



Long-term prediction of the Indian monsoon onset and withdrawal

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Forecasting the onset and withdrawal of the Indian summer monsoon is crucial for life and prosperity of more than one billion inhabitants of the Indian subcontinent. However, accurate prediction of monsoon timing remains a challenge, despite numerous efforts. Here, we present a method for prediction of monsoon timing based on a critical transition precursor. We identify geographic regions - tipping elements of the monsoon - and use them as observation locations for predicting onset and withdrawal dates. Unlike most predictability methods, our approach does not rely on precipitation analysis, but on air temperature and relative humidity, which are well represented both in models and observations. The proposed method allows to predict onset two weeks earlier and withdrawal dates 1.5 months earlier than existing methods. In addition, it enables to correctly forecast monsoon duration for some anomalous years, often associated with El-Niño-Southern Oscillation.