Response to Referee #2's comments on hess-2021-580:

General Comment: *This paper presents the use of universal multifractal to generate ensembles of rainfall time series that recreates the Intensity (I), Duration (D), and Frequency (F) of rainfall time series, commonly used in the design of storm-water infrastructure. This paper may become an essential contribution to the literature body of stochastic simulations of rainfall time series. However, I found two pitfalls in the paper: 1) There is no clear definition of the research gap (including connections to previous works), and (2) Even though the paper assesses their methodology, the discussion about the results is almost non-existent. I hope my comments provide a road map to improve the important contribution done by the authors. See the attached file for a detailed description of my concerns.*

> **Response:** We thank the referee for reviewing our manuscript and providing several constructive suggestions. We are especially grateful for the positive feedback. In this document we provide our detailed response to the detailed description of the reviewer's comments and also mention how we plan to address these issues (especially regarding research gap definition and result discussion) in a future version of this manuscript.

Major Suggested Comments:

Comment 1: *The research gap is vague. The authors must address the following questions. Why is it important to explore universal multifractals in rainfall datasets? Have studies been using this technique in rainfall datasets before? What are the challenges of using stochastic techniques and/or multifractals to reconstruct rainfall time series?*

Reply: Following the referee's remarks and suggestions, we will specify the research gaps, which are of three kinds:

- a general discrepancy between standard procedures for defining reference precipitation and the strong multiscale intermittency of precipitation.
- missing procedure to adapt multifractal precipitation modelling to given partial statistical references.
- missing procedure to assess the accuracy of the method.

The corresponding challenges addressed in this paper are:

- to tackle multiscale intermittency head-on, based on extreme non-Gaussian statistics and scaling behaviour over two subranges of time scales, due to the finite size of the earth. This requires a given adaptation of the multifractal modelling procedure.
- to define a renormalizing procedure for the multifractal model to make the simulations fit with these partial statistical references.
- to define multiscale metrics to assess distance between (closeness of) two time series (observed and simulated) across time scales.

This will enable us to provide baseline precipitation scenarios that can be used as realistic inputs into hydrological models for applications such as the optimal design of storm-water management infrastructure, including green roofs.

We will incorporate the above explanation in the abstract, and introduction (after the presentation of the 6 characteristics of observed rainfall) to make the research gap addressed clearer right at the start of the paper.

Comment 2: *The ambiguity in the research gap is also reflected in the research objective: Line [57] states, "The objective of this paper is to simulate region specific reference rainfall scenarios which could be used as realistic inputs (..) to hydrological models for optimally designing storm-water management infrastructures." This needs to be more specific. What method will be used? Will this be compared to a reference? Also, the objective elucidates "hydrological models for optimally designing"; however, the paper does not address optimal design at all. Readers may believe that the paper explores the use of universal multifractal for optimal designs for specific water-related infrastructure. However, the paper covers a general procedure for estimating ensembles of rainfall time-series, but it does not cover applications and consequences for engineering design.*

Reply: We hope that the above clarification (Reply to comment 1) will dissipate any ambiguity on the goal of the paper. Moreover, we will further clarify that designing optimal storm-water management infrastructures (such as green roofs) is not an objective of this paper but a scope for applications of the reference rainfall simulation procedure (which makes use of the UM framework to properly take into account the temporal variability of rainfall) proposed here.

However, we would also like to mention that we are currently working to set-up experimental green roof prototypes (designed based on reference rainfall scenarios simulated using the method proposed in this manuscript) and establishing monitoring protocols, therefore the applicability of the present results is beyond a good wish and referee's comment will be further addressed via a separate publication in future.

Comment 3.1: *There is no discussion section! The authors go from results to conclusions, omitting key discussions that will strengthen the overall contribution of their work. Here are some general pointers that I feel are relevant to find in the discussion section. 1) How are the results compared with the previous literature? Are the scaling parameters similar to previous studies? What are possible connections in the difference of scaling parameters between the three site studies?*

Reply: We agree and will insert a specific discussion section based on result discussion already present in the paper. As far as the data analysis results are concerned: Lines [127-132] already discusses the first query. We will add a discussion part after Line [148] addressing the second and third queries.

Comment 3.2: *What are possible strategies to expand this methodology to spatial correlated rainfall datasets? What are potential limitations in the application of this methodology? How feasible is this methodology to represent rainfall structure in large spatial scales? How can the spatial scale and limitations on this methodology affect the design of water-related infrastructure?*

Reply: In the context of these queries regarding space-time vs. time modelling, we will clarify that:

i. this dichotomy is not as strong as usual for multifractal models because a time multifractal can be seen as a time cut of a space-time multifractal

ii. the aim of the present study (which mainly focusses on temporal scales) is focused over a fixed (and rather small) space extension such as a building roof

iii. the large scale deployment of rainfall-runoff management technologies/infrastructures would instead require space-time models (and space-time rainfall datasets), obtained with the help of new and rather limited developments (see (i)).

Minor Suggested Comments:

Comment 1: *[75] Add reference for MeteoFrance.*

Reply: We think the referee means line [78], if so, Ok.

Comment 2: *[110] Small sample size? Be more specific. What would be an ideal sample size?*

Reply: In line [109] it is mentioned that a single sample is used, so here the small sample (effective) dimension is 1. Larger the sample size, better will be the estimate of spectral slope (better straight line fit). But increasing sample size with a fixed dataset length means that with more samples the length of each sample is smaller, implying that there is a reduction in the largest scale considered. This may in turn lead to a difference in multifractal characteristics. The TM analysis, on the other hand, does not have this disadvantage and the straight line fits are reasonably good and not too dependent on the number of samples. Therefore, TM analysis is simply more preferable/relevant compared to spectral analysis or the question of how many samples will be ideal when using spectral analysis.

Comment 3: *[Figure] Figure 1 is not mentioned in the document*

Reply: It is mentioned in Line [50].

Comment 4: *The term "resolution" is ambiguous throughout the text. Does it refer to time or space? Probably time.*

Reply: The interest of the term "resolution" is that it is dimensionless because it is precisely defined by the ratio of the outer scale by the inner scale. As such, it is valid for time and/or space, but presently used for time. This will be specified in the manuscript to avoid any ambiguity.