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Discussions

Interactive comment on "Conditional simulation of surface rainfall fields using modified phase annealing" *by* Jieru Yan et al.

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The reviewer is correct that the "distribution function of surface rainfall" (we term "cdf-rainfall" hereafter) is important (1) to determine the point equality constraints (the local constraints) in Gaussian space; (2) to transform the simulated Gaussian fields to precipitation fields.

However, there is a misunderstanding on the acquisition of the reference field. The reference field is Z* is obtained independently from the cdf-rainfall: it is obtained from the radar quantile map (continuous quantiles from 0.000... to 0.999...) then transformed to standard normal marginal with the inverse of the standard normal distribution function (Eq.4). Thus the obtained Z* is not a truncated Gaussian field, but an ordinary, contin-

uous standard normal field. And there is no z0 involved in the stage "Sim", because we do not truncate the simulated Gaussian field, either at meta- or final-stage of the simulation, as we compare the simulated continuous Gaussian field with the continuous Gaussian field Z*. The spatial intermittency is only handled at the stages "PreSim" (in terms of the local constraints, i.e., Eq.5) and "PostSim" (this is exactly where the truncation happens, a continuous Gaussian field is converted to a spatially intermittent precipitation field and there must be a z0 corresponding to u0 at this stage).

As for the acquisition of the covariance of the "starter" (the authors notice that this point has not been clearly described in the manuscript, which should be modified), similarly, the covariance of the starter is also obtained independently from the cdf-rainfall. Specifically, we use the Z* to obtain the covariance in the Gaussian space, and rain-gauge data are not used in the acquisition of the covariance. Considering the data configuration of this work (12 rain-gauge observations), we think rain-gauge data cannot provide enough (spatial) information to derive the covariance.

As for the question raised by the reviewer "why are zeros estimated using the whole radar image while the distribution of positive rain intensities is assessed using only pixels co-located with rain gauges? ..." In the context of this manuscript, the problem can be transformed into "how u0 (the probability of zero precipitation) could be determined properly". The reviewer points out the proposed one (set u0 using the whole radar image) is inconsistent with the rest of the procedure (pixels co-located with rain gauges). We have tried a consistent way other than the proposed one as described in Yan and BaÌĄrdossy (2019), where u0 is set using the smallest sampled radar quantile (u1): if the smallest gauge observation (r1) is zero, then u1 = u0, namely, (r1, u1) = (r0, u0); otherwise u0 = u1/2. This way to set u0 has been tested and is quite robust technically. However, one could hardly explain why to use the half and not one third, etc, as the choice seems quite arbitrary.

Therefore we propose another way to estimate u0, i.e. from the whole radar image. u0 is defined as the probability of zero precipitation, yet it is reflected as the ratio of the dry area to the total area of the domain and considering the spatial continuity of radar measurements, we think it is rational to determine u0 therefrom. However, we have noticed that the description in Section 2.1.1 is not clear and the following two points should be clarified. First, it is recommended that the proposed method (in Section 2.1.1) should be used to estimate the cdf of accumulated rainfall, not rain intensity because it is based on the assumption that the rain-gauge observations represent the ground truth. Yet Rain gauges might be poor in capturing the instantaneous rain intensity, but the measurement error diminishes rapidly as the integration time increases (Fabry, 2015). Second, the original radar display in dBZ reflects the spatial distribution of the variable, radar reflectivity factor Z, which is non-linearly related to rain intensity R. Normally, the power function Z = aRˆb (with 2 parameters a and b) is used to describe the relation of the two quantities. To determine whether a pixel is zero-valued in terms of the accumulated rainfall from a series of instantaneous maps of radar reflectivity within the relevant accumulation time, one could use the maximum of these instantaneous maps and compare the maximum (reflectivity factor) to a typical value (say 20 dBZ) for each pixel. Then u0 is estimated as the ratio of the number of zero-valued pixels to the total number of pixels in the domain. Similarly, to obtain the quantile map of the accumulated rainfall directly from the same series of instantaneous maps of radar reflectivity, one could simply add them up and scale (between 0 and 1).

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