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Earth System Dynamics Discussions

# *Interactive comment on* "Return Levels of Temperature Extremes in Southern Pakistan" *by* Maida Zahid et al.

**Maida Zahid et al.**

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The authors would like to thank anonymous refree #1 for the constructive comments that helped us to improve our manuscript. The answers to the comments are given point by point in the following.

1. Both Generalized Extreme Value (GEV) and GPD distributions can be applied for assessing return levels and return periods of climate extreme events. The length of 33-year annual maximum values seems to be sufficient for deriving reasonable estimates using the GEV technique. Therefore, it is not so clear why the GEV distribution is not preferred here. Did authors examine the GEV-based return levels? Does GPD provide a better fit and a more reliable estimation?

Ans: We preferred GPD because in many applications, the POT approach is preferred



to the BM approach for fitting time series because it provides more efficient use of data and has better properties of convergence when finite datasets are considered (Lucarini et al.,2016 ; Coles 2001 ; Holmes and Moriarity; Davison and Smith, 1990). Additionally, we are here interested in investigating the actual tails of the distributions, so the GPD point of view is more appropriate.

2. GPD approach has been widely applied for estimating the statistics of extreme rainfall and temperature (e.g. Katz et al., 2002, 2010, Cooley et al., 2007, Furrer et al., 2010 etc.), and the techniques used in this manuscript are not nascent. In order to sufficiently support the argument that the application of GPD herein is "novel" and can provide "novel" information, highlighting any new or additional findings which can only rely upon the GPD approach is desired.

Ans: We definitely agree that the GPD approach has been applied widely for estimating the statistics of extreme rainfall and temperature. But by saying "novel" we meant that the GPD is applied for the first time to southern Pakistan region, extremes are never been estimated using the GPD here. This paper is the first one to introduce the climate extremes information in the region based on GPD. The word novel has been removed from the manuscript to avoid the misunderstanding.

3. By comparing the distribution parameters and return levels derived from observations and ERA Interim data, it seems that they have a large agreement in the shape parameter estimations at some stations, while the bias in the mean and variance of model simulations is the primary factor that leads to the underestimation of the return levels. Does the agreement in the shape parameters indicate that the underlying physical process which produces extreme temperature is well represented by the climate model, though there is a bias in simulating the internal variability of extreme temperature? Please consider to extend the current discussions in this regard.

Ans: The results for the shape parameter indicate that the functional dependency of the extreme value distribution is reasonably well simulated by the ERA data. This is especially relevant for the existence of absolute maxima (Eq 3, Section 2.4) in the case of negative shape parameters. The agreement of the shape parameters in the observations and simulations means that the ERA dataset captures an important aspect of extremal behavior. This is in principle a non trivial result, as reanalysis are constructed in such a way that typical conditions are well reproduced.

4. At stations such as JCB, MJD, RHI, the bias-corrected return levels underestimate the observed values. Which factor/parameter would be responsible for the consistent underestimation? For those locations, is there a way to conduct the bias correction for the shape value? Would a higher threshold correct such underestimation?

Ans: The disagreement of the bias corrected results indicates that the standard bias correction method based on the first two moments is not sufficient for these stations. A better agreement could be obtained by including the higher moments to improve the estimate of the extreme values. We do not think that the higher threshold can correct such underestimation because we are within the asymptotic regime.

5. In section 2.1, the purpose and benefit of adding noise to the data are not clear. By adding the noise, does the convergence of parameter estimation become more efficient? Why?

Ans: The advantage of adding a noise is to avoid the spurious statistical effects associated to the presence discrete values assigned to the temperature readings. This is discussed in detail in the cited paper of Deidda and Puliga 2006 for hydrological extremes. Using the described bootstrap method we reduce such problem without biasing the data.

6. Please consider to rearrange the order of tables and introduce them in sequence. For instance, Table 2 is introduced ahead of Table 1 in the context, so please switch their orders.

Ans: The order of tables has been rearranged.



7. Please provide the Q-Q plots for the 9 stations, since the authors discussed the “slight deviation” revealed by examining the corresponding Q-Q plots.

Ans: Q-Q plots are provided as additional material.

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Fig 4. Quantile-Quantile plots of observed TWmax , u= 90% for 9 stations of Southern Pakistan (Sindh).

Fig 5. Quantile-Quantile plots of ERA Interim TWmax , u= 90% for 9 stations of Southern Pakistan (Sindh).

Fig 6. Quantile-Quantile plots of Bias corrected ERA Interim TWmax , u= 90% for 9 stations of Southern Pakistan (Sindh).

Please also note the supplement to this comment:
http://www.earth-syst-dynam-discuss.net/esd-2016-72/esd-2016-72-AC1-supplement.zip

Interactive comment on Earth Syst. Dynam. Discuss., doi:10.5194/esd-2016-72, 2017.



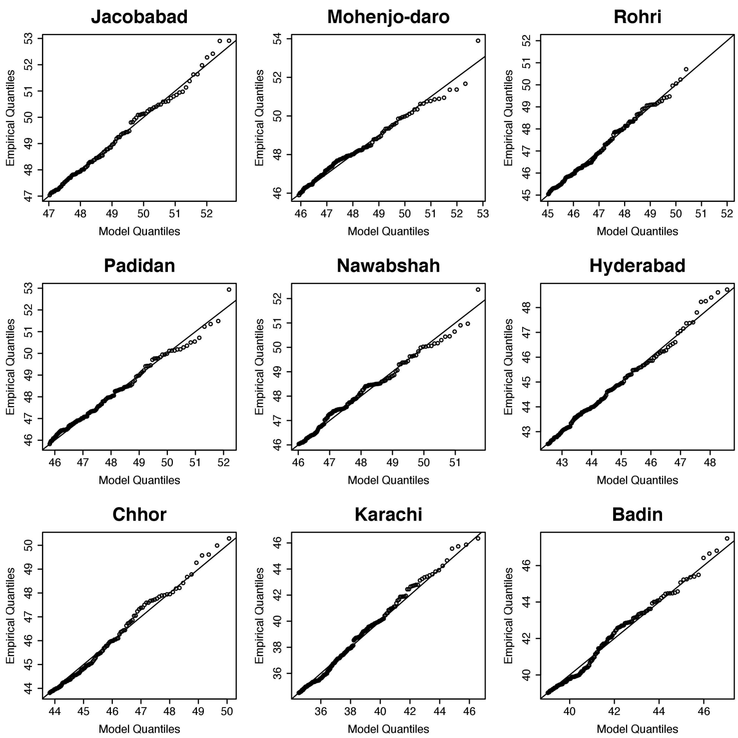
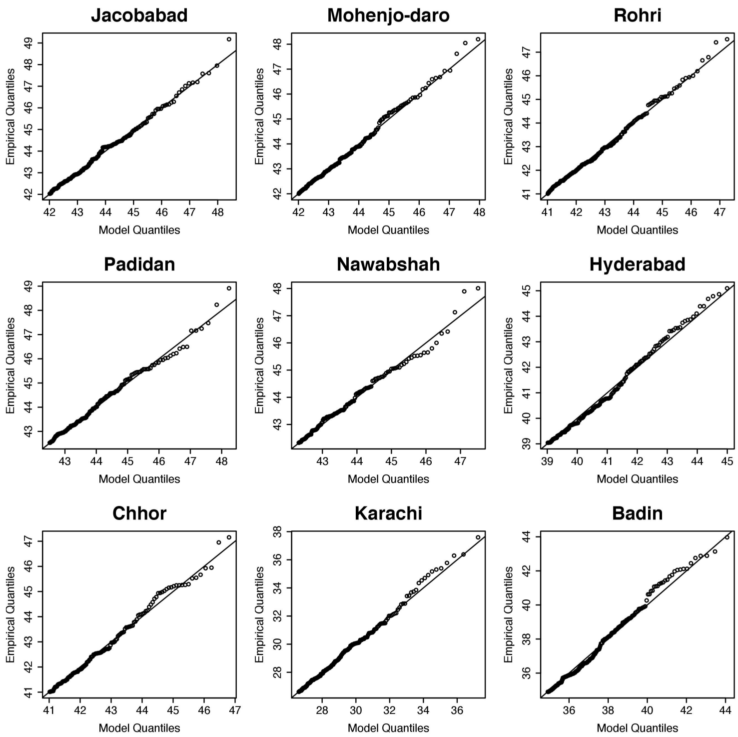



**Fig. 1.**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Badin
Empirical Quantiles
Model Quantiles

**Fig. 2.**



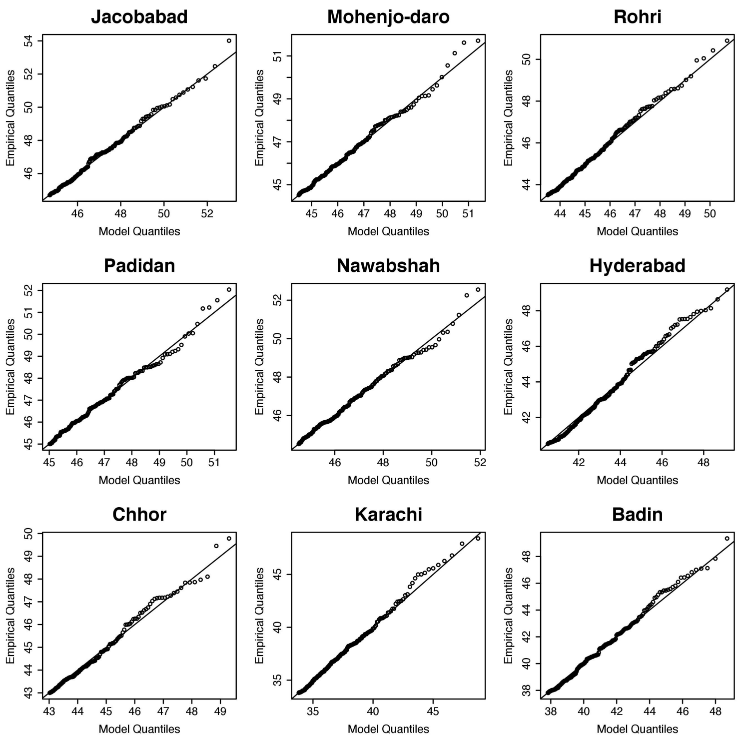
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**Fig. 3.**

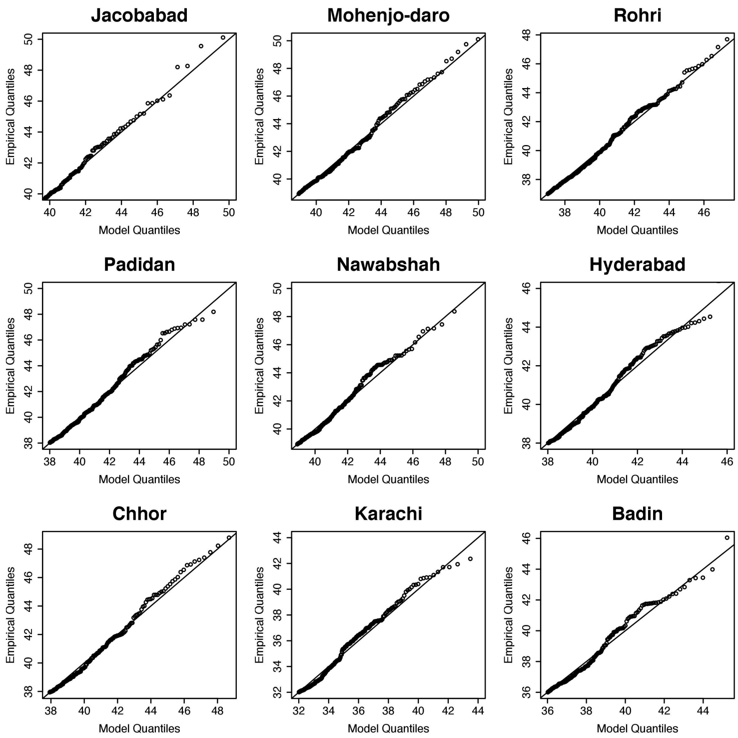
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**Fig. 4.**



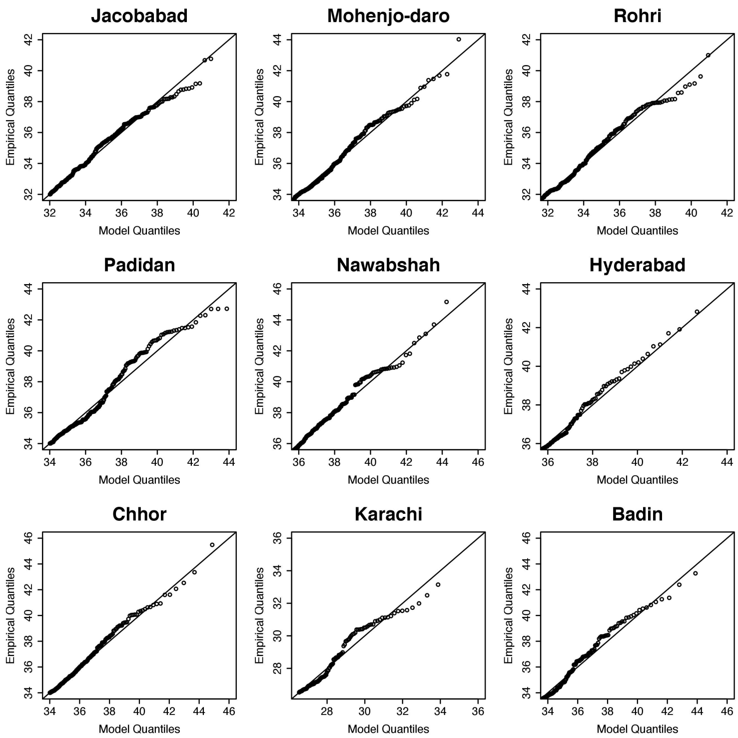
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**Fig. 5.**

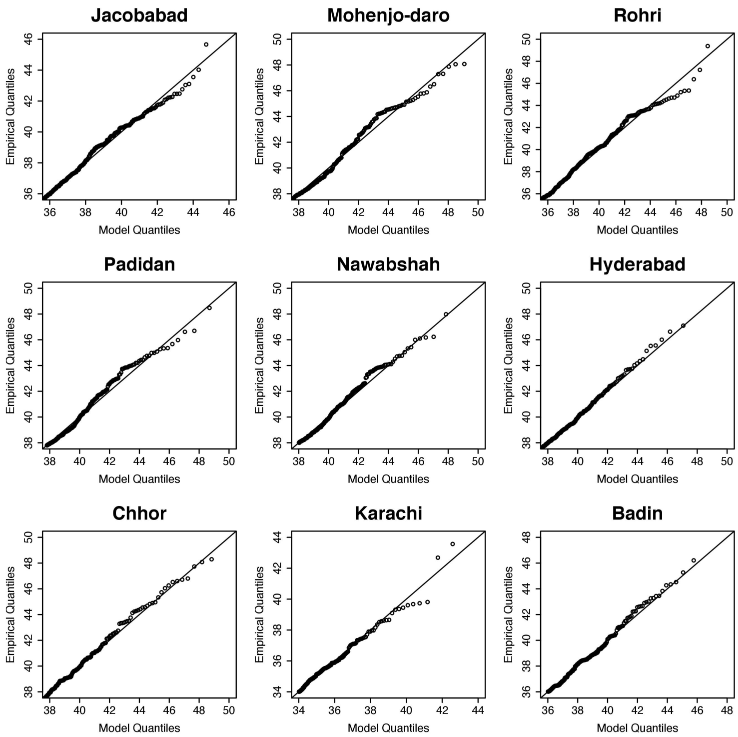
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**Fig. 6.**