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A non-stationary simulator of short duration rainfall extremes with CMIP5 ensemble uncertainty

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In the wake of the devastating 2017 Atlantic hurricane season, global insured catastrophe losses are anticipated to exceed $100 billion and may become the largest in a single year. Hurricane Harvey alone broke the record as the wettest single storm in the continental United States with 1640 mm of rain recorded at Nederland, Texas causing unprecedented flooding to Houston. Events such as this and the extensive flooding in India and China in the same year serve as a reminder of the impact of extreme rainfall and the spectre of worse under climate change. In a warming climate, extreme rainfall is expected to become more frequent. However, the limited number of observed extremes make the estimation of increasingly rare events highly uncertain. To ensure the resilience of urban environments and utilities there is a need for new estimation techniques that use more data than the small sample of observed extremes to augment existing methods.

We present a new non-stationary approach for estimating rainfall extremes by simulating storm profiles using stochastic mechanistic rainfall models of the Bartlett-Lewis variety. Focussing on sub-hourly extremes, storm profiles are simulated using the censoring approach set out in Cross et al. (2017) and the models are conditioned on continuous environmental variables obtained from the CMIP5 model experiments. Because of the limited observation range of the present climate training data, model parameter sensitivity is approximated using multivariate linear regression to derive parameter values and quantify uncertainty for future scenarios. The simplest application uses a single explanatory covariate such as near surface air temperature, but the method is easily extended to multiple covariates such as sea level pressure, humidity, and sea surface temperatures. Climate model weighting is used to obtain ensemble extreme value estimates with uncertainty, avoiding climate model bias and incorporating climate model uncertainty.

This approach is expected to have immediate impact for the estimation of very rare events at fine temporal scales. One such application is the design of nuclear power plant drainage networks which are required to operate with up to a 10,000-year return period design storm rainfall.

Cross, D., Onof, C., Winter, H. and Bernardara, P.: Censored rainfall modelling for estimation of fine-scale extreme, Hydrology and Earth System Sciences Discussions, in review 2017, 1-39, 2017.