



## **Role of convective heating in the seasonal evolution of the Asian summer monsoon**

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The seasonal evolution of the Asian summer monsoon (ASM) is closely related to the reversal of the meridional temperature gradient between the Tibetan Plateau (TP) and adjacent ocean in the upper troposphere. Sensible heating has been suggested to play a crucial role in the tropospheric warming over the TP. However, our recent study suggested that adiabatic warming, which is associated with the Matsuno-Gill type atmospheric response to tropical convective heating, plays a crucial role in the temperature increase in the upper troposphere around the TP at the onset phase of the ASM. In this study, we further suggest the crucial role of convective heating in the seasonal evolution of the monsoon trough and tropospheric warming around the TP during the onset period of the ASM. We used correlation analysis to determine the contributing factors and conducted numerical experiments for verification.

Before the onset of Southeast Asian monsoon, the active convection is still limited around the Maritime Continent. The role of convective heating over the Maritime Continent was analyzed based on correlation analysis and sensitivity experiment. The results suggest that convective heating over the Maritime Continent generates the twin-cyclones symmetric about the equator over the eastern Indian Ocean in the lower troposphere, as the Gill-type atmospheric response to an equatorial heat source. The northern low around the Bay of Bengal is associated with the upper-level warming over the southern slope of the TP that derives from adiabatic warming. Thus, the convective heating around the Maritime Continent plays an important role in inducing the southward development of the monsoon trough as well as the reversal of the meridional temperature gradient over the Bay of Bengal, resulting in the Southeast Asian monsoon onset.

The convective heating around the Bay of Bengal associated with the Southeast Asian monsoon, in turn, produces another type of atmospheric response. The convective heating over the Bay of Bengal induces the low extending to the Arabian Sea as well as the upper-level warming to the southwest of the TP, as the Gill-type atmospheric response to an off-equatorial heat source. In addition, such upper-level warming also contributes to the generation of a thermal low around the Arabian Peninsula. The combination of these factors contributes to the westward expansion of the monsoon trough from the Bay of Bengal to the Arabian Peninsula before the Indian summer monsoon onset.

The results here suggest that surface heating of the TP is relatively of the secondary importance, even though it has been previously considered as the dominating factor in producing seasonal evolution of the ASM.