Geophysical Research Abstracts
Vol. 20, EGU2018-6369, 2018
EGU General Assembly 2018

Modelling the dependence structure of concurrent climate extremes in a drought prone region

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Investigating the dependence structure of concurrent climate extremes is important to provide accurate assessment of probabilities of occurrence of extreme events. Low rainfall is often the primary cause of drought; however, accumulation of rainfall deficits with increased evapotranspiration due to high temperatures and soil moisture deficits could lead to more critical conditions. Therefore it is important to explore the underlying extremal dependence behaviour of rainfall, temperature and soil moisture for such situations. Identifying this dependence structure is crucial for scientific understanding of interaction between these variables and developing risk assessment framework. Multivariate extreme value models enable the modelling of such critical extreme combinations. The extremal dependence of rainfall, temperature and soil moisture is examined in the drought prone Marathwada region, Maharashtra state, India. The aim of this work is to estimate the probability of simultaneous occurrence of these extremes. To characterize multivariate extreme value distributions, marginal distributions are specified first and transformed into unit Fréchet marginal distributions. The coordinates of data points are transformed into pseudo-polar coordinates to make the dependence structure more explicit. The dependence structure is revealed through angular densities to gain first insight into tail dependence structure. Extremal coefficient and coefficient of tail dependence are used to summarize the extremal dependence. The results suggest a strong extremal dependence among the variables considered. The extremal dependence is further used to estimate the probabilities of excesses above high thresholds. Joint return level plots for critical combinations of concurrent extreme values are obtained for the study area.