INTRODUCTION
This study presents some of the applications of drought modelling such as drought hotspot identification, development of severity-duration-frequency (S-D-F) curves, identification of regions having similar S-D-F curves. Shifting of hotspot in future scenarios and regionalisation of different hydrological variables in various spatial scale. In a country like India, where agricultural economy contributes significantly to India’s GDP, drought can inflict severe damage by slowing down the economic growth as it affects production and water availability. Drought hotspot identification as a long-term drought mitigation strategy can help in taking severe measures and creating suitable land water management framework to counter the impact of future drought events. The S-D-F curves analysis can provide the return period of short term and long term drought events that must be taken into consideration for hydrological analysis of water management structure. Regionalisation based on S-D-F curves in historical period and future period helps understanding the shifting of hotspot and the effect of potential climate change. The study can immensely help law makers to formulate policy towards drought proofing India.

Drought hotspot

Mathematical framework

\[ f(x, w) = \prod_{s=x}^{w} \Phi(z, s) \]

\[ \mathbb{P}(x, w) = \prod_{s=x}^{w} \Phi(z, s) \]

- Using crop water stress as drought index
- Classification of crop water stress using Relevance vector machine
- Conditional copula to compute return period of any drought event

Regional drought S-D-F Curves

Mathematical framework

\[ y = \min_{x \in \mathbb{R}^d} \mathbb{E}[V] \]

- Regionalisation using K-mean clustering based on S-D-F curves for historical and future period
- Severity of the regional S-D-F curves \( S_{dx} \) for duration (d) corresponding to a return period \( t \) is calculated

Regionalisation of India based on meteorological drought pattern

Mathematical framework

\[ \mathbb{P}(x, f, v, v) = p_u \cdot [ \mathbb{P}_{d chance} \cdot \mathbb{P}_{d chance} \cdot \mathbb{P}(f(x, v, v)) \]

- Classification of hydrological variables using probabilistic graphical model for historical and future period
- Computation of heterogeneity value

Results

Figure 1: Map of western India with the four states: Odisha, Jharkhand, Chhattisgarh and Bihar.

Figure 2: Crop water stress time series for agricultural drought monitoring at a location in the region and corresponding drought characteristics: severity and duration

Figure 3: Comparison of crop water stress-based probabilistic drought monitoring with standardized precipitation index (SPI) and standardized soil moisture index (SSMI). The plots show (a) SPI and SSMI time series, (b) soil moisture time series, and (c) probabilities of near normal, moderate, severe, and extreme agricultural drought classes

Figure 4: Severity-duration-frequency curves in (a) to (d) plotted for the select four locations of the study region using conditional copula. The six curves shown in each plot correspond to return periods of 1, 2, 5, 10, 20, and 40 years

Figure 5: Risk analysis in terms of return period of droughts with characteristics of severity and duration (\( s \) and \( t \) is the return period and the severity and the duration respectively)

Figure 6: Spatial variability of the inter arrival rate (\( r \)) of meteorological drought events in the study area during the baseline (1971-2003) period

Figure 7: Map of eastern India with the four states: Odisha, Jharkhand, Chhattisgarh and Bihar.

Figure 8: Homogeneous clusters (8 regions) of grid locations identified in the study region based on projected future drought characteristics of the baseline (1971-2003) period

Figure 9: Regional S-D-F curves corresponding to the baseline (1971-2003) period developed for the 8 homogeneous regions for return periods of 1, 2, 5, 10 and 20 years

Figure 10: Homogeneous clusters (7 regions) of grid locations identified in the study region based on projected future drought characteristics of the future (2042-2068) period

Figure 11: Regional SDF curves corresponding to the future (2042-2068) period developed for the 7 homogeneous regions for return periods of 1, 2, 5, 10 and 20 years

Figure 12: Homogeneous regions of monsoon precipitation in India identified using the MRF technique for the (a) baseline period (1970-2001) and (b) future period at RCP 4.5 (2041-2070) and (c) future period at RCP 8.5 (2041-2070)

Figure 13: Homogeneous regions of monthly precipitation in India identified using the MRF technique for the (a) baseline period 1970-2001 (b) future period at RCP 4.5 (2041-2070) and (c) future period at RCP 8.5 (2041-2070)

Figure 14: Homogeneous regions based on mean monthly temperature in India identified using the MRF technique for the (a) baseline period 1970-2001 and (b) future periods at RCP 4.5 (2041-2070) and (c) future period at RCP 8.5 (2041-2070)

Figure 15: Plot of Jaccard coefficient for transitions from a) baseline period to RCP 4.5 b) baseline period to RCP 8.5 c) baseline period to monthly precipitation dataset

Figure 16: Homogeneity value and the number of grid points present in each region obtained using the MRF technique

Publications

