Is the Current Subtropical Position of the Tibetan Plateau Optimal for Intensifying the Asian Monsoon?

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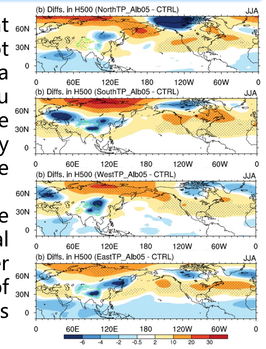
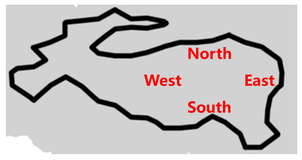
Introduction

The Tibetan Plateau (TP) exerts significant influences on the earth's climate. It can not only strengthen the Asian monsoon (e.g. via the sensible heat driven Air-Pump effect (Wu et al. 2012), but also influence the northwestern Pacific subtropical high by inducing eastward-propagated Rossby wave train (Wang et al. 2008).

Lu et al. (2020) further demonstrated the different effects of TP on various regional monsoon systems, and contributed to better understanding of the different roles of different TP portions (see figures in this section).





W-Y index			SAM		
	-0.11			0.31	
0.2	23.46	0.44	0.45	3.54	0.29
	0.89			0.28	

SEAM			EAM		
	-1.09			0.94	
-1.0	6.37	-0.80	0.67	12.04	2.93
	-0.68			-0.05	

WY - Webster-Yang ; SA - South Asia; SEA - Southeast Asia; EA – East Asia

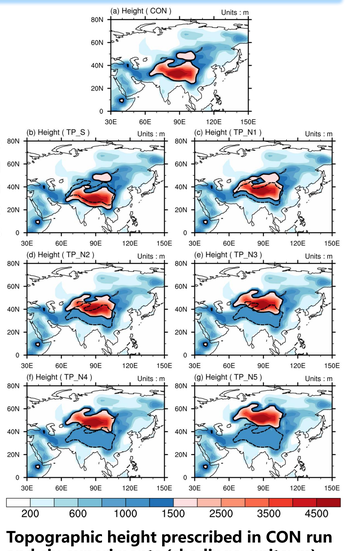
Scientific Questions:

- How will the rotational & divergent portions of atmospheric motion respond to the change in the meridional position of TP?
- Would the monsoon dynamics become simpler if the TP were located near the equator?
- Is the current **subtropical** position of the TP **optimal** for strengthening the Asian monsoon?

Model & Experiments

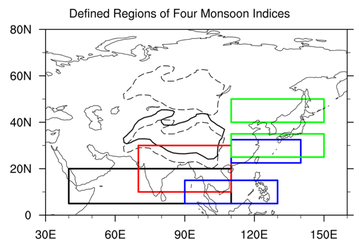
A series of experiments with the CESM were conducted by moving the TP from the subtropical position southward and northward to explore **the relationship between its positions and the Asian monsoon**:

TP_S : Move the TP 4° south
TP_N1: Move the TP 4° north
TP_N2: Move the TP 8° north
TP_N3: Move the TP 12° north
TP_N4: Move the TP 16° north
TP_N5: Move the TP 20° north

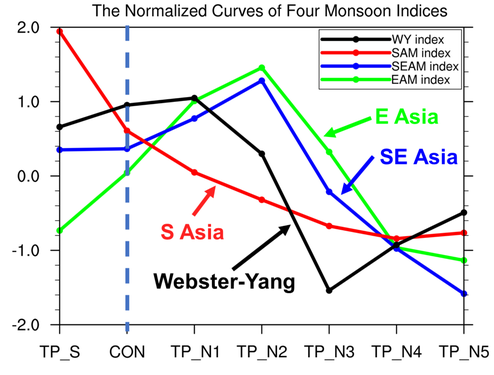


Topographic height prescribed in CON run and six experiments (shadings, units: m)

Response of Regional Monsoons

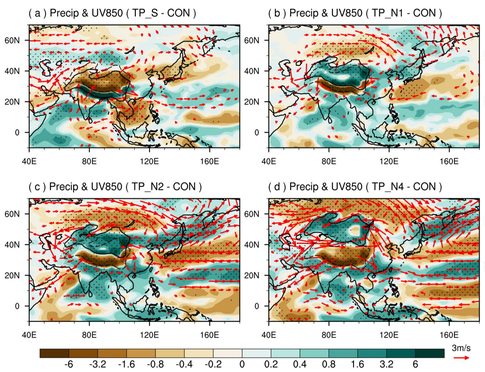


South Asian monsoon (Goswami et al. 1999):
Strengthens (weakens) when moving TP southwards (northwards)
East & Southeast Asian monsoons (Wang & Fan 1999; Lau et al. (2000):
Intensify from TP_S to TP_N2, and then weaken northwards
Large-scale Asian monsoon (Webster-Yang index):
Weakens from TP_N2 and northwards

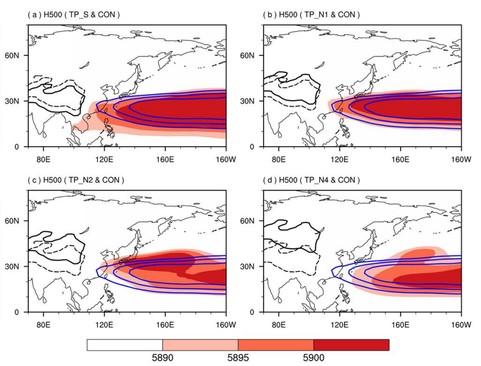


Four commonly-applied dynamical monsoon indices

Low-level Circulation and Rainfall



Changes in summer rainfall and UV850



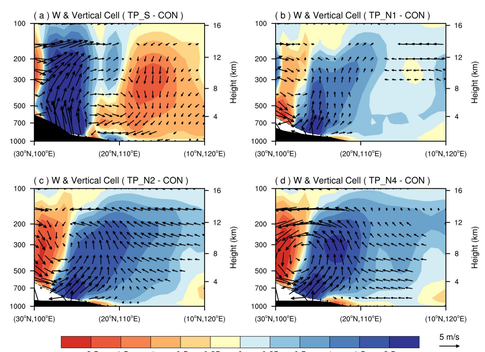
Different subtropical high patterns

TP moved southward:

- Increasing low-level meridional wind results in the enhancement of rainfall over southern India.
- However, rainfall decreases in the East Asia and over the South China Sea due to the strengthening and westward extension of the subtropical high.

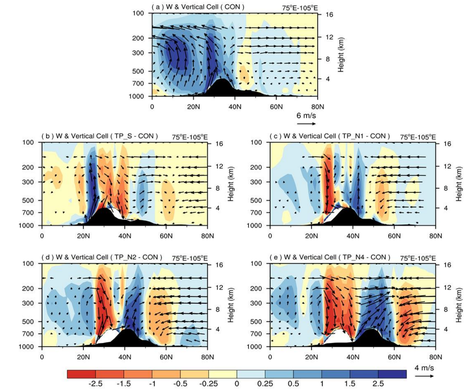
TP reaching to higher latitudes:

- Rainfall increases over northeastern Asia because of the consistent northward movement of the subtropical high.
- In the South China Sea, sinking motion turns into compensatory rising motion, leading to increased rainfall.



Vertical cells from (30°N, 100°E) to (10°N, 120°E)

Meridional Circulation

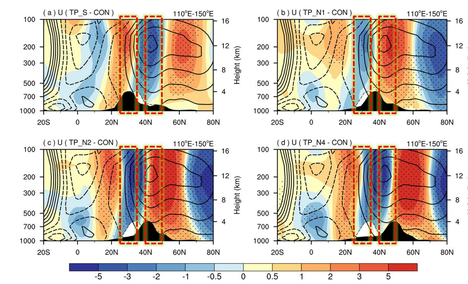


When TP is moved southward:
Thermally-driven meridional circulation intensifies, resulting in stronger South Asian monsoon

When TP is moved northward:
Thermally-driven meridional circulation weakens as rising motion shifts northward, leading to weaker South Asian monsoon

(a) 75°-105°E averaged vertical velocity & vertical cell
(b-e) Differences among various experiments

East Asian Jet Stream



In TP_S, TP_N4 & N5:
Meridional shear of U200 weakens, corresponding to weaker East Asian monsoon

In TP_N1 & N2:
Meridional shear of U200 intensifies, corresponding to stronger East Asian monsoon

(a-d) U-wind & differences among various experiments
Red rectangle represents the regions defining EA monsoon (Lau et al. 2000)

Summary

- **The subtropical position of TP is NOT optical for intensifying the Asian monsoon.**
- **When the TP shifts southward, the South Asian monsoon becomes stronger, but the East Asian monsoon becomes weaker.**
- **When the TP shifts northward, the South Asian monsoon becomes weaker, but the East and Southeast Asian monsoons become stronger.**
- **All regional monsoons become weaker when the TP shifts northward by above 10° of latitude.**