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Reply on RC1

Jieru Yan et al.

Author comment on "Conditional simulation of spatial rainfall fields using random mixing: a study that implements full control over the stochastic process" by Jieru Yan et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2021-56-AC1>, 2021

We thank the anonymous referee for the comments for improvement. In the following, we present the replies to each comment.

***** Comment 1

we have used quantiles instead of the classical nomenclature 'non-exceedance probability' in the description of the algorithm to compute the cdf of the rainfall field. Surely we should have made it clear before doing so.

***** Comment 2

The referee points out that this work involves only spatial simulation, and the temporal part is not discussed after the introduction, which is true. In the following, we present our understanding concerning the specific issue 'How to obtain QPE (Quantitative Precipitation estimates) at a high spatio-temporal resolution, which should have been discussed briefly in the manuscript.

First, it should be clarified that what we are doing in this work is not now-casting, but rather hind-casting. Given the observed radar estimates and station data (some weather condition that has already existed), we try to estimate the true rainfall field. Since we are not forecasting, we do not simulate time series of precipitation. With the high spatial resolution of radar estimates, e.g., (1 km X 1 km), or even (500 m X 500 m), the acquisition of QPE with high spatial resolutions is possible. Then how to obtain QPE with relatively high time resolutions? Though this work discusses only spatial simulation (or QPE in hind-cast mode), the hind-cast can be made at fine time resolution (every 10 min, or even 5 min). Given the above, one could say the QPE is obtained at high spatio-temporal resolutions.

It should be noted that the term 'hind-cast' is relative to the estimation of precipitation. The resultant QPE is still useful for early flood detection. Nonetheless, it should be admitted that QPF (Quantitative Precipitation Forecasts) is more useful for pluvial floods forecasting, where approaches to model the temporal evolution of precipitation fields in the future are of interest (i.e., simulation of time series of precipitation as mentioned by the referee). However, most of the nowcast models are only radar-based. Due to the indirect measurement of the intensities, radar data are prone to various sources of errors which usually cause an underestimation of the rainfall intensities (Berne & Krajewski, 2013), and underestimated intensities fed to the nowcast will not be very useful for the

urban flood application. In the recent work by Shehu & Haberlandt (2020), the authors indicate that the predictability of the nowcast model is expected to be extended by improving the rainfall field fed into the model, which might become a research hotspot in the future.

***** Comment 3

First, we would love to answer the question 'What is the value of radar data as additional information to build the cdf?' The additional information of radar data in the construction of the cdf is that it provides a hint on how representative are the samples (station data) for the entire precipitation field. Whether the samples have missed the extremes of the precipitation field? Whether the dry area has been missed (could happen during a stratiform event that is large)? Then a problem arises: what makes the samples representative? A representative set of samples means the gauge respective (radar) quantiles, or the gauge respective non-exceedance probability (in the uniformed radar data), cover the entire range [0,1]. Whether the sample size is large or small, radar data can always provide this sort of information. Yet admittedly, with large sample size, it is more likely to have representative samples.

In practice, for mesoscale hydrological studies often only small sample sizes of irregular distributed recording rainfall stations are available (e.g. about 10 stations). To obtain an accurate cdf using the proposed method, enough station data should be available. Yet there are possibilities to improve the applicability of the method by increasing the sample size in space and time.

(1) Increase the sample size in space. In the work by Yan & Bárdossy (2019), a method to decrease the wind-induced discrepancy of radar and gauge data is introduced. For small domains where only a few rain gauges (say 10) are available, one can assume the uniform movement of the rain parcels. Under this consumption, one can displace the radar grid using a vector that increases the radar-gauge agreement, and 10 new pairs can be found in the displaced radar grid. If N vectors have been used to displace the radar grid, then one can obtain $(10 * N)$ new pairs, as normally more than one such vector can be found. One can pool these pairs and compute the cdf. It should be noted that using the above method, one only enriches the original 10 pairs (station data, quantile/non-exceedance probability) in the second axis, namely the y-axis in the cdf-plot.

(2) Increase the sample size in time. One can also pool the radar-gauge pairs from a fixed time window by assuming stable distribution in the relevant time.

***** Comment 4

It is correct that another simulation method could have been used after the estimation of the cdf, for example, phase annealing (Yan et al., 2020). There are a bunch of unconditional simulation methods. Yet to our knowledge, methods for conditional simulation are rare. We have used random mixing in this work due to the following reasons (which could be discussed briefly in the manuscript):

(1) The relatively high efficiency. It took around 5.87 sec to generate a realization for Scenario: 6 x 6 rain gauges, which is comparable to the time consumption of Kriging with external drift (3.08 sec). However, with a simulation method, one naturally wants to generate a bunch of realizations to see certain statistical properties. In that case, the total time consumption is much longer than an interpolation method. Note that the above-mentioned time consumptions are based on the performance of a normal laptop.

(2) The code availability. In the recent work by Hörning & Haese (2021), the authors present a Python package for conditional simulation of spatial random fields using Random mixing.

***** Literature

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