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10, C3755–C3769, 2013

Interactive Comment

Interactive comment on "Observed variability and trends in extreme rainfall indices and Peaks-Over-Threshold series" *by* H. Saidi et al.

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Answer to Referee (F.Serinaldi):

We thank the reviewer for the constructive comments on the manuscript. We will detail in our response below how we plan to address the reviewer comments.

Comments: I believe that the true problem in the wide literature on trend analysis is not related to the lack of high quality data at fine time scale but to a (too) superficial application of statistical tools. In this case, the four digitalized time series are surely a valuable source of information which however is not carefully and correctly analyzed. In particular, Mann-Kendall and GPD POT analysis are applied (as usually happens in the literature) by overlooking all the underlying hypotheses and theory, thus leading to uninformative and probably misleading results. The four time series refer to quite a small area and are almost surely spatially correlated. Looking at the Figures 2-6, the time series could also exhibit temporal correlation. Both spatial correlation and temporal correlation reduce the effective sample size and inflate the uncertainty of the test statistics, thus resulting in over-rejection of the null hypothesis when correlation is not accounted for. POT frequency analysis relies on the even more restrictive hypothesis that data are "iid". Without a preliminary check of the basic assumption of independence every subsequent analysis is ill-posed. Moreover, in POT analyses, data must be declustered (to guarantee independence), and nothing can be said about the significance of the differences between the curves shown in Figures 9-11 if these curves are not complemented by confidence intervals (which are expected to be very large especially for the 30-year 1984-2003 POT sample). Since the statistical tests are performed on different time series at several time scales, we also deal with a typical multiple testing exercise that implies an expected "by-chance" rejection rate (i.e. spurious rejections), which must be accounted for. Finally, before analyzing data for stationarity, it should be clearly stated how stationarity is defined. Reading this paper I had the feeling that the statistical tools were applied a bit blindly. Unfortunately, the availability of a powerful statistical software such as R and its contributed packages and the ease of use of such tools do not replace the required theoretical knowledge of the implemented statistical concepts. To conclude, I think that the series presented in this study, if properly processed, can be used to perform a number of valuable analyses going from trend detection to long range dependence recognition or investigation of fractal/multifractal behavior; to do this, I strongly suggest to involve a statistician or somebody with a strong statistical background and expertise in environmental time series analyses.

Answer:

We don't agree with the reviewer statement regarding the availability of long- term high resolution data. In our study area, rainfall measurement using automated weather instruments started in the 1990s. These instruments collect and store data every minute. This is means that the longest time series comprising all stations is a mere 13 years. The short time period pose major limitations on the use of these data for climate change study. Consequently there is a lack of long- term high resolution data (i.e. hourly and sub-hourly).

Recent progress in automatic systems for rainfall signal recognition from tipping bucket gauge strip charts point out to us the importance of studying the changes in extreme precipitations with longer record. The manuscript presented the result of our initial analysis and we agree with the reviewer that other variable analysis in the future can be performed.

In addition it's known that a time series is stationary "if it is free of trends, shifts, or periodicity, implying that the statistical parameters of the series (e.g., mean and variance) remain constant through time." (Salas, 1993).

The reviewer mentioned some issues like:

- Data spatial and temporal correlation - The hypothesis that data are independent and identically distributed - Confidence interval for frequency curves. - The multiple testing issue.

The manuscript will be updated to include this complementary analysis.

1- Serial Correlation:

We agree with reviewer that Mann-Kendall does assume independent data, which may not be the case for some indices. Consequently, the "modified" Mann-kendall test proposed by Hamed and Rao (1998) can be implemented.

Based on available literature it seems that the effect of serial correlation can be eliminated by removing serial correlation from the data before applying trend test. One of the techniques, commonly known as "pre-whitening" of the data, involves the removal of serial correlation then performing the test on the uncorrelated residual.

HESSD
10, C3755–C3769, 2013

The Temporal/serial independence of the data was checked using the autocorrelation function (ACF). For each extreme index, the ACF coefficient for all the stations was plotted along with the 95% CI (figure 1, 2, 3, 4, 5).

we examined the ACF1 of the time series. Overall, the ACF was not significantly different from 0 for any index, suggesting that serial/temporal correlation is not an important element of trend detection for extreme rainfall indices. For this reason in our study we don't need any of the two technique; pre-whitening and modified Mann-kendal test.

2- The application of Regional Mann-kendall test:

Field significances were assessed using the Regional Mann-Kendall statistic (RMK). as suggested by Helsel and Frans (2006).

The Regional Kendall test is an "intrablock" test. Test statistics are computed on each block of data separately, and the overall test combines the individual test statistics so that no cross-block comparisons are made(Helsel and Frans 2006). For the Regional Kendall test, the blocking factor is location.

The Regional Kendall test looks for consistency in the direction of trend at each station, and tests whether there is evidence for a general trend in a consistent direction.

The application of RMK test to extreme precipitation indices proved that there is no evidence of a significant regional trend even if there is insufficient evidence of trend for that one station. For this reason we believe that the decision of analysing the data from the four stations separately is reasonable.

3- Independent and identically distributed data

We agree with the reviewer that we need independent and identically distributed data.

In the present study, the independency criterion is based on a procedure for extracting Peaks-Over Threshold values for rainfall which is similar to that for extracting POT values for discharges (Ntegeka and William, 2007; US Water Resources Council, 1982).

In river flood applications, consecutive peak floods are defined by the US Water Resources Council (1982) as independent if the interevent time exceeds a critical time.

The independency criterion for discharges events states that two consecutive events are independent if the occurrence of one event does not affect the occurrence of the other event. The main criterion for event extraction consequently is the interevent time. Willems (2000) proposed for extreme value analysis based on rainfall series a minimum of 12h interevent time considering two events happening within the same day or night as one event.

This criteria was indicated in the manuscript page 6057 lines 18-25

4- Confidence interval for frequency curves.

We agree with the reviewer comment that what we need to add confidence intervals to figures 9-11. We estimated the lower and upper limits of a specified confidence interval using Bootsrap method. An example of frequency curve with 95% confidence intervals is shown in figures 6-7.We will update all the figures in a revised version of the manuscript.

6- The multiple testing issue:

We agree with the reviewer that in this study we deal with multiple test issue Given the small number of stations analyzed, 4, we expected that the results are not affected by the multiple testing issue. Some corrections used for multiple testing are applied to the list of P-values; they take into account the number of tests carried out simultaneously. The adjustment methods of p-values include the “Bonferroni”, best known but not recommended because it is overly conservative and also less conservative corrections like False Discovery Rate (fdr) (Benjamini and Hochberg, 1995). The result of this adjustment is presented in table 1 (supplement file). Figure 6 showed a comparison between the results of the two methods FDR and Bonferroni.

References

HESSD

10, C3755–C3769, 2013

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Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/10/C3755/2013/hessd-10-C3755-2013-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 6049, 2013.

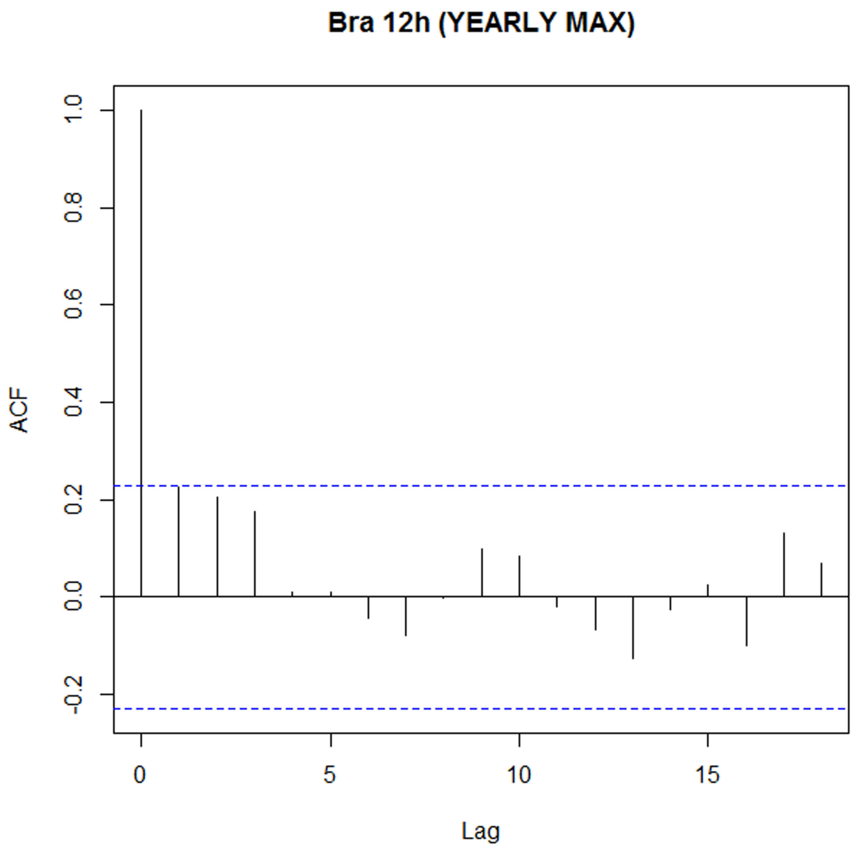

Fig. 1. Autocorrelation function: Bra 12h

HESSD
10, C3755–C3769, 2013

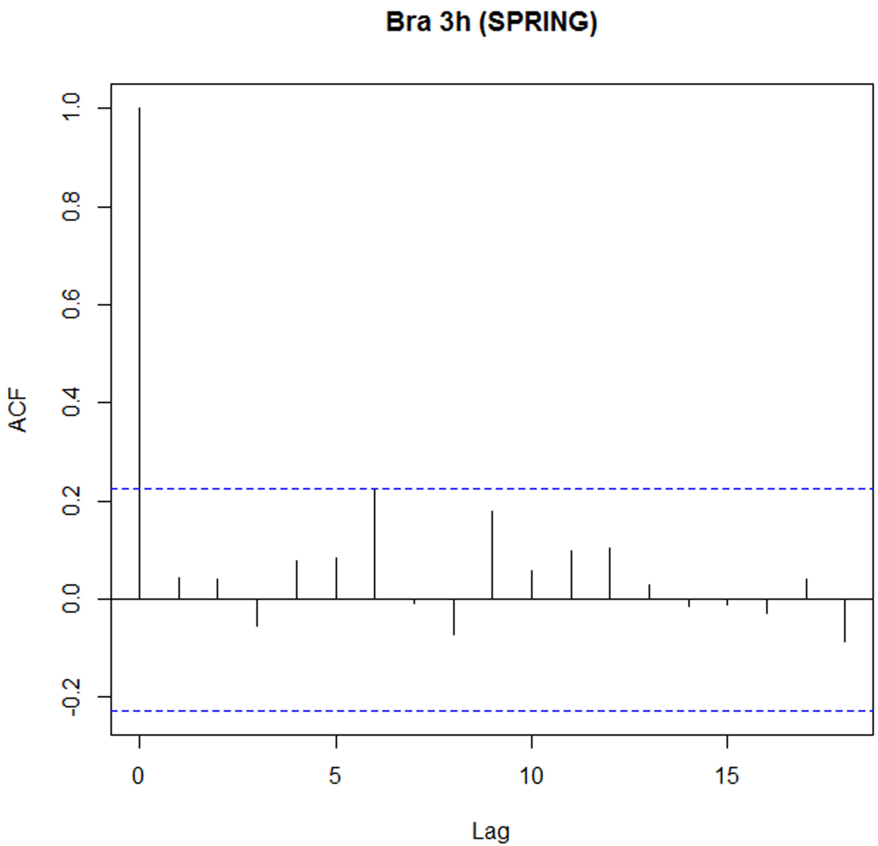

Fig. 2. Autocorrelation function: Bra 3h

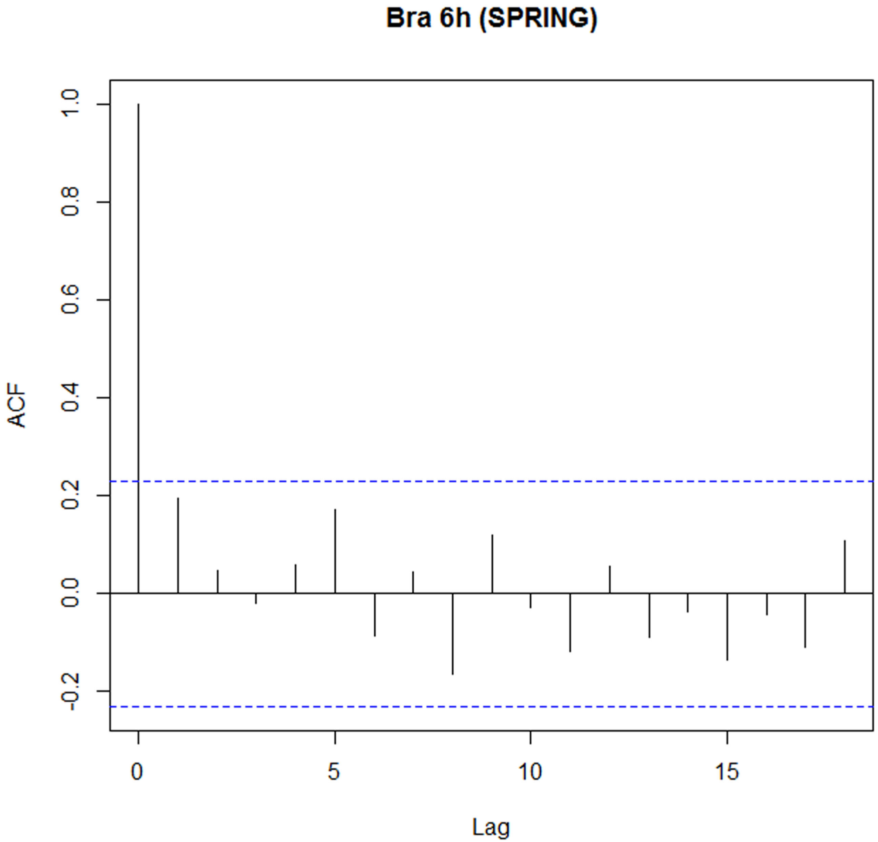

Fig. 3. Autocorrelation function: Bra 6h

HESSD
10, C3755–C3769, 2013

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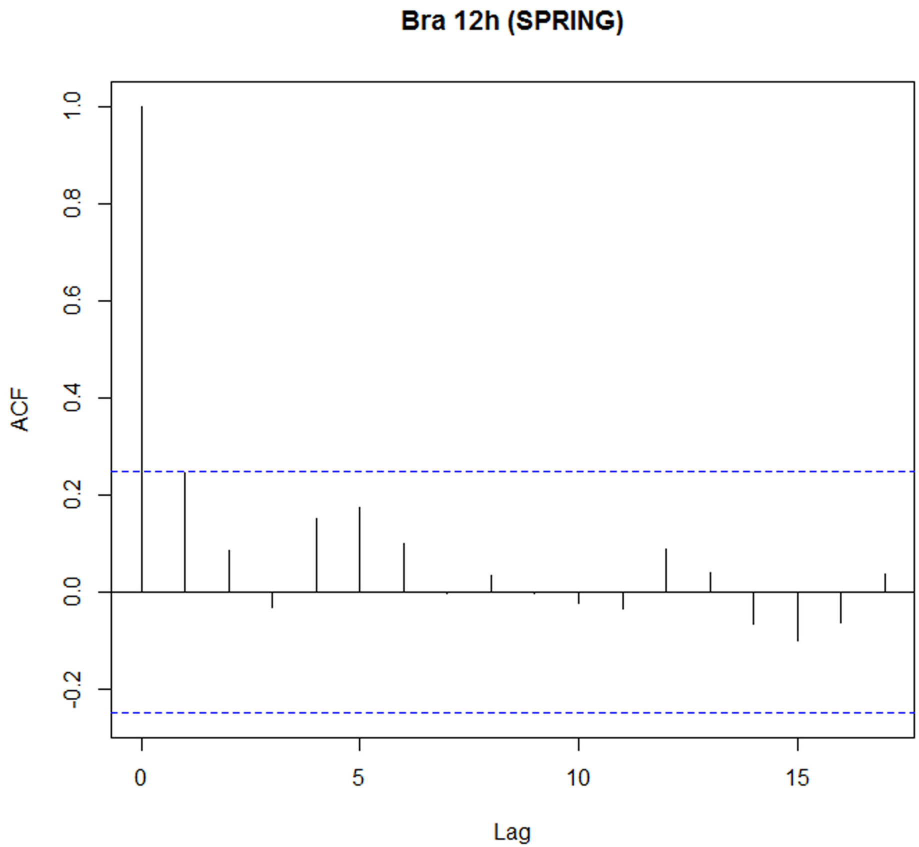

Fig. 4. Autocorrelation function: Bra 12h

HESSD
10, C3755–C3769, 2013

HESSD

10, C3755–C3769, 2013

Interactive Comment

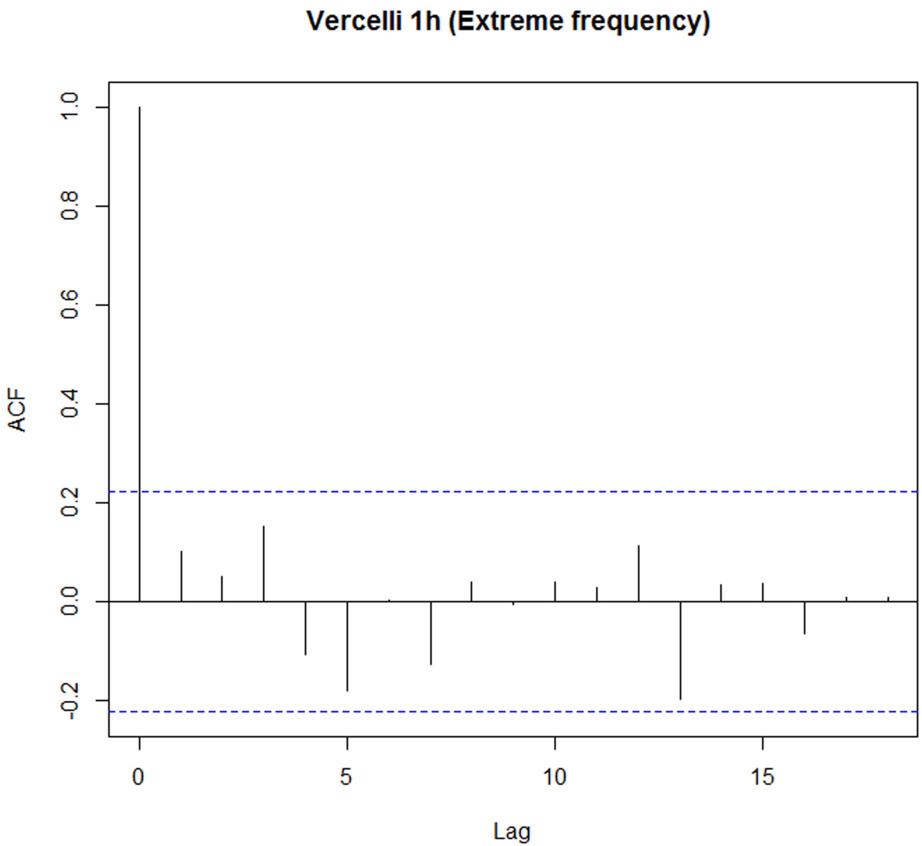

Fig. 5. Autocorrelation function: Vercelli 1h

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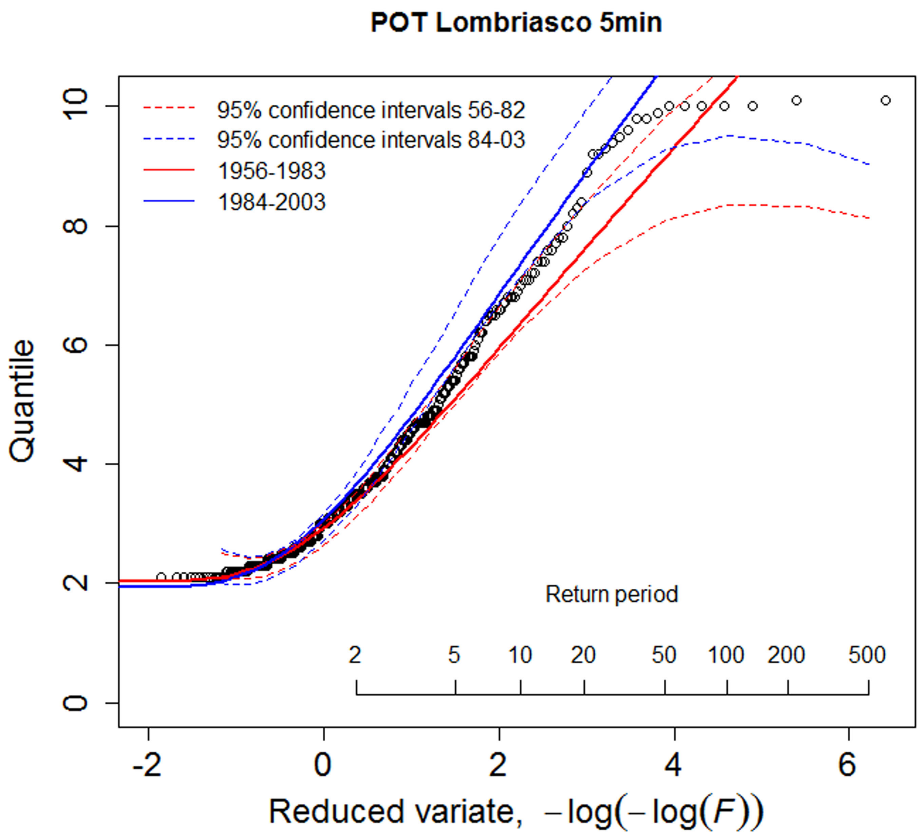

Fig. 6. Changes in POT series of 5min duration compared to the last 20 yr: Lombriasco

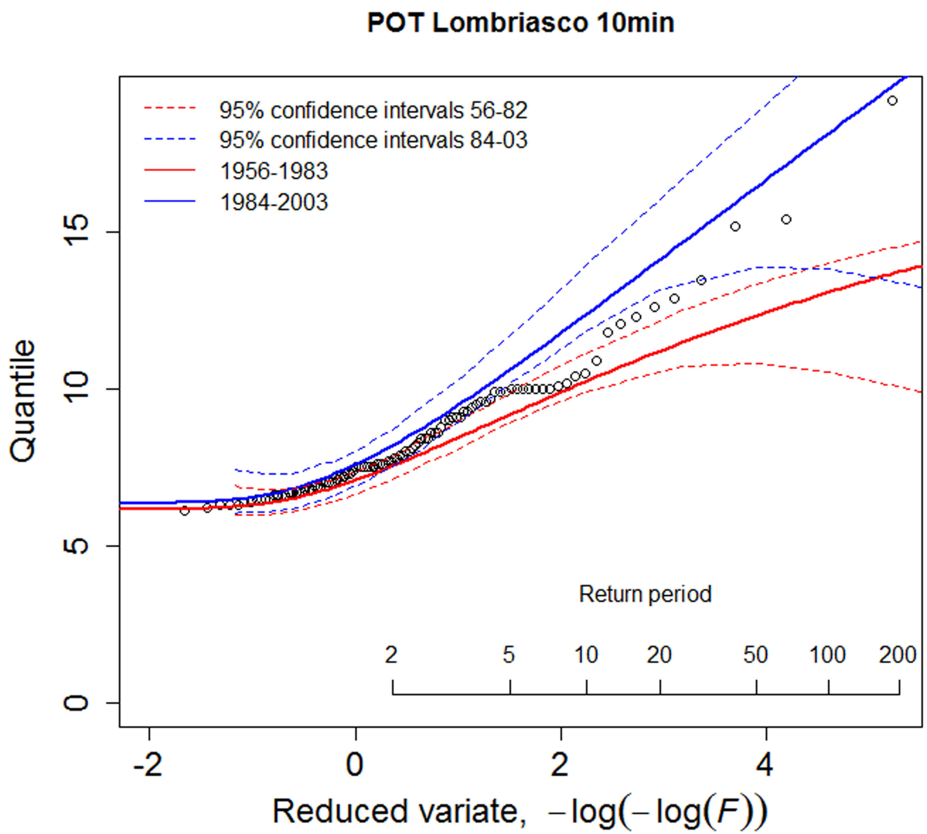

Fig. 7. Changes in POT series of 10min duration compared to the last 20 yr: Lombriasco

HESSD
10, C3755–C3769, 2013

Interactive Comment

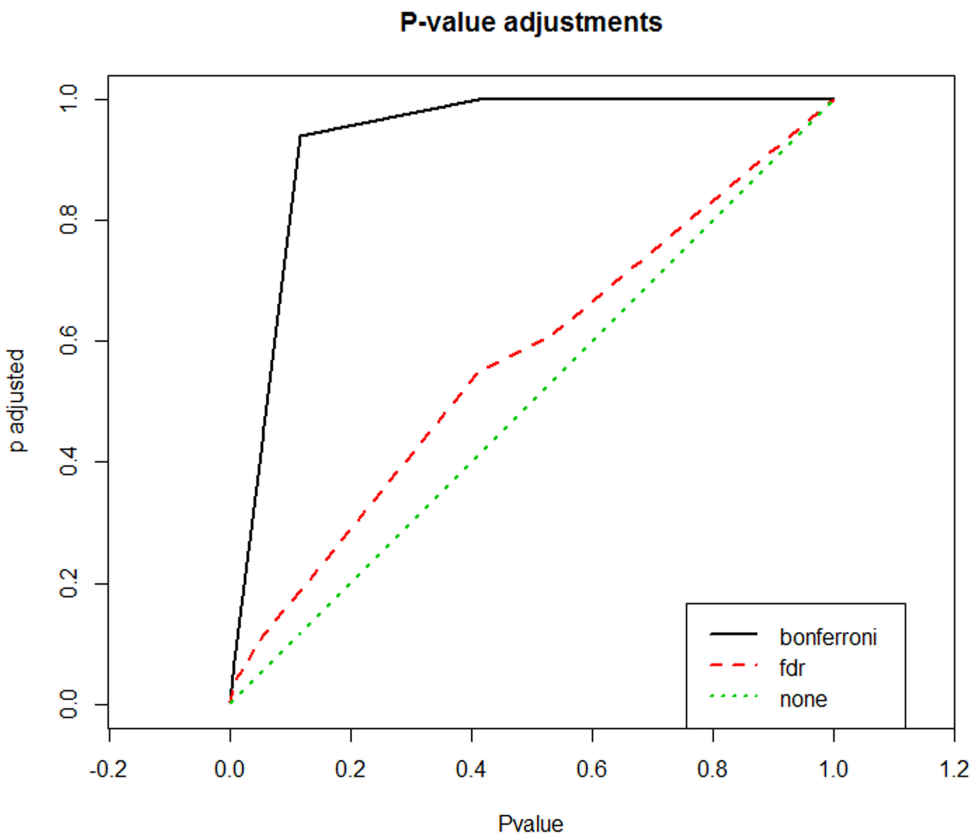

Fig. 8. P-values adjustment

HESSD

10, C3755–C3769, 2013

Interactive Comment

Table 1. P-values adjusted using FDR and Bonferroni methods:

Station	time scale	Indice	P Value	False Discovery Rate	Bonferroni
Vercelli	1h	extreme intensity	0.5946	0.8569	1.0000
		extreme frequency	**0.0429**	0.3433	0.3433
		Spring	0.4952	0.8569	1.0000
Pallanza	30min	extreme intensity	**0.0068**	**0.0438**	0.0543
		extreme frequency	**0.0109**	**0.0438**	0.0875
		Spring	0.8309	0.8309	1.0000
Lombriasco	20 min	extreme intensity	**0.0381**	0.2946	0.3048
		extreme frequency	0.2150	0.4301	1.0000
		Spring	0.7468	0.7816	1.0000
	3h	extreme intensity	0.4173	0.5760	1.0000
		extreme frequency	**0.0102**	0.0816	0.0816
		Spring	**0.0344**	0.1376	0.2753
	6h	extreme intensity	0.0574	0.1148	0.4590
		extreme frequency	**0.0090**	**0.0358**	0.0717
		Spring	**0.0003**	**0.0027**	**0.0027**
Bra	1h	extreme intensity	**0.0103**	0.0794	0.0828
		extreme frequency	**0.0199**	0.0794	0.1588
		Spring	0.1424	0.2848	1.0000
	2h	extreme intensity	0.2502	0.6385	1.0000
		extreme frequency	**0.0152**	0.1214	0.1214
		Spring	0.0961	0.3845	0.7689
	3h	extreme intensity	0.1831	0.4883	1.0000
		extreme frequency	**0.0054**	**0.0430**	**0.0430**
		Spring	**0.0113**	**0.0450**	0.0900
	6h	extreme intensity	**0.0053**	**0.0330**	**0.0426**
		extreme frequency	**0.0097**	**0.0330**	0.0773
		Spring	**0.0124**	**0.0330**	0.0991
	12h	extreme intensity	**0.0005**	**0.0039**	**0.0039**
		extreme frequency	**0.0223**	**0.0492**	0.1787
		Spring	**0.0246**	**0.0492**	0.1967

In bold: significant level lower than 5%

Fig. 9. Table_1

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