Natural Hazards and Earth System Sciences
Discussions

Nat. Hazards Earth Syst. Sci. Discuss., author comment AC1
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Reply on RC1

Melissa Wood et al.

Author comment on "Climate-induced storminess forces major increases in future storm surge hazard in the South China Sea region" by Melissa Wood et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2021-397-AC1, 2022

Thank you for the thoughtful comments from each of the two reviewers. We have carefully considered each comment and below outline the changes we have made. We believe these changes have strengthened the manuscript and so greatly thank each reviewer for their time.

REVIEWER #1 COMMENTS:

- **Figure 1: change "model location, with location of" to "model domain, with locations of". Also, I think there is a typo "at ~ 250 km depth", it should be "at ~250 m depth".**

A1. Thank you, we have made this change.

- **Table 1 should be moved to Section 2.1 for discussion. Also the title of Table 1 indicates values reported are for tidal constitutes, which constitutes?**

A2. We agree and have moved Table 1 to Section 2.1. Thank you for spotting this error in the caption; we have now corrected it to read '*Validation of astronomical tidal component'*.

- **I have some concerns on the value reported in the Table, it is very questionable that the "mean tidal range" is greater than 8.5 m for Xiamen, 7 m for Beihai, 5.9 m for Vong Tau. Figure 3 clearly showed that the max tidal range at Vong Tau is less than 4 m. Please check and clarify.**

A3. We thank the reviewer for pointing out this inconsistency and we shall examine these calculations more closely. We decided however, for this paper, to remove this column entirely from the table as it wasn't strictly adding a great deal towards the core message.

- **The model resolution of 11 km along mostly the coastal, with finest of ~2.3 km along the coastline of Vietnam, is not sufficient to represent the details of**

the shoreline and bathymetric feathers, which are critical for storm surge simulations. Discussion on model accuracy in estuaries and bays is necessary to clarify that the model results should be treated with care in those areas.

A4. Thank you for your comments and we understand your concerns. We do agree this model resolution is not adequate to represent storm surge detail around estuaries and bays and as such have added text to the discussion section to acknowledge that this resolution does not capture the level of detail in these areas. The discussion section now states, '*An additional limitation worth noting is that, even at 2.3 km node separation along the shoreline of Vietnam, the chosen model grid resolution can produce storm surge levels with sub-optimal accuracy within small coastal features such as inlets, bays or estuaries. As demonstrated by Bertin et al., (2015), within small seas wave radiation can induce set up that transforms storm surge levels along exposed coastlines, with even the small waves entering bays and inlets affecting water levels*.'

There were a couple of reasons why we did not model at higher resolution along these shorelines. Firstly, we wanted to simulate 10,000 years of Tropical Cyclone (TC) behaviour, and to do this twice-over (once for the present day and once for the future scenarios). Each synthetic year normally also having multiple TC events, within our region of interest. The execution of all these model simulations would be both computationally expensive and time-consuming to get through. Therefore, we aimed to strike a balance between model resolution and duration run time. Given our regional focus, we felt 2.3 km was a good compromise that enabled us to capture as much of the TC information as possible. In the event, even with use of a High Performance Computer at the university, we spent around ~6 months to just run all the various models.

There is also the fact that this project was supported by UK and Vietnam Government funding. Our Vietnam colleagues do not have access to a High Performance Computer, and they wanted to be able to use the model for other applications. Hence, our second reason was our aim to keep the model resolution at a point that our project partners could run it on a standard desktop computer after the project ends.

- **Section 2.3 and Figure 4: storm surge validation is important for this study. It is not sufficient to use Figure 4 to demonstrate the Holland Model is better than ERA5. Model-data comparison at more stations and error statistics should be provided.**

A5. A good point and thank you for highlighting this omission. We used TC Ketsana as an example because the event was really nicely captured as it passed fairly close to a tide gauge. As discussed within the paper a common problem is that TC events are difficult to capture on record, due to proximity or timing. However, a small handful of historic TC events were similarly close enough to a recording device to be used to determine the best methodology and validate model, and these additional TC events are shown within the supplementary section. One such TC event is Typhoon Sally (aka Typhoon Maring) which struck Zhapo, China in September 1996 the figure of which shown in the attached *Figures and Tables1.pdf* (Figure S1).

A table showing the validation RMSE between observed and modelled results, for these total four historic TC events, is also now provided within the supplementary section (also copied in the attached Figures and Tables document). Furthermore, the text of the main paper has been updated to replace 'not shown' in Line 263 with 'shown in the supplementary section', to point to this new information.

- **Figure 5. Are the values shown in the figure the number of cyclones? Please provide unit in the legend.**

A6. We are happy to update the legend of Figure 5 to make it clearer. The attached *Figures and Tables1.pdf* shows this update. Yes the values are the number of cyclone tracks passing through each gridded location, within the ~35 year assessment period. Figure 5c shows a heatmap of where activity is estimated to increase most intensely over time, under the CNRM 2015-2050 climate projection.

- **Line 449: statement "…that tides intensify storm surge hazard" implies the nonlinear effect of tide and surge interaction but in ~Line 336 the authors showed the nonlinear effect is negligible and therefore the total water level can be calculated by the sum of two separate runs: tide and storm surge. Please clarify.**

A7. This is now corrected and reworded in Lines 449 and 499 - thank you for finding this inconsistency in the document. Using 'tides intensify storm surge hazard' was just a poor choice of words since we proved that the nonlinear effect is negligible along the shorelines of interest.

- **How tidal elevation is added to storm surge to obtain the total water level since the synthetic TC does not have a realistic time and date?**

A8. Thank you for your comment. It is correct to say that the database of synthetically generated TCs does not assign literal dates. However, there is a synthetic year (between year 1 and year 10,000) and a month associated with each generation. Our approach was to firstly generate tide levels for the model domain, covering a recent 19-year period, to encompass the full 18.6 year nodal cycle. Then secondly the TC was assigned a random year, day and time, but taking care that the calendar month of the TC and tide were the same, to ensure the storm surge occurs (synthetically) in the correct season/time of year. This 19-year record of tides and storm surges was thus used to generate statistics for total return period levels that are illustrated in Figure 9.

We have clarified this in the final paragraphs of Section 3.3 of the paper which now reads, '*… we also estimated total sea level return periods for each output coastline point (OCP). To do this, we ran a tide-only simulation for a random year (2009), saving predicted tidal levels at each of the OCPs at 10-minute intervals. We input this year of tides into a MATLAB T-Tide script (Pawlowicz et al., 2002) to obtain the tidal constituents and predict the tide for a total 19-year period (randomly 2003 to 2021). A full 19-year period was targeted because it encompasses a complete 8.85-year cycle of lunar perigee and covers the 18.6-year nodal astronomical tidal cycle, both of which can influence extreme sea levels (Baranes et al., 2020; Peng et al., 2019; Haigh et al., 2011). In the baseline and future STORM dataset, as occurs also in the natural record for this region, TCs develop largely between May and November. Since the STORM TCs all have a simulated month and nominal year assigned to them, we allotted each STORM TC to a random time, day and year within this 19-year tidal cycle, but took care to match tide and TC months appropriately.*'

Please also note the supplement to this comment:
https://nhess.copernicus.org/preprints/nhess-2021-397/nhess-2021-397-AC1-supplement.pdf