Assessment of spatial uncertainty of heavy local rainfall using a dense gauge network
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Summary: A dense network of rain gauges in Austria is used to assess the spatial and temporal variability of rainfall. Special emphasis is given to quantifying the spatial autocorrelation structure for different aggregation time scales and assessing the accuracy of areal-rainfall estimates as a function of the number of available gauges.

Overall, this is a rather well written paper with clear objectives and useful new conclusions. The high-quality dataset of the WegenerNet allows for some nice experimental studies on the space-time variability of rain, providing unique insight into the importance of network density and sampling uncertainty. My main criticism concerns the lack of rigor in the the statistical analyses (see below for more details) and the way the authors select the events for drawing their conclusions. There also appears to be some minor terminology issue related to the notion of the "nugget effect" (see below).

Recommendation: Major review

Major Comments:

A. Event selection:

A1. The way the events are selected in this study (based on total daily rainfall amounts) has some important consequences which are not discussed enough in the paper in my opinion. We know from other studies that at mid-latitudes and in continental climates, the rainfall events that produce the largest daily accumulations are generally more widespread and persistent than the ones responsible for small-scale extremes. As a consequence, there are plenty of heavy localized rainfall events with high peak intensity but low to moderate rainfall totals that the authors do not consider in this analysis. Conversely, there are events in the sample that do not have very high peak intensity. This is not necessarily wrong but has important consequences as it heavily influences the conclusions. This needs to be discussed more in detail given that the focus of this paper is on heavy localized rainfall.

A2. More generally, a table summarizing the properties of the events selected for the analysis would be helpful.

B. Spatial correlation analysis:

B1. The WEGN is a rectangle of 20x15 km which means that it favors the sampling of some particular spatial directions over others. For small distances this does not really matter as all spatial directions are sampled more or less uniformly. But as you start considering gauges separated by 15 km or more, the number of different spatial directions you can sample in your network decreases. This has important consequences when estimating a spatial autocorrelation function, especially in cases when the rainfall has a preferred direction of spatial orientation (i.e., anisotropy). The proper way to deal with this is to (a) choose an appropriate cutoff distance that limits these effects or (b) fit an anisotropic correlation model. The cutoff distance you used (going up to 25 km) is probably too large, which can result in biased model parameters. I recommend that you check this more carefully to make sure that your fitted model parameters aren't contaminated by it. Typically, I wouldn't go much further than 10-15 km in distance.

B2. The fact that you use a logarithmic transform means that zero rainfall values are excluded from the analysis. However, this could be a problem at small aggregation time scales where it is possible to observe zero rainfall at one gauge and positive values at the others. Please explain how you deal with these cases and more generally, how zeros are handled in your analysis.

B3. Please explain how you fit your exponential correlation function to the sample points. Do you use any weights? What's the objective function you are optimizing?

B4. The fact that you get large yearly differences in correlation patterns (especially in winter and at 5 min resolution) might also (partially) have to do with the fact that you force an exponential model to your data without actually checking if the data comply with this model. In other words, you also need to say something about how good your model is at representing the data. Some goodness of fit statistics would be helpful for this. There is no physical justification for the exponential model you impose and other parametric fits might be equally good or better in some situations.

B5. Figure 4 shows decorrelation ranges in the order of 200-600 km. Yet the maximum range you can observe in your network is 24 km. So my questions is: how much do you trust these large range estimates? And what's the uncertainty affecting them? Please provide some form of uncertainty analysis (e.g., confidence intervals) for your parameter estimates. This would also allow you to make a more precise statement about the trend in the shape factor on p.5, line 1.

C. Nugget: I do not agree with your use of the word "nugget" in this paper. The nugget is NOT the value of the zero distance correlation. It's the drop in the correlation value when you go from zero distance to d>0 (i.e., the discontinuity at zero). In other words, it's not c1 but 1-c1. For example, when you say that the nugget is 0.73 to 0.98, actually, it's 0.02 to 0.27. The advantage of defining it this way is that you get a better interpretation in terms of sub-grid variability + measurement error. Large nugget = large differences at sub-grid scale. Please change and adapt the rest of the text to give the right meaning.

D. Areal rainfall estimates:

D1. The method used to sample the 1'000 possible combinations of gauge sub-networks is not very clear to me. Moreover, wouldn't there be a strong dependence on how the gauges are selected within the network (area of influence)? I mean, you only show graphs of accuracy as a function of the number of gauges. But obviously, having 4 gauges next to each other is not the same at all as having 4 equally spaced gauges covering the whole 20x15km area. I've read this part several times but couldn't really figure out the approach. Some further details about the approach would be helpful.

Minor comments & typos:

p.2, ll.6-8 "Although relatively high-resolution data from remotely […] cannot be fully captured at the sub-pixel scale". This sentence is not clear. Please reformulate.

p.2, l.13 "[…] intra-pixel variability of rainfall on the performance of remote sensing" A reference to the literature is needed here.

p.3, ll.3-7 "The accuracy of areal rainfall estimation is a long-standing issue […] high-resolution gauge data (e.g., Wood et al., 2000; Villarini et al., 2008;Ly et al., 2011)" This entire paragraph is out of context. It would be better to put it a few lines earlier in the introduction, before you mention the structure of this paper.

p.3, ll.31-33: I'm not sure whether "wet" and "dry" seasons is really a good choice of terminology here. Wet and dry seasons are usually seen in the context of tropical climates and using them for Austria feels weird. What you have here is a continental climate, with most of the precipitation falling in the warmer months of the year. Warm and cold season would be much better choices.

p.4 ll.16-18: in this paragraph you start by saying that "we do not make a direct comparison with other studies". However, a few lines later you say that "the functions show a broad agreement with those from previous studies". I get what you wanted to say, but it's probably a good idea to reformulate the sentence to avoid the apparent contradiction here.

p. 6, ll.27-28: "+7% to +63% of increases in extreme rainfall intensities are observed depending on the considered spatial scale". Not clear what you mean by that. Please reformulate.

p.7, l.12 Replace "Seeing that only two operational [...]" by "Given that only two operational [...]"

p.7 l.11 "shows there to be a high dependence" English.

p.7 l.13 "[…] under normal circumstances could be inadequate for particular purposes". Too vague, please reformulate.

p.7, l.30 "statistical robust results." I don't think that you can claim this. You only have 10 years of data (which is not much for extremes) and you did not do any sensitivity analysis nor do you have any confidence intervals to prove this. Please reformulate.

p.8, l.8 "afterword" replace by "afterward"