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Future occurrence of threshold-crossing seasonal rainfall totals: Methodology and application to sites in Africa

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A statistical simulation framework is developed to explore the future frequencies of threshold-crossing events, focusing here on low seasonal rainfall totals. Global change (GC) is represented by a trend on the seasonal mean rainfall total. Natural decadal to multidecadal variability (MDV) is represented by an autoregressive process. Interannual variability (IV) of seasonal totals is represented by white noise with either a normal or skew normal distribution consistent with parameters observed in the historical record at the location being modeled. Monte Carlo simulations are undertaken for various combinations of the above components, and we evaluate the extent to which future event frequencies can be estimated from the statistics of previous years. The sample of four study locations used to illustrate the approach are drawn from the Millennium Villages Project in Africa, where the potential of index insurance as a development and adaptation tool has been considered, thereby bringing a targeted problem setting to the analyses. The simulations highlight a number of general principles. For example, it is shown that a 10% change in the mean rainfall can lead to a change of order times two in the number of threshold-crossing low seasonal rainfall totals, even without invoking any change in the characteristics of the IV. The magnitudes of change are also shown to be sensitive to the threshold studied, as well as to site-specific climate features (here, coefficient of variation and skewness). The framework developed permits quantification of how, especially in the near-term (of order 30 years), MDV can strongly add to uncertainty about future event frequencies. Therefore, statistical treatment of estimated MDV magnitudes will often be a key input to optimal risk management, with further enhancements expected through explicit MDV forecasts. The results highlight the importance of finding optimal ways to update climate statistics such as event thresholds, in the presence of GC and MDV. Ongoing work applies this methodology more specifically to the regional context of the west African Sahel, where multidecadal variability is particularly strong and explores both quantification of both drought and flood extremes.