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Dynamics and Thermodynamics of the Regional Response to the Indian Monsoon Onset

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The regional influence of the Indian Monsoon is examined by both observational analysis and modeling experiments, focusing on the Rodwell-Hoskins "Monsoon-Desert" hypothesis. Rodwell and Hoskins have suggested that the strong diabatic heating associated with the monsoon produces a Gill-like Rossby wave response that thermodynamically interacts with the westerlies to produce subsidence and reduced rainfall over parts of North Africa, Mediterranean, and the Middle East. Here we analyze this proposed mechanism in the context of the monsoon onset by examining the changes to the terms of the thermodynamic energy equation and associated changes in the regional circulation between ten days prior to the onset and the ten days after. The NCEP/NCAR reanalysis is used for atmospheric daily data and the GPCP pentad precipitation product is used to estimate rainfall. The hydrologic onset and withdrawal index (HOWI) developed by Fasullo and Webster is used for the monsoon onset because it captures the onset over the ocean, where the convection is strongest, as opposed to more traditional indices which focus on the onset over India – where the societal impact is largest but the convective forcing is secondary.

A Rossby-like response to the monsoon onset is clear in the observational data and is associated with horizontal temperature advection as the westerlies intersect the warm temperature anomalies of the Rossby wave. Analysis of the thermodynamic equation verifies that the horizontal temperature advection is indeed balanced by subsidence over areas of North Africa, Mediterranean, and the Middle East, and analysis of GPCP pentad precipitation shows an associated decrease in precipitation. Preliminary analysis suggests that the reverse occurs during the demise of the monsoon, perhaps playing a role in the onset of the fall wet season in those regions. This may be a more important factor as, while the precipitation decrease associated with the onset can be considerable, it appears to come towards the end of the wet season across most of the affected area. The ability of current atmospheric models to reproduce these dynamics is assessed by enhancing the monsoon-related diabatic heating in the NCAR CAM and examining the associated changes.

The thermodynamic forcing of the monsoon onset also results in rising motion over northern India, which creates a favorable environment for the development of the monsoon over land.