Examining the MJO influence on Asian precipitation by modifying heating with a full atmospheric model

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The midlatitude wintertime response to enhanced convection over the eastern Indian Ocean is investigated by modifying diabatic heating in the NCAR Community Atmosphere Model (CAM). Variability in the eastern Indian Ocean is linked to important modes of large-scale variability, including the Madden-Julian Oscillation and some El Nino episodes. The modeled midlatitude response is quite similar to that observed; in particular, precipitation is strongly suppressed over Southwest Asia. The response is examined from both a dynamic and thermodynamic perspective. We also evaluate the sensitivity of the results to the strength of the added diabatic heating and to the climatological state of the background flow, December-February, and the method used to modify heating.

The diabatic heating is modified by adding an idealized term at every time step in the CAM 3.1, consistent with increased deep convection over the eastern Indian Ocean. The dynamic response to the enhanced heating is similar to the analytic Gill response, with Rossby wave formation westward and poleward of the increased heating. The Rossby wave response results in thermodynamic forcing, as the warm anomalies associated with the Rossby wave packet intersect the westerlies, resulting in cold advection over Southwest Asia (Iran, Afghanistan, and Pakistan). Examination of the thermodynamic balance shows that this cold advection is balanced by subsidence, and the model precipitation is correspondingly reduced, as in the Rodwell-Hoskins hypothesis. Use of the modified CAM allows us to reproduce all four links in the mechanism – Gill-like response, temperature advection, subsidence, and reduced precipitation – and unambiguously link them to tropical forcing in the eastern Indian Ocean. The reverse argument applies over parts of China. Sensitivity analysis is conducted by examining the response in different months, changing the magnitude of the heating, and the method of modifying the heating (adding an idealized term, enhancing the existing heating, and specifying a fixed heating). The response is robust in the model, but does change in strength and extent, especially as related to seasonal changes in the westerlies.