# Mechanism of spatio-temporal transition to monsoon and prospects for prediction

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The variability of the Indian monsoon onset has an enormous effect on more than 1.7 billion people. Consequently, understanding the mechanisms of the transition to monsoon and its successful forecasting is not only a question of great interest, but also a significant scientific challenge. Here we address the problem of the spatial and temporal organization of the abrupt transition to the Indian monsoon. The analysis of observational data uncovers that there is a threshold behavior at the transition to monsoon over the central part of India. Based on these observations, we consider the transition to monsoon from a dynamic system perspective and propose a novel mechanism of a spatio-temporal transition to monsoon. Our approach has several advantages in comparison to existing explanations of the Indian Monsoon nature: it describes the abrupt transition to monsoon in a chosen region of the Indian subcontinent, the spatial propagation and variability of the Indian Monsoon onset along the axis of advance of monsoon, and allows to explain the "bogus" monsoon onsets.

In addition, based on this approach we develop a novel prediction scheme for forecasting of monsoon timing. Unlike most predictability methods, our scheme does not rely on precipitation analysis, but on air temperature and relative humidity, which are well-represented both in models and observations. The proposed scheme predicts the onset and withdrawal dates more than two weeks and a month earlier than existing methods, respectively. In addition, the scheme allows the inclusion of the information about the El-Niño–Southern Oscillation in the forecasting of onset and withdrawal dates, thereby, significantly improving the prediction of monsoon timing during anomalous years associated with the El-Niño–Southern Oscillation. Finally, the proposed scheme can be directly implemented into the existing long-range forecasting system of the monsoon's timing.