IBS Center
for Climate Physics

EGU2020-3269

Future changes of summer monsoon characteristics and evaporative demand over Asian in CMIP6 simulations

Kyung-Ja Ha[1,2*], Suyeon Moon[1,2], Axel Timmermann[1], and Daeha Kim[3]

[1] Center for Climate Physical, Institute for Basic Science, Busan, South Korea
[2] Department of Climate System, Pusan National University, Busan, South Korea
[3] Climate Application Department, APEC Climate Center, Busan, South Korea
*Corresponding author : Kyung-Ja Ha, E-mail: kjha@pusan.ac.kr

K.-J. Ha, S. Moon, A. Timmermann, and D. Kim, 2020: Future changes of summer monsoon characteristics and evaporative demand over Asia in CMIP6 simulations, Geophysical Research Letter, Doi: 10.1029/2020GRL087492.

Background

- Under global warming, monsoon seasons are expected to change in terms of duration, frequency of climate extremes and altered hydrologic conditions.

- To implement sustainable water management plans, understanding the response of monsoon systems to greenhouse warming is essential.

- We use the latest subset of CMIP6 projections to further document the sensitivity of the Asian summer monsoon (ASM) to greenhouse warming.

- Despite the vital roles of the regional monsoon systems, sub-regional future changes have not been analyzed in detail.

- We focus on local changes in four subregions of the Asian monsoon domain.

Data

- **16 CMIP6 Daily precipitation**, **2m air temperature**, and **monthly runoff :**

  Historical (1979-2014) & ssp2-4.5 (2065-2100) & (ssp5-8.5)

- **To quantify the fidelity of the 16 CMIP6 models,**

  GPCP pentad precipitation data / 1979-2014 (36-yr)

  ERA-Interim daily air-2m temperature, monthly evapotranspiration

  Monthly root-zone soil moisture from the Global Land Evapotranspiration Amsterdam Model (**GLEAM**) v.3.3b for monthly runoff

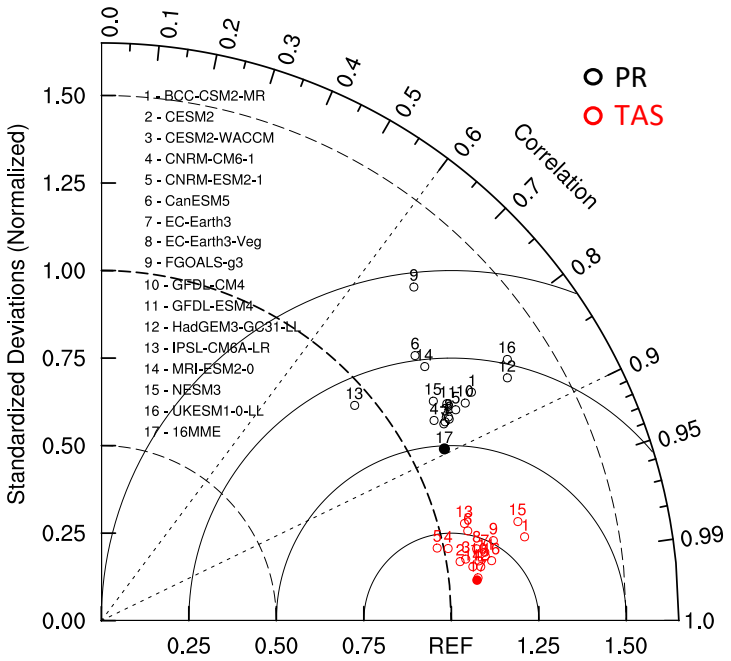
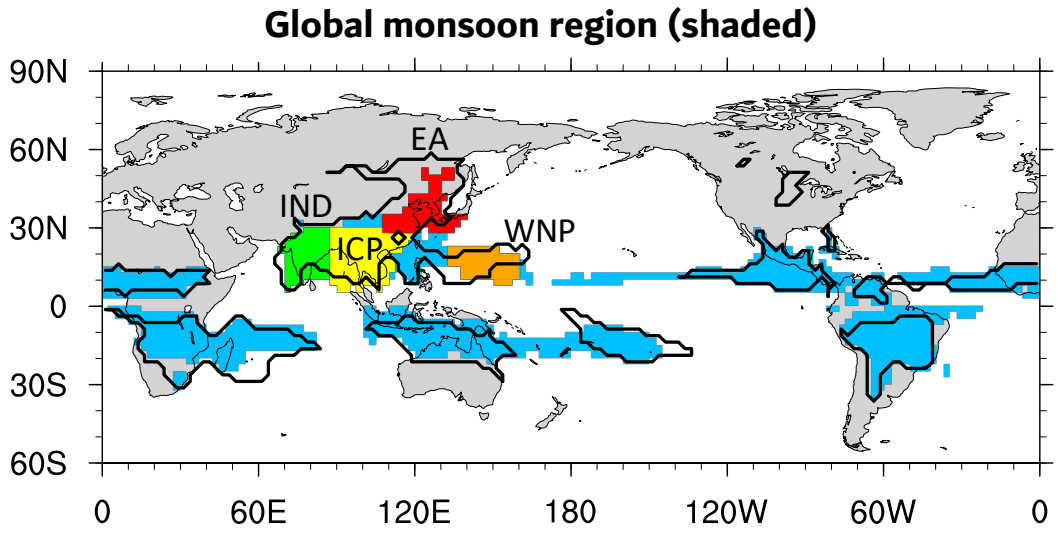


Figure. Taylor diagram for summer precipitation (black, PR) and air2m temperature (red, TAS) over the Asia [0-60ºN, 60-160ºE] during MJJAS among 16 CMIP6 models compared with the GPCP for PR and ERA-Interim for TAS during the period 1979 to 2014.

Definition of summer monsoon domain

- **Annual cycle of precipitation is the most distinctive characteristic of monsoon system.**
- Since the harmonic analysis is relatively insensitive to noise, **we can get useful signal regardless of the noise.**



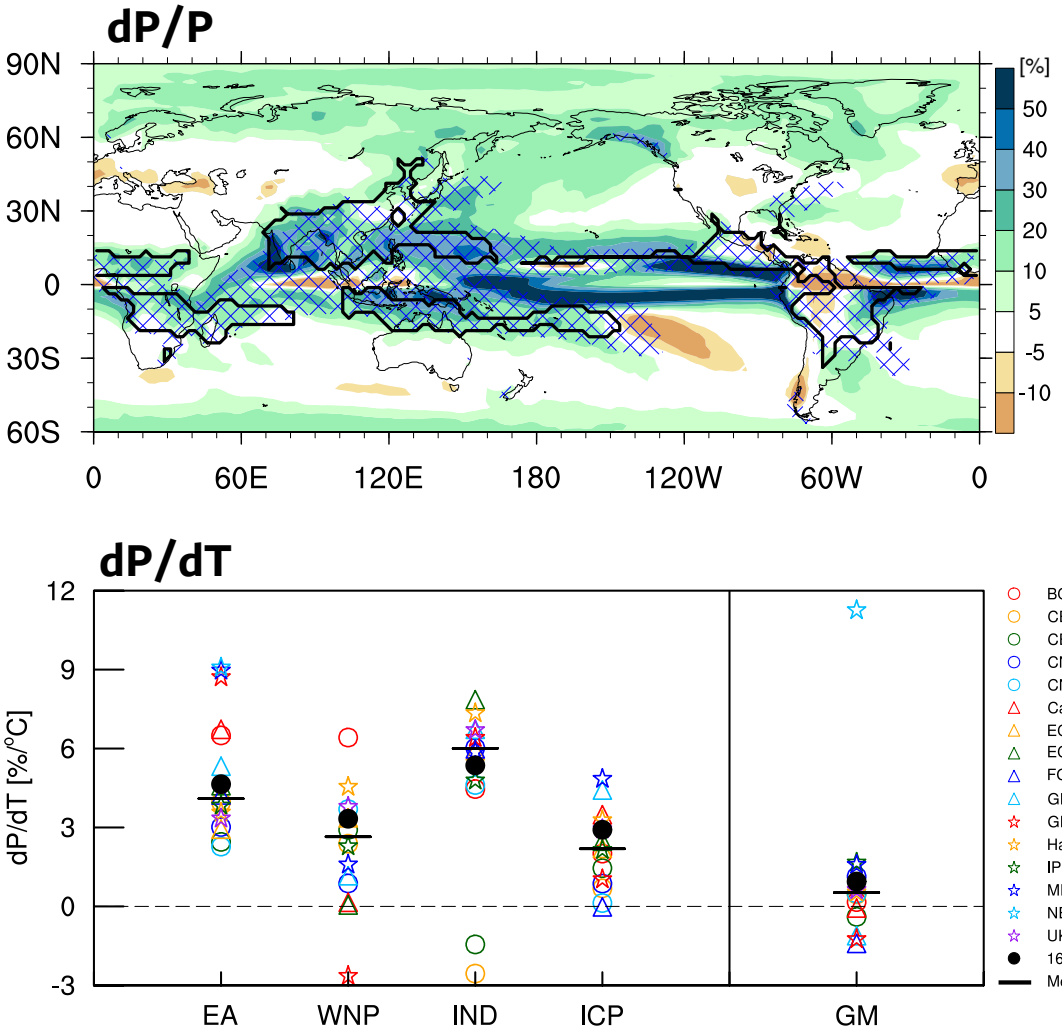
$$\mathbf{AmpR(n)} = \boldsymbol{AMP_0} + \sum_{\boldsymbol{t=Jun}}^{\boldsymbol{t=Aug}} \mathbf{AMP(n)} \times \mathbf{cos}\left[\frac{\boldsymbol{2\pi n}}{\boldsymbol{T}}\left(\boldsymbol{t - PHA(n)}\right)\right]$$

(1) $\boldsymbol{log(AmpR(2)/AmpR(1)) < -0.1}$

(2) $\boldsymbol{AMP(1) > 2mm\ day^{-1}}$

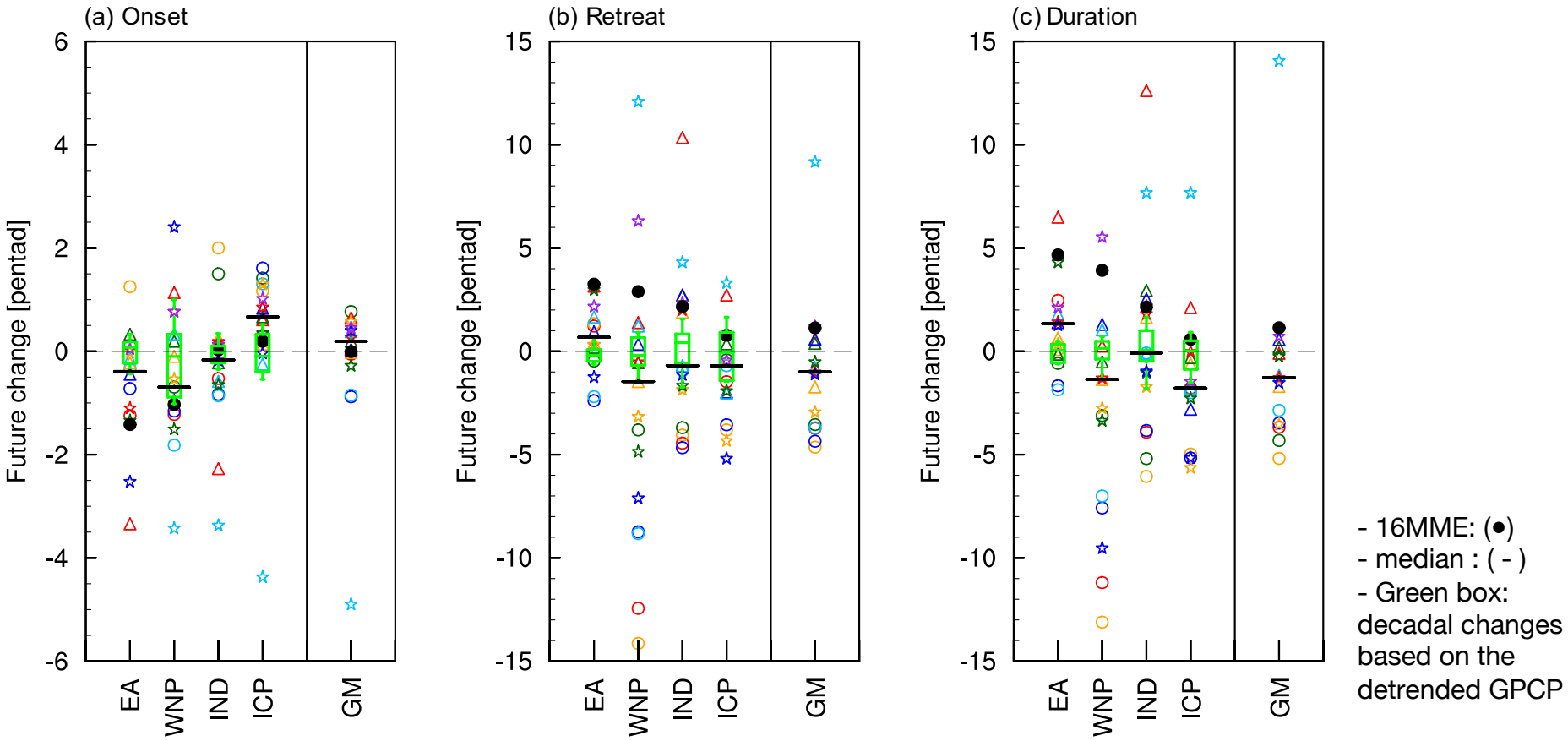
- The main advantage of our new definition is its **robustness,** as it doesn't consider precipitation in mesoscale and smaller scales by using harmonic analysis.

Changes in precipitation rate and rainy season



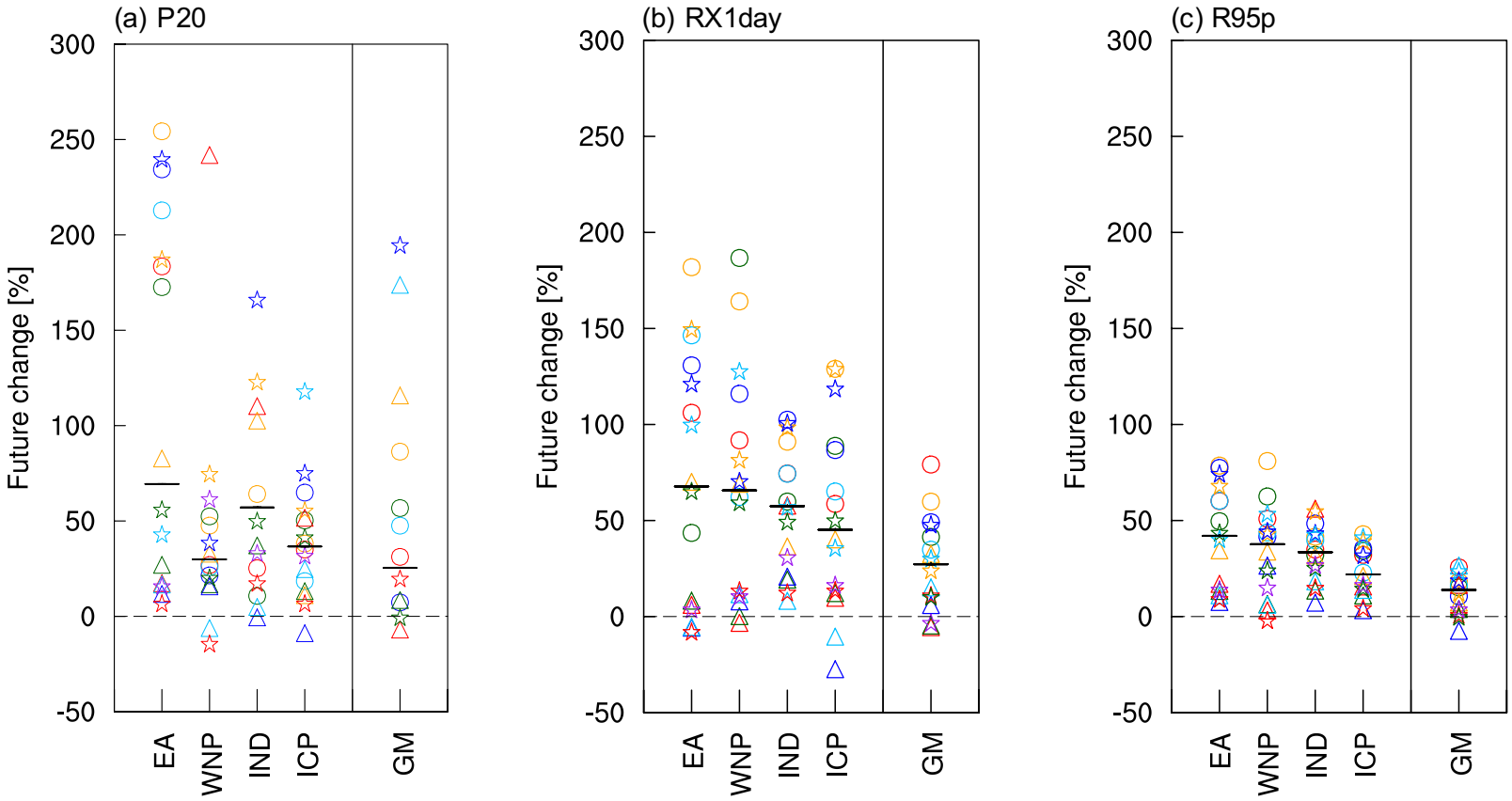
- Summertime ‘wet-get-wetter’ response is shown as the climate warms.
- Rainfall will amplify at about 20% in the future over the present wet-regions.
- The largest precipitation sensitivity is found over IND (5.4 %/°C) & EA (4.6 %/°C).
- The precipitation sensitivity in the Asian summer sub-regional monsoon systems increases considerably more than for the GM.

Changes in summer rainy season



- Modified Wang and LinHo's (2002) definition for onset and retreat of monsoon is used.
- **EA: longer rainy season (onset▼ & retreat▲)**
- **IND: longer rainy season (detreat ▲)**
- **WNP: Earlier onset (▼)**
- **ICP: slightly delayed onset (△)**

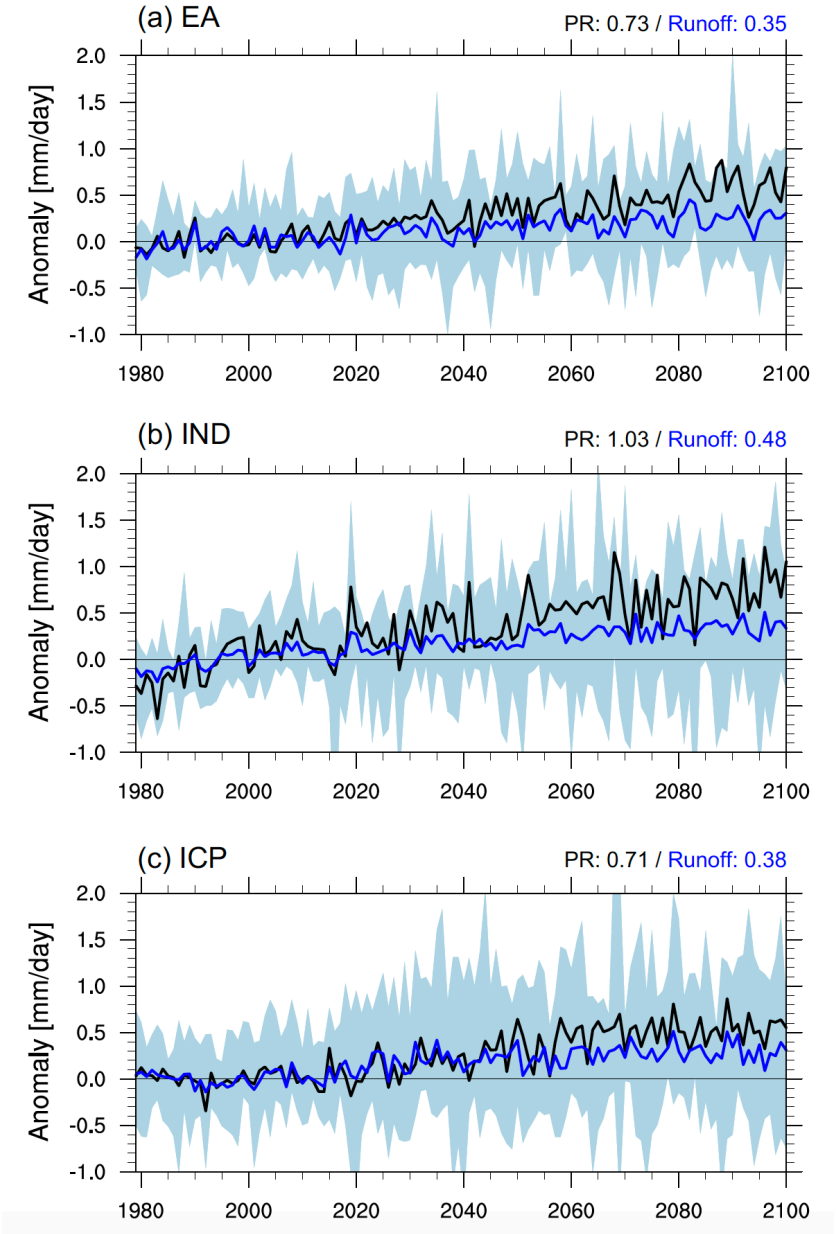
Changes in extreme rainfall



- **P20** : 20-year return value of precipitation
- **RX1day** : maximum1-day precipitation
- **R95p** : the daily precipitation exceeds the 95th percentile of the wet-day precipitation

- **The strong increase in P20 is projected for EA (69 %) and IND (57 %).**
- **Extreme change over EA is largest; RX1day (68 %) and R95p (42 %).**

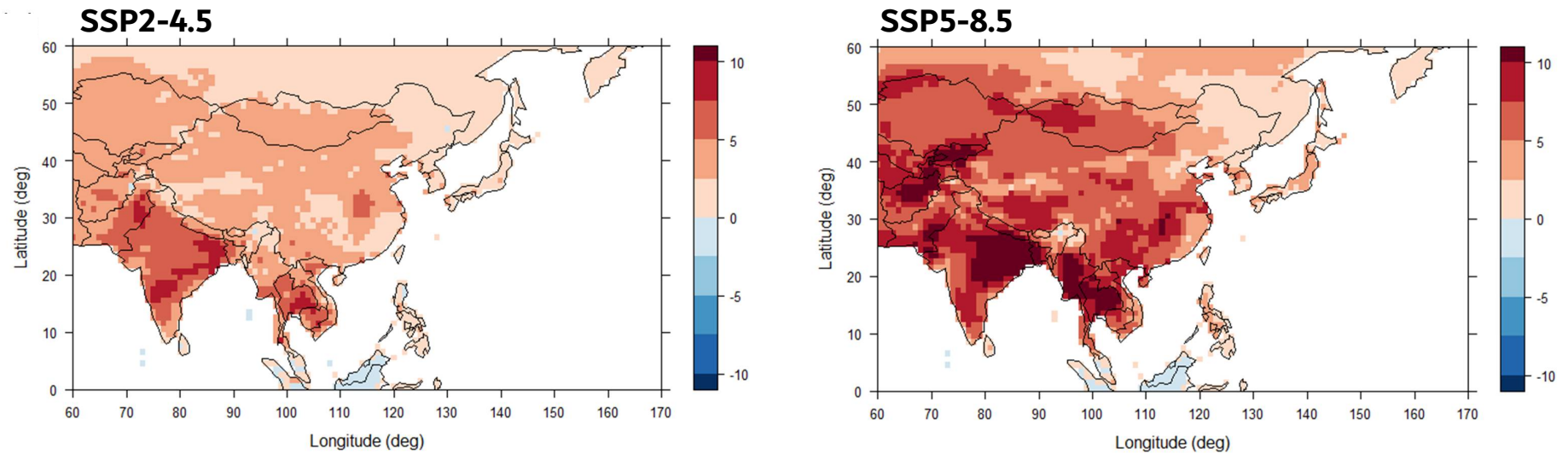
Changes in runoff and evapotranspiration



- While both summer precipitation and runoff increase.
- Increasing evapotranspiration (E) could balance the impacts of growing precipitation on runoff generation.
- E will increase together with the enhance precipitation.
- The less trends of runoffs thus could be attributed to the rising E.

Changes in runoff and evapotranspiration

Linear trend differences (mm year^{-1} decade^{-1}) **between the wet-environment ET (E_w) and actual ET (E)**



- Considering the relative drought definition, the upward E trend is not a signal of wetting land surfaces owing to more rapidly rising E_w.
- The steeper E_w trend implies that atmospheric water demands increasingly deviate from the land-surface water consumption.
- **Future droughts will become even more severe the 'business as usual' SSP5-8.5 scenario.**
- Hence, **despite growing precipitation, future droughts will become more intense due to more rapidly rising atmospheric water demands.**

Summary

- **This study investigates the response of monsoon rainfall, duration, and extremes to greenhouse warming using 16 CMIP6 models.**

- **Within the overall Asian monsoon domain, East Asia and India will be affected most strongly.**

- **The Asian monsoon region will be exposed to more frequent drought conditions.**