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Interactive comment on "Formulating and testing a method for perturbing precipitation time series to reflect anticipated climatic changes" *by* Hjalte Jomo Danielsen Sørup et al.

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Reply to Anonymous Referee #2

We very much appreciate the review and acknowledge that the comments and suggestions will lead to an improved paper.

The first concern raised regards the fact that the approach is deterministic. We agree with this concern because there are features of climatic changes that will be difficult to implement in a deterministic framework. Our focus has been on making a proof-of-concept of the methodology by testing a method currently applied on daily rainfall (Delta Change, DC, and Distribution Based Scaling, DBS) to much higher resolution.

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Discussion paper

We have formulated the framework as a semi-Markov process in order to be able to extend it into a stochastic framework.

We are happy to extend the literature review . We would suggest to cover in more detail the use of Markov models in hydrological applications as well as a more in-depth presentation of the DC and DBS methods thereby setting a better foundation for the present approach. This could, indeed, be further supported by a flow diagram in the methodology section.

The 2, 10 and 100-year return periods used for the Danish case study are included as these are the categories for which climate change predictions exist. These return periods correspond to the typical uses of extreme precipitation for pipe flow capacity, surcharging, and flood risk management, respectively. In principle we would prefer to use a smaller return period, e.g. 50 years, because of the relative short time series used in the study. However, we have chosen the return periods for which official recommendations exist and prefer to keep it that way. We note that because of the correlation introduced when ranking extreme series the 50 year event is implicitly covered by the chosen return periods and that the method can easily be adapted to other return periods.

Regarding persistence of the time series, the presented approach retains the present day time series characteristics both when it comes to intra and inter events persistence. For the intra event persistence, this is believed to be the best available option and indeed a standard assumption in most down-scaling approaches to yield precipitation series with sub-hourly resolution. For the inter event persistence, this is not an ideal approach, as some RCMs predict changes for these statistics. This is, however, a highly debated topic as the regional climate models do not agree on these parameters for the case study location (Boberg, 2010). In a future extension into a stochastic framework, we agree that this is one of the very important factors that have to be modelled specifically to further enhance the methodology.

As the generated time series for future climate maintain the structure of the present day time series, the expectation metrics calculated and reported in Figure 3 and other places are really the best way to show that the future time series are realistic with respect to the perturbation we apply in the approach.

With respect to the selection criteria reported in Section 3.3 and specifically in Table 5, we agree that the rationale behind the choices should be elaborated both with respect to mathematical description (as pointed out by Referee #1) as well with thorough explanations of the subjective choices made for option D (Table 5).

With respect to the two references in Danish that are used as references for the expectations to climate change in Denmark, we will look into if there are international literature that has come out based on these reports and, if that is not the case, add more detailed referencing (for instance the figures reported in Table 3 are based on the results reported in Tabel 1 of Gregersen et al., 2014) along with a more general presentation of the reports.

We will make changes to the paper that accommodate the more technical comments by the reviewer, including careful proofreading.

Additional reference

Boberg F (2010): Weighted scenario temperature and precipitation changes for Denmark using probability density functions for ENSEMBLES regional climate models. Danish Climate Centre Report 10-03. https://www.dmi.dk/fileadmin/Rapporter/DKC/dkc10-03.pdf.

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