Response to Referees

We thank you for your time and valuable feedback. Please see below, our responses (in blue color text) to the comments.

Referee 2

Comments on: Technical Note: Modeling Spatial Fields of Extreme Precipitation – A Hierarchical Bayesian Approach by Rahill-Marier et al.

The technical note presented a Hierarchical Bayesian Approach for modelling the spatial fields of extreme precipitation, aiming at simulate rainfall field when extreme rainfall occurring in one or more stations. Hierarchical Bayesian framework is applied for shrinking the rainfall in the space. In general, the technical note is well-written and mathematically rigorous. I am supportive of the publication of the manuscript if the following comments can be addressed.

1. The contribution needs to be highlighted in the introduction. To my understanding, the key difference between a tradition regional rainfall frequency analysis and this spatial fields analysis is the input data, while the Hierarchical Bayesian model is not very different. Thus, it is important to clarify the contribution of this work.

We will add the following paragraph towards the end of the introduction.

"Hierarchical Bayesian models have been applied in the past to spatial fields of annual maximum rainfall. The purpose of these models is to pool information to reduce the uncertainty associated with the return periods of extreme rainfall, and for intensity duration frequency curve analysis. Here, we are interested rather in the spatial distribution of storm rainfall associated with an extreme rainfall event, that is defined such that any location in the region experiences an extreme rainfall event. This is a different goal and informs the rainfall loading a spatially extended drainage network may experience during such an event."

2. For a T-year return period, the return level at a gauge is usually calculated based on the quantile of the annual maxima, which should be independent of the model. In another word, even if calculated with different models or different subsets of data, the return level should be somehow consistent. On line 99, the logged-mean is pooled in the space, where annual maximum (from the target gauge) and non-annual maximum (from other gauges) are pooled. Since the non-annual maximum will usually be smaller than the annual maximum, will the T-year event be systematically under-estimated with the approach developed in this technical note? If so, there is a way of overcoming this shortage?

The traditional approach implicitly considers a T-year event at each site occurring independently. At the event scale, it is rather unlikely that the T-year event estimated using annual maximum data would occur simultaneously at all locations. Thus, from a systems operation perspective, one needs to estimate a model that allows realistic rainfall fields corresponding to extremes to be estimated. To our knowledge, ours is the first approach to consider that. Indeed, it is very likely that for a given event simulated from our model the rainfall at most locations will be smaller than the rainfall experienced at the location with the highest rate. The application of our model would be to draw simulations from the fitted model, such that one or more sites experience a T-year extreme rainfall event, while the other sites experience a rainfall field that is consistent with the pattern to be expected for such an extreme event. The site that gets the extreme event would be simulated randomly in each case for each draw from the model.

3. Line 30, the definition of R_djki is hard to understand.

We use A for annual maximum event for each site and duration and year. Then, based on these events, for each anchor station, we also capture all the rainfall in other stations along with this event. This we denote using R. We will clarify this using a simple example based on a sample year data.

4. Line 80. The simultaneous fraction analysis showed how many events are concurrent, while it does not provide any information on the spatial dependence of the intensity of extreme rainfall. Although considering spatial structure is important anyway, authors need to make a better justification for this sentence.

The counts analysis was developed to summarize the overall fields across all stations. The dependence here is mainly to show if extremes happen simultaneously or not, thereby motivating the need for modelling specific fields for various durations. Once we motivate this, the models have the spatial dependence of the fields constructed through the multi-variate normal distributions on the log-transformed data. We changed the section heading to spatial concordance instead of spatial dependence to clarify.