Interactive comment on "A Hybrid Stochastic Rainfall Model That Reproduces Rainfall Characteristics at Hourly through Yearly Time Scale" by Jeongha Park et al.

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Dear Dr. Hannes Müller

We sincerely appreciate your constructive comments on our manuscript. All your comments tremendously helped us to improve the quality of the article. We have prepared the following responses to your comments:

Comment 1. The rainfall model generates hourly rainfall time series. Are there any investigations/plans to extend it to e.g. 5 min resolution (instead of applying cascade models as suggested in the outlook)? Do you see any restrictions or arising problems, if the method would be extended to a finer temporal scale?

Authors' Response. Yes, we do have a plan, and we invited to collaborate in the near future if you are interested.

Comment 2. To enable comparisons with other rainfall generators, maybe the authors want to spend a few words on the total number of parameters required to generate the hourly rainfall time series? E.g. for the MBLRP-module you use 6 parameters per set and one set per month, resulting in 72 parameters for module 3. What is the total number of parameters?

Authors' Response. Thank you for your suggestion. We added the following sentence according to your suggestion:

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[(new) page 29 line 1] *5.2 An Issue with Model Parsimoniousness: six versus fifty five*

Our hybrid model uses one MBLRP model parameter set per one simulation month of one year while the MBLRP model needs only 6 parameters regardless of the simulation length. However, this does not mean that our model requires 600 MBLRP model parameters (6 per month × 100 months) to generate 100 months of rainfall. This is because parameters are estimated based on the sub-daily scale rainfall

statistics that are synthetically generated through the process of the SARIMA model and the regression analysis (See Figure 5). Therefore, the parameters of the SARIMA model and the parameters of the regression analyses shown in Figure 5 should be considered as the "true" parameters of this model because once these parameters are given, our model can generate infinite length of rainfall record. The SARIMA model has 6 parameters, and a set of regression analysis shown in Figure 5 has 49 parameters (2 for each of ten solid arrows in Figure 5 = 20, 3 per 8 bivariate normal distributions relating two subsequent residual terms (ε_i) in Figure 5 = 24, and one for each of 5 normal distributions perturbing autocorrelation terms (c_i) = 5). Therefore, our model has a total of 55 parameters. This discrepancy of number of parameters (6 for the traditional of MBLRP model versus 55 of our hybrid model) can be considered as a cost taken to reproduce the large-scale rainfall variability that the traditional MBLRP model cannot.

We admit that this large discrepancy of model parsimoniousness is an issue to be resolved for our model to be applied in practice. Regarding this, we are planning to apply our model to additional gauge locations across the world and share the result through the website (http://www.letitrain.info). The work has been already initiated for the rainfall data of Korean Peninsula.

Comment 3. P15l18-20 ". . .the MLRP model that reflects the original spatial structure of rainfall in reality, . . ." What is the connection between the point statistics mentioned before and the spatial structure? Is it planned to extend the introduced model to be able to generate spatial rainfall? Even if not, maybe the authors want to include in their outlook, how this can be achieved, for example i) during the rainfall generation by e.g. the circle approach with the radius of single pulses or their velocities as additional parameters (Cox and Isham, 1988, Bordoy and Burlando, 2014) or ii) subsequently be a resampling approach (Müller and Haberlandt, 2015)? Where do the authors see opportunities/limitations?

Authors' Response. Thank you for your suggestion. That sentence you mentioned in our article can indeed confuse many readers because the Poisson cluster model mentioned in this study is purely a single-site model. We added a sentence in the conclusion according to your suggestion as follows:

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[(old) page 26 line 18 / (new) page 30 line 5] … *Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO). Lastly, the genuine structure of our model that is composed of a large scale rainfall generation module and a downscaling module, may be integrated to the existing space-time rainfall generators to enhance their ability to generate large-scale rainfall variability (Burton et al., 2008, Müller and Haberlandt, 2015, Paschalis et al., 2013; Peleg and Morin, 2014; Peleg et al., 2017; Benoit*

et al., 2018).

Reference. Benoit, L., Allard, D. and Mariethoz, G.: Stochastic Rainfall Modelling at Sub-Kilometer Scale, Water Resour. Res., 2018.

Burton, A., Kilsby, C., Fowler, H., Cowpertwait, P. and O'Connell, P.: RainSim: A spatial–temporal stochastic rainfall modelling system, Environmental Modelling & Software, 23, 1356-1369, 2008.

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Paschalis, A., Molnar, P., Fatichi, S. and Burlando, P.: A stochastic model for high-resolution space-time precipitation simulation, Water Resour. Res., 49, 8400-8417, 2013.

Peleg, N. and Morin, E.: Stochastic convective rain-field simulation using a high-resolution synoptically conditioned weather generator (HiReS-WG), Water Resour. Res., 50, 2124-2139, 2014.

Peleg, N., Fatichi, S., Paschalis, A., Molnar, P. and Burlando, P.: An advanced stochastic weather generator for simulating 2-D high-resolution climate variables, Journal of Advances in Modeling Earth Systems, 9, 1595-1627, 2017.

Technical notes 1. Fig. 13: For the observations extreme values with return periods of 200 yrs are shown for all stations, taken from a fitted GEV distribution. The observation length is only 30 yrs (1981-2010) and it can be questioned if the comparison of extrapolated values for 200 yrs return periods is reliable from a statistical point of view. I would rather limit the comparison to 50 yrs or 100 yrs.

Authors' Response. While we agree with the reliability issue of the extrapolated values, we still think that presenting the 200-year value may be necessary because it can clearly show the limitation of our model and the traditional MBLRP model.

Technical notes 2. Fig. 14 (caption): I think the model colors have been swapped by mistake: 'our model' should be red, 'MBLRP' should be blue.

Authors' Response. Your comment is correct. We changed the caption of the figures.

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Figure 14: Degree of over/underestimation of extreme values by our model (red) and the traditional MBLRP model (blue).