

Response-1 Creating story-lines manuscript review

By Natasha Pullan and Onno Bokhove

Text for both reviewers

Thank you for your helpful comments. A quick summary: Overall, the text can be shortened by circa three pages. The old sections 4.1 and 4.2 can be moved to an updated "Methodology: ..." section 2. The old sections 3 and 4 can be combined in an updated section 3 "Results: ...". Subsection 5.2 will be moved to a new Appendix A, yielding a shortened updated or new "Results: ..." section 4 (old section 5). The difference between the scientific storylining in the main text and the additional "story" can be explained more extensively. The replicability of the storyline approach will be highlighted in extra explanations. All footnotes will be folded into the text and three figures can be removed. All changes except for some minor ones will be highlighted in coloured texts in a revised manuscript, for your (and our) ease of verification. Note that additional comments were made online prior to these responses. Furthermore, to be sure that what we state in our replies can be done truthfully, the proposed changes have already been implemented in a draft manuscript revision.

Comments reviewer-1

Pullan & Bokhove propose a storyline on floods using two flood events and estimate the future effectiveness of current measures. In doing so, they apply an uplift approach to estimate future hydrographs. They also propose using this information to create storylines to inform citizens.

Reply: Thank you for your extensive and valuable comments and efforts.

However, several issues prevent me from advising publication:

- 1. The FEV methodology is very appealing, but applying it to two extreme events in a single location does not add insight in terms of interpretability and usability. For such results, authors must report a full qualitative experiment.*

Reply: We do not quite comprehend the remark. Flood events are single unique events, not academic or scientific "experiments". The 2015 Boxing Day event factually, so in real-life, triggered the FASII flood-mitigation works in Leeds, which FASII modelling or design hydrographs were predominantly based on this single extreme flood event. The analysis of single flood events in terms of FEV and subsequent flood-mitigation cost-effectiveness graphics has been useful as shown in work in the various references. Do note that we did and do advocate an ensemble approach but as it stands those ensembles are neither available to us nor to the best of our knowledge do they exist. (Neither the EA nor LCC/ARC

seem to have created those data, despite our requests.) We did in a limited way use a three-member ensemble in the square-lake plots of figures 11 and 12. Moreover, it is not clear whether such ensembles can be made for the future, here 2100, with sufficient accuracy.

We can explain and have explained better that the scientific storyline approach used does extend to other minor/major flood events across the UK, given their data, the uplift factors and cost figures, the former which are publicly available across England. (In the draft revised text, this would be seen in coloured revised text pieces and links).

Storylines appear in the title, but they are presented in Appendix B. To reproduce or validate the narrative, the storylines should be annotated, and each key message properly supported, with an explanation of why it is important to communicate.

Reply: Unfortunately, that is an understandable misconception. The storyline approach to climate is a scientific approach (involving graphs, mathematics, codes and such), in which individual or a few extreme events are created to test their impact on society in “counterfactual” or “what-if” scenarios. We quote the clear abstract from Shepherd et al. 2018 (cited) below. The storyline approach is a scientific approach to communicate actionable information on climate impacts, here pertaining to climate-change uplift factors of floods. That should not be confused with “storylines” in *stories*. What the non-fiction story in the last appendix is, is a translation of our scientific storyline for the general public in the form of a nonfiction story, so without resorting to graphs, fluid dynamics and such.

Nonetheless, we can better emphasize what is communicated where and why it constitutes the (scientific) storyline approach. Hence, the storyline approach in our article consists of the following:

- The intercomparison of the uplifted 2020 flood to the 2015 flood, and the observation that they are then essentially similar in magnitude, thus translating and relating the abstract climate-uplift factor of 1.51 applied to the 2020 flood to the experienced 2015 flood (we did say so but can emphasise that more extensively).
- The cost-effectiveness analysis of this 2020 uplifted flood is covered by FASII⁺ (old Fig. 10 and the old section 5), so that extends the storyline intercomparison to this analysis (which we did not say but can emphasise more).
- The uplifted 2015 flood is a storyline approach in itself since we translate it to a flood rising above the raised arm of the coach in the Crossfit-gym that flooded in 2015 and finish the paper with the conclusion (figures 11 and 12) that planned and extended mitigation measures in Leeds appear to be insufficient for the year 2100. We did not say so but can state that this conclusion is also part of a storyline approach, here applied to flooding. All in all, we feel this largely justifies our title, also to reviewer-2. However, we can make the title more precise, as follows: “*Storylines on floods: climate-change uplift of extreme River Aire flooding*”

events and the cost-efficacy of flood mitigation". Furthermore, the various square-lake graph analyses and additional short summaries in the text lead in our view to new and important observations on how the efficacy of mitigation measures changes (lowers or stays put) under more severe uplifted floods. Please note that we can make several text alterations to effectuate the above in a draft revised manuscript.

- To wit, here is Shepherd 2018 et al.'s abstract: *"As climate change research becomes increasingly applied, the need for actionable information is growing rapidly. A key aspect of this requirement is the representation of uncertainties. The conventional approach to representing uncertainty in physical aspects of climate change is probabilistic, based on ensembles of climate model simulations. In the face of deep uncertainties, the known limitations of this approach are becoming increasingly apparent. An alternative is thus emerging which may be called a 'storyline' approach. We define a storyline as a physically self-consistent unfolding of past events, or of plausible future events or pathways. No a priori probability of the storyline is assessed; emphasis is placed instead on understanding the driving factors involved, and the plausibility of those factors. We introduce a typology of four reasons for using storylines to represent uncertainty in physical aspects of climate change: (i) improving risk awareness by framing risk in an event-oriented rather than a probabilistic manner, which corresponds more directly to how people perceive and respond to risk; (ii) strengthening decision-making by allowing one to work backward from a particular vulnerability or decision point, combining climate change information with other relevant factors to address compound risk and develop appropriate stress tests; (iii) providing a physical basis for partitioning uncertainty, thereby allowing the use of more credible regional models in a conditioned manner and (iv) exploring the boundaries of plausibility, thereby guarding against false precision and surprise. Storylines also offer a powerful way of linking physical with human aspects of climate change."*

Prior to our submission, we had discussions with an expert on the storyline approach, in order to check whether our flooding application slots under this approach. The conclusion of these discussions was that it does.

- II. *The manuscript is not well structured; sections mix methods, definitions, and results; and it contains repetitive or overly long sections.*

Reply: This can be fixed without making the text incomprehensible to a wider readership. Sections 4.1 and 4.2 can be moved to section 2, which original part can be shortened/parsed and the headings can be expanded. Words "Methodology: ..." and "Results: ..." can be added to headings where appropriate and section 5.2 can be moved to a new Appendix.

NB. Please do note that our article is not a standard "method-modelling-results-conclusion" article as readily emerges in modelling studies we also undertake (i.e., OB's numerical/theoretical modelling work in fluid dynamics). Our present article and the series of articles on the FEV topic concern the description and application of a flood diagnostic, with reference to the use of diagnostics in

dynamic meteorology, which is not a modelling method per se but is comprised of a methodology (FEV) and a tool: cost-effectiveness graphics and the justification of figures used therein. Our work does not concern an experiment but concerns analysis of real flood data and the unfortunately messy or incomplete ways flood-mitigation works are applied, described (or lacking description) or proposed to mitigate those floods within our society. The article as such followed the (accepted) structures of our 2019 and 2020 articles, which were well received, and related articles (cited by us) in which the FEV approach was applied. Also, reviewer-2 and our pre-submission reviewers were happy with the presentation.

Nonetheless, we can accommodate the reviewer's request by presenting our revised manuscript more towards such a classic "method-results-discussion" set-up, as explained above.

III. The use of uplifts for two events is not a novel case study or a methodological innovation.

Reply: The comparison of two flood events via climate uplifts, thus giving meaning to the abstract notion of climate-uplift factors, is a novel and worthy observation, which is scientific storylining when those floods are experienced by citizens and flood professionals/scientists. Moreover, that meaningful comparison can be repeated and as such is (in this sense) "reproducible or replicable" to floods in other locations where other citizens and flood professionals have experienced (two) floods events. In fact, such a meaningful comparison (with uplift factors) can be undertaken for any extreme events (i.e., other than flooding ones) which citizens and professionals/scientists have experienced. That is exactly the storylining point we have been selling. It is a novel and meaningful approach and observation. It is scientific because, here in the case of floods, it requires understanding and application of data, graphs, codes to make those, and some mathematics and fluid dynamics. Moreover, our codes and tools can be adapted to data sets at other locations. That can be readily done in England where uplift factors and flood data are freely available. It thus necessarily underpins the real-life non-fiction story in the appendix, which is exclusively extra PR meant for the general public. Without that science, the story in the appendix would be fiction, a mere made-up story, which presently it is not. We can add additional texts to reflect this replicability issue.

I suggest sharpening the paper's focus and using a more standard writing style (even though I must disclose that I am not a native English Speaker).

Reply: We can parse and simplify the text throughout but not to such an extent that some of the (excellent) writing disappears. Hence, the article can be shortened by circa three pages. Moreover, the extra five-page story in the last appendix, for the general public, can be removed, but we prefer not to do that.

The current version does not include enough information for replication (e.g., how to create storylines) or sufficient contextual information.

Reply: Our article does include that information and also says so: the tools we made can be applied to any two floods (at one location or more locations) across England or across the globe for which uplift factors are known. Uplift factors are publicly available for various regions in England. That means that anyone can take and adapt our Python codes and see how two floods at different locations and for different rivers can be related, in terms of FEV and when the costs of mitigation measures are known in terms of cost-effectiveness, and be seen to be approximately equivalent in terms of (uplifted) water levels and (uplifted) FEV, and in terms of (local) experiences (by citizens, professionals and scientists) of such chosen floods. We can expand the text to make the above clear. One can replace the data files of the floods we used (2020 and 2015) by files of the chosen floods in our code, find the uplift factors for the chosen future time interval, and one can start playing, analysing and testing. Our approach is hence completely transferable, in that sense “replicable”, and we have made all tools open access (see our bespoke GitHub site).

Moreover, it is unclear where to find the Methods, Results, and Discussion sections.

Reply: Our article is not a standard numerical or theoretical modelling work but concerns diagnostic analysis of real flood date. However, we did address the reviewer’s concerns by adapting the presentation across the revised manuscript towards a more conventional format, i.e., see our reply to point-II above.

Detailed comments

1. *As a simple reviewer, I do not know when Boxing Day is. Please keep in mind that your potential readership is global.*

Reply: “2015 Boxing Day Flood” is a named flood like “1887 Yellow River Flood” and “Lynmouth Flood” and “North Sea Flood of 1053”. To clarify that, we can highlight this name-giving (e.g., at first mentioning between quotes) and we can include the date at first mentioning (note that the 2015 flood date was already included in section 3).

Also, because two extreme events are used as case studies, you must provide a clear and complete hydrological, hydraulic, risk (i.e., hazards, exposure, vulnerability), and land-use description.

Reply: We have and had done that in parts already by describing the catchment, the 2015 rainfall (see figure), and also by referring to the 2020 *Water* article, where more information is found, in order to avoid repetition. Moreover, the most important aspect used are the floods’ return periods. We already included hazards by describing the damage done by the 2015 flood. A more complete hydrological and land-use description does, however, add little to our analysis or is provided in the 2020 *Water* article. See sections 3.1, 3.2 and the *Water*

article, and we can also add a new DEFRA (2025) reference to the interactive UK Government site, where a lot of the requested information is publicly available.

Again, do not assume that readers are familiar with how extreme storms behave in time and space in the UK. I recommend including information regarding the annual cycle, detailed precipitation, temperature, and saturation (if available) for days before and after the storms at 15' resolution. If not available, justify the omission.

Reply: See the above answer for more information of the River Aire. We are not analysing UK storms at large, but two most recent extreme floods, of 2015 and 2020, of the River Aire in Leeds. The saturation levels of 2015 are not available (to us), except that eyewitness information by OB over the last 13 years reveals that the November and December 2015 period was the wettest by far seen in those 13 years, given tell-tale locations between Bradford and Leeds. Only February 2026 started to get close to the 2015 saturation levels. However, section 3.2 contains a discussion and references on soil saturation and terrain which we can streamline a bit more.

2. *Several paragraphs mix methods, results, and discussion. For instance, in lines 34-47, lines 36-43 could be shortened to 2-3 sentences without losing flow. Move those lines to a dedicated Methodology subsection.*

Reply: This can be fixed. The (old) sections 4.1 and 4.2 on the FEV-methodology for climate-change uplift can be moved to an expanded methodology section 2, which heading can be expanded to include the word "Methodology". Subsection 5.2 can be (and has been) moved to a new Appendix, as suggested. Words "Methodology:" and "Results:" can be added to several relevant section headings. The (old) lines 34-47 summarise the state of the art prior to this work, so without the climate-change uplift, also in a schematic, which schematic thus fits better in the introduction.

3. *Avoid using footnotes. Avoid labeling the results from arithmetic operations as equations (e.g., L250). Do not use Wikipedia sources; there are for sure better references. This is not a trust issue, but a matter of using traceable data from agencies or universities.*

Reply: Thank you. We can change this labelling throughout. Footnotes can be removed and placed in the text. The Wikipedia reference can be removed and replaced by another reference. Some of the data and reports stemming from (local) UK Government can, unfortunately, not be replaced by better traceable references. That is an unfortunate consequence of analysing real flood-mitigation cases, as opposed to imaginary academic ones, which main data stem from local and national government.

4. *The paper's aim could only be the fourth. The first two apply known methods, while the third one is not replicable or methodologically explained.*

Reply: Thank you. We prefer to offer an alternative. The cost-effectiveness analysis cannot be commenced without the climate-change uplift analysis and the storyline intercomparison; the climate-uplift analysis and intercomparison

are new and separate aims and results; the old aims one and two can be combined into aim one. Herein we can accommodate the reviewer, by following the proposed changes to section 2 and to a (new) section 3 (the latter combining the old sections 3 and 4).

5. *Shorten Section 2*

Reply: Thank you. Since the FEV introduction is needed to justify and juxtapose the climate-change uplift analysis sufficient explanation is required: moreover, water levels are directly measured and result through more indirect measurements and simulation data of the discharge via a rating curve into the hydrograph while –in contrast— in the climate-change uplift scenario it goes the other way around, which is a subtle difference, with water levels then inferred via the rating curve. Moreover, our experience over the years is that people need the FEV-explanation and the current section contains various new presentation aspects to avoid confusion. Also, reviewer-2 (as well as earlier reviewers) found the paper easy to read and had asked for clarifications in section 2. We prefer to avoid the FEV aspect to become unclear. However, the section can be parsed and hence shortened significantly, but the old subsections 4.1 and 4.2 can become part of this renewed section 2.

6. *Section 3.1 could be shortened and converted to a comparative table.*

Reply: Thank you. This request may conflict with the earlier requests to provide (more) information on the river and its catchments, including on errors, which are found in sections 3.1 and 3.2. Hence, that information was not removed but we can parse text and captions, in order to shorten them. As said, the manuscript can be reduced by three pages. Also, the old sections 3 and 4 can be combined into one section 3.

7. *Figures 4, 6, 8, 9: Put values into comparative tables, add the date, and use the same limits on the horizontal axis.*

Reply: Thank you. Using the same limits on the horizontal axis would make some graphs illegibly small, so we prefer to refrain from doing that. Also doing this would bring the “easy-to-read” observation from reviewer-2 at risk.

8. *Delete Figure 5 and Figure 7.*

Reply: Thank you. These graphs, as well as the old Figure 3, can be removed.

9. *Lines 260-264 should be part of the Introduction.*

Reply: Thank you. These lines can be moved to the introduction.

10. *Sections 4.1 and 4.2 should be shortened. I suggest adding a critical appraisal and moving your conclusion to the Introduction (as in L336-344 and L354-359). Lines 318-330 could be made into a table.*

Reply: Thank you. We can move sections 4.1 and 4.2 to section 2. We can parse the text to shorten it.

11. *Section 5 should be a Results subsection. Section 5.1 could be made into a table.*

Reply: Per your suggestion, section 5.2 can be moved to an Appendix. Section 5.1 already has the requested Table 3. Hence reducing section 5.1 to only a table would create a section without introductory paragraphs. Not introducing the cases S0, S1, and S2 or only display them in a Table 3 would make matters incomprehensible; anonymous reviewers in contrast had asked for a clearer exposition (resulting in the old sections 5.1, 5.2, 5.3), and reviewer-2 found the paper “easy-to-read”, so reducing the text to only a table would make matters not easy-to-read. However, texts can be parsed and thus shortened. This square-lake section can become a new section 4.

12. *An opinion on style: captions of tables and figures should be descriptive, but not a repetition of results and discussion that should be (already) in the text body.*

Reply: Thank you. We checked text and figure captions and can condense them where appropriate. This is also an-opinion-in-style conflict in that we prefer self-explanatory captions, which for figures 10-12 was requested by pre-submission reviewers. Quite a few captions, however, can be parsed and shortened.

13. *Section 5.2 must be significantly shortened. The sub-subsections are unbalanced in structure and depth. It could be converted into a table. Another option is to relegate it to the Appendices.*

Reply: The results are already summarised in Table 3 and the (old) figures 10 to 12. The reviewer may understandably not appreciate that the (cost) figures used in the square-lake graphs in realistic (non-academic) cases like ours can be very difficult to obtain or estimate, as highlighted. That means that for some mitigation measures the necessary (cost) figures are readily available while for others they are not and a significant (and in terms of text space seemingly disproportionate) effort is required to obtain them. That has been our unfortunate finding in a range of publications on FEV and cost-effectiveness graphs. Simply stating the results will make the results unverifiable. However, we can move the entire subsection 5.2 to a new appendix and can streamline the new section (to a new results’ section 4 in the revision). Note that we already had made the original section 5.2’s reading optional at a first reading.

14. *Combine Figures 10, 11, and 12. Use the same scale in a four-panel arrangement.*

Reply: We offer an alternative view, please, as we were advised to make these key figures more prominent and enlarge two of them; also, the information herein won’t fit or be legible for 60-year-olds like co-author OB when this reduction request would be undertaken.

15. *Section 5.3 summarizes the results. However, focus on presenting the most salient results. Indeed, L730-750 are a good summary of results that could open the Results section.*

Reply: We offer an alternative view. (The old) Lines L730-L750 are only part of the result summary, and only keeping these lines would remove a necessary description of the square-lake graphs, which description was requested by our earlier reviewers and deemed easy-to-read by reviewer-2. Moreover, the results’

section splits in two parts: the in-depth description of the cases S0, S1(S1') and S2 and the important (novel) findings one can discern by intercomparing the three square-lake graphs (using also the information from the new Appendix A/the old section 5.2). In what the reviewer-1 proposes those descriptions and findings ("results" by themselves) are completely lost and removed, which would make matters incomprehensible. We can, however, parse the text.

16. *Last but not least, I would like to commend Prof. Bokhove for the chance to read undergraduate work. I also commend N Pullan for taking on the challenge of communicating your work to the community.*

Reply: Thank you. Note that the original undergraduate report of NP was the best in maths and was awarded the maths-Leeds' King Prize that year. Furthermore, note that jointly we significantly altered and extended the undergraduate report of NP to reach the submitted and now revised manuscripts. To wit:

- NP originally had undertaken linear calculations but concluded that nonlinear ones would be better; hence, we made those calculations nonlinear; that changed the numbers within their large error bars, thus refining the conclusions.
- Initial error calculations were replaced by the statistics in Table 2.
- NP had climate-uplifted the very wet winter 2015 flood (a.o.). Without much explanation, that gave certain mitigation methods quite a bit of retention. That did not make sense, since very wet winters such as in 2015 mean passive retention methods don't do much, if anything at all. This led us to rephrase matters in terms of ensembles for AFM and NFM, also given ideas triggered by the work of Goudarzi et al. (2024) and a presentation thereon.
- OB made apparent that what NP had done, which was entirely NP's idea, is a so-called storyline approach to climate-change. While NP's idea is novel, for our manuscript we reframed the work to align within the current climate-change literature on storylining.
- The story as opposed to scientific storyline approach in the main text (and new Appendix A in the revision) was added in a last appendix by OB.
- Finally, we took all NP's original codes, updated them, and made all figures reproducible, verifiable and available on GitHub, with full instructions, as part of our submission. We also highlight that our approach is replicable to other floods when sufficient information (data of a minor and major flood, uplift factors, data of costings, stories of the floods, e.g., floods in Sheffield?) is available, by adapting and changing the codes provided.

17. *I used a grammar checker for this review. My review and comments come from my own reading and appraisal. I did not use any LLM.*