DYNAMICS AND THERMODYNAMICS OF THE REGIONAL RESPONSE TO THE INDIAN MONSOON ONSET

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Background

- Rodwell and Hoskins have suggested that the strong diabatic heating associated with the rainfall in the south-east Asian monsoon region sets up:
  - Subtropical anticyclone to the west at upper levels (Gill-type Rossby wave response).
  - Rossby wave response to the west of subtropical summer monsoon heating, interacting with the midlatitude westerlies, produces a region of adiabatic descent in the North African and Eastern Mediterranean regions.
  - Descent suppresses the precipitation in North Africa and Eastern Mediterranean regions (*Monsoon-Desert Mechanism*).
- We test 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 precipitation. The onset period is represented as difference between the 11-day period after onset (day 0 to day +10) and the 11-day period prior to onset (day –10 to day 0).

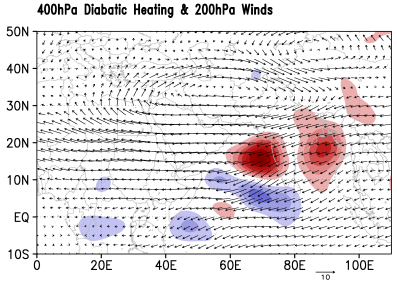


Fig. 1 Composite of diabatic heating (shaded red) that induces an anticyclonic Rossby wave pattern (vectors) to the west of monsoon onset. Contour interval is 0.7 Kday^{-1}.

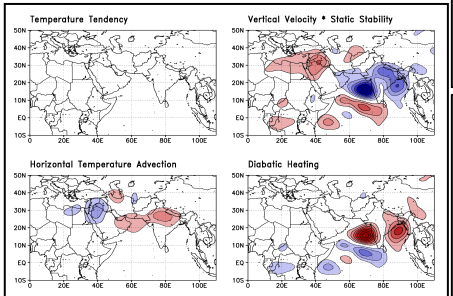


Fig. 2 Composite of thermodynamic balance, represented as the difference between 11-day period after (day 0 to day +10) and 11-day period before monsoon onset (day –10 to day 0) for the terms of the thermodynamic equation at 400 hPa: (a) the tendency term, (b) the vertical velocity term, (c) the temperature advection term, and (d) the diabatic heating term. The contour interval is 0.7 K day^{-1} throughout.

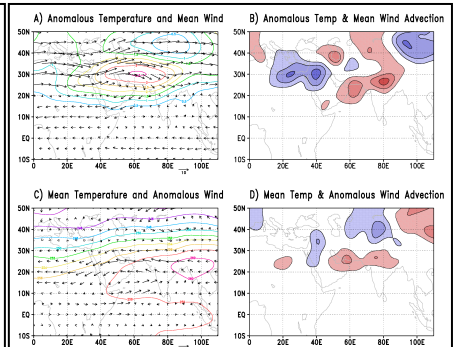


Fig. 3 Changes to 400hPa temperature associated with the large scale onset and the 400hPa wind for the onset period. Contour interval is 0.5 K for (A), 0.35 K day^{-1} for (B), 2 K for (C) and 0.35 K day^{-1} for (D).

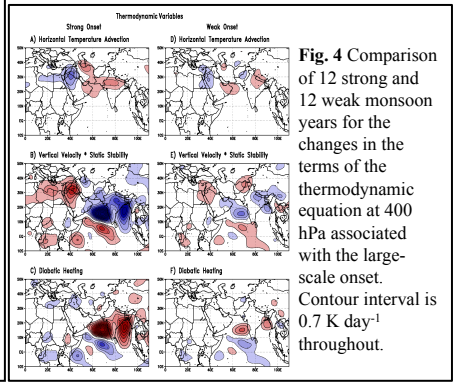


Fig. 4 Comparison of 12 strong and 12 weak monsoon years for the changes in the terms of the thermodynamic equation at 400 hPa associated with the large-scale onset. Contour interval is 0.7 K day^{-1} throughout.

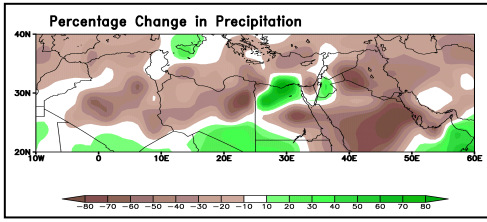


Fig. 5 Percentage change in precipitation, represented as the difference between 11-day period after onset (day 0 to day +10) and the 11-day period prior to onset (day –10 to day 0) in North African and Mediterranean regions (descent regions). The region shaded brown represents the decrease in rainfall resulted by the remote effect of the onset of Indian monsoon, thereby, enhancing drier conditions in those areas.

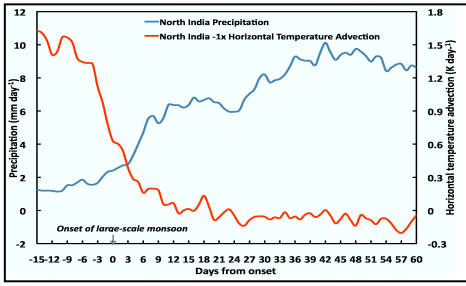
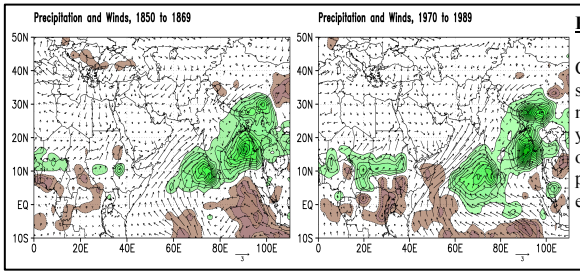


Fig. 6 Composite of North Indian precipitation (APHRODITE's Water Resources) and horizontal temperature advection (from thermodynamic analysis) averaged over the longitudes 70°E to 90°E and latitudes 20°N to 30°N for a period of 40 years from 1961-2000 relative to the HOWI monsoon onset dates, with "0" representing the day of monsoon onset, negative numbers are days prior to monsoon onset and positive numbers are days after monsoon onset.

Conclusions

- Diabatic heating during monsoon onset induces a Rossby wave to its west, which results in adiabatic descent. This is associated with horizontal temperature advection as the mid-latitude westerlies intersect the warm temperature anomalies of the Rossby wave.
- The horizontal temperature advection is balanced by subsidence over areas of North Africa, the Mediterranean, and the Middle East.
- Satellite data confirms a decrease in precipitation over North Africa, Middle East and the Mediterranean regions at the time of Indian monsoon onset.
- The thermodynamic forcing of the monsoon onset also results in rising motion over northern India due to horizontal temperature advection, which indicates the development and hence progression of the monsoon with time.



Preliminary analysis of CMIP5 data

Comparison between precipitation and surface winds for the large-scale Indian monsoon onset for a period of 20 years: 1850-1869 and 1970-1989 using output from CanESM2 Model for 1 percent per year CO_2 increase experiment run.

Publication

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