



## Extreme droughts of Indian Summer Monsoon with and without El Nino

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The Indian summer monsoon is one of the important seasons over the Indian sub-continent, which contributes about 70 to 90% of the annual rainfall. Here, we made analysis using different data sets of high research quality. From the rainfall distribution, during drought years which are not associated with El Nino, it is evident that most of the places of the Indian continent are below normal rainfall, except peninsular India and eastern region. Most of the drought conditions of the ISMR are associated with El Nino (11 years out of the 16 years) indicating that about 68% of the drought years are associated with Pacific influence. Among the 11 drought years, there were 6 drought years are associated with strong El Nino. The below normal rainfall hits mainly over the west coastal stations. Entire north Indian and most of the central Indian regions are under the below normal conditions. The cumulative distribution over central India shows that the drought with El Nino gives clear indication of droughts from the early June onwards, however, in the case of normal droughts, it goes to below normal distribution from the normal values only during the first week of July. By assessing the amount of rainfall during June, it is not easy to predict the rainfall during that year is below if there is no El Nino. In the case western ghat region, during El Nino years the below normal rainfall shows clear indications from the early June onwards as in the case of central India. The amount of rainfall till the first week of August showing almost similar cumulative property, but after that the contribution of rainfall is getting lower in both types of drought years. The droughts associated with El Nino is getting more weaker than the droughts that are not associated with El Nino.

Spatial patterns of SST anomaly during both the drought years with and without El Nino have significant differences. The SST during droughts associated with El Nino clearly depicts that a pool of positive SST anomalies over the east of 180° E longitude. This positive band confined only over the equatorial region and therefore it can play a dominant role in atmospheric circulation pattern thereby controls the ISMR. However, during the drought years that are not associated with El Nino, the SST pattern is much different in the Pacific and Indian Ocean. In the Indian Ocean, SST is getting much lower than the normal, especially over the west equatorial Indian Ocean. This band of low SST creates high pressure over the region and thereby descending motion of atmospheric circulation especially west equatorial Indian ocean. This abnormally cold SST decelerates the wind speed at lower levels. This decreased value of LLJ considerably reduce the moisture supply in to the Indian continent and ultimately decreased rainfall.