

## ***Interactive comment on “Millennial scale variability in high magnitude flooding across Britain” by N. Macdonald***

**Anonymous Referee #3**

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The paper has the ambitious aim of trying to create a chronology of large-scale floods in Britain (England, Scotland, Wales) over the last 800 years and then uses this series to analyse trends in past and recent flooding. The context and importance of the subject are underlined by the issue of ‘a perceived increase in extreme floods in recent years’ and attempts to demonstrate with the help of the long-term British data that the ‘current flood rich period is not exceptional’.

Longer flood chronologies and information about the extent of past flooding are indeed needed. Wide parts of Europe, including England, possess a comparatively long tradition of historical writing and therefore documentary sources can be employed to supplement modern hydrological measurements with past observations.

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However, there is a number of problems attached to the paper.

For a paper with the ambition to investigate the drivers of flood trends over the larger part of the last millennium, too little is done to appraise quality, reliability and potential of the data. The further back in time an event took place the more a correct historical methodology – source criticism – is needed: accounts should be at least near-contemporary to the event, reliability of the observer needs to be established, and dating and interpretation need to be checked. This becomes problematic in the pre-1750 data (after c. 1750, depending on region and administration, newspapers and modern record keeping greatly facilitate research). Figs. 2 – 4 show that only about 10 per cent of the total data fall into the pre-1750 category which covers 550 out of the studied 800 years, so the reliability of those data is crucial to the conclusions of the study. However, out of the twelve flood series used in the paper, only seven are published to allow a critical assessment of the information used. Most of these seven publications (rivers Findhorn, Tay, Tweed, Tyne, Ouse [York], Trent, Ouse [Sussex]) do not have the creation of a flood chronology as a primary aim, but – focusing on the post 1800 data – seek to define return periods for major floods, the pre-1750 data being not an integral part of the statistical analysis. Two papers do not collect pre-1750 data at all, respectively did not even attempt to construct a flood series (no pre-1750 data is presented for the Ouse in Sussex; for River Findhorn the authors give an excellent in depth study for one major flood event in 1829 mentioning in passing two previous floods). The pre-1750 data for Rivers Tay and Trent do not contain a single occasion of contemporary evidence. All sources for the listed flood events are not reliable primary sources but either compilations, nineteenth or early twentieth century water board publications or nineteenth century local histories, types of work that frequently are unaware of historians' methodology and therefore abound in errors concerning dating, doubling events, overlooking events and mislocating evidence. The situation for the River Ouse at York is somewhat better thanks to the existence of flood marks at the city wall, so that the listed flood events for which no reliable evidence has been cited pre-date for this river 1625. For the River Tyne a reliable flood chronology down to 1711, the time

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of the beginning of regional newspapers, exists and was analysed; no data before this time were collected. In the original study of the River Tweed some pre-1750 floods are listed, four of these around 1300 come from reliable sources in the form of (almost) contemporary medieval chronicles by authors who were geographically close to the Tweed. However, even though the Tweed pre-1750 data are at least as reliable as the nineteenth century flood collections employed for other river flood chronologies, these data are missing in this paper. This is not to say that no reliable flood data before the mid-eighteenth century exist, but these have not been extracted from original contemporary sources for most of these studies. The Britain-wide flood chronology in the pre-1750 period presented in this paper also suffers from a lack of understanding of the historiography of medieval and early modern Britain. The apparently flood free period from c. 1400 to 1500 as visible in Fig. 2 – 4 coincides with the lowest ebb of historical writing in England since c. 1200, few historical works were written in this time. The lack of floods may therefore be simply due to a lack of sources and not reflect any natural variability at all. As it stands the data quality in the pre-1750 data is too low to base any analysis upon.

The above mentioned problems would affect the post-1750 data to a much lower degree or not at all. Even though data density and reliability for this period are good and the paper aims to establish phases of overlapping flood periods in various British regions and also with continental Europe, very little information on the floods is actually given. For a study that ultimately aims at determining the driver(s) of these events, it would be of great benefit to identify the seasonality and causes of flooding. Shifts in these over time and regional variation on seasonality and causality need to be investigated. Do the worst floods occur in seasons when flooding is most common? Is the morphology/causality of flooding the same in northern and southern Britain? Is there a difference between groundwater fed and overland flow fed rivers? A lot of information on flooding and its causality actually seem lost by piling the various rivers into one national series. (To facilitate the comparison of levels of regional flooding for the reader, it would be helpful if Fig. 4 displayed regions of close geographical proximity in neigh-

bouring columns instead of criss-crossing Britain.) The assumption behind searching for overlapping flood phases in the various rivers in Britain is not clearly pointed out. The author himself states that large scale flood patterns are similar in western and eastern Britain, but that 'northern and southern England divisions [...] show considerable differences, particularly for the period since 1950 [...]'. It appears as if the inclusion of southern England and not just northern England, but even Scotland, in one national flood index is actually primarily reducing potentially highly relevant regional complexity. To contextualise the information of the national flood index, it is important to know if a national flood pattern can be detected in the hydrological data since c. 1950. The summing up of the regional flood periods is unsatisfactory: 'regional FIs show both coherent flood-rich phases across all catchments but also regionally specific flood rich periods'. No conclusion is drawn or quantification attempted. A similar approach is taken to a comparison of British flooding with continental European flooding, here 'flooding appears to be synchronous and asynchronous during different phases'. Again no further conclusion or quantification follow.

Concerning the statistical side, the formula for creating the flood index FI as the author states represents the post-1750 data (though it should be better explained how it allows for non-linear record growth) and it would be difficult to see how pre-1750 data could be treated in this way as indeed it is done in Fig. 4. However, the author does not indicate how this was achieved. The vocabulary used in regard to the formula is confusing, apparently the number of 'records' per year were accounted for. Surely the author means the number of actual 'floods', since of course multiple records can refer to one and the same flood hereby inflating the event count especially for the earlier part of the 1750-2012 period considering the scaling factor as a function of time in the flood index formula.

It is probably possible to roughly rank recorded floods predating c. 1750 according to magnitude, however, it is unlikely to do this in such a refined manner as to define those 'exceeding the 90th percentile based on the instrumental period'. For such an

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undertaking ideal conditions such as continuous documentary records, a set of specific unchanging landmarks used of long periods of time for determining flood levels and overlapping with hydrological measurements to allow calibration of past floods, and a largely unchanged riverbed are needed. In none of the seven published flood series used in this paper are these conditions fulfilled. Generally, during England's Industrial Revolution and later, major changes to the river systems as well as riverbeds are common.

The main conclusion of the paper is the link between flooding on the millennial scale and external forcing mechanisms in the form of solar magnetic activity. No reliable quantitative relationship is established between these factors. The paper fails to provide a convincing link despite the conclusions given, especially as the data can only be considered reliable after c. 1750. In this context the author should also explain, why global scale climate forcing mechanisms should have an effect similar in direction and magnitude on national or even regional scales.

In light of the discussion so far given in this review, the paper requires very significant restructuring and changes. The cross comparison of rivers is more important than trying to construct a national series. The data before 1750 add nothing to the discussions for reasons outlined above and should be dropped. Seasonality and causality of the floods and their trends in the various regions have to be incorporated in the paper; the post-1750 data will allow such an analysis. The link between flooding in Britain and solar magnetic activity needs to be supplemented with quantitative data and a clearly defined physical explanation.

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