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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.

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This review results from six reviewers, all interested in the topic of the manuscript. Due to the number of six additional reviewers, the review is organized in major comments, suggestions and technical notes.

Brief summary: The manuscript deals with uncertainties resulting from upscaling of

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rainfall data. Upscaling hereby includes temporal aggregation as well as the determination of areal rainfall from point measurements. The topic is highly interesting and the investigation can be a good contribution to this field. However, we think that the manuscript can be improved significantly in the methods and the results part.

Major Comments:

Data:

p4 l7-21 The measuring period is quite short with two summer periods in 2012 and 2013. However, for such a dense network this is often the case. The two periods differ clearly and hence it is difficult to draw general conclusions from results. Open questions to the data set:

- From the two periods events are selected using a certain threshold. Why are events selected and why is the investigation not carried out for the whole observation periods? The results shown later are not based on/related to events. Is there a need for the event separation?

- A threshold of 10 mm network average rainfall depth and a minimum of 20 min rainfall duration were chosen for the event selection. How have these thresholds been chosen? The chosen thresholds can lead to exclusion of convective events with high rainfall amounts at one station, but no rainfall at the other stations. This is also indicated by the durations of the resulting events, ranging from 1.5 h to 11.4 h, which are more typical for stratiform events and not convective ones. Indeed these convective ones are crucial for urban hydrology and the resulting uncertainty in spatial upscaling is very high. Have convective events be excluded from the investigation by the chosen thresholds?

- How is the network average rainfall depth calculated for the event selection? In the introduction several methods are discussed. Is ordinary kriging applied here?

Methodology:

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p5 l12 What is pooled – events or single time steps? In the text before, time steps (p5 l1) and events (p5 l6-7) are mentioned. If time steps are pooled (and not events), later for one event different variograms may be used due to different intensities of the single time steps in the event, right?

p7 l14 What is spatial stochastic simulation? All results are based on this method, so an explanation in the text is necessary (not only a reference). Is it applied as a subsequent step to the ordinary kriging or instead of the ordinary kriging? What is the stochastic simulation based on?

Results:

p8 l25 The nugget-to-sill ratio is interpreted as measurement error, decreasing with an increasing temporal aggregation. The movement of events is ignored, which could significantly contribute to this ratio. With 2 min time steps, the event has reached one (pair) of the gauges, after 30 min all gauges are influenced by the event. This explanation should be implemented. Is it possible with other measurements (wind velocity,...) to exclude / quantify this effect? Also, can the whole nugget effect be described as measurement error from the author's point of view?

Conclusions:

General comment: Some conclusions are trivial (e.g. the intensity becomes less with increasing averaging interval), and there could be more conclusions out of the investigation. What is the message to the urban hydrologic modelers? How can this uncertainty be involved in the calibration process/result discussion? Is the uncertainty greater/smaller than other uncertainties in urban hydrological modeling? Is it useful to take this uncertainty into account, if others are higher? What are results of other investigations concerning areal rainfall uncertainties? Is it assumed, that the uncertainty increases with increasing area sizes in the lumped model? What is the recommendation for rain gauges number per square kilometer from this investigation? How sensitive are the results, if the station density/combination of stations is changed in the investi-

gation? The measurement set-up is quite dense. Can general conclusions be drawn to less dense networks (and how)? Can the results be validated with an urban hydrologic model?

Suggestions:

Title: The title doesn't fit to the content of the manuscript. There are no urban hydrological models applied. Also, if no kriging is applied (not sure about that, see major comment p7 l14), it's not an geostatistical upscaling. The title "Estimation of uncertainties from spatial and temporal upscaling on an urban scale" is therefore misleading.

Introduction:

p2 l19-25 There exist other methods for the estimation of uncertainties (bootstrapping,...), which should be mentioned in this context. Indeed, a focus should put on these methods, their comparisons and a reasonable decision for the applied method should be given at the end.

p2 l8-19 In the introduction a number of interpolation methods are mentioned, which are not used afterwards in the investigation. They could be left out.

Methodology:

p5 l11 How have the thresholds for the pooling been chosen?

p6 l2 Methods and results (Fig. 6) are mixed.

p6 l10 The method of NST could be explained briefly.

p6 l17 Step 4 is not a step, only a description, and can be moved to step 5.

p7 l4 explanation for q is missing

p7 l11-13 Even if block kriging cannot be applied, an ordinary kriging with subsequent back-transformation and averaging could. What is the disadvantage in comparison to the spatial stochastic simulation? Since block-kriging is not applied, it could be left out.

p8 l9 With the standard deviation and the mean of areal rainfall intensities the re-standardisation is carried out. For the former standardisation the standard deviation and the mean of point values have been used (since it is not clear, what has been pooled (see comment p5 l12), we assume time steps). Shouldn't be standard deviation and mean for standardization and re-standardisation be from the same type, so either from area or point values?

Results:

p8 16-17 The nugget is interpreted as spatial rainfall variability or measurement error. The network offers the great possibility to have rain gauge pairs with distances of 1 m. Measurement errors have been excluded before by the paired measured time series. So the spatial variability can be shown for these small distances, or why should this not be possible?

p8 l28 Since all errors have been excluded under the usage of the paired time series, the word TB error is somehow misleading. "Sampling error" could be more appropriate.

p10 l3 Showing the CV would be more effective then showing the standard deviation in Fig. 8. An increasing of the standard deviation with an increasing intensity is trivial (which is even stated on p11 l7-10). Also, a logarithmic plot would be useful.

p10 l31-32 Design on peak rainfall intensity: The intensity AND the duration are important and both are used for the dimensioning of e.g. a sewer system.

p11 l1 Fig. 10 Maybe it would be useful to use violin plots instead of only the standard deviation to show the uncertainty.

p11 l12 Fig. 11 The readability of the figure could be increased by colors and/or drawing only contours, not filling them. Showing the means as functions, not as fixed values, would give better conclusions. The high mean for 2 min, <10 mm/h is caused by only one extreme CV ($\sim$13 %) and is not representable.

Conclusion:

p12 l10-13 Decreasing peaks due to aggregation in time is trivial and not a conclusion.

p12 l32-33 “This information can help to avoid false calibration and force fitting of model parameters” It remains unclear, how the result of the investigation can be used for the avoidance of the before mentioned issues.

Technical notes:

p7 l5 “locationsxl” to “locations xl” and “locationsx0” to “locations x0”

p8 l5 Eq. (6) “pi” and not “px”, also the division by “m” is missing – Since this is a simple equation, it could left out, also Eq. (7)

p8 l6 Eq. (7) The term under the root has to be squared.

p8 l25 “nugget-to-still ratio” to “nugget-to-sill ratio” (several times)

p9 l3 “in their study found” to “found in their study”

p9 l15 “(2003) in their” to “(2003) found in their”

p10 l11-13 In Fig. 9 event 10 is shown, not event 11 (regarding to Fig. 10).

p12 l22 “methods to a certain extent” – fuzzy phrase

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