Reply to Anonymous Referee #3

This paper suggests a novel approach to assess spatio-temporal extremes of precipitations and implements it over of the Loess Plateau of China. The topic is interesting and relevant for the community. The data used seems of quality. The framework of Universal Multifractals (UM) is appropriate for such an issue. However I would not recommend to publish this paper in its current state, mainly for methodological reasons.

Reply: Thank you for your attention reviewing our manuscript.

Indeed the methodology developed to determine the EPT(section 2.2) seems to contradict the underlying ideas of a multifractal framework. If I understood well the suggested methodology, it consists in performing UM analysis on the series after removing more and more extremes (replacing them with which values ?). Then the retrieved parameters are analysed and a so called "physically meaningful" threshold determined.

Reply: the eliminated "extremes" were replaced by zeros in the procedure of EPT determination.

I have trouble understanding the logic behind this choice. Indeed, the interest of UM analysis is to analyse the whole data available and obtain K(q) and c(gamma) which then fully characterize the variability across scales. Removing the extremes will simply degrade the quality of the scaling (hence the reliability of the estimates), bias the analysis, and not improve the knowledge on the studied series. EP should be derived directly from the co-dimension function or scaling moment function obtained on the best data available. gamma_s could actually be a good choice, but other could be developed notably to include notion of both intensity and frequency as suggested by the authors. Since all the following depends on the the indicators obtained from this methodology, I believe that this methodology should either more justified (I may have miss a point) or updated before any further study.

Reply: In universal multifractals analysis, $c(\gamma)$ is the statistical scaling exponent characterizing how its probability changes with scale (Lovejoy and Schertzer, 2013). In other words, the codimension function $c(\gamma)$ characterizes the sparseness of the γ-order singularities (maximum) (Tessier et al., 1994). The parameter γ_s, i.e. the singularity of a data set with finite sample size, represents the maximum of intensity (φ_λ) at the scale ratio λ (Douglas and Barros, 2003). Therefore, $c(\gamma)$ and γ_s naturally capture the statistical properties of extremes of a data set. Further, simulation with different $c(\gamma)$ or γ_s give rise to great differences, especially in extremes (Lovejoy and Schertzer, 2007; Lovejoy and Schertzer, 2013).

Obviously, as it was commented, *Removing the extremes will simply change the scaling property of the data set*. If we gradually eliminate extreme precipitation (EP) (replacing extremes by zeros), these exponents or functions will change and will sharply change if the majority of extremes are removed, because singularity largely depend on extremes (Lovejoy and Schertzer, 2007); and these abrupt point can be determined as extreme precipitation threshold (EPT). This is the theoretical basis for EPT determination, as shown in Figure 1 of the manuscript.

But the procedure determining EPT does not give rise to any bias in the following analysis, as the spatiotemporal variation of EP were analyzed using original data. Therefore, the methods in this study will not resulted in quality degradation etc., as it was concerned in this comment "*Removing the extremes will simply degrade the quality of the scaling (hence the reliability of the estimates), bias the analysis, and not improve the knowledge on the studied series*".

As it was commented "*EP should be derived directly from the co-dimension function or scaling moment function obtained on the best data available.*" It is sure that the multifractal representation captures the observations independently of when or how extreme precipitation came to be. In this way, the UM can be applied to infer the magnitude of precipitation maximum within a return period, and more precise results can be obtained in comparison with traditional parameter functions, see Douglas and Barros (2003). The first author had also applied the UM to estimate maximum precipitation with a duration in his doctoral dissertation, as shown in Figure 1 below. However, such an estimation of maximum precipitation within a duration has nothing to do with spatiotemporal EP variation assessment over a long period in a large area.

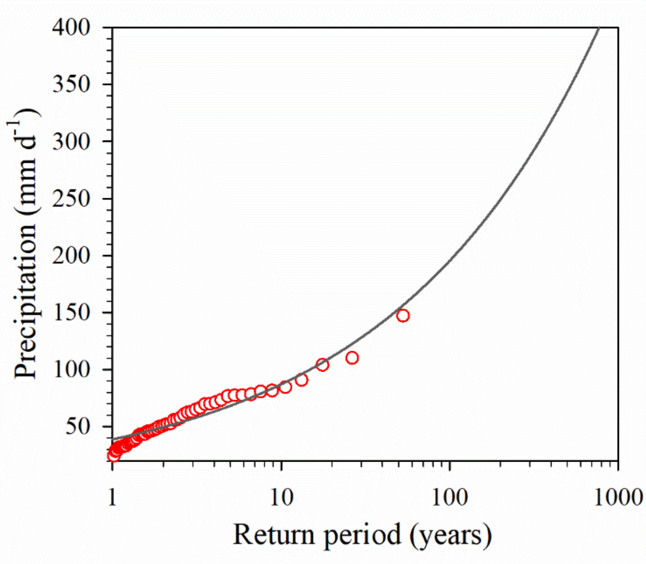

Figure 1. Projected extreme values as a function of their return period.

There are two techniques exploring multifractals: the UM and the multifractal detrended fluctuation analysis (MFDFA). The UM explores the characteristics of "extremes" while the MFDFA focuses on "normal variation". The MFDFA have been applied to determine EPT, see Du et al. (2013) and Liu et al. (2013). Motivated by these studies, we concluded that the UM, characterizing extremes, is appropriate to determine EPT. Thus, the method integrating UM and segmentation algorithm was proposed for EP assessment in the Loess Plateau, China. Besides, as the Short

Comments (SC1) noted, the results of spatial EP obtained in this study is much more rational at present.

Reference

Douglas, E.M., Barros, A.P., 2003. Probable maximum precipitation estimation using multifractals: application in the Eastern United States. Journal of Hydrometeorology, 4(6): 1012-1024.

Du, H., Wu, Z., Zong, S., Meng, X., Wang, L., 2013. Assessing the characteristics of extreme precipitation over Northeast China using the multifractal detrended fluctuation analysis. Journal of Geophysical Research: Atmospheres, 118: doi: 10.1002/jgrd.50487.

Liu, B., Chen, J., Chen, X., Lian, Y., Wu, L., 2013. Uncertainty in determining extreme precipitation thresholds. Journal of Hydrology, 503: 233-245.

Lovejoy, S., Schertzer, D., 2007. Scaling and multifractal fields in the solid earth and topography. Nonlinear Processes in Geophysics, 14(4): 465-502.

Lovejoy, S., Schertzer, D., 2013. The weather and Climate: emergent laws and multifractal cascades. Cambridge University Press.

Tessier, Y., Lovejoy, S., Schertzer, D., 1994. Multifractal analysis and simulation of the global meteorological network. Journal of applied meteorology, 33(12): 1572-1586.

In addition, indication of the quality of the scaling, and scaling curves should be provided to the reader.

Reply：According to this comment and comments from Anonymous Referee #2, the authors concluded that the part of methodology should be described in more detail.