Authors Response to the comments of the anonymous reviewer **RC1** on the manuscript *egusphere-2024-2664*

„Recent Baltic Sea Storm Surge Events From A Climate Perspective“

by Nikolaus Groll, Lidia Gaslikova, and Ralf Weisse

We thank the anonymous reviewer#1 for the comments, which helped to improve the manuscript. In the following, the reviewers comments are shown in blue. The authors response will be under each comment and suggested changes in the text will be in *italic.*

This manuscript is a nice piece of analysis of three recent dangerous storm surges in the western Baltic Sea, an area famous for extensive variability of drivers of water level, their combinations and resulting properties of high water level events. The main outcome is that two of these events, even though seemingly severe, belong to the pool of relatively frequently occurring episodes in contemporary climate while the third one has at least one truly unusual feature in terms of wind direction. This outcome is in line with the general perception of the nature of climate change in the Baltic Sea region. Namely: storms have not become systematically stronger in this area. Instead, most severe events are driven by specific combinations of various drivers. Another important message is that wind direction may become the most critical feature in development of extreme events.

The manuscript is written professionally, with very good command of English. The setup of the problem is clear, the used methods are described properly and applied correctly, and statistical methods are employed adequately. The images are clear and informative. The conclusions are firmly backed up by the analysis. It is thus my pleasure to recommend this manuscript for publication, possibly with marginal technical revisions.

The reviewer has suggested minor corrections to the text. Most of them are either typos or clarifications, we agree with all of them and will correct them in the revised version.

The reviewer noted that there is a discrepancy between the estimated return values and the observations, which is also described in the literature and that the annual maxima may not be independent.
Following this suggestion, we also calculated returns based on July to June values and found some small differences. By using the block maxima from July to June to derive the return values, we lose the October 2023 event for the estimation of our return values, so we still use the annual (calendar) maxima for our calculation. However, we add some text and discuss this source of possible differences between the results presented and others in the revised version.

Line 4: remove “of”.
„or of prefilling of the Baltic Sea“ changed to „*or prefilling of the Baltic Sea*“

Line 5: remove either “hindcast” or “simulation”.

changed to „*A numerical hindcast is used to*“

Line 8: it makes sense to add a couple of words to “water level” to explain what is meant.

combination of „*atmospheric induced*“ water level „*changes*“ and

Line 15-16, 42, 48-49 and in some other occasions below: please check the sequence of references.

cited references are put in chronological order
L15: (Suursaar et al., 2006; Suursaar and Sooäär, 2007; Männikus et al., 2019)

L42: (e.g. Wübber and Krauss, 1979; Otsmann et al., 2001; Jönsson et al., 2008)

L48: (e.g. Suursaar et al., 2006; She and Nielsen, 2019; Aakjær and Buch, 2022; Kiesel et al., 2024)

L372: Feser et al. (2015) and Lorenz and Gräwe (2023)

Line 19: it is recommended to use MWL.

changed to „*MWL*“ and in Line 319,320,321,322 and 330

Line 27 and in many occasions below: perhaps “south-western” is more traditional.

changed to “*south-western*” and in Line 17, 46, 60, 99, 100, 110, 250, 335 and 372

Line 28: remove “that” and “occurred” for brevity.

changed to „*winds persisted for two days and reached peak wind speeds of 102 km/h (Kiesel et al., 2024).*“

Line 37: I guess that the authors actually have in mind the publication [Soomere, T., Eelsalu, M., Kurkin, A., Rybin, A. 2015. Separation of the Baltic Sea water level into daily and multi-weekly components. Continental Shelf Research, 103, 23–32, doi: 10.1016/j.csr.2015.04.018]. The paper (Soomere and Pindsoo, 2016) made use of the 8-day time scale detected in the previous paper.

We add the reference Soomere et al. (2015) and add some clarification on length of prefilling events.

„Typically, such variations that may lead to a prefilling (Lehmann and Post, 2015; Andrée et al., 2023) of the Baltic Sea have timescales of about 8 days (Soomere et al 2015 et al.) or even longer from week to even month in same cases (Soomere and Pindsoo, 2016) and …“

Line 43: perhaps “unfavourably” would sound better.

changed to „*When unfavourably coupled with storm surges*…“

Line 60: consider replacing “last” by “finest” or similar.

changed to „… *and the finest nest covers* …“

Line 82: must be Degerby.

changed to „*Degerby*“

Caption to Figure 2: replace “and” by comma before ‘’Warnemünde”.

changed to „…*Travemünde (top row), Warnemünde*…“

Lines 130-132 mostly repeat information presented on lines 115-120.

We totally agree and removed the first parts of L130 to L132

Line 198: something is wrong with the end of the sentence.

We rearranged the sentence

„Thus, on 19 October at 21:00 the water levels for “-60h” simulation reached 1.3m, whereas at the same time the “-24h” simulation started with zero water level. As a result, the subsequent wind affected 1.3m deeper water in case of “-60h” simulation than in case of “-24h” simulation, which could account for about 5-10\% reduction in surge height for the former.“

Line 221: “persist even after the winds have ceased” is not entirely correct as in many occasions the seiche is only launched when the wind starts to decay.

change to
„…and persist even after the winds have ceased or even just started to decay.“

Line 247: “of severe storm surges”

changed to
“*… of severe storm surges*”

Lines 247-249: it seems that that return value curves and values of parameters of extreme value distributions estimated from measured and simulated water levels deviate systematically in many locations of the Baltic Sea. Eelsalu et al. (2014) [Eelsalu, M., Soomere, T., Pindsoo, K., Lagemaa, P. 2014. Ensemble approach for projections of return

periods of extreme water levels in Estonian waters, Continental Shelf Research, 91, 201–210, doi: 10.1016/j.csr.2014.09.012] hypothesize that wave set-up could be one of reasons while Soomere et al. (2018) [Soomere, T., Eelsalu, M., Pindsoo, K. 2018. Variations in parameters of extreme value distributions of water level along the eastern Baltic Sea coast. Estuarine, Coastal and Shelf Science, 215, 59–68, https://doi.org/10.1016/j.ecss.2018.10.010] demonstrate substantial mismatch of estimates of parameters of the generalized extreme value distribution retrieved from modelled and measured water level time series. Anyway, this is a minor and almost irrelevant aspect in the context of this manuscript.

We added one line to further point to this differences between observed and models estimates.

L252: „This discrepancies between return value estimated from observations and from simulations is also found and discussed in detail by others (e.g Soomere et al. 2018).“

Soomere, T., Eelsalu, M., Pindsoo, K. 2018. Variations in parameters of extreme value distributions of water level along the eastern Baltic Sea coast. Estuarine, Coastal and Shelf Science, 215, 59–68, https://doi.org/10.1016/j.ecss.2018.10.010]

Line 236: It might be mentioned that the some pairs of annual maximum water levels are not necessarily independent in the Baltic Sea because of possible prefilling covering December and January. This feature may slightly affect applicability of the generalised extreme value distribution in the interior of the Baltic Sea. For this reason some authors recommend using maxima over windy autumn and winter season that are definitely independent. However, the possible difference in the results apparently would be very minor.

As reviewer #2 also pointed to this fact and wanted to shift the description of the GEV, and a section with the methodology is introduced

2.3.2 GEV

Several methods can be used to estimate return periods. Here, the Generalised Extreme Value (GEV) method (Coles, 2001) based on annual maxima was applied to the 66 years of hindcast data. In order to calculate the GEV distribution, block maxima have to be derived over a certain time period. The definition of the time period is depending on variable. For wind and wind-related variables, such as extreme water levels, the storm season between autumn and spring (Eelsalu et al. 2014) or summer and the following summer (Liu et al. 2022) is often used. Especially for the Baltic Sea, possible prefilling at the end of the year can also influence extreme water levels in the following year, which would then cause dependent variables. Here, however, we have chosen the calendar year (January to December) to derive the block maxima. One reason is that the extreme event of interest occurred in October 2023, and as our dataset ends in 2023, we would not have a full storm season 2023-2024 and be missing this event. A comparison with the results using block maxima from July to June shows only minor differences at the longer periods (not shown).

Line 426: must be Küste.

correct to „Küste“

Line 456: must be Leppäranta.

corrected to „ *Leppäranta*“

Lines 474, 486, 488: must be Suursaar, Ü.

corrected to „*Suursaar,Ü*“ accordingly

Line 494: must be Dailidienė.

corrected to „*Dailidienė*“