

Dear Andrea

As requested following the last review and the editorial guidance, I have revised the manuscript's timeframe of study to now focus solely on the period since AD 1750, where appropriate occasional reference is made to earlier events, but singularly to help the reader understand the significance of a subsequent events within the period since AD 1750.

Please find below my comments and responses (*italics*) to the points raised by the reviewers, I would like to thank all the reviewers through the process for the helpful and insightful comments through the numerous revisions to the manuscript.

Best wishes

Neil

Report 1

I would like to thank the reviewer for the constructive comments which have improved the paper, in addressing the wide ranging comments from all four reviewers in the previous version unfortunately a couple of points were overlooked which I take full responsibility for, I hope the responses below will address the concerns of the reviewer.

L61 "This paper presents the first coherent large scale national analysis undertaken of historical flood chronologies, .." This is perhaps a little too strong given the data presented and the more comprehensive studies available in other countries.

I have revised the sentence to read "This paper presents the first coherent large scale national analysis undertaken of historical flood chronologies in Britain". The reviewer was correct to highlight this, I thought I had corrected in the previous revision, my apologies, it must have been dropped between iterations.

L738 I have a number of problems with Eq. 1. First, what is the basis of coming up with this equation? Is it curve fitting, or any physical justification? Also, the equation is not quite clear to me. FI is calculated for every decade or every year? I guess z does not vary in time, but t does, and why would you use t factorial? Second, the author says the records were ADJUSTED. I suspect the discharges were replaced by the FI rather than adjusted. I would think that the equation removes the long term trend. If this is so, the long term trend should not be interpreted in the paper, only time scales shorter than 100 years.

The basis for the equation is that it accounts from the changing number of records within the series through time, resulting from increased availability of records nearing the present, whilst not removing flood rich/poor phases within the series. I have made this more explicit in the text in this section. As the prevalence of records increases through time, with few occasional references and accounts in the tenth century and much larger numbers in the twenty-first century, with rapid growth in the late seventeenth and early eighteenth century (Figure 4). The methodology proposed here

permits the FI to remove the underlying trend presented because of increasing recording frequency arising for anthropogenic behaviours, but retains short term changes in flood recording that are more likely the function of hydroclimatic changes (flood events). The equation is calculated for each year, with z the number of flood events in any given year exceeding the threshold, a fuller explanation and justification is now provided in this section of the manuscript.

The term adjusted was replaced as correctly suggested by the reviewer, as the FI is a new indices and not an adjustment.

L963 “The principal finding of this work is that of the strong correlation between flood-rich phases and solar magnetic activity, indicating a clear driver for flooding patterns across Britain,” If this is the principal finding, perhaps the one sentence identifying this finding quantitatively is just not enough. *I have revised to remove the emphasis that this sentence structure placed on just solar magnetic activity and broadened to include the other findings discussed in this paragraph in relation to NAOI and AMO which are equally important.*

I believe these comments should be addressed before the paper can be considered for publication. *Thank you for the comments, I hope the revised version satisfies your concerns.*

Report 2

In amending the timeframe of study many of this reviewer’s concerns are addressed, however where points are raised that remain relevant these have been addressed.

The corrections that have been made in the revised manuscript, largely consist of the addition of detail on a per catchment basis. The author insists that this paper merely attempts to use a broad-brush approach, but in a field – historical floods on the British Isles over the last 800 years – where very little has been published so far, a ‘rapid communication’ approach is premature.

The quality and validity of the pre-1750 data is insufficient, as described at length in my previous review. For example, medieval and early modern data are displayed in Fig. 2 for six out of twelve rivers, but for two out of these six flood histories, the rivers Tay and Trent, no contemporary data are provided at all in the original papers (Macdonald, Werritty et al. 2006; Werritty, Paine et al. 2006; Macdonald 2013); nor in the information presented here. The floods pre-dating c. 1750 for these rivers are taken entirely from ‘compilations, nineteenth or early twentieth century water board publications or nineteenth century local histories, types of work that are frequently unaware of historians’ methodology and therefore abound in errors concerning dating, doubling of events, overlooking of events and misallocating evidence’; information given in such works is a starting point for research but requires verification. For the problem with the flood histories of the rivers Tyne and Tweed (the comparatively well documented floods around 1300 are now included in the Tweed series, however, so are the sixteenth and seventeenth-century floods referenced only in non-contemporary works) see the previous review. If historical methods are not employed in such a verification process, then the error-risk remains very high.

Much of this discussion is now obsolete for the purpose of this study given the change in timeframe considered; however I would like to highlight that extensive historical analysis of source materials was undertaken, with over 500 accounts/records for the period pre-1500 alone identified, with nearly 8,000 in total for the full period. To suggest that for “floods pre-dating c. 1750 for these rivers are

taken entirely from ‘compilations, nineteenth or early twentieth century water board publications or nineteenth century local histories’ is inaccurate, though I accept of the examples quoted within the paper many focussed on more contemporary sources, simply as they provided clearer references – I will endeavour to include more original source materials in subsequent works.

As an illustration for the confusion that ensues when original contemporary sources are not consulted, the early flood history of the River Severn given in lines 494-505 is a good example. Three early floods from ‘reliable data’ are noted: the ‘Duke of Buckingham’s Great Water’ in October 1484, a flood in 1258 and a series of unspecified inundations 1377-81. The source given is the ‘Annals of Tewkesbury’ edited in Luard, H.R., *Annales Monastici*, vol. 1, London 1864. The inundations for 1258 are indeed referenced in those annals, and the year is also correct. However, the annals end in 1263 and neither the floods around 1380 nor the high waters in 1484 can be found in this text. The reference to these two late medieval floods is actually taken from Fosbrooke, T.D., *An original history of the City of Gloucester*, London 1819. (cited incorrectly as Fosbroke 1819 in line 505). Fosbrooke’s ‘History of Gloucester’ is exactly one of the generally unreliable antiquarian works of the earlier nineteenth century, that always need verification. Fosbrooke might be an honourable exception, his reference to the flood 1258 is after all correctly dated (p. 42). When mentioning the inundations and further problems in the years 1377-81, Fosbrooke even cites a charter (p. 175), which raises confidence and would make verification possible. Fosbrooke also tells the story about the ‘Duke of Buckingham’s Great Water’ in October 1484, except that he cites this event for the year ‘1483’, not ‘1484’ as in this paper. Indeed, the flood and the associated rebellion against Richard III. took place in 1483 and in the November of that year the relevant Duke of Buckingham was executed for his failed attempt to overthrow the King. The change from the correct ‘1483’ of Fosbrooke into the ‘1484’ in the paper is an adequate example of medieval and post-medieval transcription errors. A dating error by one year seems negligible at first glance, but in a study concerned with the drivers of floods it is essential to have precise dating, for being able to connect the floods to possible large-scale forcings such as volcanic eruptions, that over England certainly have the power to turn a summer half year rainy and cause flooding.

I accept that there were some errors on my part e.g. that noted for Fosbrook (a typo) and the year should have read 1483 not 1484, a product of the time elapsing between the research and the publication (10 years). These flood events fall below the threshold and were not included, though this section is now removed as predating the study period.

The paper refers to the floods 1258, c. 1380 and 1484 [sic] as ‘clearly documented in reliable sources’ (line 501) and so distinguishes them from a set of floods for which ‘original sources have not been located’ (line 504-505). For this second set of floods ‘such [threshold] estimates for these events are not included’. However, no floods of either set are actually shown in Fig. 2, does this imply that none of them qualifies as ‘events that exceed the 0.9 percentile (based on the instrumental record; river discharges are given as ‘cumeecs)’?

Correct, they all fall beneath the threshold. No longer included within the manuscript as a result of the revised timeframe

To alleviate the lack of recorded floods c. 1300 to 1500 and to show that this is not a lack of sources or search for records, but a result of natural forcing, a connection between peat water levels and river flooding is implied (line 795-797). The peat record does indeed not display any wetness in those 150 years, nor does it display much else until c. 1800. What the peat record does definitely not show

is any connection to solar magnetism. There is no reaction in the peat record to the increased levels of solar magnetism around 1375 or 1600 or to the sustained increase after c. 1750. During the high level of twentieth-century solar magnetic activity, when flooding increased, the peat water levels were low. Since the peat reflects neither the high level of flooding in the recent decades nor the rather high level of solar magnetism, it is not clear how it could be connected to these factors in the Middle Ages and serve as an independent indicator of flooding on the British Isles for this period.

The relationship between the peat series and flooding in the UK is complex, few long instrumental precipitation series predate the late eighteenth century, as such the peat sequences provides a near-annual resolution of wetness (and relative dryness) for the UK, this does not necessarily directly relate to flooding, as a high-magnitude flood event may occur during a dry year. I acknowledge that the relationship for the last 250 years is difficult to relate to that of the UK flooding record – I have made such a statement in the revised version.

No attempt was made to draw a direct relationship between the magnetic activity and peat wetness chronology, this is beyond the focus of this paper. The Charman (2010, pg14) paper specifically states when considering the peat sequence “a simple linear link between solar variability and terrestrial climate change cannot be demonstrated”. It remains helpful though for the reader to see that not all proxy series show clear relationships, I have moved this further down the discussion though to remove any chance the reader considers this to be suggested.

The argument brought forward in the first review, that the lack of recorded floods in the late Middle Ages, a time when the historiographic activity in England was dwindling and the population was reaching a sad nadir, is less to do with the actual occurrence of floods than with the cultural, demographic and socio-economic environment, remains valid.

We do state earlier within the paper that an absence of record does not necessarily mean that no event occurred, simply that we do not have an account of it (first line in section 4- Series Composition), the cause may be a multitude of reasons. With the timeframe used in the revised paper, this is of less concern.

More context is now provided for the catchment areas and the changes over time. This background is generally helpful, although it is mostly limited to the recent centuries. However, whereas for London and the Thames the construction of the Old London Bridge (medieval) in 1209 is correctly described and the ‘weir beneath the arches’ is referenced, an analysis of the impact of the massive Old London Bridge and the weir on river flow is missing. In fact the bridge caused a noticeable restriction on flow and the pooling of water at the bridge made the freezing of the Thames more likely and therefore had an influence on the frequency of Frost Fairs. The restriction of flow, however, would also likely raise the risk of river floods and increase their severity. Old London Bridge was taken down in 1831 and maybe the noticeable sequence of severe floods in the 90 years preceding this removal (8), which is not matched in the subsequent decades, owes something to the influence of Old London Bridge on river flow.

I agree, the paper by Jones 2008 which is referenced to, discusses in detail the erroneous links that have previously been drawn to climate change based on the presence of frost fairs on the River Thames, it also details the hydrological impact of the structures. I acknowledge that the weir and the former bridges have had an important role, and also refer the reader to Galloway for an analysis of the Thames in the period 1250-1450. Unfortunately, there is not sufficient space for the paper to

detail every structure and its impact on each river, though I have redrafted the section in the manuscript to support some of this discussion, and guide the reader more clearly to Jones, 2008.

Simply dismissing flood seasonality as an avenue for further investigation neglects the fact that the seasonality should be an intrinsic component of any analysis that attempts to link flood occurrence to large-scale forcing mechanisms. The conclusions relating to solar forcing cannot be made without a thorough appraisal of the seasonality of flood events.

I do not dismiss the issue of seasonality, I identified that it is important but within the constraints of this paper there is insufficient space to do the subject justice, I have previously published a paper addressing the issue of seasonality on just the Ouse catchment alone within the historical period, with many of the catchment specific papers also discussing seasonality. I had added some further comments on flood seasonality to the discussion. This manuscript has grown from its initial version of 22 to 43 pages and ~15,000 words, papers in hydrological journals are typically around 7-8,000, to address the seasonality of each series would require a further c.20 pages. I agree though this is an under-examined area, and an important one for further study.

In summary the data simply do not support an 800-year comparative analysis of flood events across British catchments; data density and reliability are only sufficient from c. 1750 onwards. The conclusion 'The principal finding of this work is that of the strong correlation between flood-rich phases and solar magnetic activity, indicating a clear driver for flooding patterns across Britain' (line 963-964) is not supported by the data in the period before 1750, but also not afterwards. The solar magnetic activity maximum around 1375 is not reflected in the flood data, and the picking up of solar magnetism from c. 1720 onwards is only matched with a national flood rich period in the 1770s (this seems to be based largely on the 'Eastern and Southern British regions, both containing the Thames data). The flood peak around 1600, a core period of the Little Ice Age, might or might not be connected to solar magnetism, but it is certainly connected to increased record keeping starting in the late sixteenth century and probably growing until the onset of Civil War.

My main concern with the paper remains that the conclusions drawn regarding forcing mechanisms on the millennial scale are simply not supported by the data.

I do not understand how the reviewer can argue based on a visual inspection that the findings are not supported by the data, when they are statistically significant (line 901-909). I fear I am at a loss if a significant statistical value linking solar irradiance to the flood indices is not evidence, considering the reviewer states this as a key reason for rejection "My main concern with the paper remains that the conclusions drawn regarding forcing mechanisms on the millennial scale are simply not supported by the data". On this point I fundamentally disagree with the reviewer. If I considered all flood events (no threshold) within the paper I accept that the reviewer's issue with increased data resulting from human practices rather than climate would be critical, but two actions are taken to address this:

- i) Only the largest events recorded are included (>0.9 percentile); and,*
- ii) The changing rates of recording are accounted for in Equation 1 (text revised in this section to make this clearer).*

Both of these help reduce the influence of recorder bias leading to inaccurate results, coupled with the revised shorter timeframe considered, this should hopefully alleviate some of the reviewer's concerns. A clearer explanation is also provided for the equation.

Finally incoherent sentences, ambiguous sentence structures, as well as grammar and spelling

mistakes abound in the manuscript. Examples of the spelling mistakes are: line 481 'the instillation of the weir', line 497 'Tewksbury', line 578 'whist', line 964 'flooding patters'. For the grammar and sentence structure problems the section on London and the Thames serves as an indication (line 544-582): 'By the late seventeenth century the city of London was starting to develop its quays and docks along the banks and as such confine the river, as evident in Morgan's map of the Whole of London (1682); by John Rocques map of 1746, it is evident that the channel is increasingly confined, particularly around London Bridge. The map of Bacon (1868), clearly illustrates the development of the Embankment reach with further constriction of the river and extensive development and expansion of the city of London both up and downstream of the bridge area, which influenced the channel hydraulics, with the constriction of the channel resulted in channel deepening. [...] An earlier event in 1555 appears to have resulted from heavy rains, but also possible tides, though unclear. [...]the 1774 flood mark appears to be the earliest, on the wall at Radnor Gardens, Twickenham, with G.B Laffan giving the 1774 level as being 0.85m higher than that of 1894, though recognising a tidal influence was present, though at Windsor 1894 was considered higher (Symons and Chatterton, 1895), as such a notional discharge of 850 m³s⁻¹, is used. [...] Channel changes, river modification and uncertainties involved in estimating discharges makes the ranking of events challenging, as such these are notional magnitudes based on apparent ranking of events for the area around Kingston upon Thames and should only be used as indicative.'

Thank you for identifying these grammatical errors, these have been addressed.