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Subseasonal warming of surface soil enhances precipitation over the eastern Tibetan Plateau (ETP) in early summer

Xin Qi, Jing Yang*, Yongkang Xue, Qing Bao, Guoxiong Wu, Duoying Ji

OUTLINE

1. Background

2. Scientific issues

3. Results

3.1 Subseasonal variation of surface soil temperature (T_{soil}) over the ETP

3.2 The ***cause*** of the warming surface soil

3.3 The ***effect*** of the warming surface soil on the precipitation

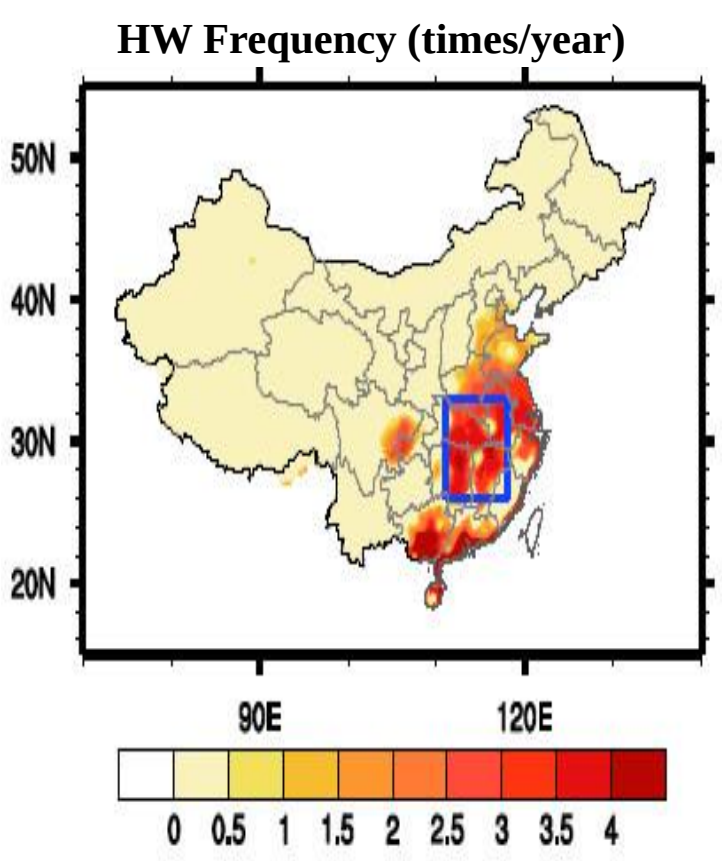
(observation evidence & numerical study)

4. Discussion

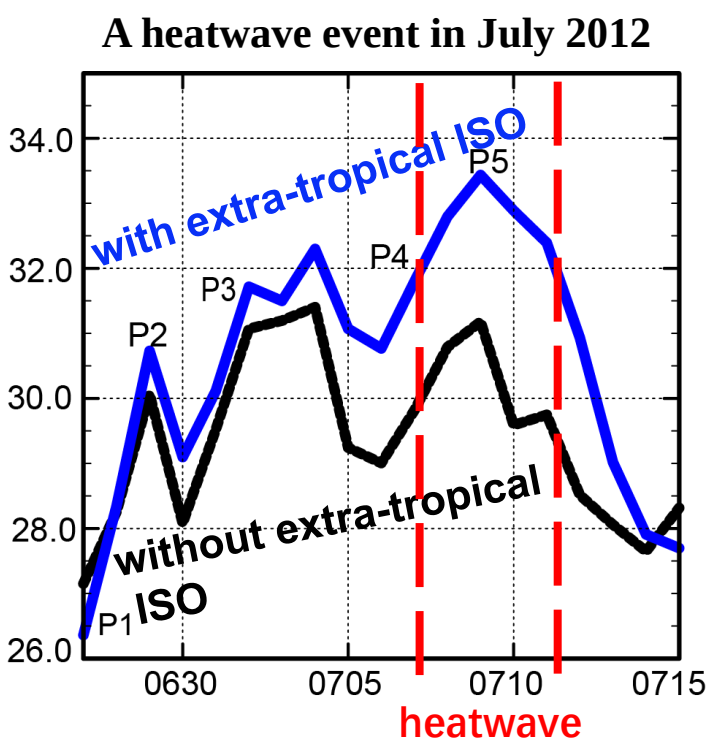
5. Summary

1. Background

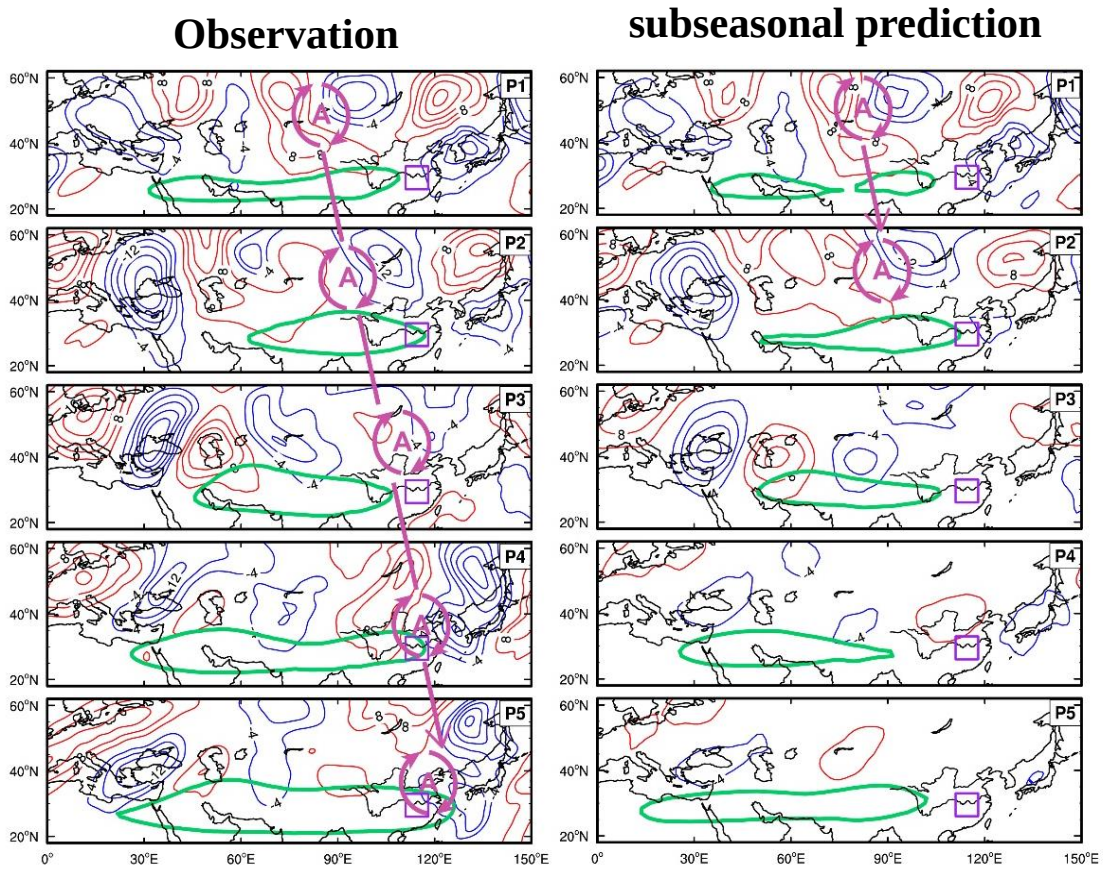
- Extra-tropical intraseasonal oscillation (ISO) is important for both the **occurrence** and **subseasonal prediction** of heatwaves in eastern China.



(Gao et al., 2017)



(Qi et al., 2019a)

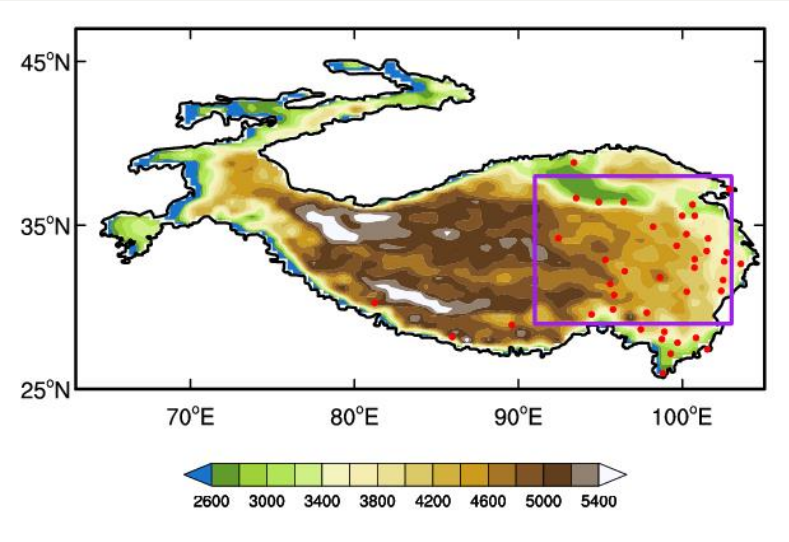


(Qi et al., 2019b)

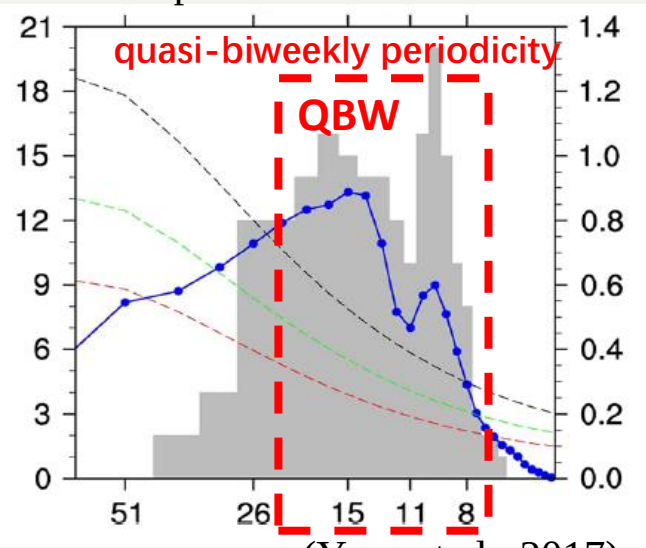
1. Background

- The ETP features **significant atmospheric intraseasonal variations (ISV)** in boreal summer.
- The **amplitude** and **duration** of intraseasonal oscillation over the ETP is crucial for local and surrounding subseasonal variation.

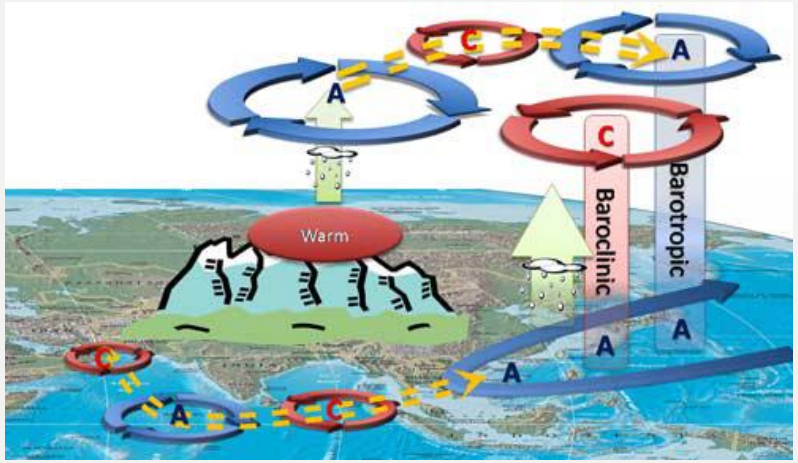
ETP (29–31°N, 91–103E°)



power spectra of the rainfall ISV component over the ETP



(Yang et al., 2017)



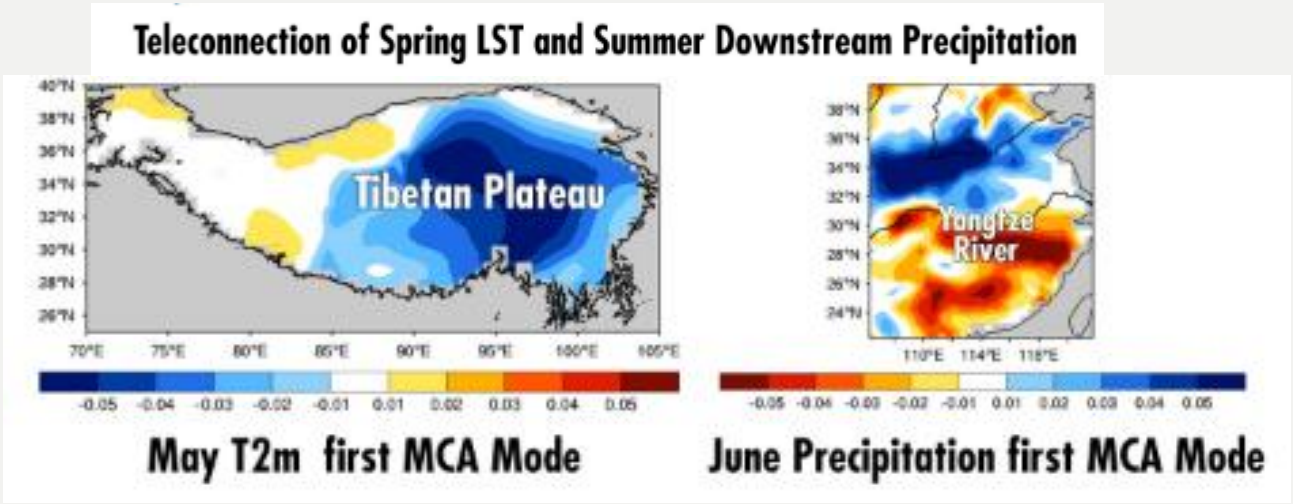
(Bin Wang et al., GRL, 2008)

1. Background

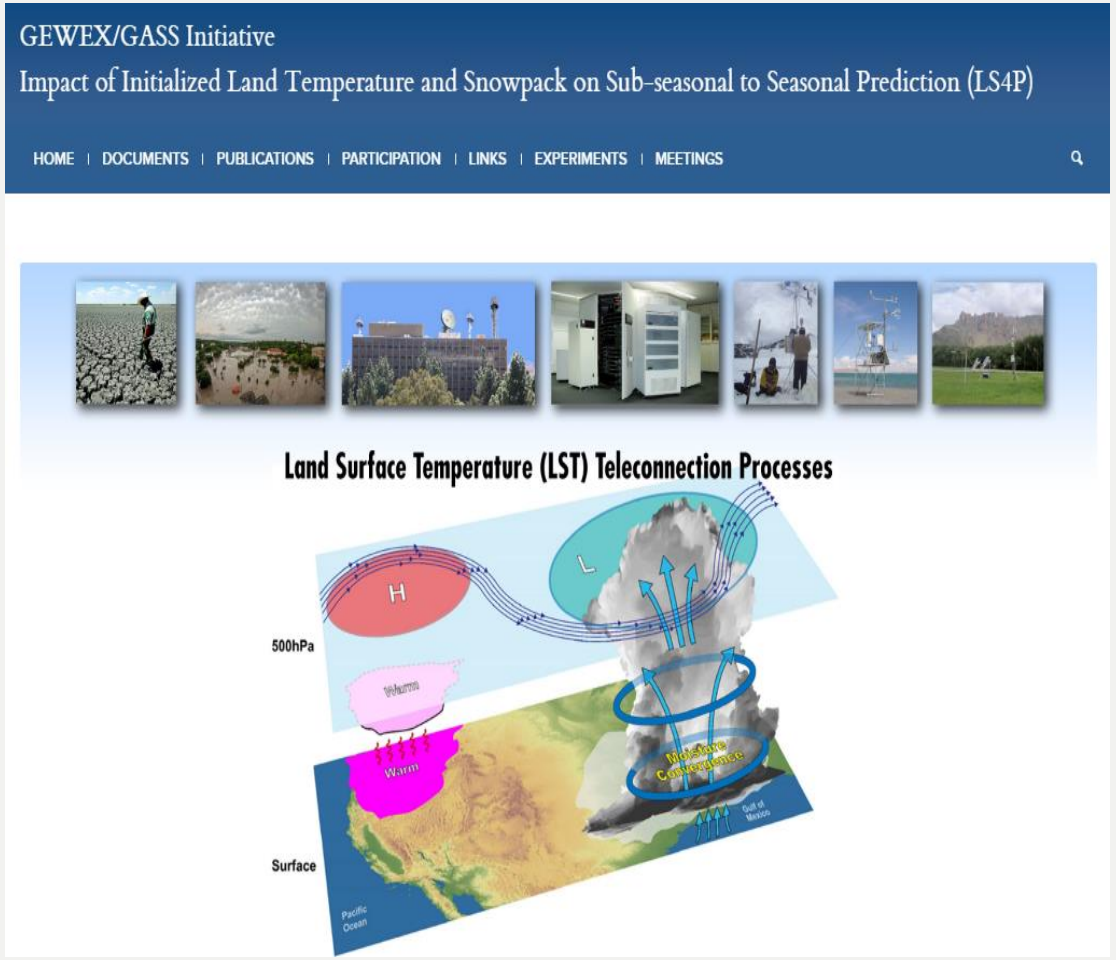
LS4P international research project

*(Impact of Initialized **L**and **S**urface Temperature and **S**nowpack on **S**ub-seasonal to **S**easonal **P**rediction)*

- To explore the non-local impact of initializing land surface temperature and subsurface Tsoil in high mountain regions on subseasonal prediction using multi-climate models (Xue et al., 2021).



(Xue et al., 2018)



https://ls4p.geog.ucla.edu/

2. Scientific issues

- **What are the subseasonal features of surface T_{soil} over the ETP ?**
- **What causes the QBW warming of surface soil ?**
- **How does the warming surface soil affect precipitation ?**

Data & Methods

Data

- station data from China Meteorological Administration
- CN05.1 grid data
- ERA-Interim reanalysis dataset
- CFSR reanalysis dataset

[Variables]

soil temperature, soil moisture

2m air temperature, skin temperature

precipitation

Circulation variables (UV wind, omega, GHT, …)

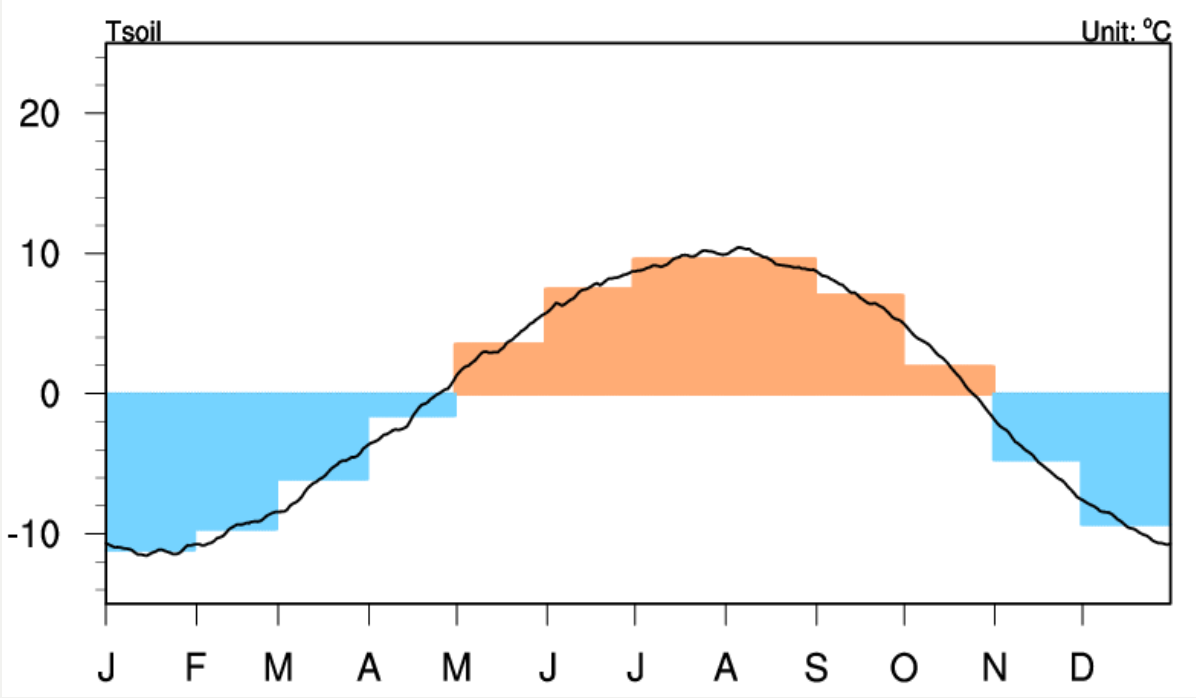
Methods

- Composite analysis
- Power spectrum analysis
- Auto-correlation / lead-lag correlation
- **Numerical experiments (WRF)**

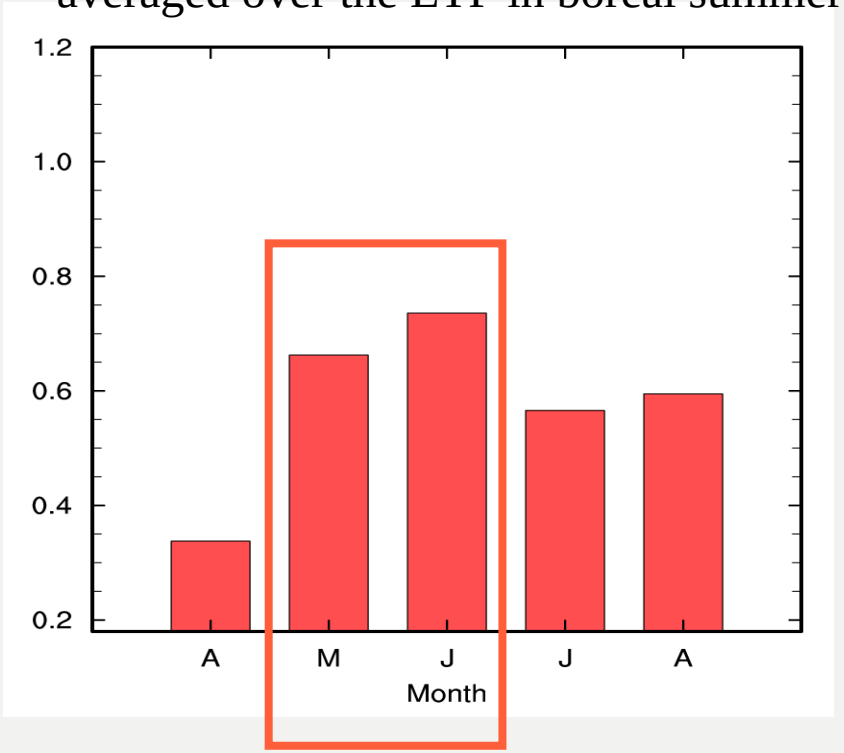
3. Results

- The **early summer (May–June)** as the target period to study the subseasonal variation of surface T_{soil}

Surface T_{soil} averaged over the ETP



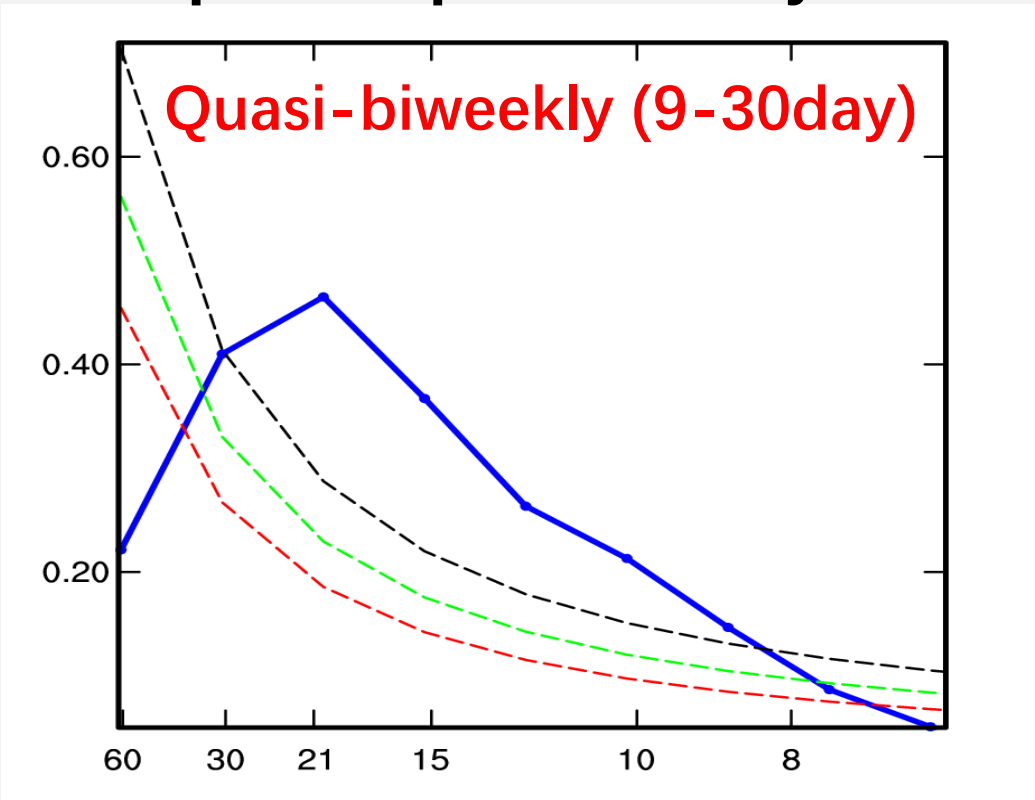
Variance of the intraseasonal surface T_{soil} averaged over the ETP in boreal summer



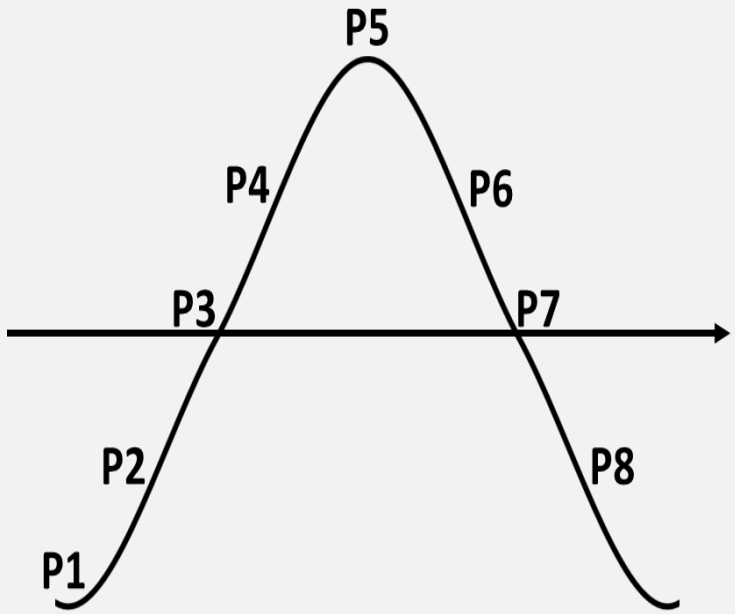
3. Results

QBW as the dominant subseasonal periodicity of surface T_{soil} over the ETP

power spectral analysis



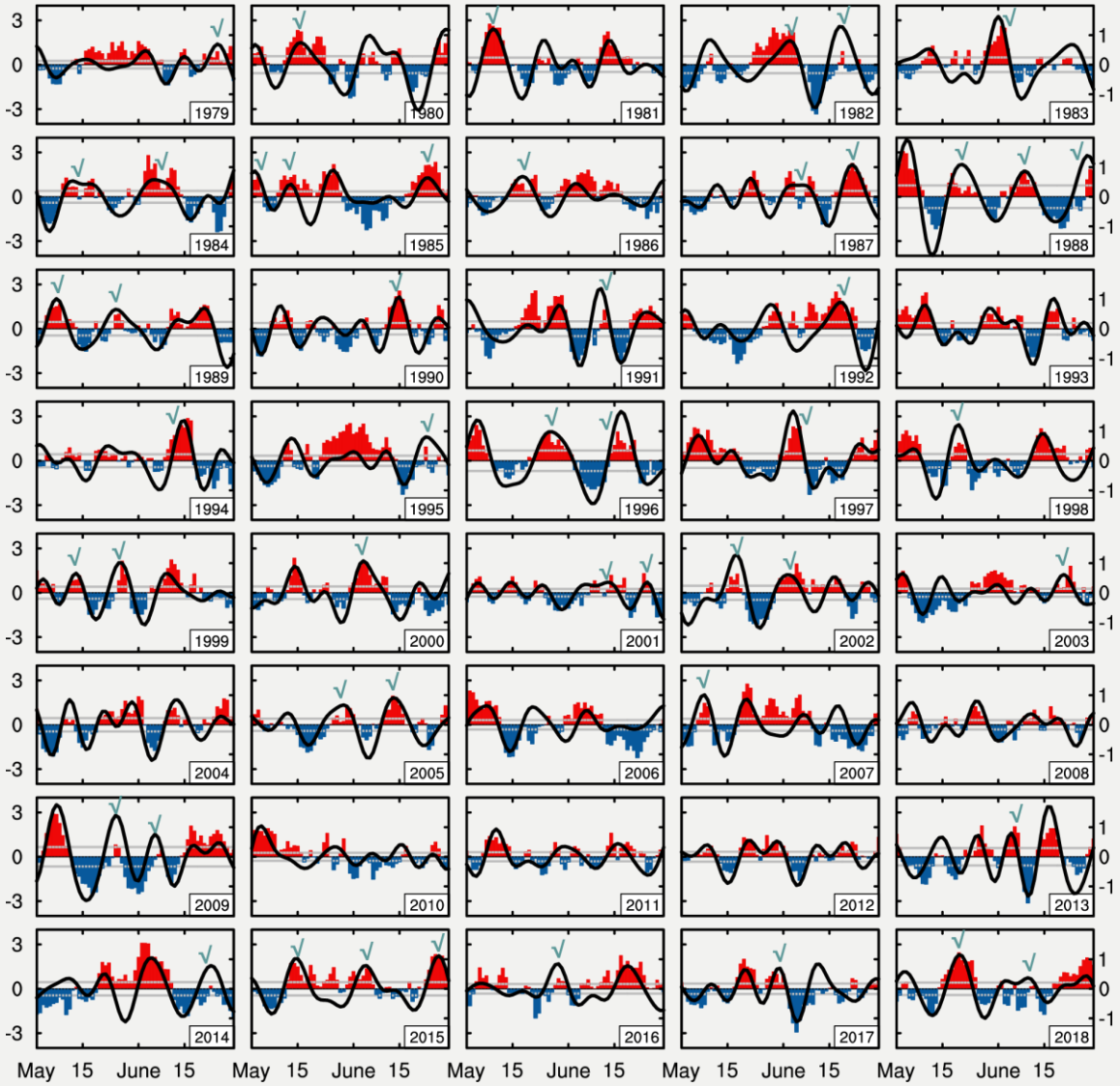
Cases selection



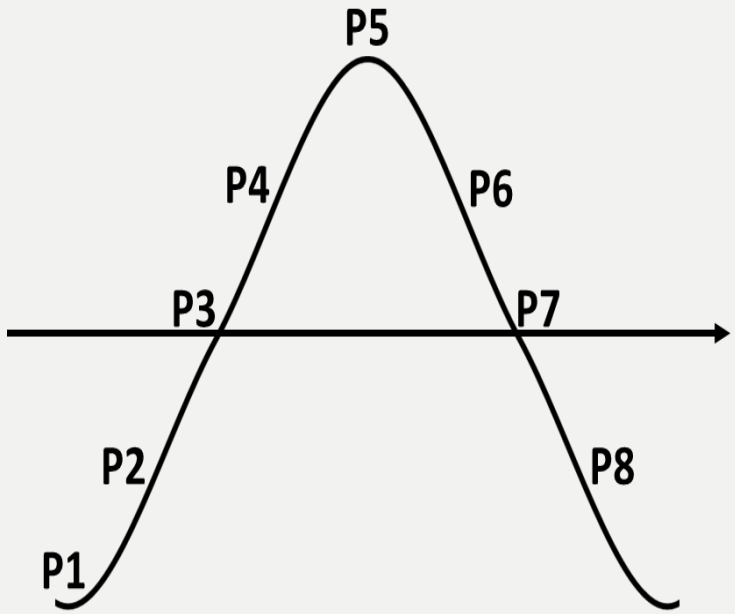
phase compositing technique for QBW time series

3. Results

QBW as the dominant subseasonal periodicity of surface T_{soil} over the ETP



Cases selection



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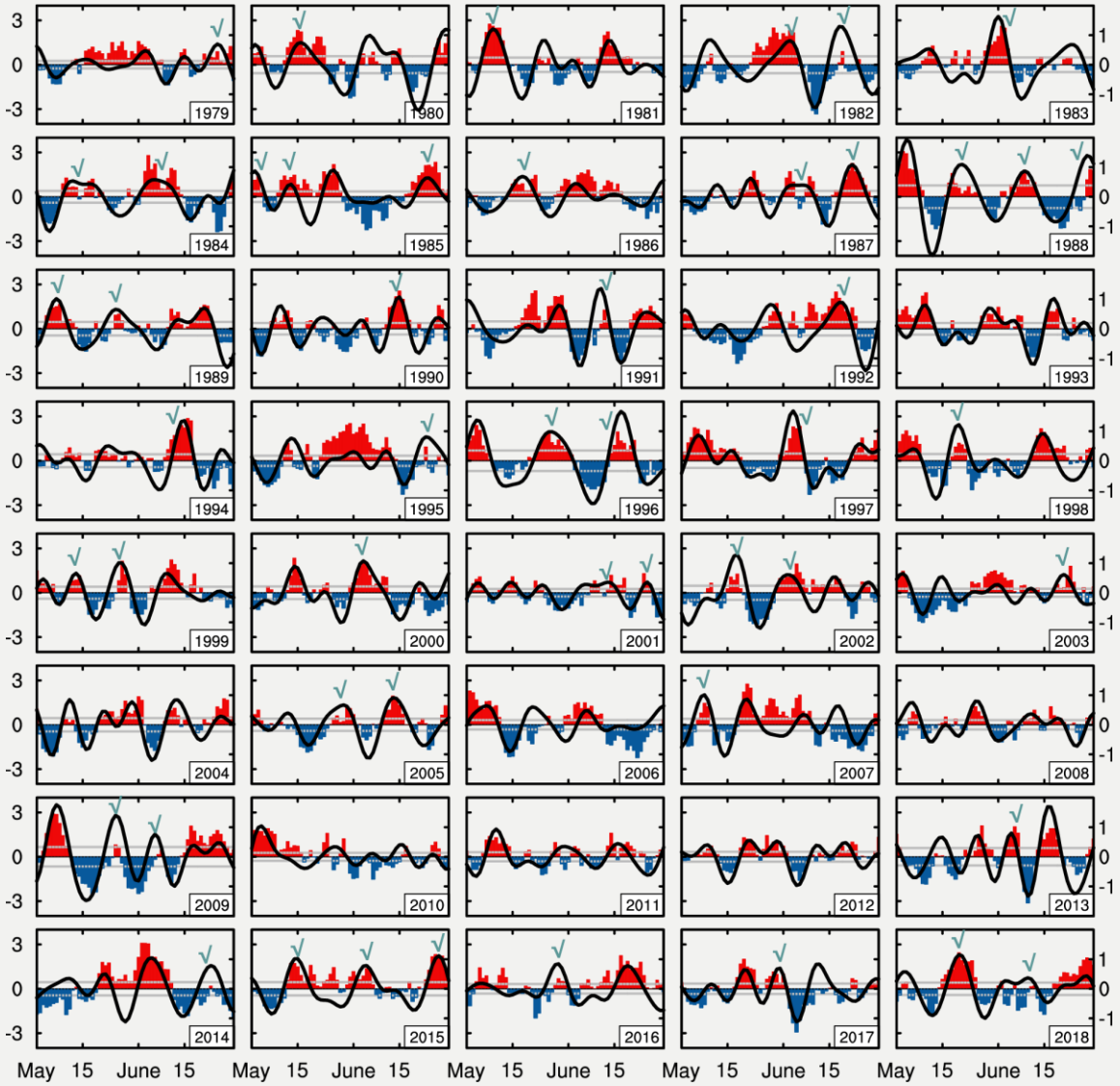
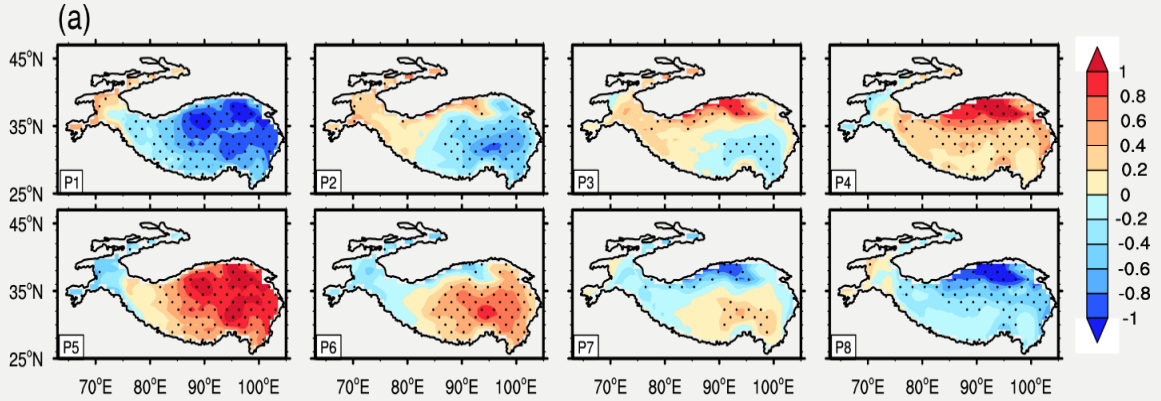
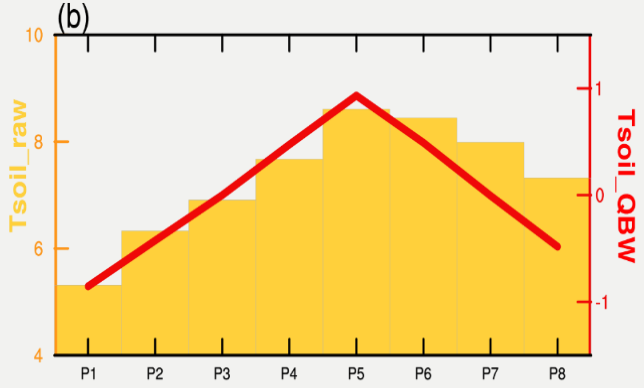
QBW as the dominant subseasonal periodicity of surface T_{soil} over the ETP



composite surface T_{soil} for 50 cases



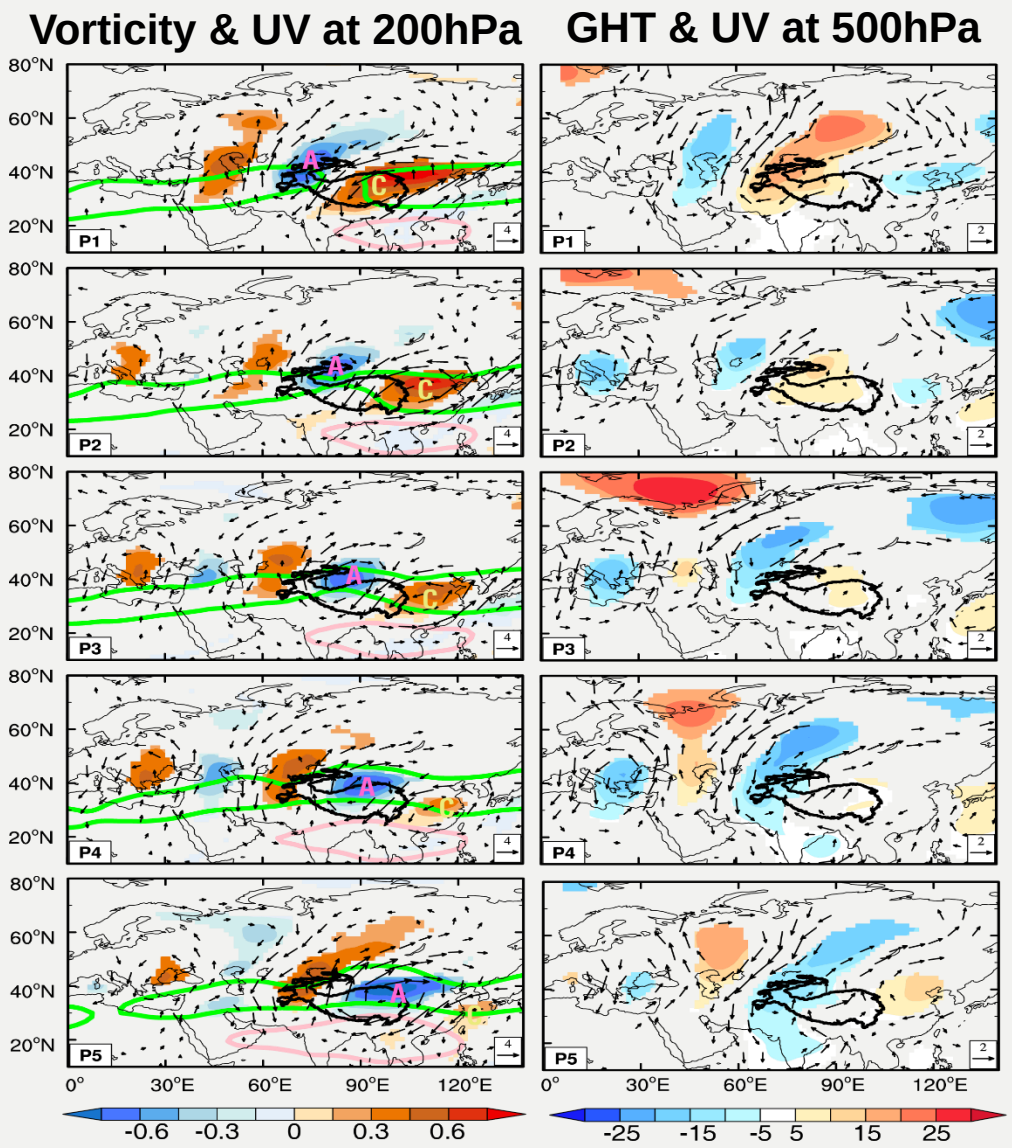


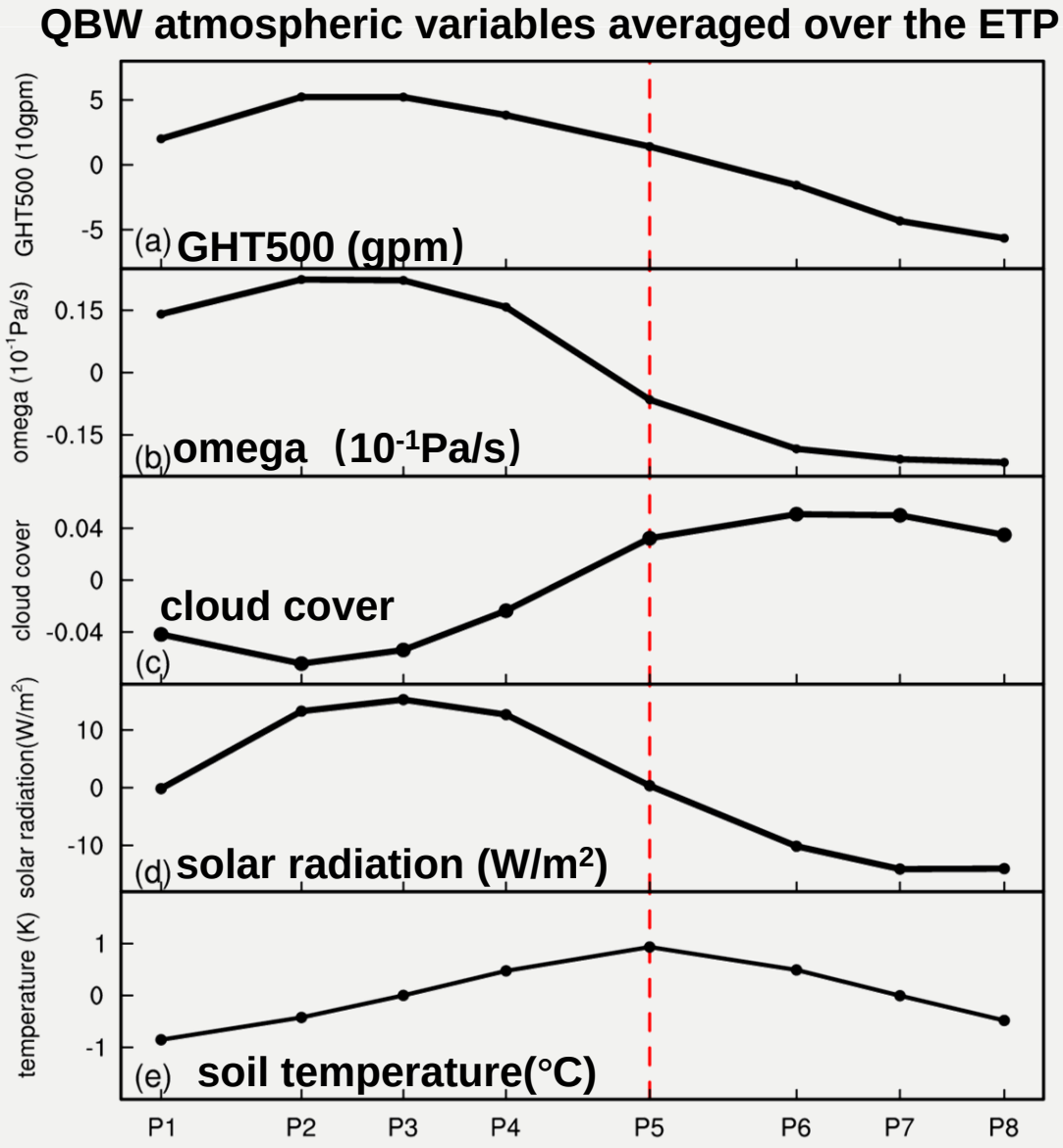
warming amplitude

$$\frac{QBW\ (1.8℃)}{Raw\ (3.3℃)}$$

3. Results

QBW warming of surface T_{soil} forced by QBW atmospheric waves



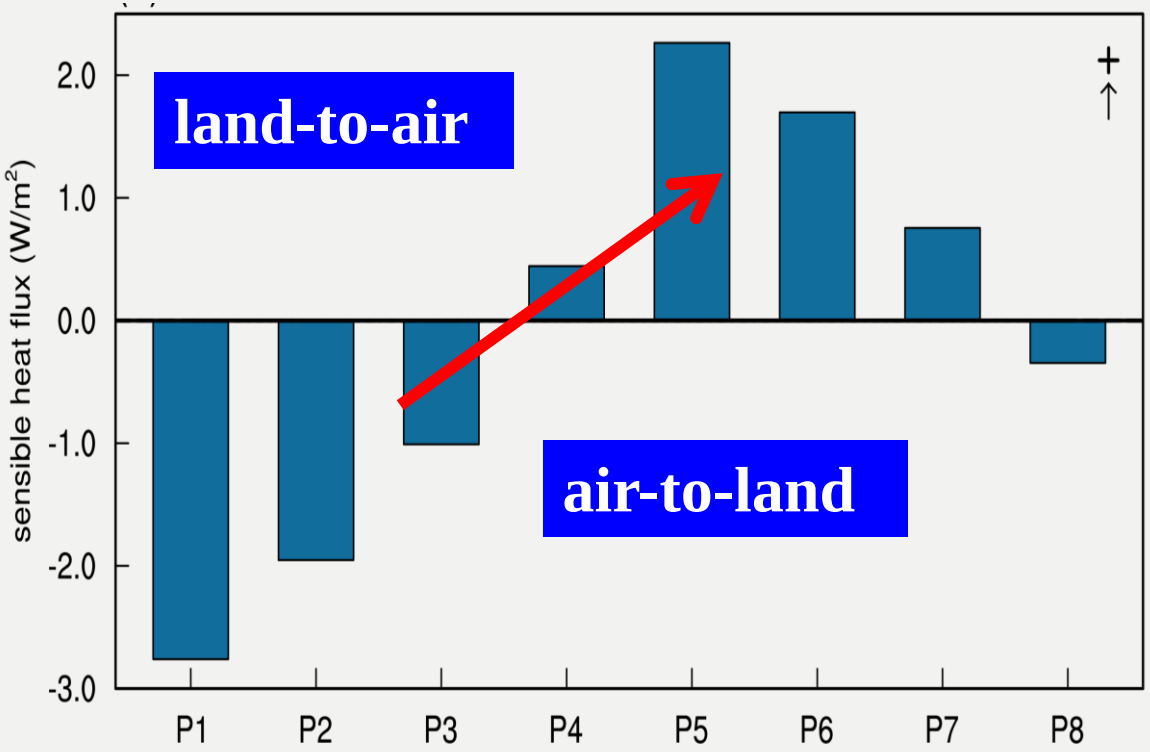


3. Results

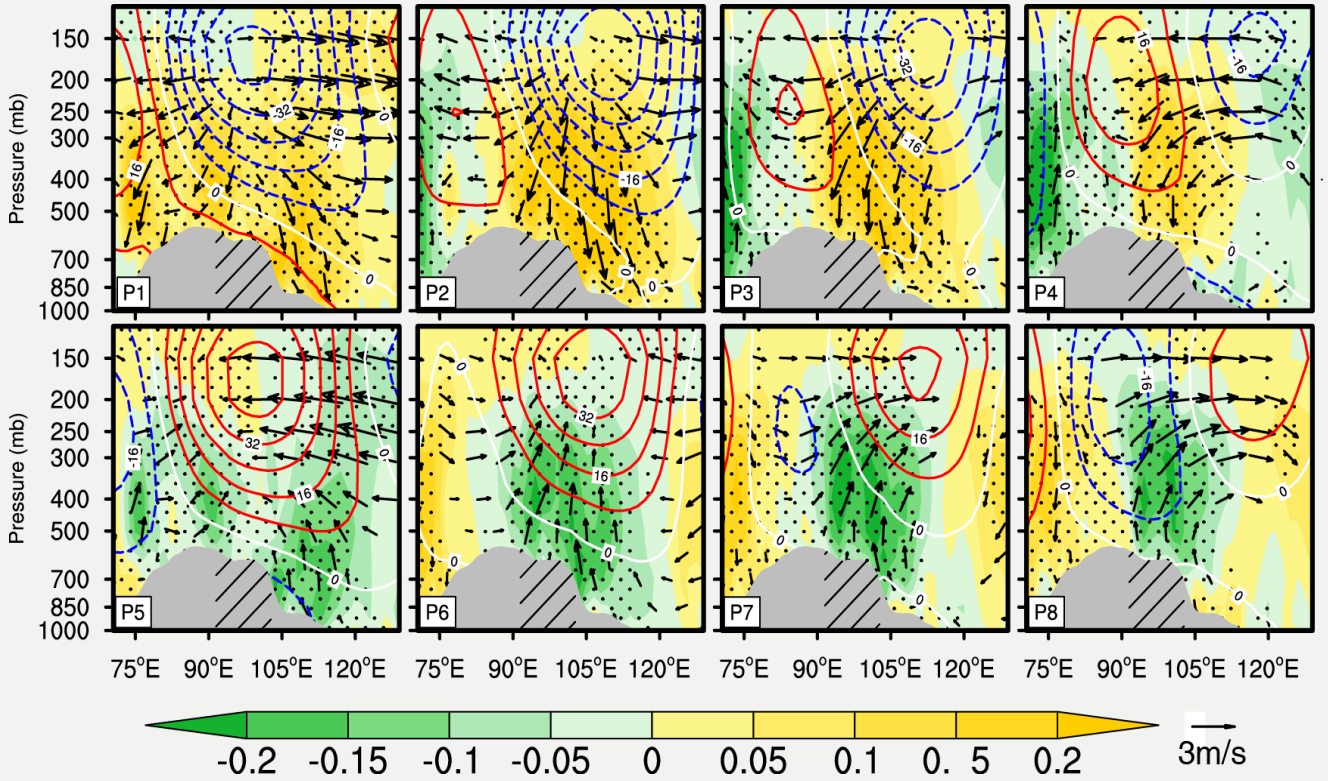
Warming surface T_{soil} enhances precipitation over the ETP in QBW variation

■ **a significant impact of land on atmosphere could occur from P4 to P6.**

Averaged sensible heat flux over the ETP



Omega (shading) & GHT (contour) & Wind (vector)



3. Results

Warming surface T_{soil} enhances precipitation over the ETP in QBW variation

the **atmospheric** role dominates

precipitation anomaly ↑

surface T_{soil} anomaly ↓

(a **negative** correlation)

the **land** role dominates

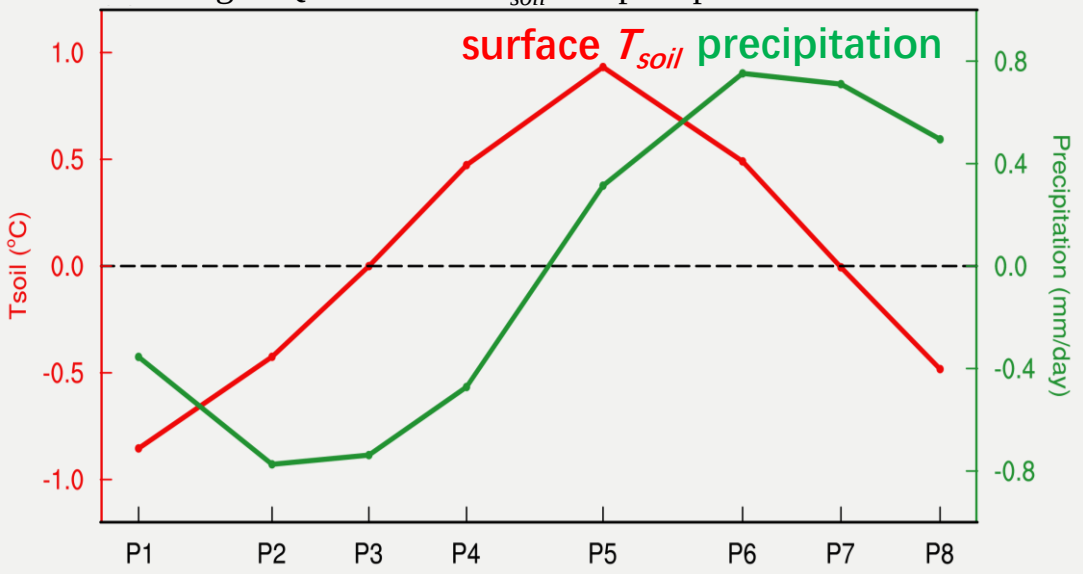
surface T_{soil} anomaly ↑

precipitation anomaly ↑

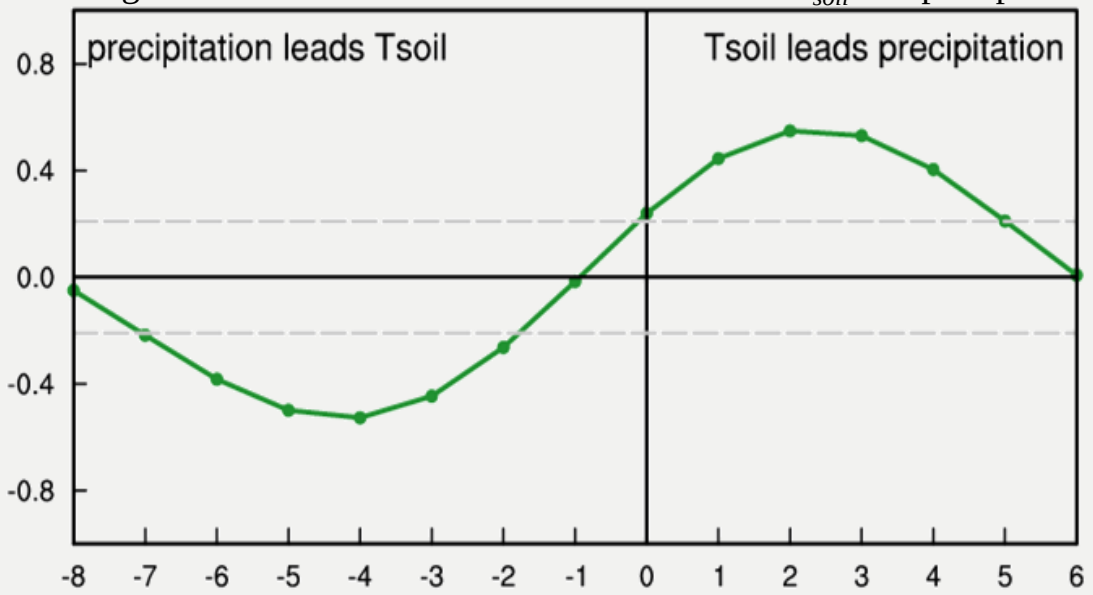
(a **positive** correlation)

■ **The QBW peak value of the precipitation lags the peak warming phase of the surface T_{soil}**

the averaged QBW surface T_{soil} and precipitation over the ETP

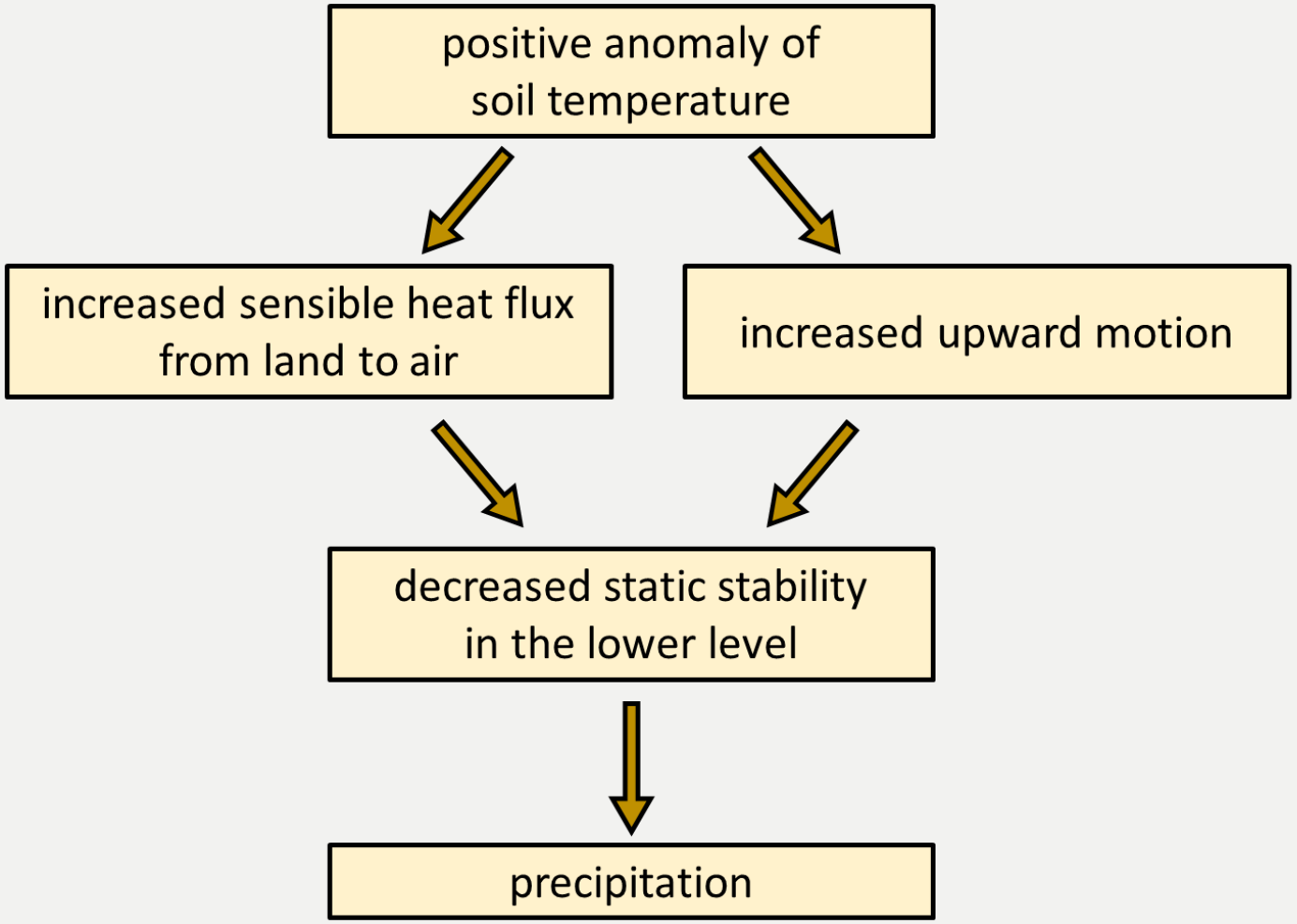


lead-lag correlation coefficient between the surface T_{soil} and precipitation



Warming surface T_{soil} enhances precipitation over the ETP in QBW variation

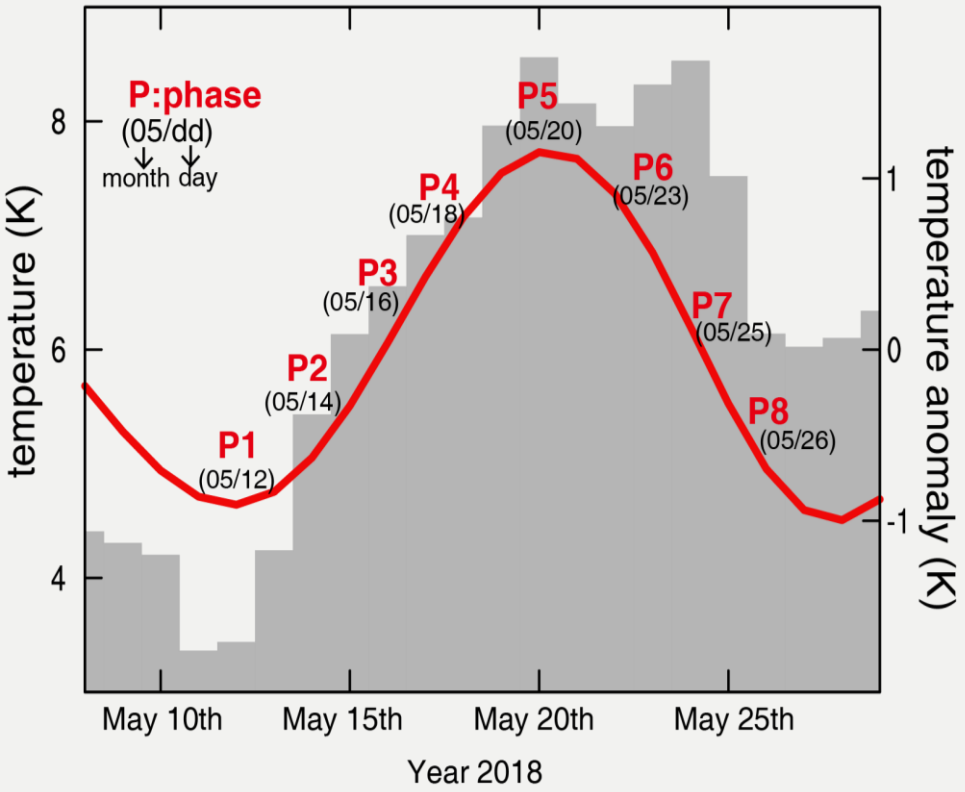
■ **How does the warming surface soil affect precipitation?**



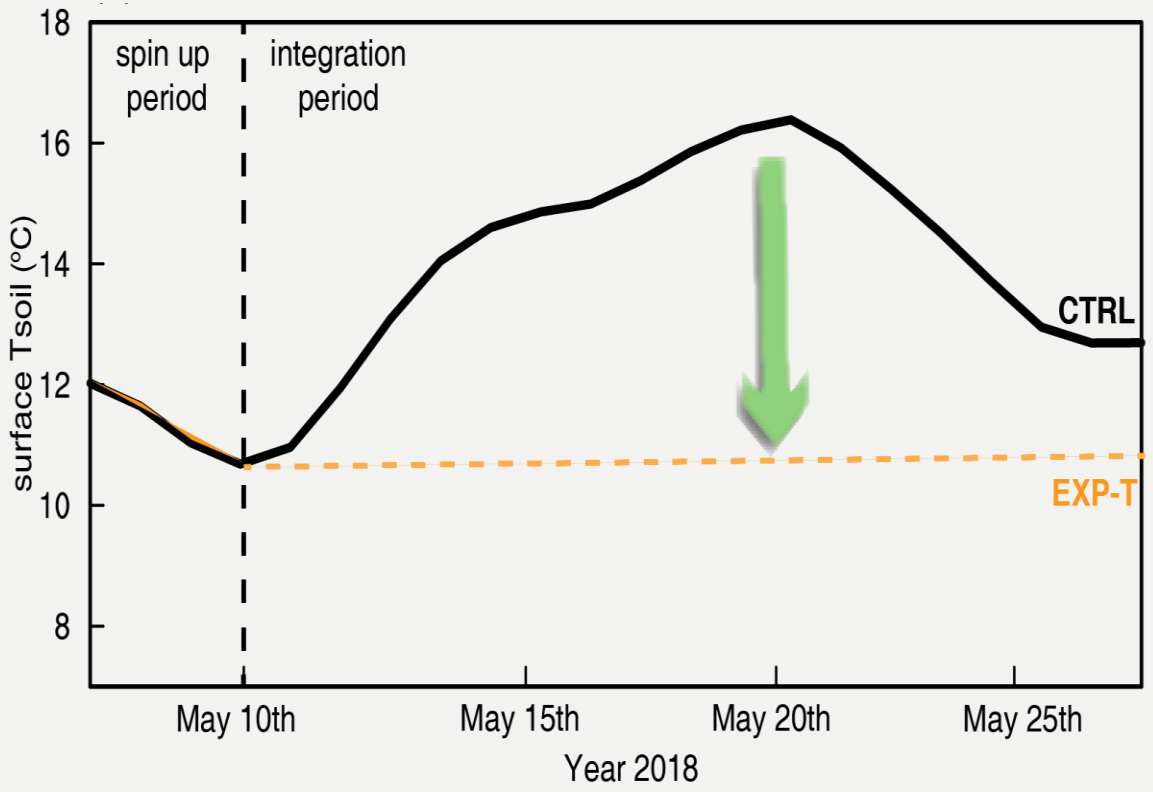
3. Results

Warming surface T_{soil} enhances precipitation over the ETP in QBW variation

the selected case



Experimental design

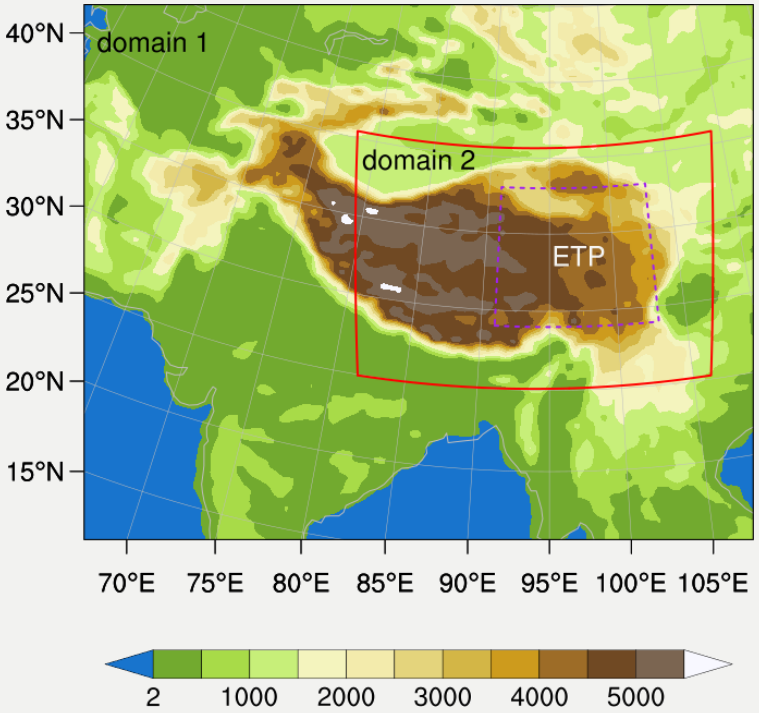


3. Results

Warming surface T_{soil} enhances precipitation over the ETP in QBW variation

Numerical experiment configuration

- **Advanced Research WRF model (version 4.2)**
- **2018_05_07_00:00—2018_05_30_00:00 (23days)**
- **D01 (30km) / D02 (10km)**



- **Physical scheme**

【microphysics scheme】 WSM6 WRF Single-Moment 6 class

【radiation】

Longwave： RRTMG Longwave scheme

Shortwave： RRTMG Shortwave scheme

【cumulus parameterization】 Multi–scale Kain-Fritsch scheme

【land process】

planetary boundary layer： Yonsei University scheme

surface layer： Revised MM5 scheme

land surface： Unified Noah Land Surface Model

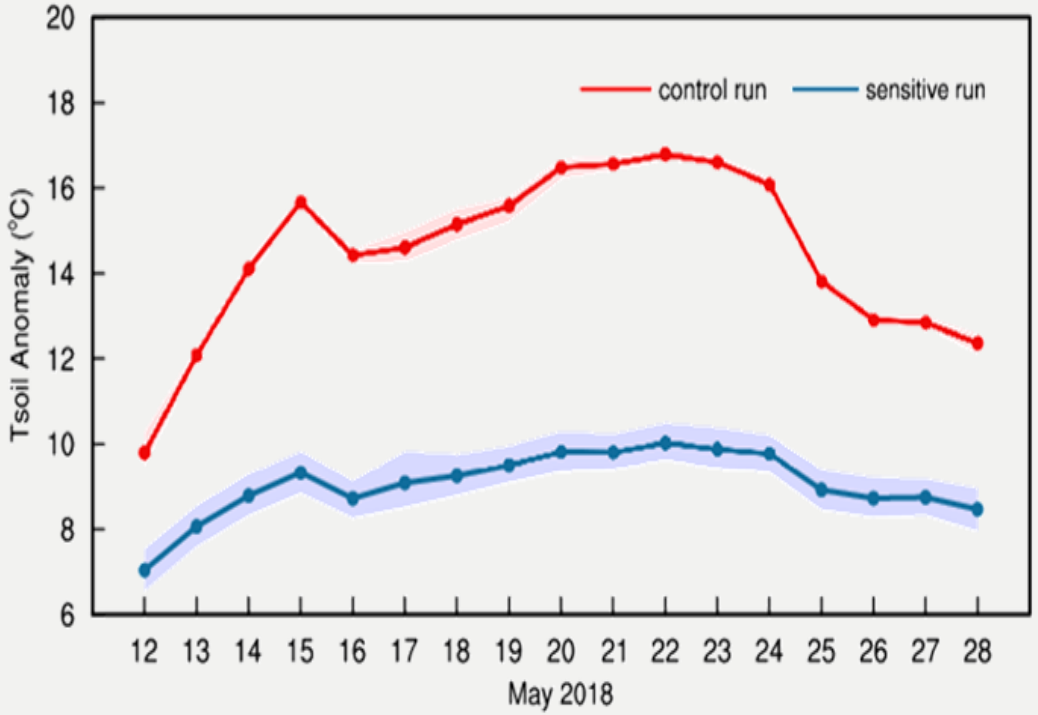
Ensemble：5 members

3. Results

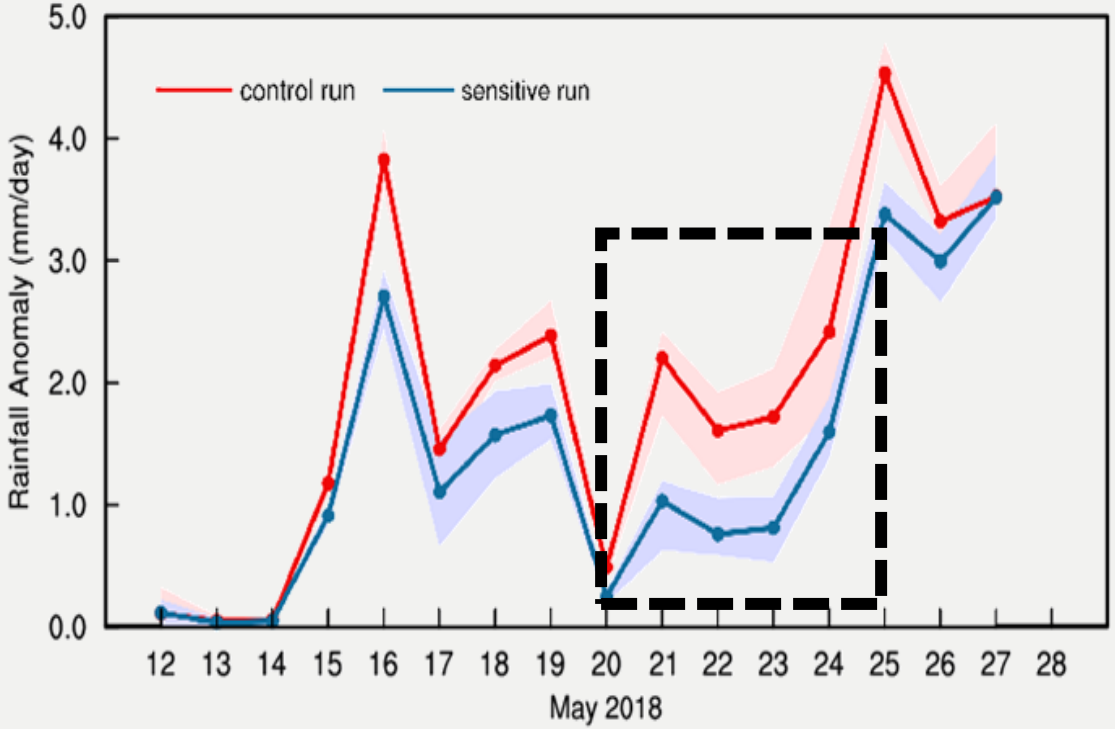
Warming surface T_{soil} enhances precipitation over the ETP in QBW variation

EXP-1 Remove the soil temperature forcing

soil temperature



precipitation

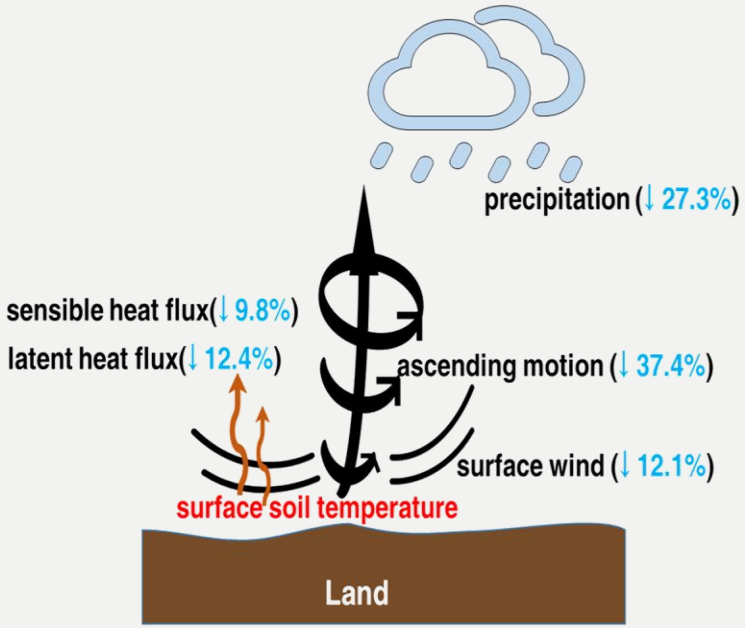


3. Results

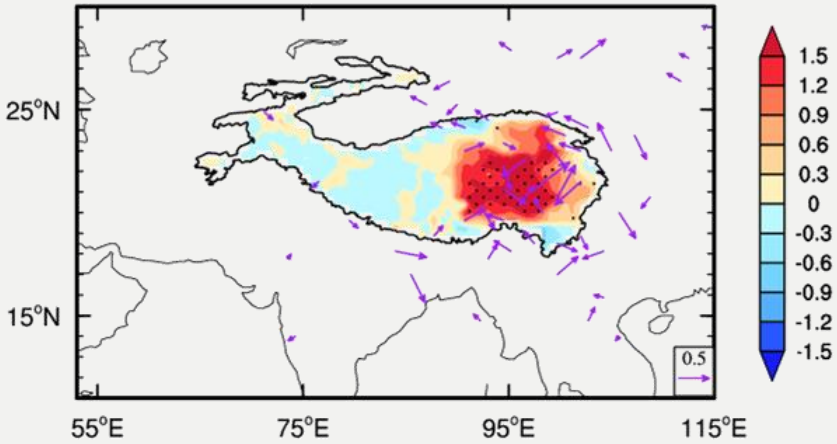
Warming surface T_{soil} enhances precipitation over the ETP in QBW variation

EXP-1 Remove the soil temperature forcing

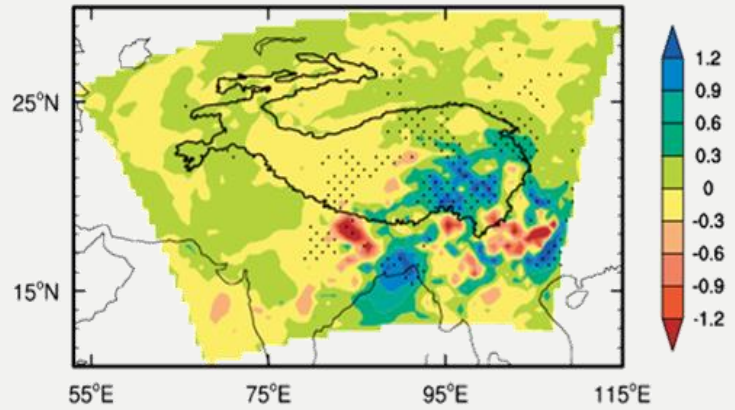
The difference between control run and sensitive run



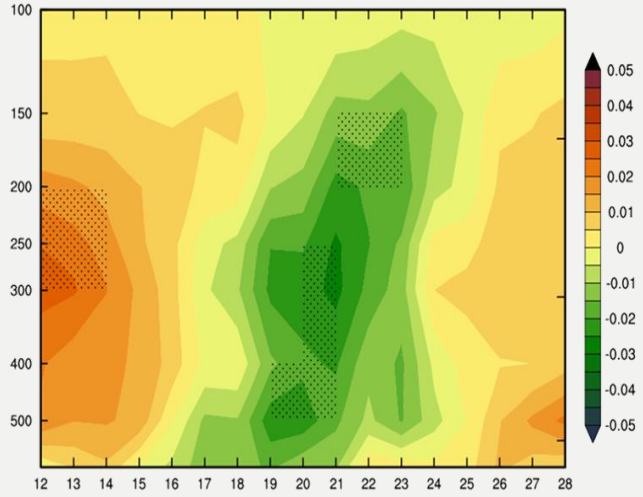
surface T_{soil} (shading) & UV (vectors) at P5



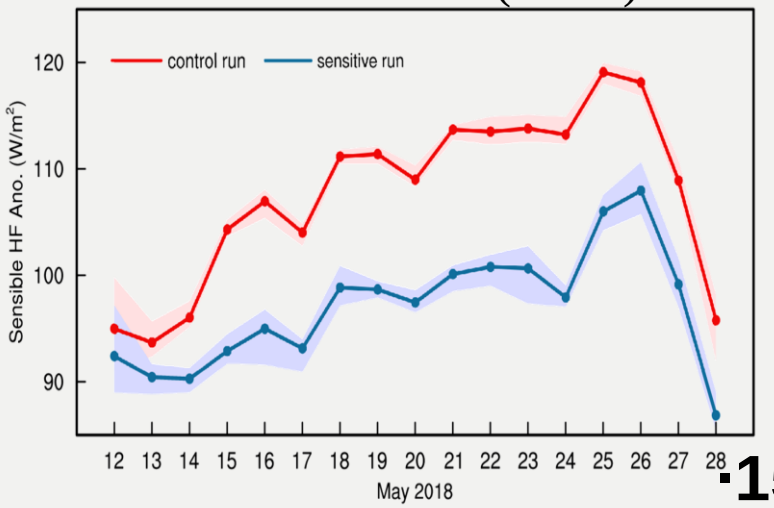
surface vapor flux at P5



omega (Pa/s)



sensible heat flux (W/m^2)

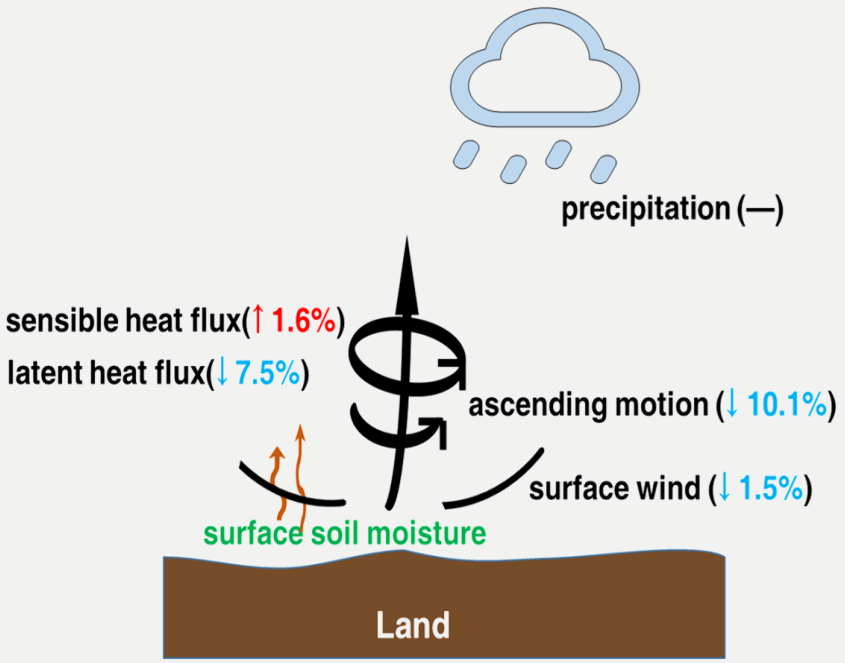


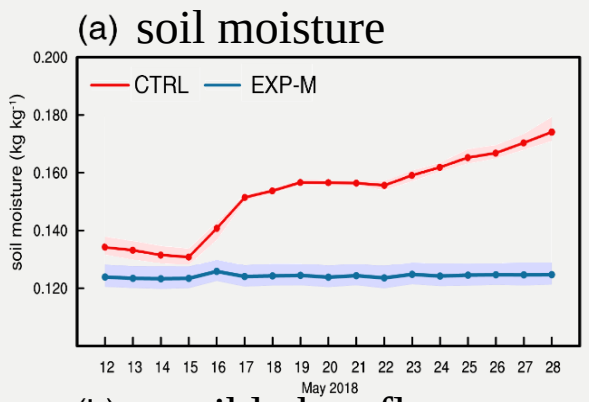
4. Discussion

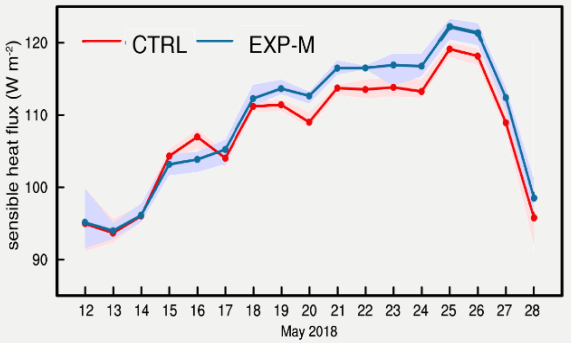
surface T_{soil} V.S. soil moisture

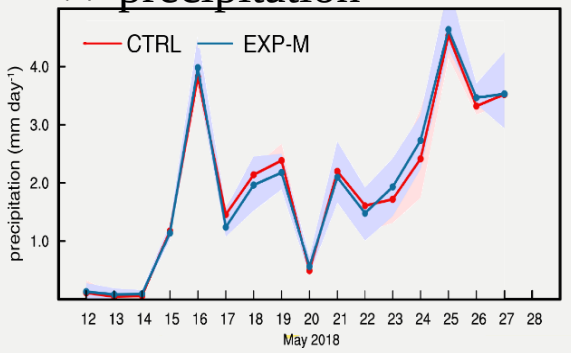
EXP-2 Remove the soil moisture forcing

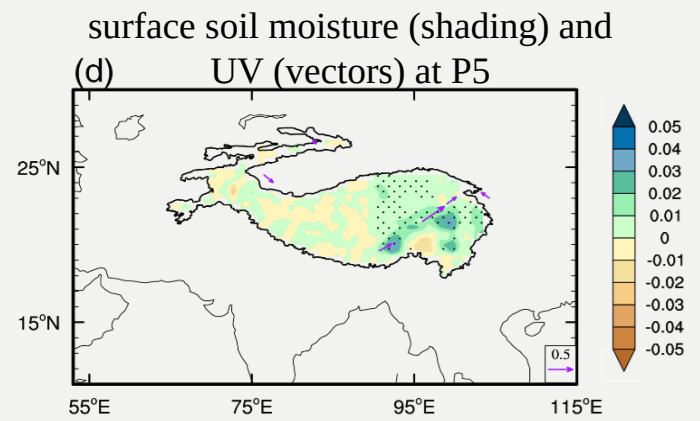
The difference between control run and sensitive run

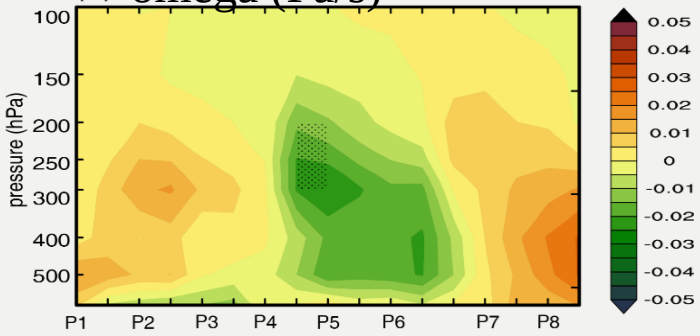


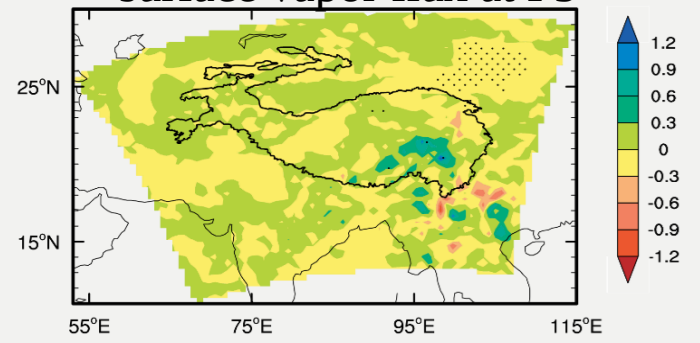








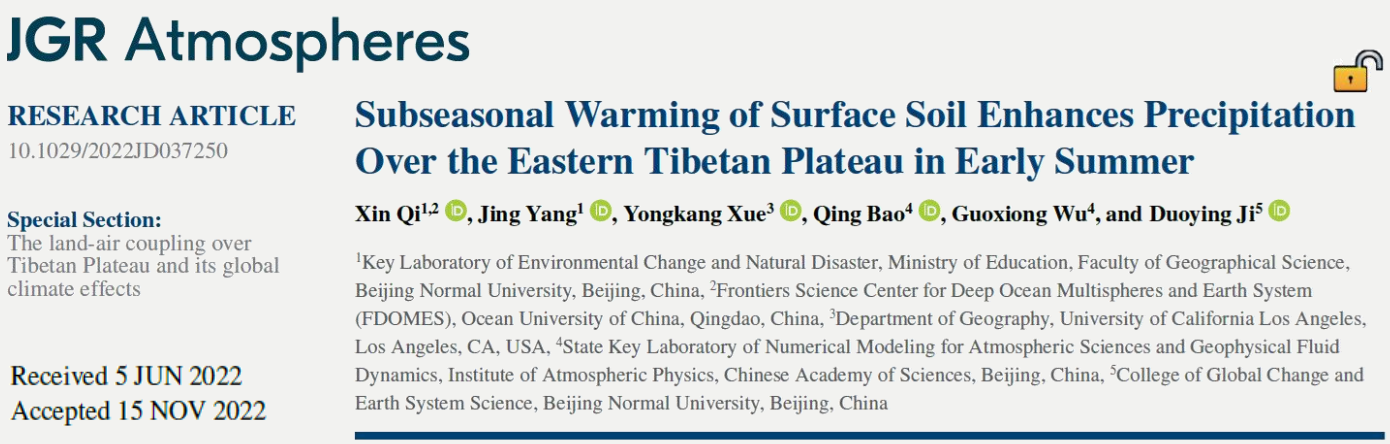




5. Summary

- Surface T_{soil} over the ETP features **subseasonal** variations with **quasi-biweekly** period in early summer.
- The **warming surface soil** over the ETP could **enhance** the **subseasonal precipitation** through altering the lower-level convective instability.
- WRF experiments confirm that ETP soil thermal effect on precipitation is much more crucial than soil moisture in the **subseasonal** time scale.

Publication



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The land-air coupling over Tibetan Plateau and its global climate effects

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