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Detecting subseasonal far-away causal drivers and empirical prediction of the Indian Summer Monsoon

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The Indian summer monsoon (ISM) is crucial for the economy, society and natural ecosystems on the Indian peninsula.
Predict the total seasonal rainfall at several months lead time would help to plan effective water management strategies, improve flood or drought protection programs and prevent humanitarian crisis.
However, the complexity and strong internal variability of the ISM circulation system make skillful seasonal forecasting challenging. Moreover, to adequately identify the low-frequency, and far-away processes which influence ISM behavior novel tools are needed.
We applied a Response-Guided Causal Precursor Detection (RGCPD) scheme, which is a novel empirical prediction method which unites a response-guided detection scheme with a causal discovery algorithm. This tool allows us to assess causal pathways between different components of the ISM circulation system and with far-away regions in the tropics, mid-latitudes or Arctic. The scheme has successfully been used to identify causal precursors of the Stratospheric polar vortex enabling skillful predictions at (sub) seasonal timescales (Kretschmer et al. 2016, J.Clim., Kretschmer et al. 2017, GRL).
We analyze observed ISM monthly rainfall over several regions in India and at different time scales. Applying causal discovery techniques, we identify several causal precursor communities in the fields of 2m-temperature and sea level pressure. Specifically, our results suggest that surface temperature conditions in both tropical and Arctic regions contribute to ISM variability. A linear regression prediction model based on the identified set of communities has good hindcasting skills with 4-5 months lead times.
Further we separate El Nino and La Nina years from each other and find that the causal precursors are different dependent on ENSO state. The ENSO-state dependent causal precursors give even higher skill, especially for La Nina years when the ISM is relatively strong.
These findings are promising results that might ultimately contribute to both improved understanding of the ISM circulation system and help improving seasonal ISM forecasts.