Understanding the Predictability of East Asian Summer Monsoon from the Reproduction of Land-Sea Thermal Contrast Change in AMIP-type Simulation

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ABSTRACT

Understanding the physical processes that determine specific climate variability phenomena and performing climate predictions requires heavily reliance on the response of AGCM to specified SST forcing. The skill of this kind of SST-constrained AGCM simulation in East Asian monsoon region is generally lower than that in the other monsoon regions. Given that the monsoon circulation is dominated by land-sea thermal contrast, the reproducibility of EASM circulation is studied from the perspective of land-sea thermal contrast change simulation. The main results are summarized below:

1) The observational change of EASM circulation is dominated by a combination of meridional and zonal land-sea thermal contrast change. A stronger phase of monsoon circulation follows a tropospheric warming over East Asian continent, a cooling over the tropical western Pacific and extra-tropical North Pacific, indicating an enhancement of the summertime “warm-land-cold-ocean” mean state. The land-sea thermal contrast measured by tropospheric mean temperature is a better indicator than that measured by surface air temperature.

2) The AMIP-type simulation shows significant skills in reproducing the tropospheric cooling over the tropical and extra-tropical western Pacific. The observed tropospheric warming over East Asian continent is reasonably reproduced, as evidenced by the statistically significant correlation coefficient at the 5% level. The tropospheric temperature responses in the model indicate that both the meridional and zonal land-sea thermal contrasts are predictable, but the meridional thermal contrast is better reproduced than the zonal thermal contrast.

3) The predictability of two frequently-used monsoon indices is examined. The meridional land-sea thermal contrast monsoon index (i.e., Han-index), which are defined as the normalized zonal wind shear between 850 hPa and 200 hPa averaged within 20°-40°N and 110°-140°E, is highly predictable, as indicated by the statistically significant correlation coefficient at the 5% level between the simulation and the reanalysis. Another index (i.e., the Guo-index), which is defined as the zonal sea level pressure difference between 110°E and 160°E, is unpredictable, based on the result of CAM3 simulation.

4) The skill of the predictable wind-shear monsoon index comes from the predictability of meridional land-sea thermal contrast. Evidence is also seen in the successful simulation of changes in the subtropical westerly jet over East Asia which is a representative of meridional land-sea thermal contrast.

5) With regard to the lower predictability of monsoon index defined as the zonal SLP difference across the land and ocean (i.e., the Guo-index), the primary reason is related to the definition of the index, which attaches great importance to land SLP change. In the model's response, the weaker SLP signal along 110°E over the land, together with a cancellation of positive ocean SLP anomalies owing to the northward penetration of tropical signal result in the low skill of predictability. The model also shows significant skills in reproducing the zonal land-sea thermal contrast

change, albeit with clear bias, the potential skill of the Guo-index should be higher than that we observed.

6) In comparison with the predictable monsoon circulation change, the regional features of monsoon precipitation anomalies are still unpredictable. In the observation, a stronger phase of monsoon circulation is associated with a warmer surface air temperature over East Asian continent and a colder surface air temperature over the tropical ocean, highlighting a meridional land-sea thermal contrast. The model shows significant skill over the tropical ocean but lower skill over East Asian continent. A realistic reproduction of surface air temperature and precipitation anomalies over East Asian continent remains a challenge.

Reference:

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