Historical rainfall data in Northern Italy predict larger meteorological drought hazard than climate projections

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We are grateful to the Editor for managing the review process of our paper and the positive feedback for our previous revision. We are also grateful to the additional reviewer for the positive comments and further suggestions which helped us to improve the manuscript.

Within this rebuttal document we describe how the remarks by the Reviewer were addressed. Quotes from the reviewer are reported in italic. We include here below selected quotes from the revised manuscript to better explain how the related concerns were addressed. Quotes from the revised manuscript are highlighted in blue.

Reply to Anonymous Reviewer #4

We thank the additional reviewer for the positive feedback of our previous revision and the helpful review of our manuscript. Here below we explain how the comments of the reviewer had been addressed. Comments are quoted in italic.

- Eq. 1. I am not sure if it correct, Should mh(t) be the denominator?

Thanks for your comment. We checked the Eq. 1 and it is correct. In this equation, it is true that the denominator is the value in historical period. However, it cannot be directly represented by *mh(t)* due to that *t* represents future period in this equation. This equation uses the empirical frequency of not exceedance in future period qf (t) to represent the same quantiles in historical period and then uses the distribution of empirical frequencies in historical period to calculate the correspongidng value. We deleted *mf(t)* and *mh(t)* in Line 101 to avoid misleading.

- Line 260. In my opinion, it is not just an underestimation. The GCM time series are simply random. I would not be surprised if the ACF_lag1 coefficients would be not significant for all 13 scenarios. This is crucial for drought analysis, of course, since in the observed time series the rainfall amount collected in one year is linked to the amount collected in the following year. Since the coefficient is only 0.22 I expect that the observed time series show data "grouped" in pairs or triplets while the GCM ones are decorrelated.
Maybe the authors could better specify this aspect.

We agree with the reviewer. To better specify this aspect, we modified the line 260 as follows:

"It is interesting to note that the correlation of observed data is slightly higher than all the models, therefore highlighting possible model weakness in simulating temporal correlation. Since the coefficient of the observation series is 0.226, the observed values may be correlated in pairs or triplets while most of the GCMs' series are uncorrelated, thereby implying a possible inadequacy of bi-annual or triennial fitness."

- Figure 8. I would use the same y-axis range of Figure 7, that is 0-180 mm

We agree with the reviewer. The y-axis of Figure 8 has been changed to the same range of Figure 7.

- Line 396. The same previous comments concerning the underestimation and in addition, I would not say "long term cycle" but "short term cycle (bi-annual, triennial)".

We agree with the reviewer. The sentence in Line 396 has been change into:

"In particular, the GCMs show weakness in capturing the correlation of annual rainfall, thereby implying a possible lack of fit in the simulation of cycles."