Geophysical Research Abstracts
Vol. 21, EGU2019-15371, 2019
EGU General Assembly 2019

A stochastic rainfall generator for intertropical regions: Simulating seasonality, occurrence, and extreme storms

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Stochastic rainfall generators aim at reproducing the main statistical features of rainfall occurrence and intensity at small spatial and temporal scales. Used to simulate long-term synthetic rainfall series, they are recognized as suitable for use with impact analysis in the fields of water, agricultural, and ecological management.

While many stochastic rainfall generators have been developed in the last decades and applied in regions with contrasted climates, only a few of them have been developed and used in intertropical regions. The largely convection-driven rainfall in the intertropical belt presents properties that need to be specifically considered and included in stochastic rainfall generators. These include (i) a strong intermittency of rainfall, (ii) high variability of intensities within storms, (iii) strong spatiotemporal correlation of intensities, and (iv) a marked seasonality that affects the statistical properties of storms (i.e. occurrence, intensity). In addition, intertropical storms are among the most powerful on Earth, and an intensification of the most extreme ones is already observed in some regions, tied to global warming.

In this paper, improvements for an existing statistico-dynamic stochastic rainfall generator that models convective storm systems in the intertropical zone are presented. Notable improvements include (i) the ability to model the occurrence of precipitation events via a model based on the distribution of the inter-event time parameter, (ii) an improved temporal disaggregation scheme that better represents the rainfall distribution at all sub-event scales, and (iii) the use of covariates that reflect seasonal changes in precipitation occurrence and marginal distribution parameters. Extreme values are explicitly considered in the distribution of storm event intensities. In this study, the simulator is implemented in the Sahelian region, specifically in southwest Niger. The simulator is calibrated and the simulations validated using 28 years of 5-minute precipitation data from the 30 rain gauge AMMA-CATCH network. The simulation is used to generate both large propagative systems and smaller local convective precipitation. Results show that the improvements in the simulator coherently represent the local climatology. The simulator can be used to generate scenarios for hydrological and agricultural impact studies with a more accurate representation of convective precipitation characteristics.