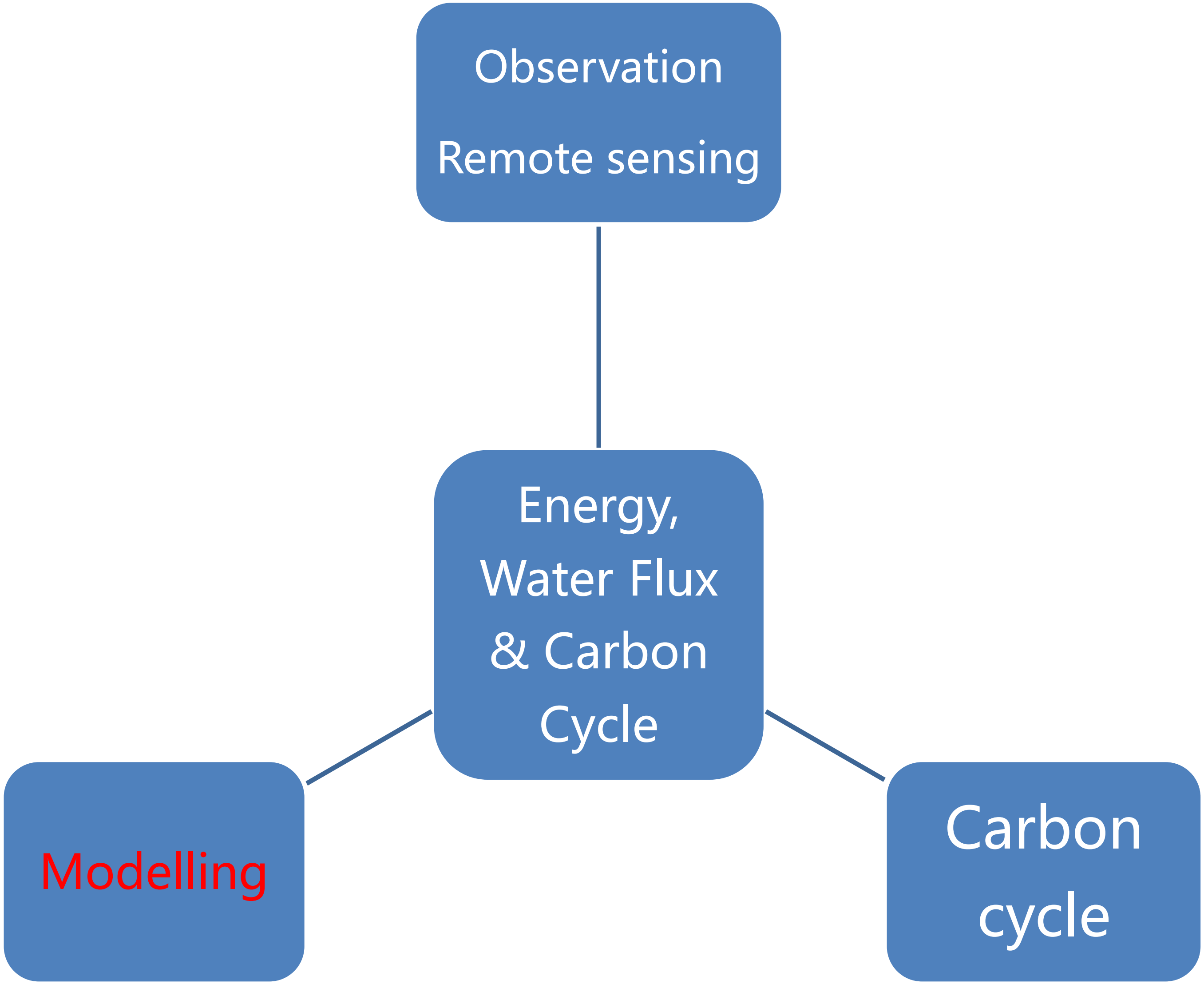
Energy, Water Flux & Carbon Cycle

Weiqiang Ma

ITP, CAS

2019.11.21

Chongqing

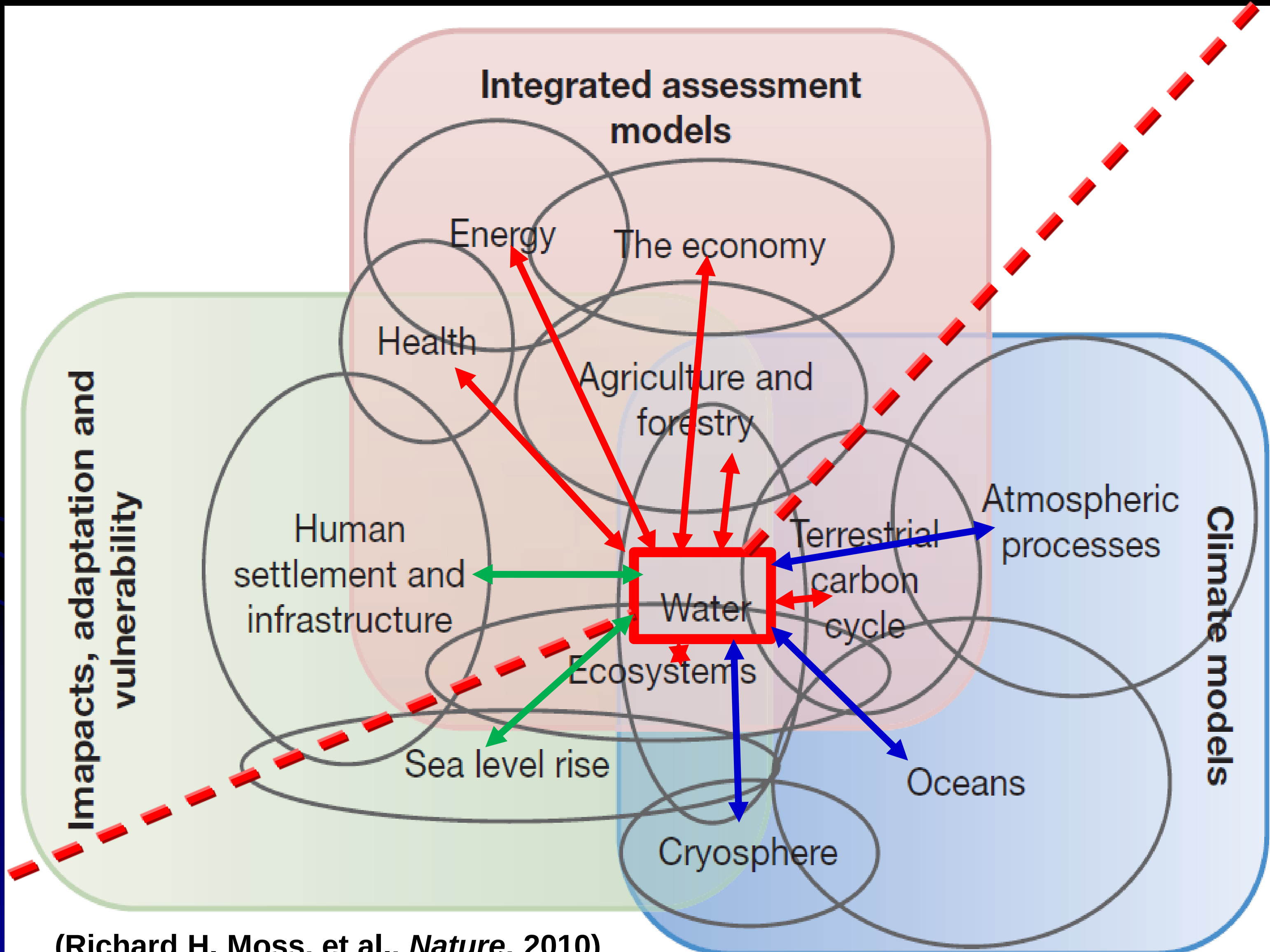

Observation
Remote sensing
Energy, Water Flux & Carbon Cycle
Modelling
Carbon cycle

Modeling of Land Surface Fluxes on the regional climate of the Tibetan Plateau

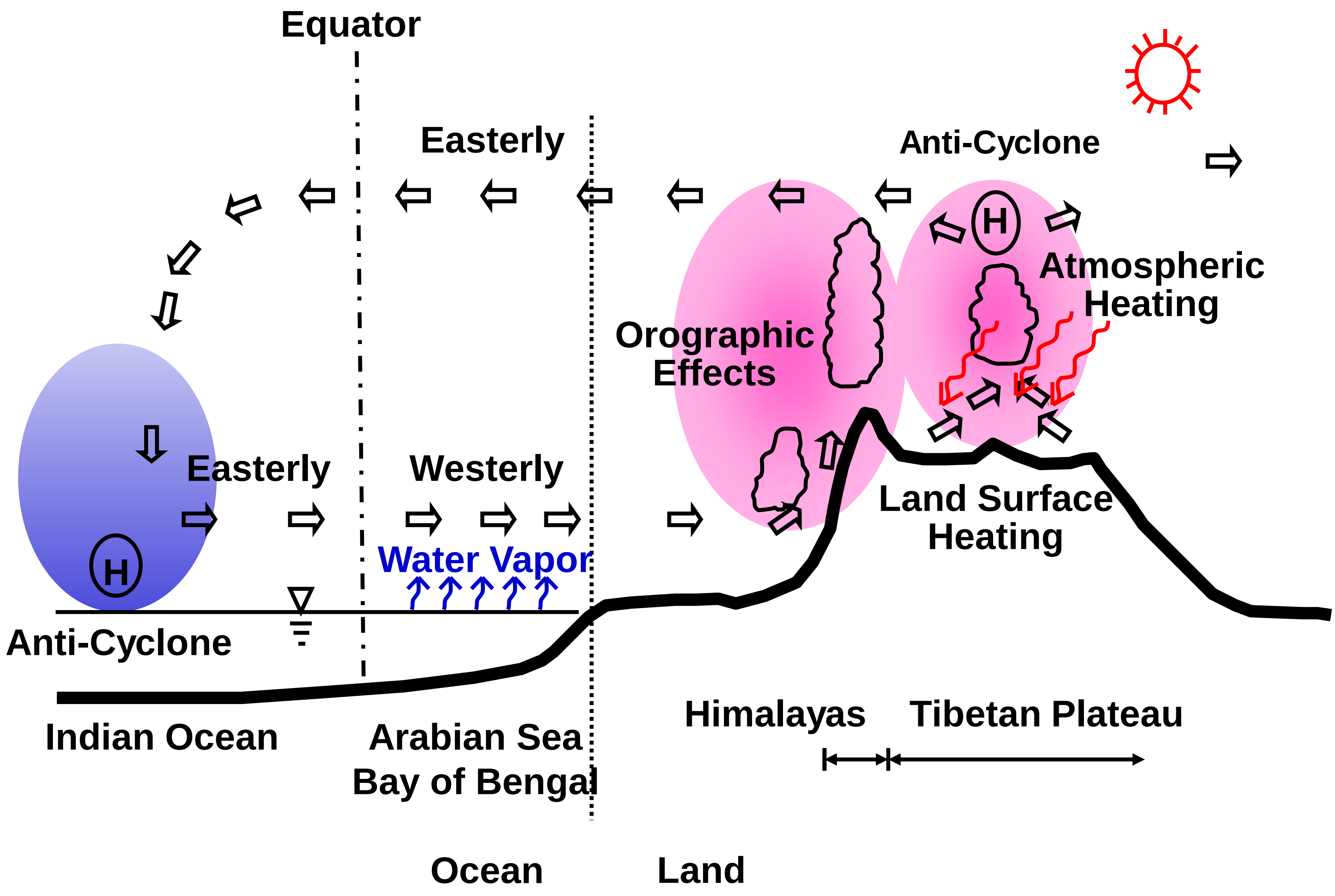
Outline

- **Soil moisture, Why?**
- **Methodology**
- **Next step**

Water is a Key bridging between climate processes and societal benefits.



(Richard H. Moss, et al., *Nature*, 2010)

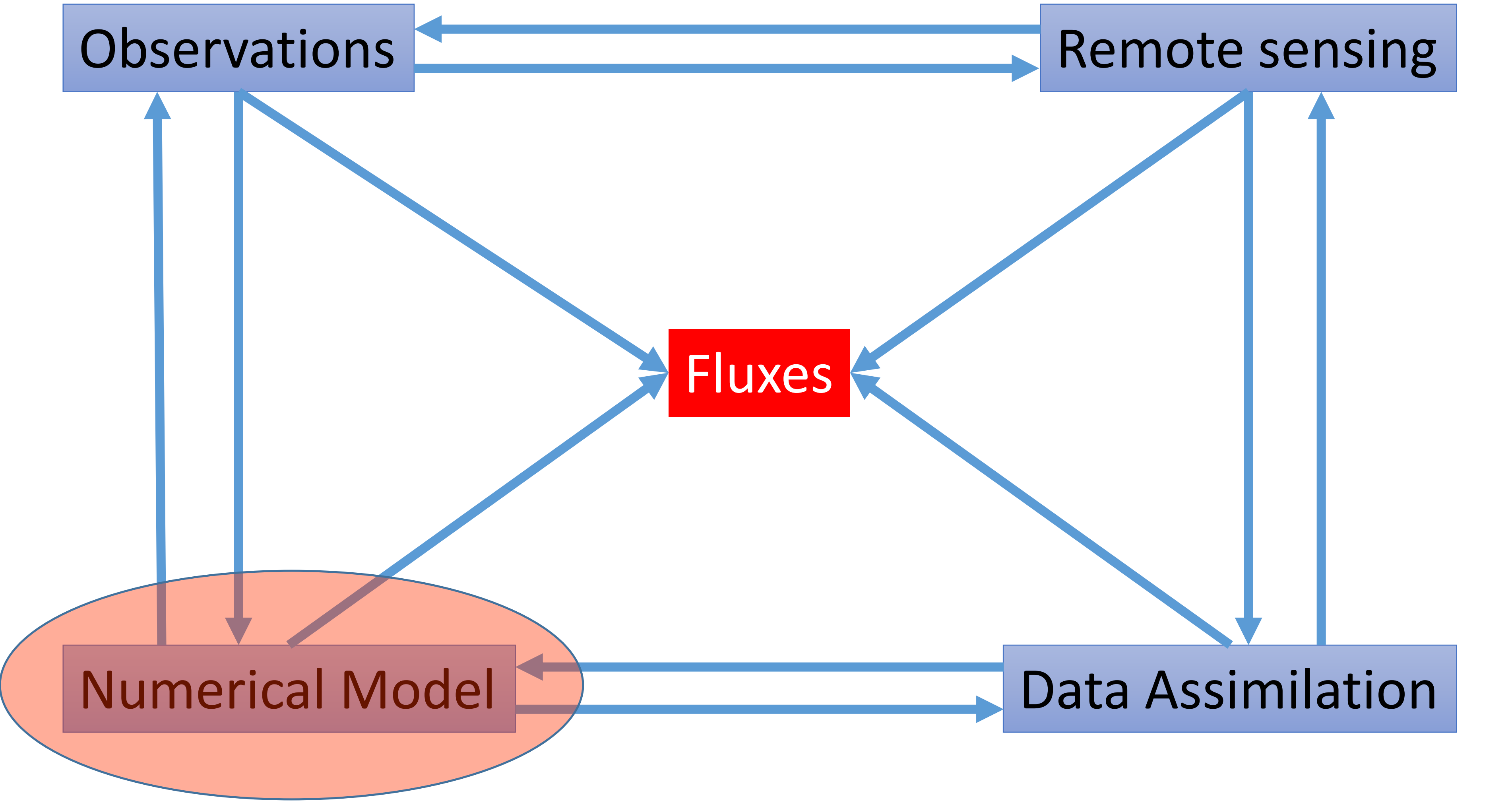

Equator
Easterly
Anti-Cyclone
H
Atmospheric Heating
Orographic Effects
Easterly
Westerly
Land Surface Heating
Water Vapor
H
Anti-Cyclone
Himalayas
Tibetan Plateau
Indian Ocean
Arabian Sea
Bay of Bengal
Ocean
Land

From T. Koike

Land surface process, do?

The basic physics of land surface processes affect atmospheric circulation and climate change, one of the biochemical processes, a more accurate prediction of momentum, energy, material, radiation exchange, has become an urgent need for global climate change research.

How: Land surface heat fluxes?



The sensitivity of the climate system to a different land surface:

1. The response of the climate on surface albedo (Charney,1975)

Sahel, The biological - Geophysical feedback, Overgrazing→Albedo→Change the surface energy→Radiant heat source→Atmospheric cooling sink→Exacerbates drought→Vegetation degradation.

0.14→0.35, ET reduce, Precipitation by half, Precipitation belt in South, Intensify droughts.

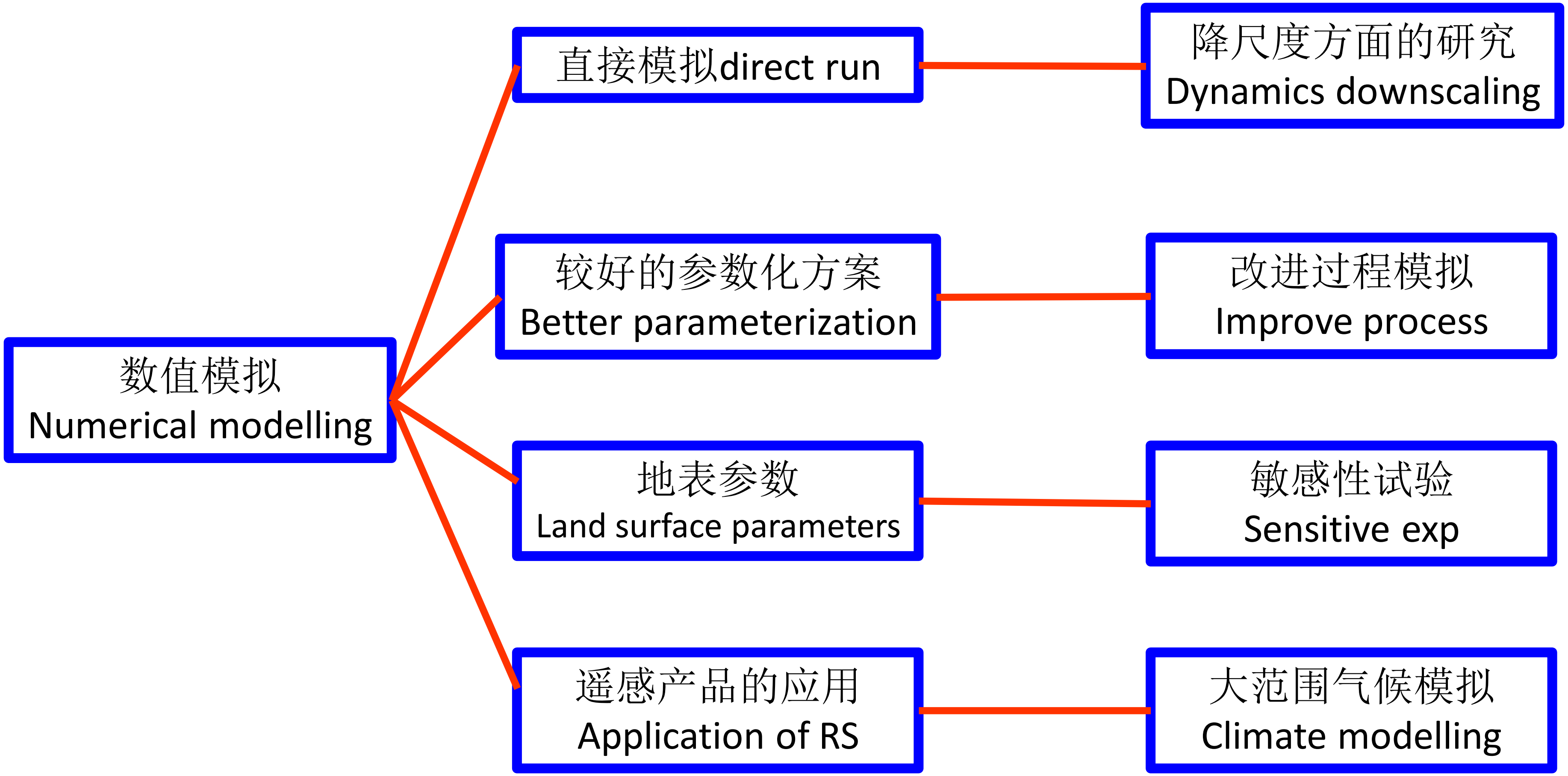
2. The response of the climate on soil moisture (Shukla,1982)

Control the distribution of H and lE, diff SM, change albedo, Water and heat balance, Vegetation supply water, infiltration.

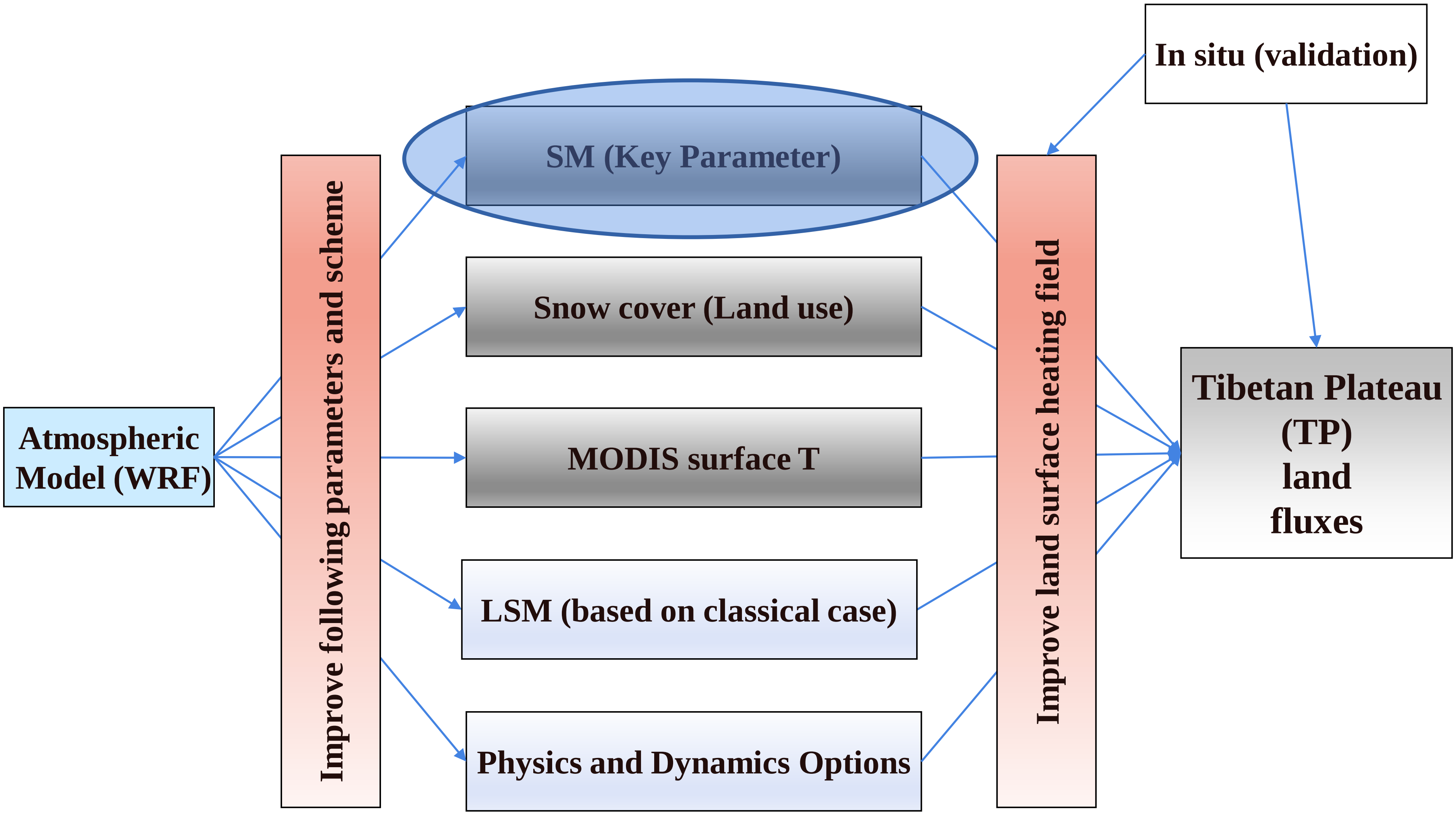
3. The response of the land surface roughness (Sud, 1985)

4. Land use / land cover on the impact of climate change (Dale,1997)

closely related with the surface fluxes, accurate surface fluxes study is particularly important!


数值模拟
Numerical modelling
直接模拟direct run
较好的参数化方案
Better parameterization
地表参数
Land surface parameters
遥感产品的应用
Application of RS
降尺度方面的研究
Dynamics downscaling
改进过程模拟
Improve process
敏感性试验
Sensitive exp
大范围气候模拟
Climate modelling

Tool: WRF


In situ (validation)
SM (Key Parameter)
Improve following parameters and scheme
Snow cover (Land use)
Improve land surface heating field
Atmospheric Model (WRF)
MODIS surface T
Tibetan Plateau (TP) land fluxes
LSM (based on classical case)
Physics and Dynamics Options

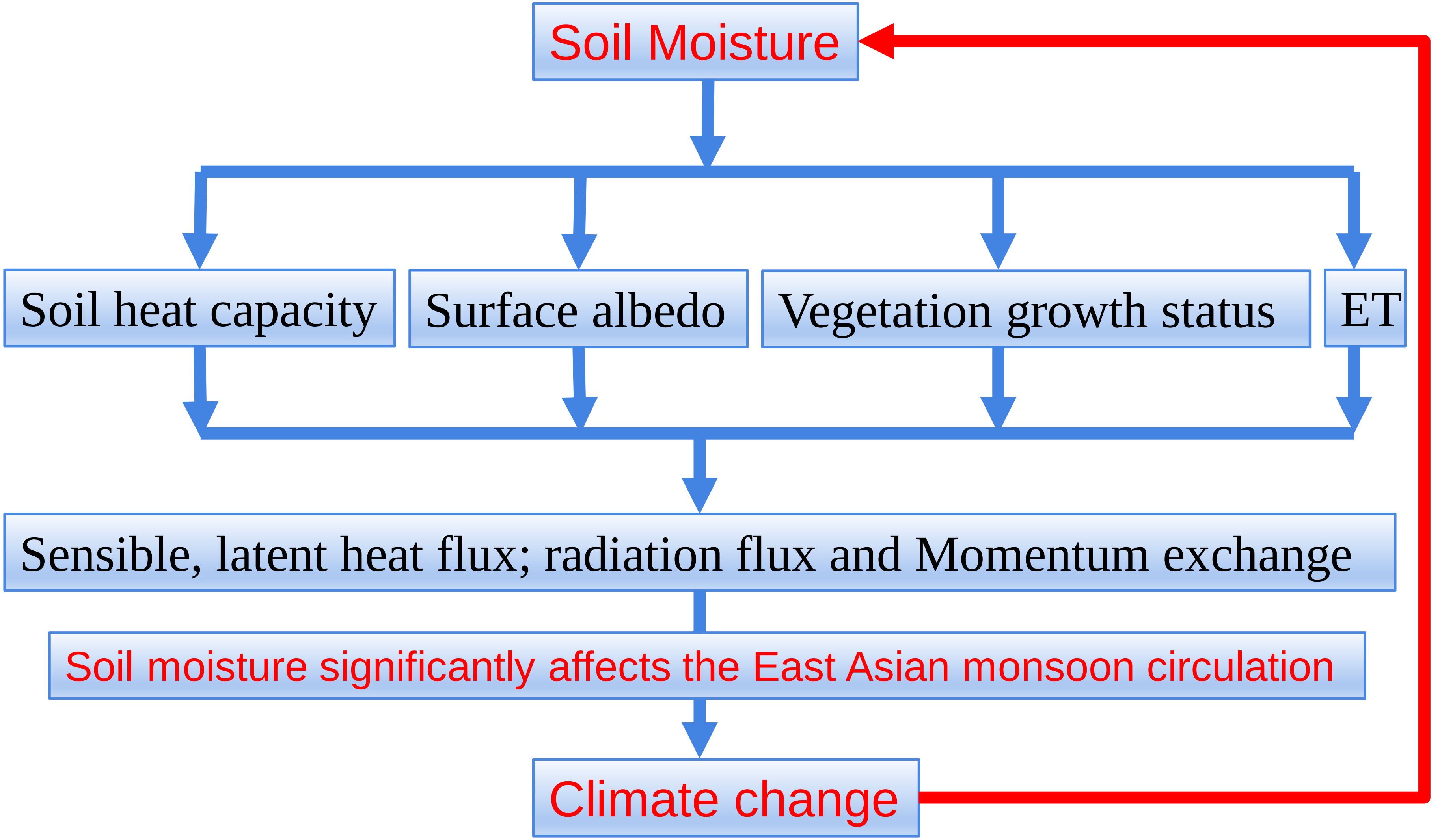
Why Soil Moisture?

- **Namias (1958) first discovered: it is important for seasonal soil moisture anomalies on seasonal atmosphere.**
- **Manabe (1965). As an important aspect of the process of land surface hydrology studies, recent research related to soil moisture are also affected by climate and hydrologists attention.**
- **Henderson Sellers (1965) emphasized the research on soil moisture.**
- **Chahine (1992): on land, 65% of the precipitation from the land surface evaporation, 35% from the ocean moisture transport, which shows a large extent of land surface evaporation of precipitation from the land surface, and the evaporation is closely related to soil moisture.**

Soil Moisture related to climate change

- **Yeh (1965) emphasized the research on soil moisture.**
- **Walker and Rowntree (1977). Sensitive experiments. Dry soil can make future temperatures rise, wet soil can sustain the late rainfall.**
- **Sukala and Mintz (1982) simulated dry and wet soil. It has a big difference between dry and wet soil for later precipitation and temperature.**
- **Chahine (1984): using GCM. Research irrigation impact on climate. Soil moisture increases, →the precipitation increases and the temperature decreases.**

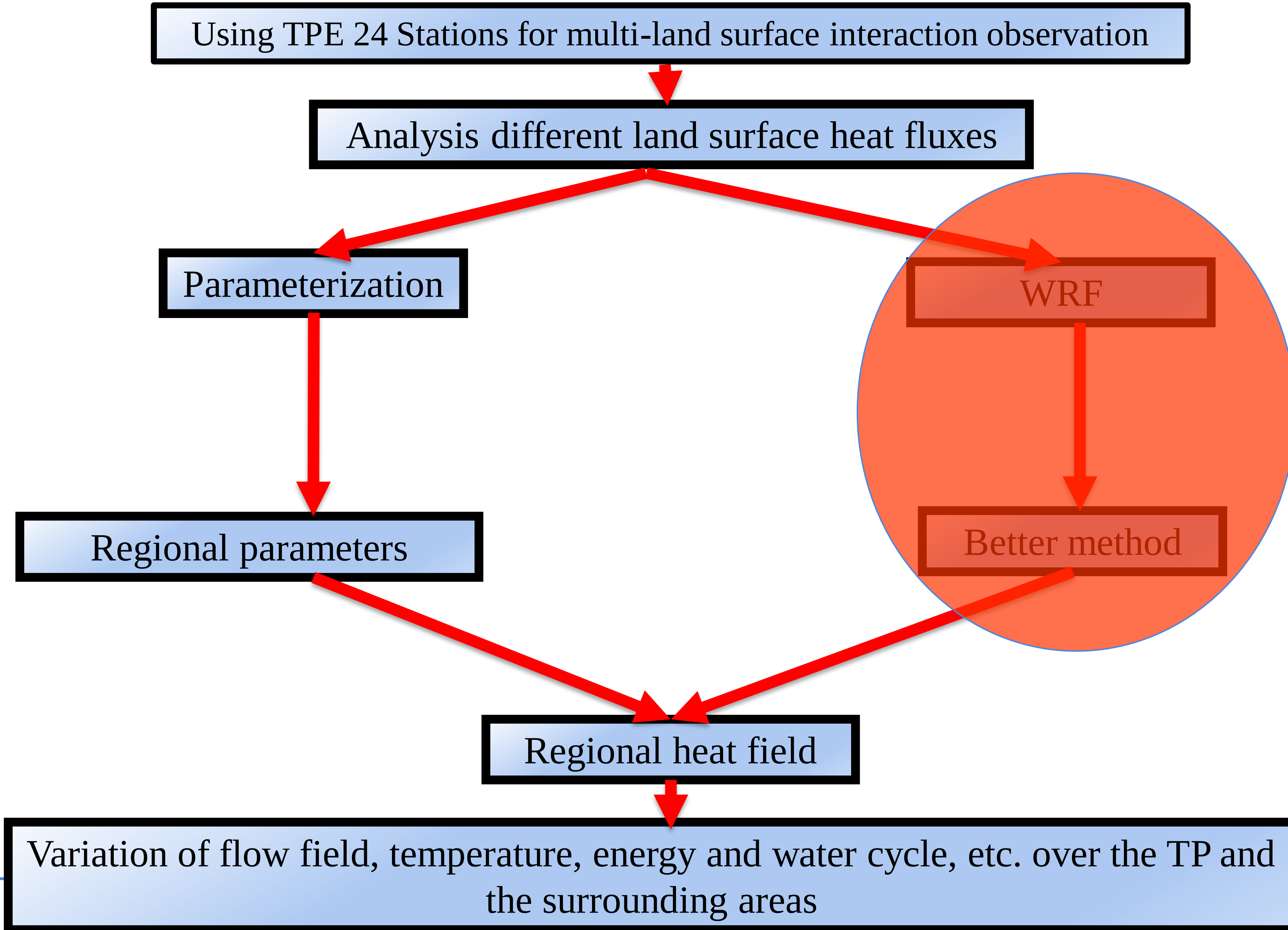
Physical image of the impact of soil moisture on climate change



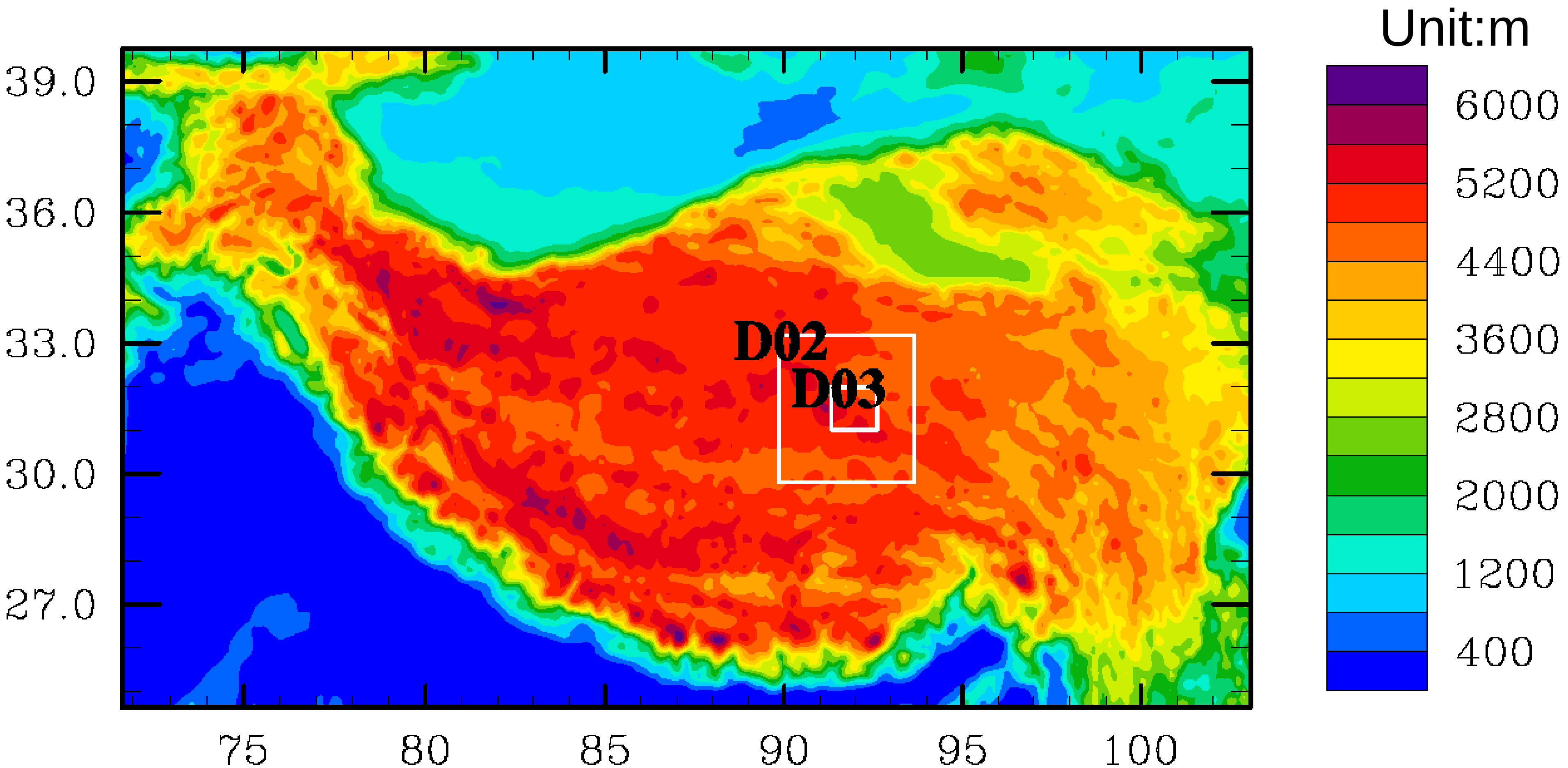
Kim, Jung-Eun, Song-You Hong, 2007: Impact of Soil Moisture Anomalies on Summer Rainfall over East Asia: A Regional Climate Model Study. *J. Climate*, 20, 5732–5743.

What can I do?

- Soil Moisture is very important for land-surface interaction. SM was used and replaced the WRF initial SM values in the Tibetan Plateau.
- To test how much effective in the model?
- compare the model results and in-situ data.


Using TPE 24 Stations for multi-land surface interaction observation
Analysis different land surface heat fluxes
Parameterization
WRF
Regional parameters
Better method
Regional heat field
Variation of flow field, temperature, energy and water cycle, etc. over the TP and the surrounding areas

Modeling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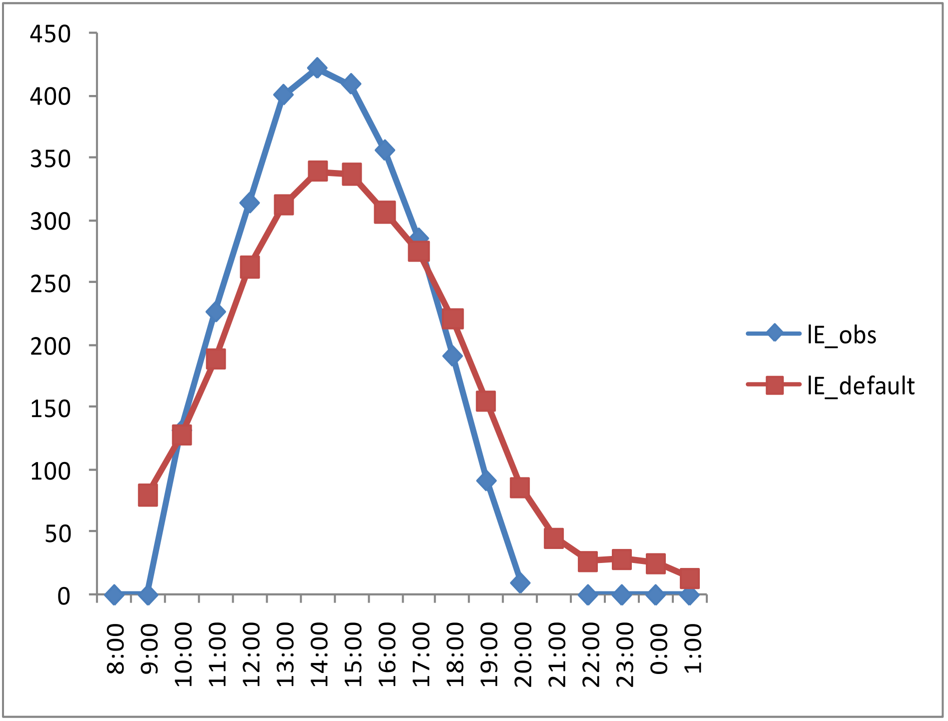
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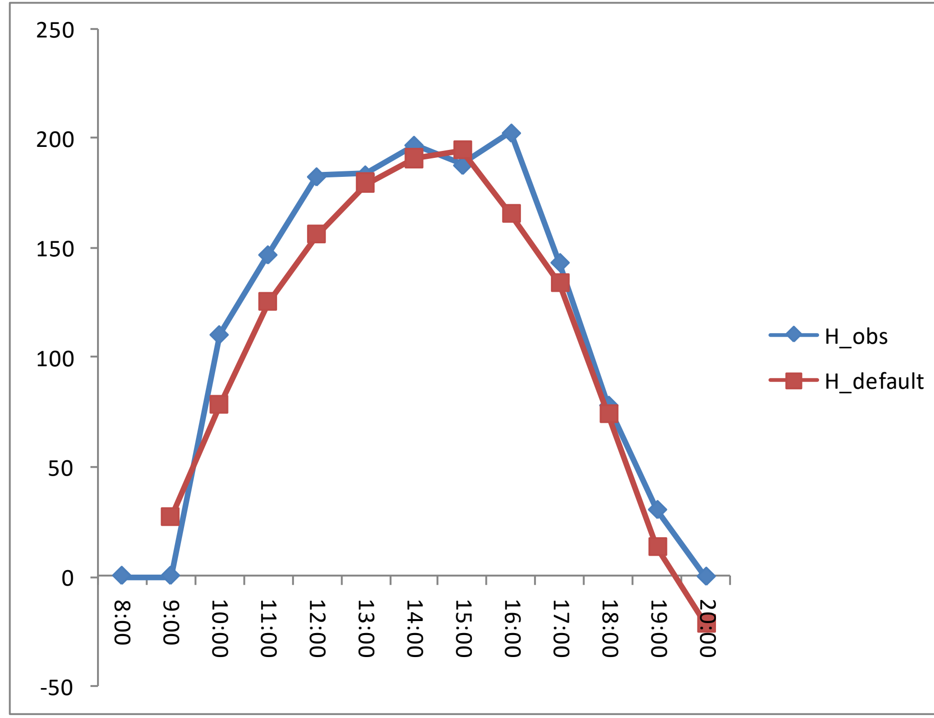
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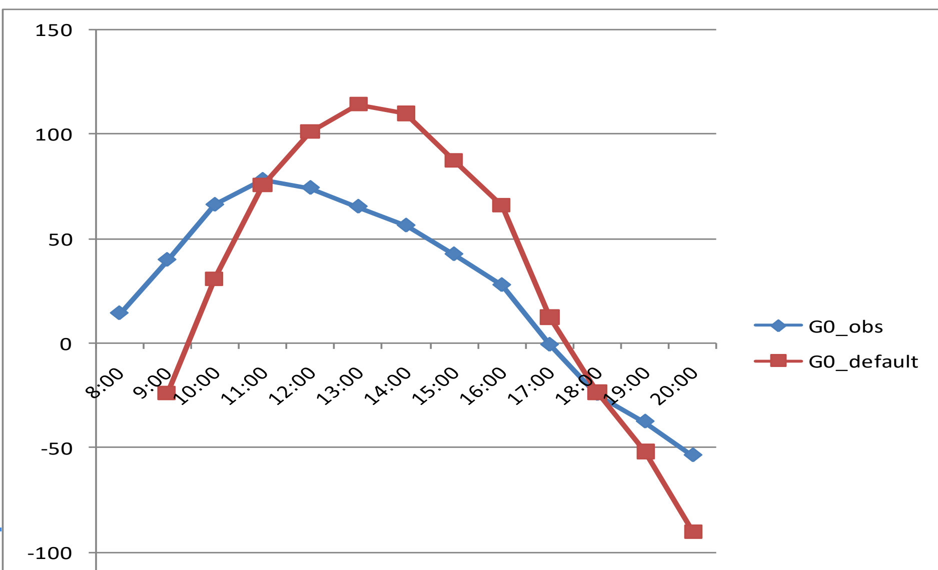
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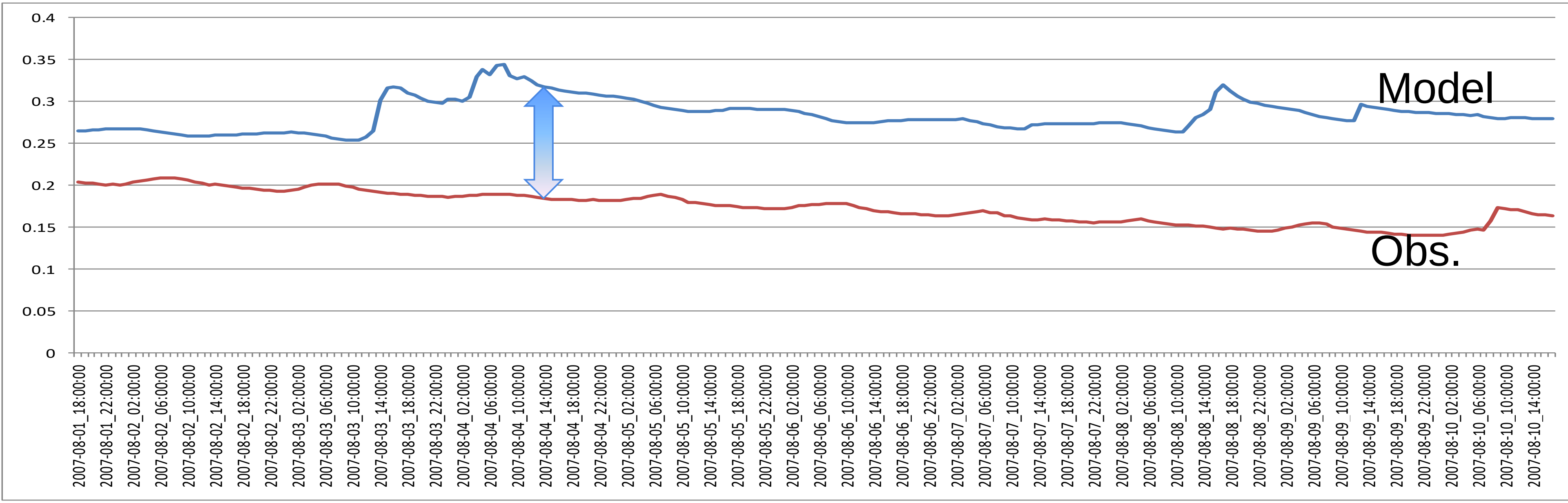
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0.05
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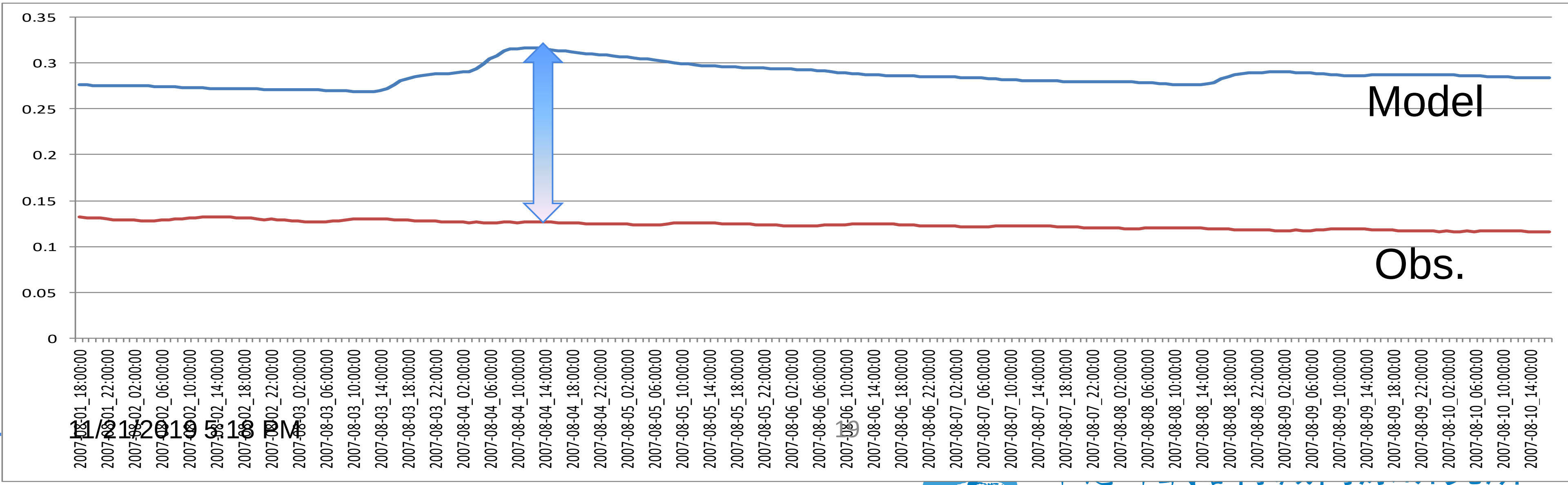
Model
Obs.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0.1
0.05
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Model
Obs.

Case studies

Default

↓

Soil Moisture

↓

Soil Temperature

↓

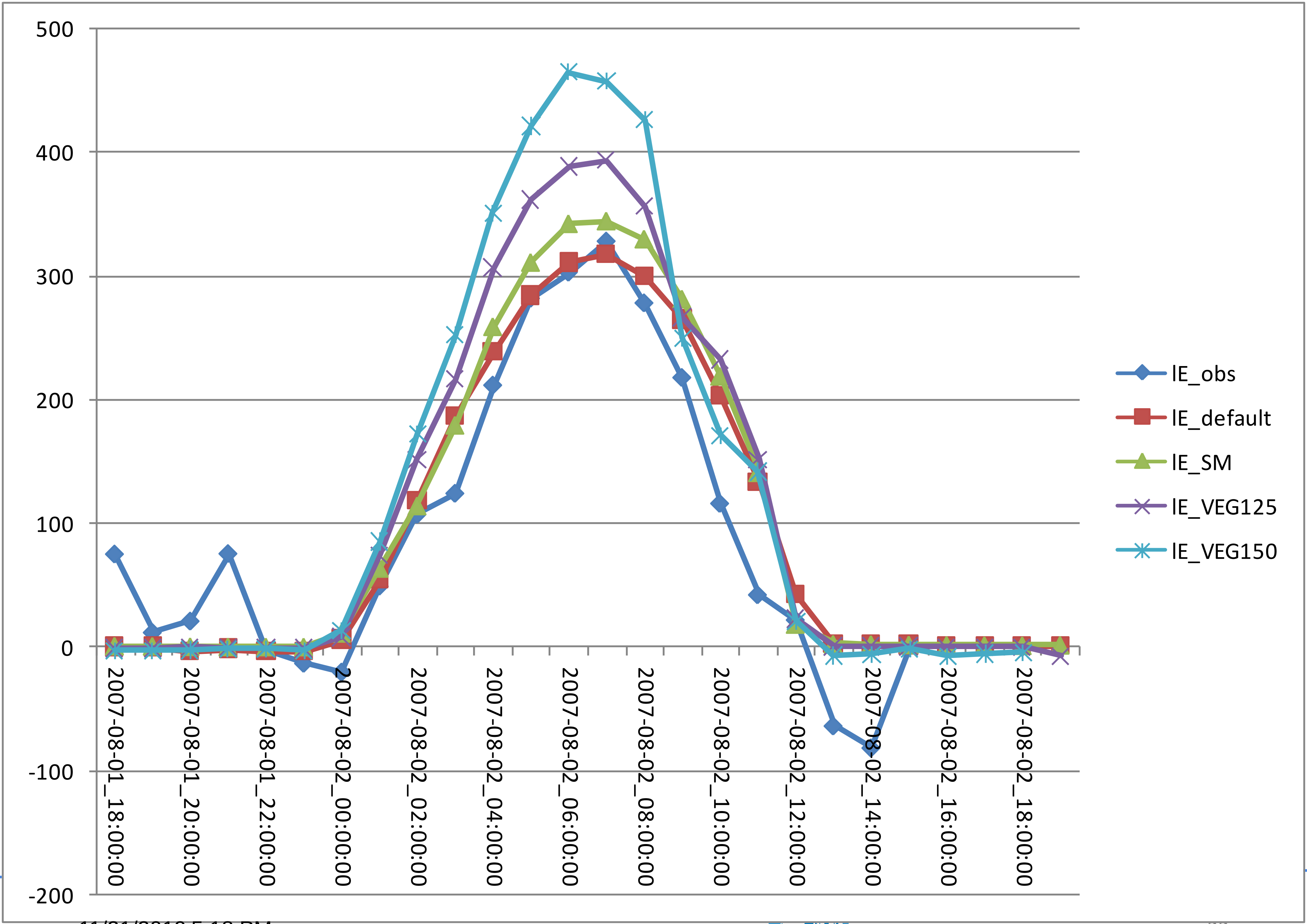
Vegetation coverage

↓

Vegetation coverage…

Experiments

Default (case1)	WRF FNL(1deg, 6 hourly)
SM (case2)	WRF SM1 0.5; SM2 0.55; SM3 0.928; SM4 0.57
SM-ST (case3)	WRF ST1.031; ST2 1.028; ST3 1.025; ST4 1.033
Vegetation Coverage (case4)	Based on the NDVI, increase 25% (good)
VEGFRA increase (case5)	Based on the NDVI, increase 50% (little big)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2007-08-02_02:00:00
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2007-08-02_16:00:00
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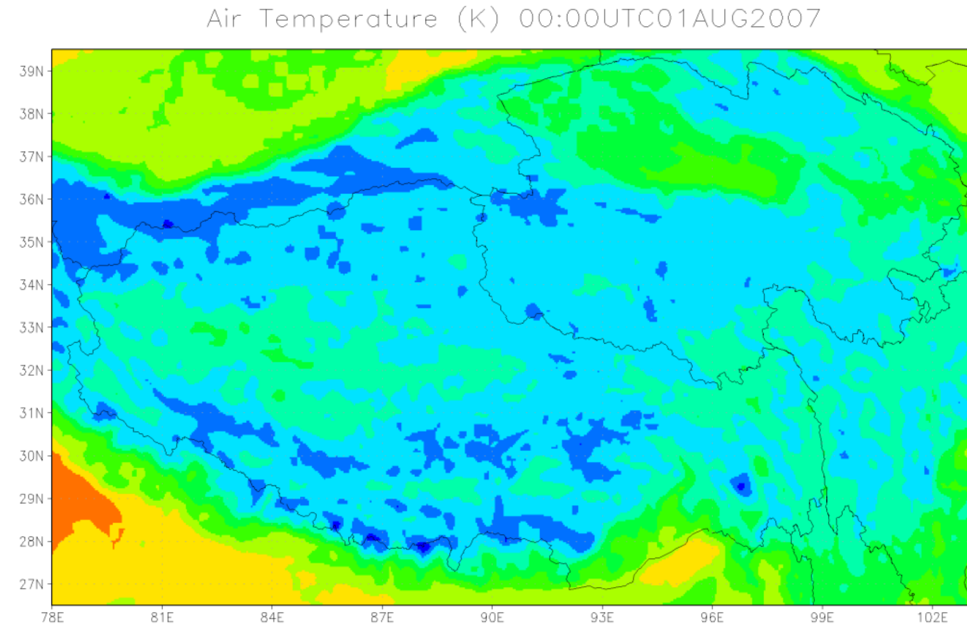
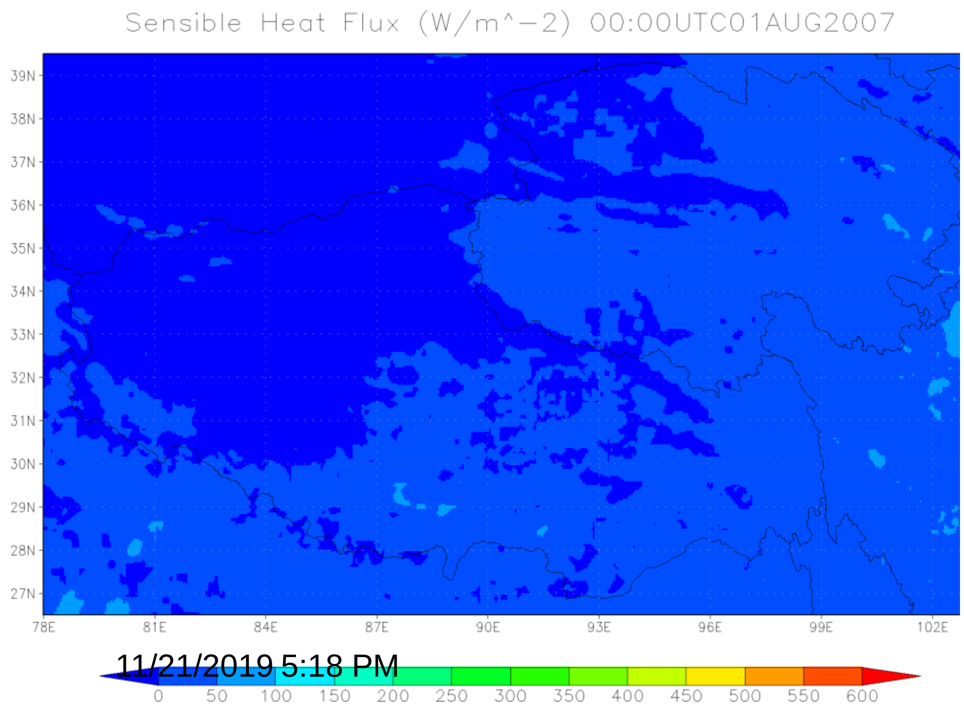
lE_SM
lE_VEG125
lE_VEG150

Model results for each hour





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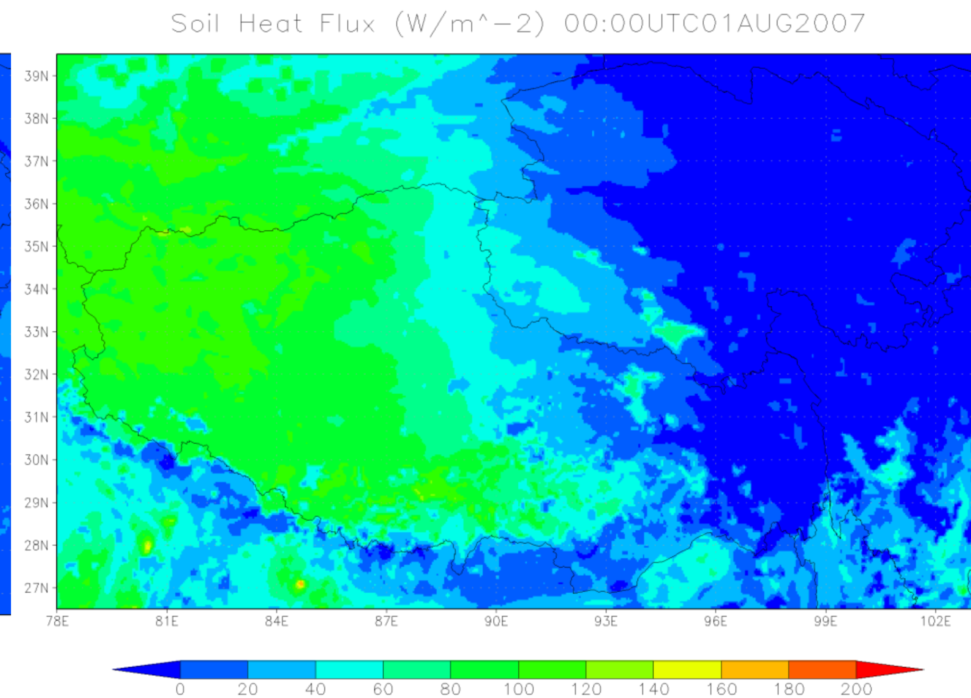

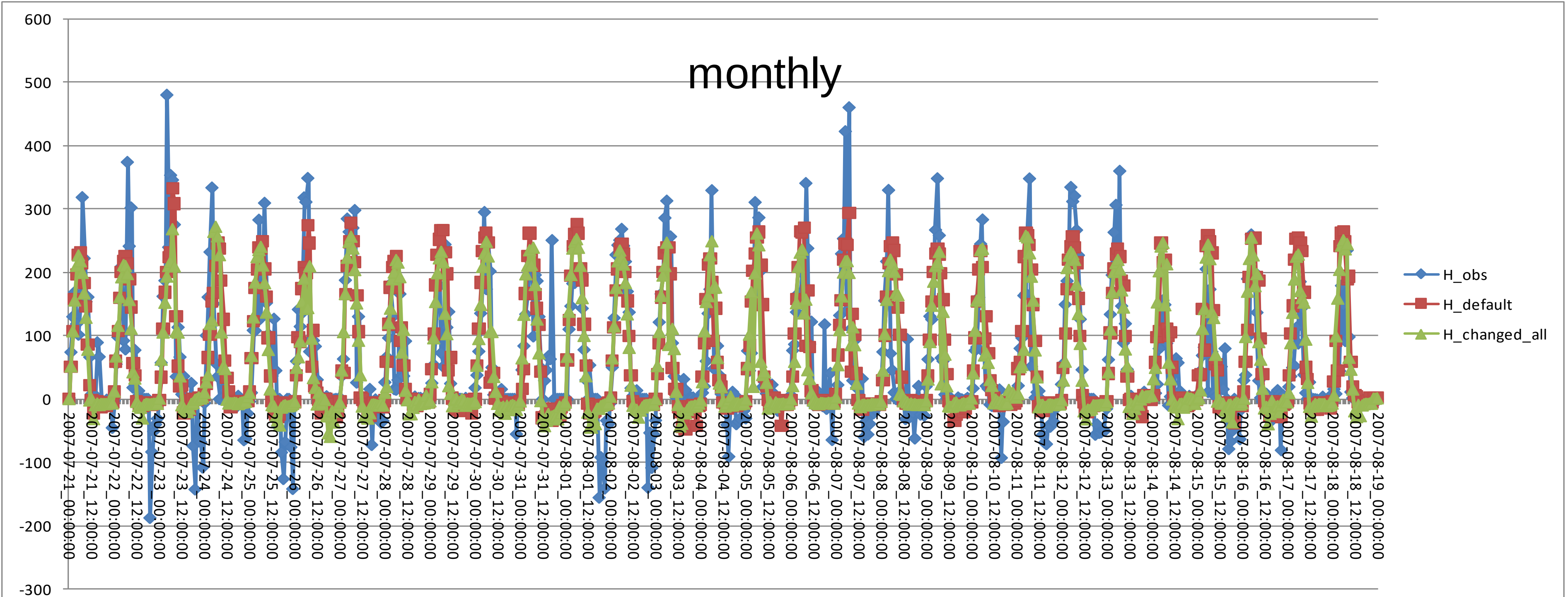
monthly
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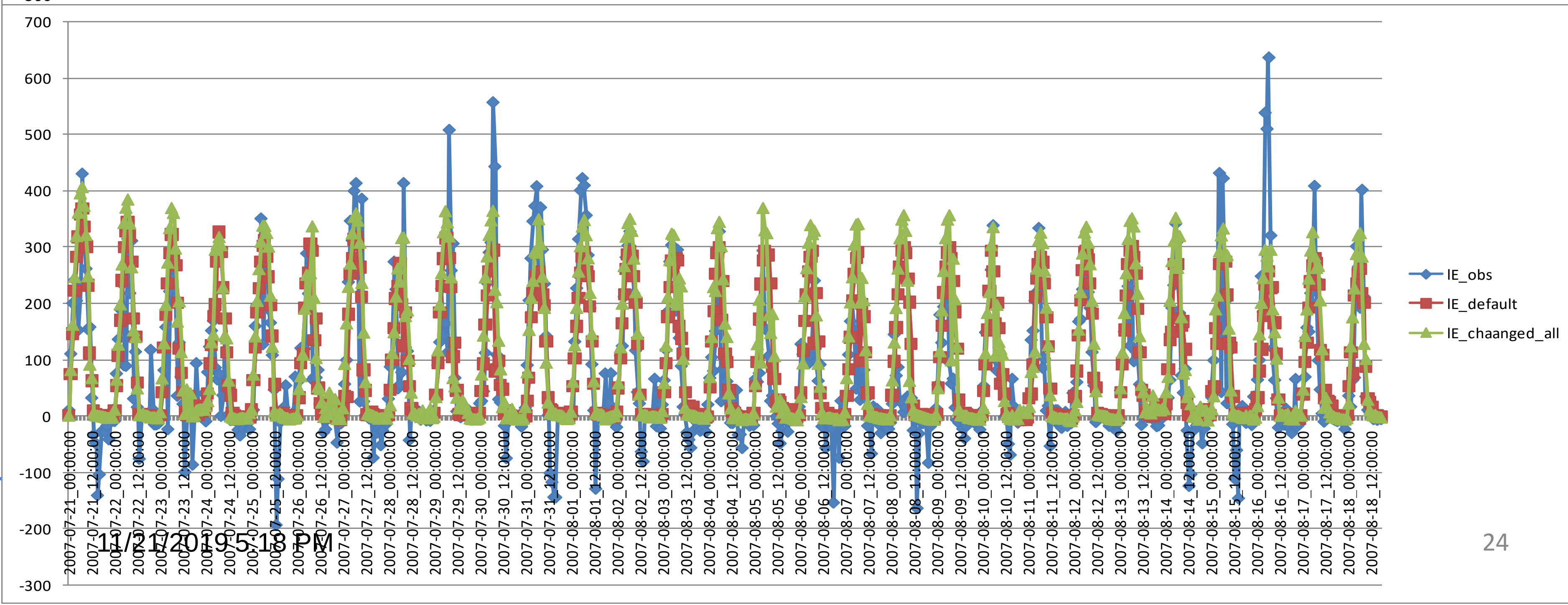
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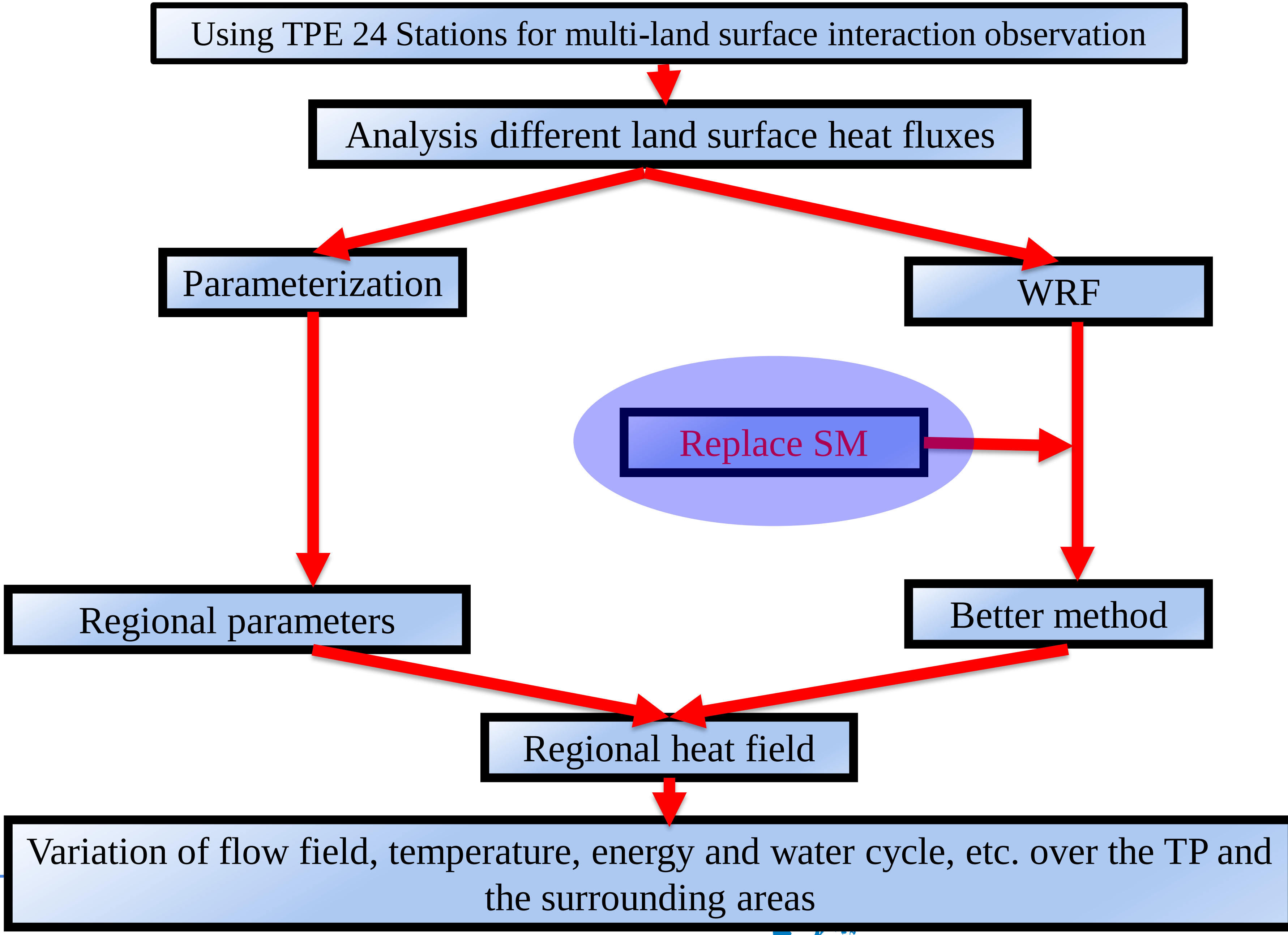
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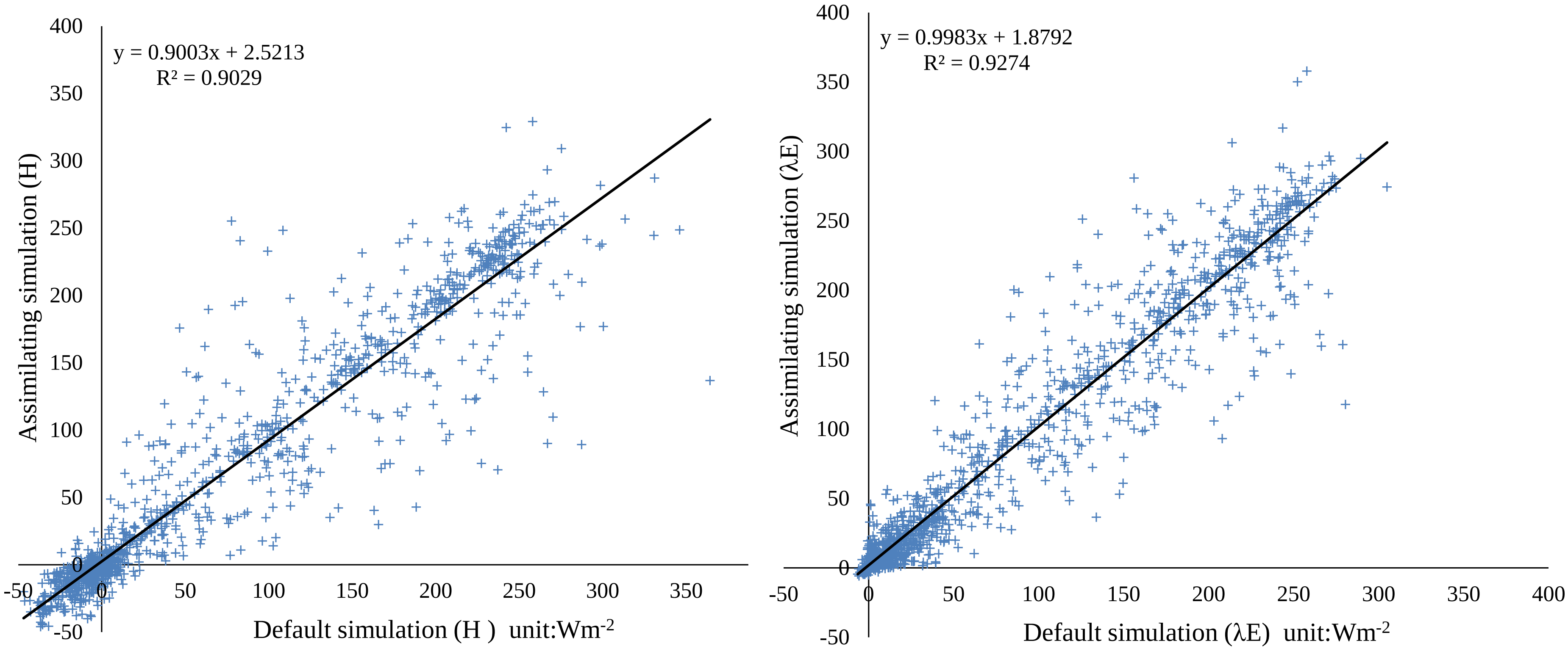
Physical Options

- Based on a series of tests, a set of physical options were selected for subsequent WRF simulations. The simulations used the Kessler microphysics scheme.
- The Rapid Radiative Transfer Model (RRTM) and the Dudhia shortwave radiation scheme were used to calculate the longwave and shortwave radiation.
- The surface layer physics was based on the Monin-Obukhov and standard similarity functions.
- Noah land surface model was chosen for the land surface physics model.
- Yonsei University scheme was selected for the planetary boundary layer physics.
- Cumulus clouds were simulated using the Kain-Fritsch convection scheme.

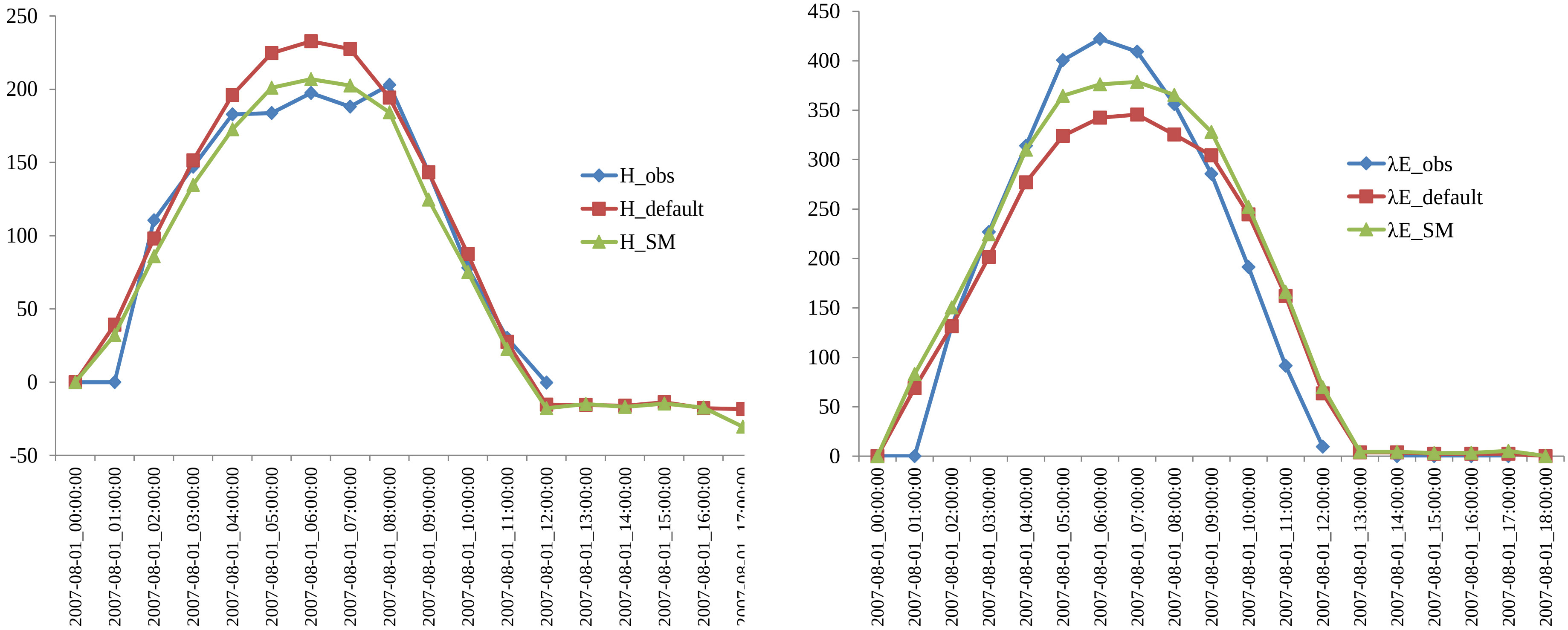
The simulations from1 July 2007 to 30 August 2007.
The 6-h NCEP FNL data used for the the initial and lateral boundary conditions for the WRF simulations.

- **Case 1: This experiment used the default values for all parameters of the WRF model. The domain was designed based on the USGS 1-km terrain data, and the soil parameters were obtained from the NECP FNL analysis dataset.**

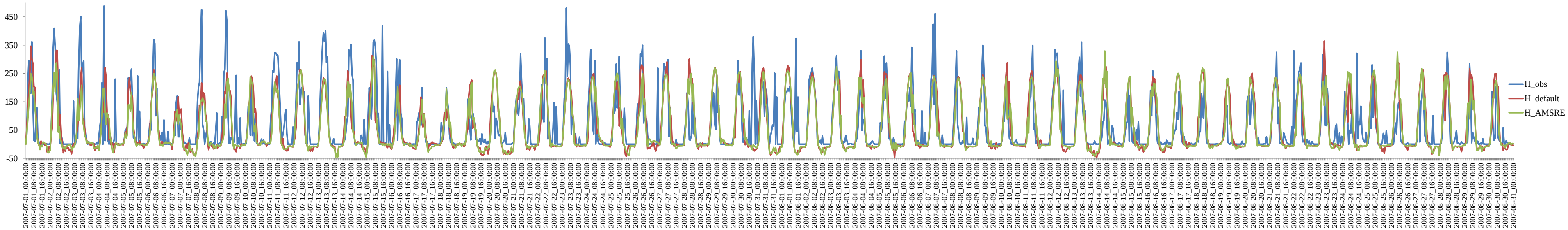
- **Case 2: In this case, the initial SM values were changed in the first layer of WRF model using the Noah land surface model and based on AMSR-E SM data.**

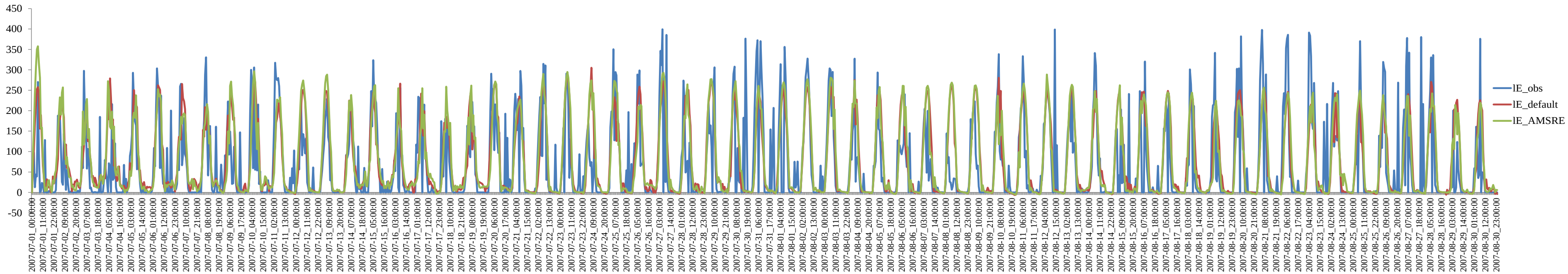


Scatter diagrams of H and λE estimated using the default and assimilation WRF model simulations.



Comparisons of the sensible and latent heat fluxes obtained from the in situ data, default model configuration and assimilation experiment (units: Wm^{-2}).





Comparisons of the sensible and latent heat fluxes obtained from the in situ data, default model configuration results and assimilation experiment (units: Wm^{-2}).

Conclusions

- We replaced AMSR-E SM products into the WRF model over the Tibetan Plateau. In the present study, we tested and assimilated AMSR-E SM products, which can be used to reduce the modeled heat flux bias in long-term simulations.
- We found that the WRF model successfully simulated the land surface heat fluxes over the Tibetan Plateau with a diurnal variation.
- Based on the observations, when the initial model values are assimilated using the AMSR-E SM products, the WRF model can reproduce changes in heat fluxes. Also model-simulated sensible and latent heat fluxes were improved.