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Reply on RC1

Julia Rulent et al.

Author comment on "Distribution of coastal high water level during extreme events around the UK and Irish coasts" by Julia Rulent et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2021-118-AC1, 2021

- P2L36 Might be also interesting to mention that an individual storm (in this case Xaver) is able to increase the water level estimates for a 1 in 200 years event by up to 40 cm (see Dangendorf et al., 2016, https://doi.org/10.1088/1748-9326/11/5/054001). This study is also interesting regarding the estimation of worst-case scenarios.

Thank you for this reference, it makes a very interesting point. This was added in P2L41-L44.

- P2L46 Delete 'coastal' at '... the coastal distribution ...' as you already say along the UK coast afterward.

Done.

- P2L53 Delete reference to Fig 1; one cannot see that 2013/2014 was an extreme winter from this Fig

Done.

- P3L55 Would be interesting to compare not only the 2013/2014 90th percentile values for Hs and surge but also if/where winter 2013/2014 exhibits maximum values for Hs and surge in comparison to the climatology
- P14L163 Based on your results (having the climatology and the 2013/2014) case: can you make any assumption about worst-case scenarios.
- Figure 5 How do Hs and surge maxima look like in the climatology? Would probably also show the benefit of the high resolution in UK4.

We thank you for raising these good points and comparing the maxima considering the climatology was something that we meant to originally include in paper. However, our aim was to only use the climatology to justify our selected case study and only refer to the high-resolution model for the science, to not make this work a comparison between models but rather focus on the outputs of the UKC4.

The climatology run and the UKC4 have very different set ups and cannot be easily intercompared. To include a comparison with the climatology in our main discussion our options would be to 1- use the maximum Hs and surges values for

winter 2013 coming from the same climatology run, which would make the discussion about a mix of two model, or 2- we could include the maximum from the UKC4 model to compare to the climatology, which would lead to a complex intercomparison between models.

Ultimately the best solution would be to produce a long UKC4 run, but because it is quite computationally expensive it was not possible to do this yet. It would be great for a future study.

Having said this, we have included the following lines in the discussion about the maximum surge and Hs: '*The climatology run compared to the maximum surges and waves shows that the highest residuals are distributed over the North-West and South-West coast of England, while the highest Hs are distributed over the regions open to the Atlantic Ocean.*' P14L184-185 and '*If the maximum waves, surges and tide (fig 5) could occur simultaneously, the highest TWLs would reach above 16 m in areas of the west of Ireland 13 m in areas of the Bristol channel.*' P14L195. We hope this addresses your question.

- P3L62 More information about the model setup is necessary: What are the initial and boundary conditions for the atmosphere and ocean? How often are boundary conditions updated? Is there only 1 domain (1.5km) or any nesting to reach such a high resolution (also depends on the resolution of input data)? What about model spin-up time? The first event (Xaver) occurred on Dec 5th/6th; so is the model already in balance or would more spin-up be necessary?

P3L75-85. We have now added more information on the model as well as more references that better explain the configuration of the model.

To summarise, the initialisation and boundary conditions of the model is as follow:

- **The Atmosphere model is initialised on 30 Oct 2013 by downscaled operational global UM analysis. The hourly lbcs come from a 24h global simulations initialised from archived operational global analysis and are updated daily. The grid resolution is variable, going from 1.5km in the inner (shelf) area of the domain and stretching out to 4km outer region to reduce impact of coarser-scale lateral boundaries (operational input data at 25km for dates of this study).**
- **The ocean model is initialised from long-run AMM15 hindcast. The daily lbcs come from an operational NATL12 1/12 North Atlantic model. The model grid is fixed resolution 1.5km grid (overlapping with the atmosphere grid over the shelf region).**
- **The wave model is initialised from a 10-days from rest wave-only spin-up. The hourly lbcs come from a global wave-only hindcast simulation. The model grid varies from 3km in deep water (> 40 m) down to 1.5km in near-coastal areas.**

The atmosphere will spin up from the global initial state in about a day, the ocean and waves components are already spun up using the different initialisation strategies (i.e. long-run ocean hindcast and waves initialised 10-days prior to start time. The impact of coupling is also spun up as the simulation is initialised on the 30th October, more than one month before the first event. All files are obtained from/ saved to the Met Offices archives.

- P3L82 'higher temporal frequency than model output': where is this used in the study?

This is part of a sentence that refers to the methodology used in the model validation against observation. This line was moved in the appendix where we are giving information on the model validation, it does not belong in the main text. It has now been added to the captions of Table1 and Table2 that show the results from the comparison of model and observation.

- P13L115 Based on the Figures, it looks like surge increased much more than Hs; in the text, it says Hs is 138% higher on average, surge is 120% higher on average. Since the color bar (for the positive percentages) seems to be the same, the much more reddish shades in Fig 4 conclude a much stronger average increase in surge. Please check and verify.

Thank you for noticing this, it is an error. These numbers refer to a different experiment and not the data plotted on the figure. The correct numbers were replaced. The Hs is only 35% higher than on average, while the surge 106% higher than on average. Sorry about this.

- P13L134 The curve representing simultaneous Hs and surges seem to be mostly influenced by surge; the effect of Hs seems negligible.

We have now specified this in P13L154.

- P13 L145 A bit more interpretation of HP would de helpful: what does a value of 1.8m mean? It is calculated as SSH + 1/2Hs, where SSH is sea surface height including astronomical tides and surges. I'm having a problem how to interpret the HP value; maybe a bit more information should be added.

P13L167-P14L170 We have added the following line better describing what the Hp value represents.

'This value, similarly, to the TWL, represents the simultaneous contribution to the water level from waves, surges and tides. However, operational thresholds are not based on just the maximum values of the TWL but are set considering extreme conditions, therefore the HP is calculated from the SSH (including astronomical tides and surges) summed to only half of the Hs rather than the maximum'.

The average HP from winter 2013/4 is given in the paper, and what should be noted is the difference between the average value and the maximum values during that period. The limitation of the study is that with only 3 months of data we cannot show a true so climatology, with robust statistics derived from a long term run and what a typical value of the HP should be, however even during those 3 months it possible to see how drastically the TWL can be increased by an extreme event. Operationally speaking, whether that increase in HP is a threat or not for a specific coastal region will depend on other factors (such as further changes to the water level induced shallow water dynamics as the water propagates towards the coast, or local infrastructures and coastal defences). What we want to point out using the HP is how the water level can be affected by extreme events.

We could have used the TWL values to show this instead, but the HP value seemed more appropriate as it is more like what flood warning thresholds would use as reference. Hopefully, this is clearer now.

- P14L156 'which of these are significant': have you applied any significance test? Otherwise, you should not use the word significant here?

Changed in P14L182. We have not applied significance tests, therefore this sentence was changed.

- P14L163 Based on your results (having the climatology and the 2013/2014) case: can you make any assumption about worst-case scenarios. & 15 Figure 5 How do Hs and surge maxima look like in the climatology? Would probably also show the benefit of the high resolution in UK4.

We have answered this together with point 4, see above.

- Figure 1 Is there a reason why you use mean atmospheric pressure as background? Why not topography/bathymetry?

Yes, the reason why we used the mean atmospheric pressure was to show how the pressure tended to be lower over the northwest region as most storms during that period travelled from the north Atlantic. We did not want to use the bathymetry as we though it could be misleading; while the bathymetry is used in the model processing steps, the SSH output is not given from the bathymetry itself but from an equipotential surface.

- Figure 2 The dark blue boxes highlight the periods, where HS and surge are both above the 90th percentile. Seems that the surge falls below the 90th percentile already at hour 35. Please verify.

This was a mistake in plotting the box, the new figure was corrected.

- Figure 4 'Note that the colour scales are different between figures 2-3.' Should be Figure 3 and 4, correct?

Yes, it should 3-4. This was corrected.

- Figure 5 How do Hs and surge maxima look like in the climatology? Would probably also show the benefit of the high resolution in UK4.

We have answered this together with point 4, see above.

- Figure 8 Add blank between HP and max in (b)

Done.