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Interactive comment on "Geostatistical upscaling of rain gauge data to support uncertainty analysis of lumped urban hydrological models" *by* Manoranjan Muthusamy et al.

Anonymous Referee #2

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General

This paper suggest a method to upscale rainfall intensity from point scale to catchment scale. The authors suggest a Kriging-based stochastic method for this upscaling; a method that allows an uncertainty estimation of the areal rainfall. I found the method suggested by the authors very interesting. I think that it will be of interest mainly for the hydro-meteorologist community (dealing with weather radar estimations) rather than for the urban hydrologist community. Main problem in the paper is the short period of observation (two seasons) that is expressed in a low confidence in the presented results. I found that some key papers dealing with dense rain-gauge networks and rainfall variability in the past were not mentioned and that some trivial aspects discussed in the

past are repeated in here. I would suggest the authors to thoroughly revise the paper as follow: make the upscaling method as the main focus of the paper, explain it with much further details and with a much clearer language. Use the data you have from the dense rain-gauge network as a case study to demonstrate how you can upscale rainfall for the catchment / weather radar scale and show the advantages of estimating uncertainties with the method you are suggesting. Please find below my specific comments, following by some general comments.

Specific comments

[Page:Lines]

[2:4-6] Please support this statement with a reference.

[2:19-21] Since you are dealing with rainfall uncertainty for small domains, taking into consideration the rainfall spatial and temporal variability, I am strongly recommend you to check also the following papers that were published in the recent years, which I think you will find them all relevant to your study:

Peleg N, Ben-Asher M, Morin E. Radar subpixel-scale rainfall variability and uncertainty: lessons learned from observations of a dense rain-gauge network. Hydrol. Earth Syst. Sci. 2013 Jun 14;17(6):2195-208.

Krajewski, W. F., Kruger, A., and Nespor, V.: Experimental and numerical studies of small-scale rainfall measurements and variability, Water Sci. Technol., 37, 131–138, doi:10.1016/s0273-1223(98)00325-4, 1998.

Pedersen, L., Jensen, N. E., Christensen, L. E., and Madsen, H.: Quantification of the spatial variability of rainfall based on a dense network of rain gauges, Atmos. Res., 95, 441–454, doi:10.1016/j.atmosres.2009.11.007, 2010.

Fiener, P. and Auerswald, K.: Spatial variability of rainfall on a sub-kilometre scale, Earth Surf. roc. Land., 34, 848–859, doi:10.1002/esp.1779, 2009.

Seo, B. C. and Krajewski, W. F.: Investigation of the scale dependent variability of radar-rainfall and rain gauge error covariance, Adv. Water Resour., 34, 152–163, doi:10.1016/j.advwatres.2010.10.006, 2011.

Gebremichael, M. and Krajewski, W. F.: Assessment of the statistical characterization of small-scale rainfall variability from radar: Analysis of TRMM ground validation datasets, J. Appl. Meteorol., 43, 1180–1199, doi:10.1175/1520-0450(2004)043<1180:aotsco>2.0.co;2, 2004.

Ciach, G. J. and Krajewski, W. F.: On the estimation of radar rainfall error variance, Adv. Water Resour., 22, 585–595, doi:10.1016/s0309-1708(98)00043-8, 1999.

[2:27] Reference typo.

[2:32] I would even claim that it is rare to find locations where the rainfall is normally distributed.

[3:3] word “often” can be deleted.

[3:19-20] This is a very short period of observation, and winter rainfall is not represented at all. How does it affect your results? Moreover, in [4:7-12] you mention the large difference between the two years of observation. This imply that the climatology was different between the two years and therefore I would expect that it will somehow influence on the rainfall spatial correlation. With only two years, the variability expected for the spatial rainfall structure cannot be represented and this should be discussed.

[Fig. 1] The recommendation is to mount rain-gauges elevated at 1.2 m above ground, where here the gauges seem to be placed directly on ground level (roof top). I wonder how this affects rainfall intensity estimations.

[3:29] What about time drift? Did you reset the loggers every 4-5 weeks to avoid this problem?

[4:1-5] This is not clear to me. If I got it right, you are comparing paired gauges for

each rain event by accumulating the rainfall over the gauges and comparing them and if the difference exceed the 4Peleg, N., Marra, F., Fatichi, S., Paschalis, A., Molnar, P. and Burlando, P., 2016. Spatial variability of extreme rainfall at radar subpixel scale. Journal of Hydrology.

[5:10] three rainfall intensity classes were SUBJECTIVELY selected? What was the criterion?

[6:8] n.d.?

[6:26] “It is negligibly small in the case of rainfall intensity data”. Not necessarily, Peleg et al. (2013) reported a 0.92 nugget for 1-min time resolution. I am not sure that this can be neglected.

[7:13-22] spatial stochastic simulation – Please provide more information about how the actual stochastic engine works. How was the variogram reproduced?

[7:22] I would except that a finer grid would improve your predictions. Especially when very high rainfall intensity is recorded over the domain, as a rapid (exponential) decrease in rainfall intensity from the center away is expected (for convective rainfall at least).

[Equation 6 and 7] Equation 6 – doesn’t it also need to be divided by m? I think the readers are aware to the statistics of mean and standard deviation thus you can probably delete these equations.

[8:17] “nugget effect . . . at zero lag distance due to measurement error” – are you sure it is just because of a measurement error? Rainfall variability exists between pair gauges, even for a 1 m distance, at least for temporal resolution of 1-5 min. Please check over the paper I have mentioned at comment [2:19-21] above. Your statement is repeated several times again during the text. I would at least discuss the possibility of having the nugget effect as more than a simple representation of rain-gauges measurement error.

[9:18-21] I would argue that reason why “the behaviour of spatial correlation against rainfall intensity class is not very distinctive" in your study is due to the short period of data you have used.

[Equation 8] CV equation is also commonly known, I suggest you to delete this equation as well.

[12:23] X-band radar can reach 250 m and 3 min resolution. I think it is good enough for small urban catchments.

[12:29-31] for a similar climate.

[General comment 1] I think your method suggested for rainfall upscaling is really interesting and can be very useful to some of the reader. However I, as a reader, would like to have more information, such as: What is the minimum number of rain-gauges required for a given catchment is order to apply your suggested upscaling (e.g. are 3 gauges over 1 km2 are enough?)? What should be the spatial configuration of these rain-gauges over the domain? Another question- if you would leave one of the gauges out of your analysis, how it would affect the results (what is the sensitivity of the network design?)?

[General comment 2] You stated that the stochastic model require some "computational demands". Can you give some details? How much time is needed to run the stochastic model per time step? What kind of machine do you need to use? It can be given as supplementary information but some readers might be interested to know.

[General comment 3] The paper is oriented for the urban hydrology community, but if fact who will benefits the most from your method are hydro-meteorologists that are often looking for different methods to upscale rainfall observation from point scale to weather radar scale. Consider changing the title and addressing this as well. I think that due to the lack of sufficient length of observation, you should focus more on the method and who can benefit from it and less on your results.

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