Revisions Manuscript:

"A new modelling framework for regional assessment of extreme sea levels and associated coastal flooding along the German Baltic Sea coast"

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Answers to reviewer #1

We would like to thank anonymous referee #1 for the feedback and helpful comments concerning our manuscript. We have addressed all points (see our answers below) and added the aspect of glacial isostatic adjustment to section 2. (Study area).

Our detailed responses to every referee comment are listed below.

The responses of the authors are written in green to enhance readability. All citations of text in the new, revised version of the manuscript are written in italics.

Comments anonymous referee #1

1. Line 84 Explain what a hydrograph is, term might not be familiar to all readers

Revised as suggested. At the first occurrence of the term hydrograph, the text now reads:

In order to account for spatial variations in water levels within each model domain, we defined a total of 32 'boundary stations' (Fig. 1), for which hydrographs (water level time series) were modelled in GETM for the four storm surge scenarios (2019 surge, 200-year event, 200-year event plus 1 m and 1.5 m).

2. Line 167 Is the boundary condition the same for neighbouring boundary points? I understood from the text that the boundary point has as its boundary condition the hydrograph from the nearest boundary station. This could be explained in detail in the text.

Thank you for this remark. Reviewer #1 is right that neighbouring boundary points may have similar boundary conditions, as they receive their boundary conditions from the nearest flood boundary station (see Fig. 1). We have clarified this point in the text in section 3.2.3:

Each boundary point received the boundary conditions (the hydrograph used to force the coastal inundation model in Lisflood) from the nearest boundary station (Fig. 1). In cases where the nearest flood boundary station to a boundary point located on the open coast was situated inside protected fjords or lagoons, or vice versa, we manually corrected that point to ensure that open coast boundary points are not forced with hydrographs of sheltered locations.

3. Line 234 Has the land uplift due to postglacial rebound taken into account when SLR has been subtracted with a linear fit? You could mention the land uplift rate on the German Baltic coast and discuss whether it is relevant in this study.

Thank you for raising this important point. In contrast to the northern Baltic Sea, parts of the southern Baltic Sea, including the German Baltic Sea coast, are sinking as a consequence of postglacial rebound. Certainly, this is even more relevant for a modelling framework with the aim to assess coastal flood risk. However, subsidence in the southern Baltic Sea is generally variable and mostly well below 1 mm yr-1 but in places up to 2 mm yr-1 (Weisse et al. 2021; Richter et al. 2012). In addition, information is generally sparse across the study area and no consistent spatial information exists. For the above reasons and because subsidence is small compared to the extreme water levels and sea-level rise (IPCC 2021), we do not account for it in the present analysis. We have now clarified this in Section 2 (Study area) the manuscript:

Study area:

In contrast to the emerging northern Baltic Sea coast, parts of the southern Baltic Sea coast are subsiding as a consequence of glacial isostatic adjustment. While subsidence is generally variable and mostly well below 1 mm yr-1, it can locally reach up to 2 mm yr-1 (Richter et al. 2012; Weisse et al. 2021). Due to the spatial variability, limited consistent information and rates mostly well below SLR, we have excluded subsidence from the present analysis.

4. Table 4 and Figure 5:
   It would be nice to have the station names of Table 4 in Figure 5 to be able to locate the stations in the map. The station could be given a number which is shown in Figure 5 to avoid too much text in the Figure. Figure 5 could also be larger, because it is one of the most interesting figures in the paper.

We added numbers to the TG stations in Tab. 3 and 4 and in former Fig. 5 and 6. We have added the identifying numbers and have changed the text accordingly. See also the response to comment 3.8 of reviewer 2.

5. Line 357 You could discuss why the peak water levels are higher in SH than in MP in the 200-year event. Is it due to the shape of the coastline, does the bathymetry affect it?

Thank you for the comment. We have added some text explaining why the surges are higher in SH than MP. The simple reason is that the fetch length, i.e. the distance over which wind stress can affect the water level undisturbed, is larger for SH than MP (e.g. the west-east axis of water). The added text reads:

The spatial distribution of the 30-year and 200-year return levels (Fig. 5) shows that the highest ESLs occur at the coasts, with decreasing ESLs from west to east. The pattern and return levels have *already been described in the literature (Gräwe and Burchard 2012; Wolski et al. 2014), and are primarily due to fetch length, which is longer for the coast of Schleswig-Holstein (SH).*

We have furthermore rewritten the entire paragraph and have improved the discussion with respect to the differences in mean inundation depth and peak water levels. This section now reads:

Our results show that the differences in flood depth between both states are due to variations in peak water level and coastal morphology. For the 200-year event, peak water levels are on average 0.46 m lower in MP compared to SH (2.03 m in SH and 1.57 m in MP, Table 4). In both SLR-scenarios, flood depth is slightly higher in MP, which we attribute to the substantially larger flood extent and lower elevations within the floodplain. Within the flood extent of the 200-year event and 1.5 m of SLR, mean elevation is 1.1 m NHN in MP compared to 1.27 m NHN in SH.

Publication bibliography

Gräwe, Ulf; Burchard, Hans (2012): Storm surges in the Western Baltic Sea: the present and a possible future. In *Clim Dyn* 39 (1-2), pp. 165–183. DOI: 10.1007/s00382-011-1185-z.

IPCC (2021): Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger et al. Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, USA. Available online at doi:10.1017/9781009157896.

Richter, A.; Groh, A.; Dietrich, R. (2012): Geodetic observation of sea-level change and crustal deformation in the Baltic Sea region. In *Physics and Chemistry of the Earth, Parts A/B/C* 53-54, pp. 43–53. DOI: 10.1016/j.pce.2011.04.011.

Weisse, Ralf; Dailidienė, Inga; Hünicke, Birgit; Kahma, Kimmo; Madsen, Kristine; Omstedt, Anders et al. (2021): Sea level dynamics and coastal erosion in the Baltic Sea region. In *Earth Syst. Dynam.* 12 (3), pp. 871–898. DOI: 10.5194/esd-12-871-2021.

Wolski, Tomasz; Wiśniewski, Bernard; Giza, Andrzej; Kowalewska-Kalkowska, Halina; Boman, Hanna; Grabbi-Kaiv, Silve et al. (2014): Extreme sea levels at selected stations on the Baltic Sea coast. In *Oceanologia* 56 (2), pp. 259–290. DOI: 10.5697/oc.56-2.259.