Identification of tipping elements of the Indian Summer Monsoon using climate network approach

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Spatial and temporal variability of the rainfall is a vital question for more than one billion of people inhabiting the Indian subcontinent. Indian Summer Monsoon (ISM) rainfall is crucial for India's economy, social welfare, and environment and large efforts are being put into predicting the Indian Summer Monsoon. For predictability of the ISM, it is crucial to identify tipping elements – regions over the Indian subcontinent which play a key role in the spatial organization of the Indian monsoon system. Here, we use climate network approach for identification of such tipping elements of the ISM.

First, we build climate networks of the extreme rainfall, surface air temperature and pressure over the Indian subcontinent for pre-monsoon, monsoon and post-monsoon seasons. We construct network of extreme rainfall event using observational satellite data from 1998 to 2012 from the Tropical Rainfall Measuring Mission (TRMM 3B42V7) and reanalysis gridded daily rainfall data for a time period of 57 years (1951-2007) (Asian Precipitation Highly Resolved Observational Data Integration Towards the Evaluation of Water Resources, APHRODITE). For the network of surface air temperature and pressure fields, we use re-analysis data provided by the National Center for Environmental Prediction and National Center for Atmospheric Research (NCEP/NCAR). Second, we filter out data by coarse-graining the network through network measures, and identify tipping regions of the ISM. Finally, we compare obtained results of the network analysis with surface wind fields and show that occurrence of the tipping elements is mostly caused by monsoonal wind circulation, migration of the Intertropical Convergence Zone (ITCZ) and Westerlies. We conclude that climate network approach enables to select the most informative regions for the ISM, providing realistic description of the ISM dynamics with fewer data, and also help to identify tipping regions of the ISM. Obtained tipping elements deserve a special attention for the meteorologists and can be used as markers of the ISM variability.