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Discussions

Interactive comment on "Non-stationarity in annual and seasonal series of peak flow and precipitation in the UK" *by* I. Prosdocimi et al.

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Point to point authors' reply to Referee 2 report (referee's original comments in italic; changes done to the original text in the manuscript in red).

General comments

- *Page 2, Line 20: It is stated "understanding the relationship between magnitude and frequency of hydrological extremes is of vital importance..." This is true, but this paper (along with many others) only assesses change in the magnitude of annual maxima series, and as a result could fail to detect changes in the fre-*

  quency of large flood events which would be characterized by a POT series (but not the AMS). As such, the approach used is unable to provide a complete assessment of changes in relationship between the magnitude and frequency of hydrological extremes.

  The sentence has been rephrased to avoid explicit mentioning of the frequency of events and a sentence on the potential advantages of using POT data added in the end of Section 1.

  However, we do not fully agree though that the study of changes in AMAX series does not deliver information on the changes in frequencies of extremes. A change in the location parameter of a distribution fitted to an AMAX series would imply a change in the frequency of events of a given level.

- *Page 4, Lines 22-23: The high variation in the test results may be partly explained by the analysis not being restricted to catchments with a natural flow regime. Since current design standards only include an allowance for climate change, is it possible to separate the results for catchments with a near-natural flow regime to see what trends are identified in these catchments, and whether the design standards can be considered suitable for this sub-set?*

  Changes found in natural rivers would suggest that the changes can be associated to marcoscopic factors, rather than modifications of the local catchment conditions. The new Section 4.1 discusses results of an analysis done separately on series with non-natural and near-natural flow. Different patterns of changes can be detected only for Model (c) in summer flows, where a higher proportion of significant negative slopes are found in the near-natural series compared to the non-natural series.

- *Page 6, Line 1: Please could you provide a couple of examples of why missing data are present in some of the records.*

Due to the nature of the dataset from which the series are extracted it is hard to give examples of the causes of the missing data as these information reside with the gauging authority. It some cases, for years in which no records are present in the monthly peaks dataset used in this study, an annual maximum value is present in Hi-Flows UK, the ultimate official source of information for flood data in the country. This seems to indicate that some data might have not be transmitted from the local gauging authorities to the National River Flow Archive, but it is not possible to investigate the reason why this transfer did not happen, whether this is due to issues with the gauging facility or in the transferring procedures themselves. Further, Hi-Flows UK does not often give clear explanations on why data are missing from the AMAX records, and a systematic review of the history of the gauging stations would be needed to have a better understanding of the reasons behind the missing data.

The thorough comparison between the annual maxima extracted from the monthly peaks dataset and the ones found in Hi-Flows UK showed that the two datasets mostly agree: this indicates that the monthly peaks data should not be affected by quality issues, and the missing data are likely to reflect issues in the data transmission rather than in the validity of the data themselves.

- *Page 6, Lines 1- 2: For each station, data for a year were considered missing if records were missing for more than three months in a water year. Three months of a year is a significant period, and could mean the peak flow is missed, particularly as data could have been lost to due to gauging equipment being wiped out during a flood.*

  Data for a year was considered missing if records were missing for three months or more, the wording in the manuscript has been corrected to clarify that. Nevertheless the proportion of data which have incomplete records for a year is fairly small. In the final annual dataset more than 95.4% of the total 17529 station-years has a complete record of 12 months, 3.2% has a record of 11 months

and only 1.4% has a record of 10 months. 922 station-years (5% of the original dataset) have been discarded because of a record shorter than 10 months. In 40.1% of the stations all years have a complete record of 12 months, in 65.4% only one year has an incomplete record and in 86% of the stations the proportion of years with an incomplete record is less than 10%. Only a small proportion of years has been discarded based on this minimal completeness requirement, and although a tighter selection could have been put in place, most of the station-years are complete. Using a different completeness requirement would probably not have a major effect on the final analysis.

- *Lines 11-13: Are the differing spatial locations of stations of the stations available for each decade in Fig.2 likely to have a notable impact on the results presented?*

  In order to verify the impact of the different samples used to do each boxplot in Figure 2 and 3 in the manuscript we did a similar figure including for each decade only the series which have at least 7 years of data in each decade. In this way the location of the stations is the same in each decade. In Figure R.1 the proportion of summer events in the annual and seasonal series for each decade is shown. In contrast to Figure 2 in the manuscript, in Figure R.1 the same stations have been used in each decade. The same patterns seen in Figure 2 of the manuscript are discernible in Figure R.1, although a higher variability is present due to the smaller sample size. Similarly Figure R.2 appear to be largely similar to Figure 3 in the manuscript. The location of the stations with at least 7 years of available data per decade and for all decades together are shown in Figure R.3. Northern Ireland and the north of Scotland tend to be slightly under-represented, especially in the first decades.

- *Page 6, Lines 17-18: It is unclear what should be compared with the time series W-SEPA in Fig.1.*

  To improve readability the sentence has been changed to (compare the time series for west Scotland, W-SEPA, against the series from the south-east area, N-EA, Anglian-EA, S-EA in Fig. 1).

- *Can you suggest an explanation for the rainfall medians being quite variable from decade to decade, with varying patterns for different seasons?*

  While it is possible to relate the variability of the winter medians to the fluctuations of the North Atlantic Oscillation Index, which is known to have an effect on winter rainfall patterns in the UK, it is less clear what drives the variability of summer and annual medians. The following paragraph was added at the end of Section 2.2.

  This is probably related to the large scale atmospheric circulation. For example, for the winter season (Panel (b)) the decadal pattern of the rainfall medians agrees with that of the North Atlantic Oscillation Index, which is known to have an influence on winter precipitations in the UK Burt and Howden (2013). The difference between the decadal patterns for rainfall (Fig. 5) and river flow (Fig. 3) is an indication of the complexity of the factors which regulate the interplay between precipitation and run-off generation.

- *The 99^{th} percentile of catchment average daily rainfall is used as an indication of "storminess". Storminess is more typically characterized by low pressure and strong winds, and often, but not always precipitation. Storminess is therefore a poor choice of term here and should be replaced.*

  We have removed references to the concept of "storminess" from the text and rather use the term "potential for large rainfall events".

- *Page 15, Line 10: Could the resolution of the data partly explain why the river flow and rainfall data gave different results? Maybe the analysis of sub-daily rainfall data could be expected to generate more similar spatial patterns to the river flow data.*

  It is possible that sub-daily rainfall maxima behaviour would show patterns more similar to the ones found in river peaks. Unluckily averaged sub-daily averages are not readily available at present. Further, the actual gauged sub-daily rainfall records tend to span a much shorter period (10-20 years) than the daily records.

- *Page 15, Line 13: It is stated that the annual process is a combination between the different seasonal processes, but what are the different seasonal processes? Does dividing the data based on dates of the year work sufficiently to separate out the different flood processes, or is there still a mixing of processes?*

  The division of the original dataset into summer and winter series is done so that the two processes should have equal length. It is a pragmatic choice which aims at trying to separate the dominant different flood-generating processes (convective events and drier soils in summer, frontal rainfall and saturated soils in winter).

  The following paragraph has been added a the end of Section 4:

  The annual maxima series are a realisation of different high-flow generating processes, which can be pragmatically divided into summer and winter processes, characterised by different conditions, like rainfall patterns, soil moisture and evapo-transpiration. Looking at both annual and seasonal series can give a better understanding of possible changes in the hydrological processes.

  Some confusion in the wording might be due to the fact that the word *process* is sometimes used to refer to a stochastic process which is used to describe the magnitude of extreme flood, rather than the hydrological process itself. We added the word *stochastic* in the text when needed, to improve the readability.

- *Page 16, Lines 14-16: It is stated "it can also be seen as a test on whether the current precautionary levels are safe enough". However, the test can only consider current observed levels of change. It is unable to consider whether the 20% safety margin is sufficient should the rate of change increase in a changing climate. Without the use of future projections, it is not possible to comment here* *on whether the 'levels are safe enough', only whether the 20% safety margin is sufficient to accommodate flood levels in 2085 given the current rate of change.*

We clarified that in order for the test to be informative on future behaviour the change rate is assumed to be the same as the one currently found in the data. The whole paragraph has been updated as follows:

Having accepted the premise of increased flood risk and put the appropriate safety procedures in place, rather than investigating whether or not a trend is detectable in the data, it would be more relevant to investigate whether the trend which can be currently detected in the data is larger than the increase that the current design criteria already take into account. Assuming the change rate would stay the same as the one identified at this point, this can also be seen as a test on whether the current precautionary measures are safe enough and whether they are supported by the currently observed levels of change.

- *Page 17, Line 18: It is suggested that the sample size can only be increased by waiting more years. However, there are alternative options that could be considered such as the use of historical data or regionalization.*

We have stressed that the sample size calculations only apply to at-site analysis of gauged peak flow by modifying the following paragraph

It is important to stress that the sample sizes indicated in Fig. 12 are only giving an indication of the time needed to attain a required power when performing at-site trend analysis on gauged peak flow under some pre-specified conditions.

and the final sentence of the manuscript

Methods to better account for, and use, the spatial correlation between nearby stations and historical information might lead to more informative results.

The possibility of using historical data and regionalisation are also mentioned in the introduction and in the end of Section 5. Throughout the manuscript the pos-

sibility of using methods different from the ones employed in this work is acknowledged and discussed: we do not feel that more discussion on regional methods or the use of historical data is needed.

- *Page 22, Line 26: It is recognized by the authors that some short-term and long-term autocorrelation is likely to be observed in the hydrometric series, and would have an impact on the variability of the test statistic and therefore the power levels. As such, assessing the autocorrelation in the series is an important step which should have been undertaken prior to trend analysis.*

The masking effect that auto-correlation would have when identifying a linear trend is well known issue. Long term persistence is another issue which is acknowledged to have an effect mostly on the variance of the test-statistics. Nevertheless the nature of the data under study in this work, the annual and seasonal extremes, are less likely to be affected by short-term autocorrelation, as they describe the unusual rather than the main behaviour of the hydro-meteorological variables. Indeed the auto-correlation function (acf) up to lag 25 was computed for each peak flow and rainfall series analysed in this work and for never more than 7% of the series was there a significant auto-correlation at any lag-time. For longer series the acf has been computed for higher lag-times as well and for almost all series no significant acf was found even at higher lags. Unluckily it is not easy to formally test for long-term persistence with the limited length of the time-series available. The weak evidence of short-term and long-term auto-correlation in annual maxima is discussed in Hannaford and Marsh (2008), who also show that using a Mann-Kendall test with a block re-sampling approach to account for the auto-correlation does not lead to noticeably different results than the standard Mann-Kendall test.

The following paragraph has been added in Section 5 (page 25):

Some short-term and long-term autocorrelation might be observed in hydrometric series, and would have an impact on the variability of the test statistic and therefore on the power levels, although less so for series of extremes (see Hannaford and Marsh (2008)). Auto-correlation for the river-flow and rainfall maxima series analysed in this work have been found to be largely not significant (results not shown) and Hannaford and Marsh (2008) show that correcting for the auto-correlation in river flow annual maxima series lead to only marginally different results. Methods to overcome the auto-correlation present in hydrometric data are discussed, among others, in Yue et al.(2002).

One of the additional reasons why corrections for auto-correlation were not introduced in the study lies in the fact that this study partially aimed at reproducing for the UK the results on the North American river flow series presented by Vogel et al. (2011). In order to have a fair comparison between the results for the UK and the US the same estimation procedure used by Vogel et al. (2011) was employed.

Technical corrections

Page 2, line 7: Correct '2-parameters' to '2-parameter'

Page 6, Line 16: 'rainfall' instead of 'rainfalls'

Page 7, line 11: 'drier' instead of 'dryer'

Page 24, Line 10: Correct 'small proportion stations one' to 'small proportion of stations can one'

Page 24, Line 11: Correct 'can be rejected' to 'be rejected'

Fig 1. Start axis in 1930 instead or 1940.

All changed, thanks for pointing these out.

1 References

References

Hannaford, J. and Marsh, T. J.: High-flow and flood trends in a network of undisturbed catchments in the UK, Int. J. Climatol., 28, 1325–1338, 2008.

Vogel, R.M., Yaindl, C. and Walter, M.: Nonstationarity: Flood Magnification and Recurrence Reduction Factors in the United States. J. Am. Water Resour. As., 47, 464-474, 2011.

Yue, S., Pilon, P., Phinney, B. and Cavadias, G.: The influence of autocorrelation on the ability to detect trend in hydrological series. Hydrol. Process., 16, 1807-1829. doi: 10.1002/hyp.1095, 2002.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 1, 5499, 2013.

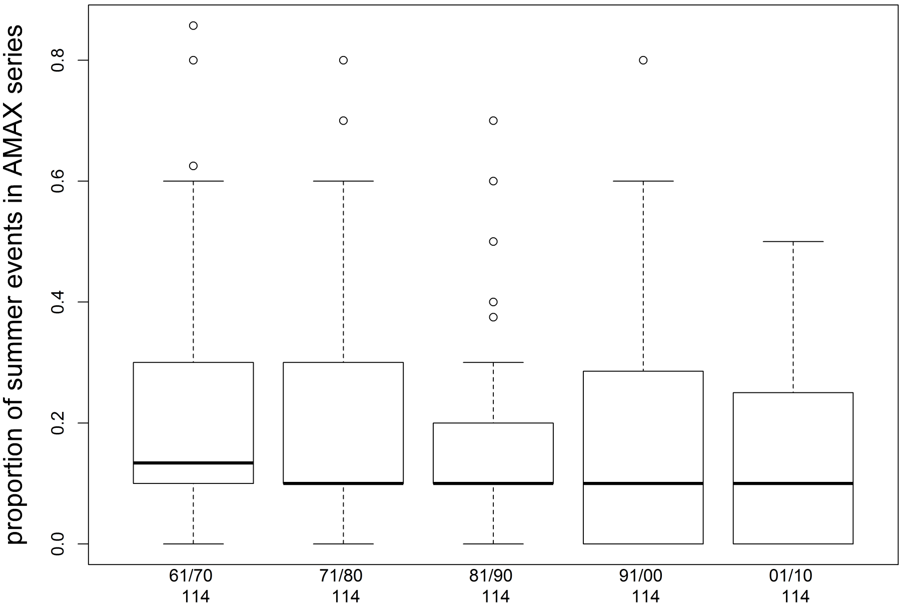

Fig. R.1. Proportion of summer events in the annual maximum rainfall series, shown separately for each decade. Only stations for which sufficient data is available in all decades are used.

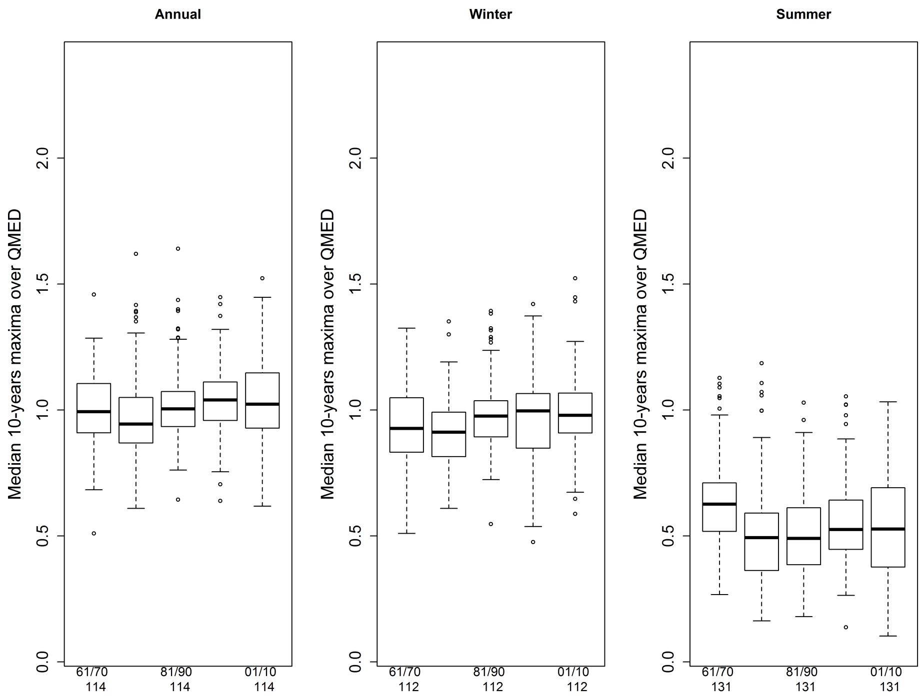

Fig. R.2. Median ratio of annual and seasonal maximum peak river flow over long-term median of the annual maximum, shown separately for each decade. Only stations for which sufficient data is available in all d

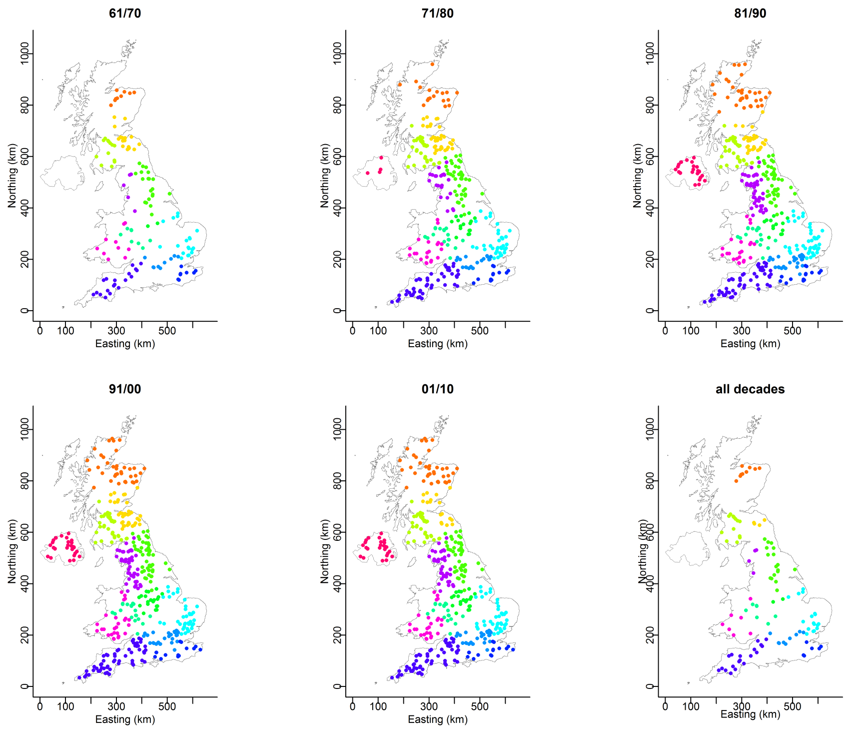

Fig. R.3. Location of the stations available in each decade and for the whole study period: colours identify the different hydrometric areas.