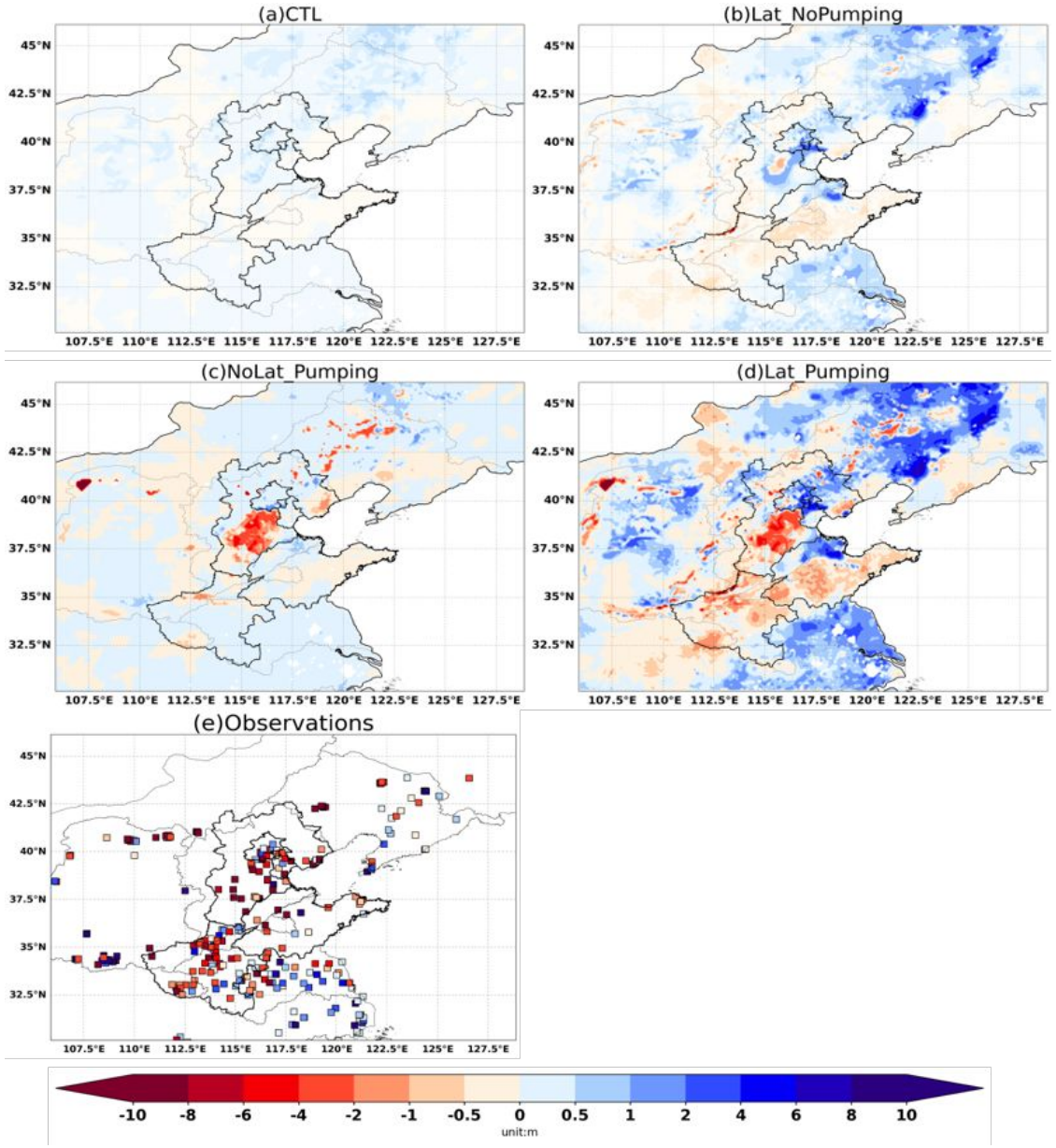
Experiments design

Experiments	Parameter calibration	Lateral-flow	Pumping
CTL	No	No	No
Lat_NoPumping	No	Yes	No
NoLat_Pumping	Yes	No	Yes
Lat_Pumping	Yes	Yes	Yes

- Simulation driven with CMFD forcing data (0.1°)
- Simulation spanning from year 2000 to 2015
- Spin-up time is 120 years

Results

Cumulative water table depth change

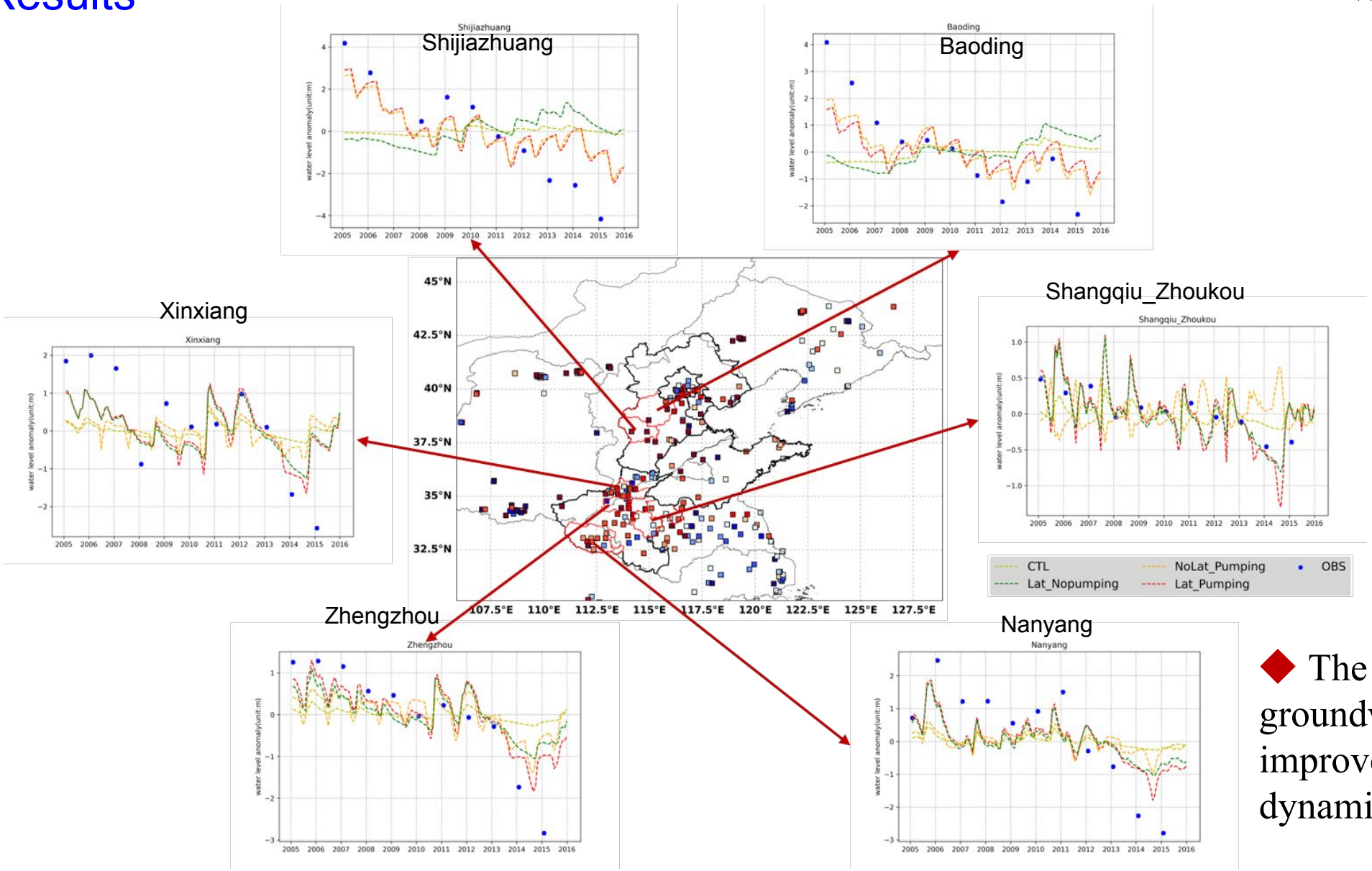


- The cumulative changes in groundwater level during the period from 2005 to 2015 (unit: m)

- The Lat_Pumping experiment based on the MMF scheme is consistent with the spatial distribution of observed groundwater level changes in wells.

Results

Water table depth change

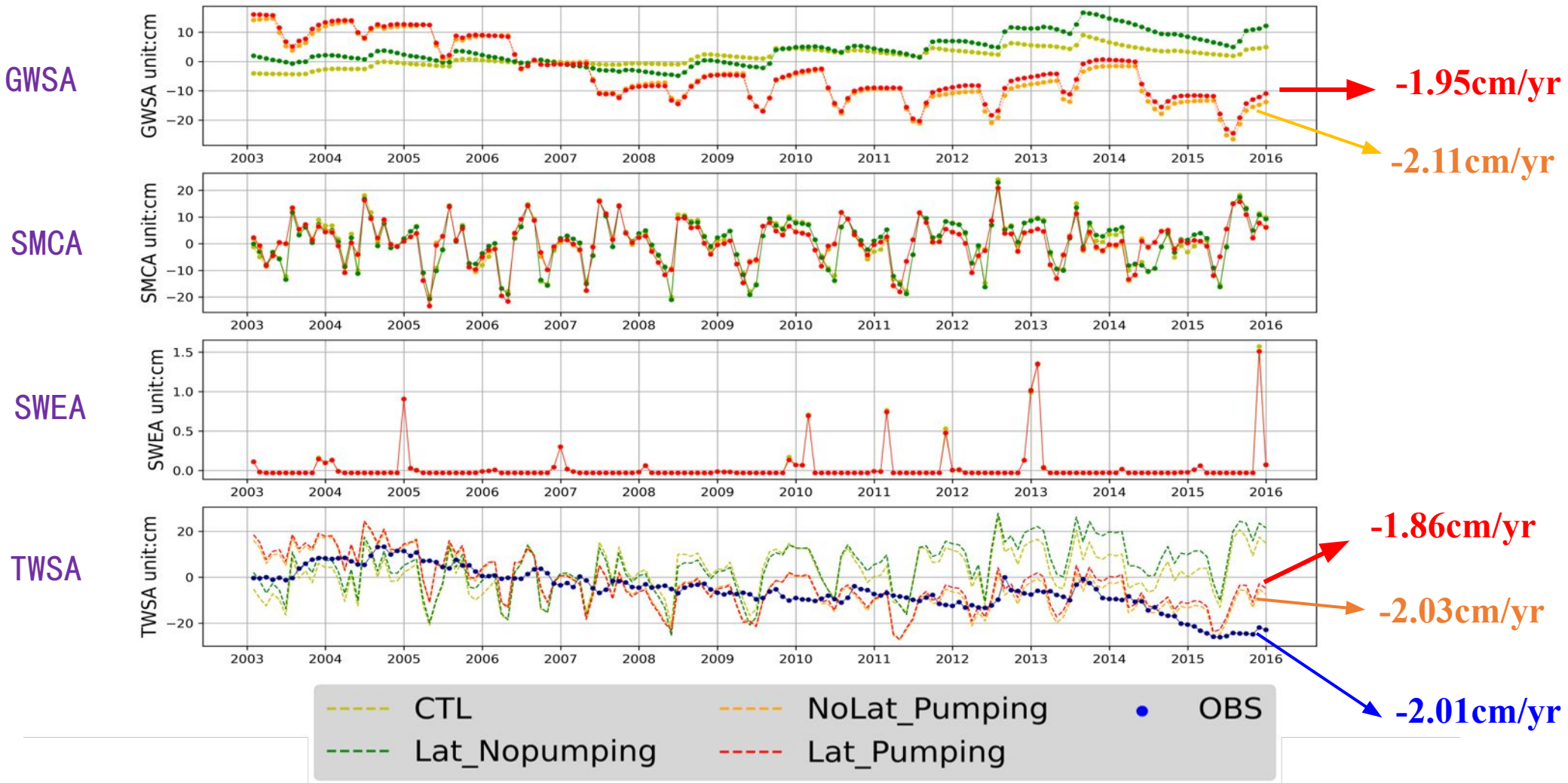


◆ The representation of groundwater-fed irrigation improves groundwater dynamics simulation.

• Time series plot depicting the anomalies of groundwater levels from 2005 to 2015.

Results

terrestrial water storage change



◆ Comparing with the declining trend in terrestrial water storage (-2.01 cm/year) observed by the GRACE satellite, both the NoLat_Pumping experiment (-2.03 cm/year) and the Lat_Pumping experiment (-1.86 cm/year) can effectively simulate the declining trend in terrestrial water storage.

Summary and application

- presenting an automatic parameter calibration framework integrated with Noah-MP model to improve estimation of irrigation water use.

- incorporating groundwater-fed irrigation module helps reproduce the terrestrial water storage trend in land surface model.

- including more human activities in land surface model is called for in the future work