Report on "Downscaling future precipitation extremes to urban hydrology scales using a spatio-temporal Neymann-Scott weather generator" by H.J.D. Sorup, O.B. Christensen, K. Arnbjerg-Nielsen and P.S. Mikkelsen

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1 General Comments

In their manuscript "Downscaling future precipitation extremes to urban hydrology scales using a spatio-temporal Neymann-Scott weather generator" H.J.D. Sorup, O.B. Christensen, K. Arnbjerg-Nielsen and P.S. Mikkelsen use a spatio-temporal precipitation generator of the Neymann-Scott-type to to study climate change signals in high resolution precipitation fields. They consider also extreme precipitation events. These types of precipitation generators are very useful for the hydrology community using the output of these models as input to hydrological models. Particular for those settings where a high spatio-temporal resolution is important (e.g. urban drainage or small catchments), there is not yet a feasible alternative to precipitation generators. Running RCMs at this resolution is numerically very costly and suffer from problems as biases. I thus consider the topic of this manuscript as very important.

The manuscript is relatively well organised and some parts are also well written. However, even as somebody who is also working with spatio-temporal Poisson-cluster models (as the Neymann-Scott), I could not follow at several stages of the document and would not be able to reproduce the results. It is obvious that the authors have already thought a lot on balancing the level of details with the readability. While it is working well in some parts, it does not in others. One solution to this would be to split the manuscript into two: one desribing the setting up of the WG for the chosen region, including parameter estimation and model validation for the present climate (only observations); the other manuscript would deal with the climate change study and has then more room to discuss the results found. Another solution would be to have an extensive appendix with all the details or suplementary material (not a Video, rather clear describtions of the approaches with equations and more detailed validation results). At the current stage, the manuscript does not seem to be convincing enough as a) methods being somewhat too simple have been used (e.g. Eq. 3), b) a too small

ensemble to estimate the uncertainty (ensemble size 10) and c) the description is not clear enough to be reproducible.

I recomment publishing this work but with this manuscript undergoing a major revision. A suggestion would be to split the manuscrip or to transfer the model building (parameter estimation and validation) in large parts into an appendix to allow for more details without negative effects on readability.

2 Specific Comments

The authors mention very frequently that they generate "realistic" rainfall. This leaves the impression that they want to convince by repeating the word "realistic". I'd furthermore not use this in a scientific article as it does not have a well defined meaning.

I'd miss a sketch (either verbal or as a figure) describing how the study is carried out and what assumptions are behind that. The RCMs show changes in summray statistics obtained from a grid of a few kilometers. The WG actually works in continuous space and the reseult is discretized later (which is actually never talked about). Does it make sense to simply scale the summary statistics ontained on the coarse grid and aplly the same scaling to the statistics from gauges (if this is what is done, which I suppose but I am not sure).

2.1 Abstract

- "used to perturbe the WG" is a strange description of what (I think) is actually done. WG parameters are estimated from summary statistics scaled by change factors.

2.2 Introduction

- p2 l32 what is "one hour or higher"? Is that two hours or a half?

2.3 Data and weather generator

2.3.1 Data representing present conditions

- p5 l10ff I don't think the unexperienced reader can follow why you introduce a third set of data which are ten realisations of the WG. What is meant by "refitting and rerunning"? Why does it corroborate the results? I think a different motivation for this is needed.

2.3.2 Weather generator

- In this chapter, a figure sketching the idea of the WG would be good. The reader not familiar with the NSRP will not get an idea. You need to give the model parameters as they are needed later. Why not using a figure to explain them?

2.4 Methodology

2.4.1 Fitting of the weather generator

- For me it is strange to see that the parameter estimation is not just in another subsection but in a completely new section. Why not havig a section on data, a section on the WG (as it is central here) with subsection on describing the model and another subsection on describing the parameter estimation. Then have a section on "Methods" and describe the way you validate the model and obtain change factors

- "Fitting of the weather generator" is not a nice title. Why not using "Parameter estimation"?

- I find it strange that you don't specify the objective function minimized to obtain estimates but you specify the name of the minimization algorithm. Why is that important? I guess it somehow avoids local minima but not completely otherwise you would not have to run it three times ("thrice" is not so frequently used).

- I suggest to show the objective function as the construction has probably a larger influence on the result than the minimization algorithm.

- the auto correlation function is estimated by the lag-1 and then an exponential decay is used, thus you have a parametric form for it (I supppose). What about the cross correlation function? Looking at Fig.9, I think this is the same: an exponential decay and the rate is estimated. If this is the case, you could also draw lines in Fig. 9 for the WGs instead of re-estimating it.

- p9 l3 if you introduce the weighing scheme, you could also show the objective function such that one can see where the weights go in practice.

2.4.2 Evaluation of simulated time series

- p8 l24ff I thought the idea of generating an enesemble is to obtain an estimate for the uncertainty of parameters, statistics, simulations. I was confused by the sentence "to evaluate if the realisation is representative". My idea of a WG is that it is relatively easy to generate lots of realisations to propagate uncertainty to hydrological models. I would not be looking for "one" representative realisation.

- p8 l29ff I wonder why this procedure takes so long. A central advantage of WGs is that it is easy to generate simulations. Refitting of the simulations could be sped up by giving the parameter values used for simulation. The algorithm is than already in the local minimum you are looking for.

- Eq.1 is not clear to me. Are the Y_{WG}s sampled over space? The notation needs to be clearer.

2.4.3 Perturbation of the weather generator with climate change signals

- p9 l8 I suggest to introduce the notation of the statistics $Y_{i,j,k}$ on page 7

2.4.4 Evaluation of Extremes

Unfortunately, the structure of this section does not reveal itself to me.

- p9 l23 "spatial correlation distance" needs to be defined
- p9 l24 "simulated data set" ... "better than RCM" Also RCM data is "simulated".
- p10 l1 the description of the concept used does not become clear to me. You talk about "maximum average intensities" which sounds like a block maxima approach. Shortly later you a POT approach is mentioned.

Extreme event statistics

- I do not see why you are first estimating return periods by plotting positions and later by a POT approach?

Seasonality of extreme events

- Here you do not consider magnitudes, only the number of events over a threshold. This is a weaker criterion than the magnitudes but I would not expect the WG to reproduce the magnitudes. This is OK but need to be made transparent.
- You might cite Wilks [2011] for the χ^2-test.

Unconditional spatial correlation extremes

- I do not understand the concept "unconditional" here. What would be conditional?
- I do not understand the notation in Eq. 8. The expectation values $E\{Z_A \mid U\}$ and $E\{Z_B \mid U\}$ are constant values (as all expectation values) and thus I do not see how a covariance is obtained between them

2.5 Results and discussion

2.5.1 Fitting the weather generator

I prefer the term "estimation of parameters" over "fitting". But that is a personal preference.

- p12 l19 "The WG converges to an optimum" I suggest to be more precise with the concepts here. The WG is a stochastic model. The parameters are estimated by minimzing an objective function. The minimization algorithm can converge to an optimum, not the WG.

- p12 l20 what is a "realistic" rainfall field?
- p14 l3 what are the "features expected to have the highest influence on the produced extremes"?

2.5.2 Evaluation of extremes for present climate conditions

- p14 l10 Why are you choosing an 68% intervall? 95% is more common. How is that obtained?

2.5.3 Perturbation of the WG with climate change signals from RCMs

- p15 l8 I do not understand this sentence. Why a 30-year realisation?

3 Technical comments and typos

- p18 l11 "Neuman" change to Neyman

References

D. S. Wilks. *Statistical methods in the atmospheric sciences.* Academic Press, San Diego, CA, 3rd edition, 2011.