

## **Analysis of droughts in the Indian summer monsoon rainfall in relation to drivers of the global climate system**

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The possible causes for the incidence of droughts in the ISMR(JJAS) have been under investigation for over 140 years. The rainfall of India is one of the important climatic indicators in the global climate system as highly reliable data on the all-India and homogeneous regions of India are available in the form of time series produced by Indian Institute of Tropical Meteorology (IITM). This data series is examined to identify the extreme years in the seasonal rainfall and we use the data on the droughts for this study. The Indian rainfall is known to fluctuate on the monthly scale as well as on the sub-regional scale in such a manner that there is compensation among the months as well as on the spatial domain of homogeneous regions. ISMR on the all-India drought years has been examined in relation to the persistence of drought in the four months of the seasons as well as in the simultaneous occurrence of drought over five homogeneous regions in relation to all India. It is found that in the extreme drought seasons of the seasonal rainfall remains below its normal for three or four months, indicating that temporally drought monsoon season occurs as a quasi-persistent feature on monthly scale. During the drought season the following features are noted on the spatial scale. 1. For all the five or four homogeneous regions rainfall amounts are below the respective standard deviation. These account for most widespread droughts, which have occur only on a few seasons. 2. The homogeneous region of north-west India, west-central India and Peninsular India (three of the five regions) are in drought while the two eastern regions have positive departure from the normal, showing areal compensation in rainfall. 3. There are seasons during which the regions of Peninsular India is in opposition to West-Central India and North-West India. These features show the spatial homogeneity in relation to the incidence of droughts and the causes for this are sought in the study. The temporal and spatial persistence of the seasonal droughts would suggest linkages with the global climate system. These drought events are examined in relation to the driver of the global climate system such as El Niño (ENSO), North Atlantic Oscillation (NAO), Quasi Biennial Oscillation (QBO) in the stratosphere, solar activity, volcanic activity and Eurasian cryosphere. The data on all these drivers are examined in relation to the incidence of monsoon droughts. The relation is sought with respect to the QBO in the zonal winds in 10, 30 and 50 mb inferred from the NCEP reanalysis (1951 onwards). Some volcanic eruptions in the tropics are also studied in relation to monsoon droughts. The analysis suggest that whereas warm-ENSO-monsoon relationship could account for nearly 55% of the droughts, there are other associations with the other climatic drivers too. Drought occasions are identified with reference to simultaneous association with more than one drivers of the climate system.