Earth Syst. Dynam. Discuss., author comment AC2
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Reply on RC2

Ralf Weisse et al.

Author comment on "Sea level dynamics and coastal erosion in the Baltic Sea region" by Ralf Weisse et al., Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2021-6-AC2, 2021

We thank Referee #2 for the constructive comments that have helped us to clarify and improve some points in our manuscript. In the following, we show how we will address the individual issues raised by the reviewer in the revised manuscript.

In the first two paragraphs, the referee acknowledges the extensive list of up-to-date scientific references and the timeliness of this review paper. We thank the reviewer for this assessment.

In the subsequent paragraphs, the reviewer addresses several shortcomings which he/she would like to see addressed in a revised version.

In the third, fourth, and sixth paragraphs the reviewer addresses the different levels of detail provided in the different sections. Several suggestions are made, how this can be addressed. We will take these points into account and will carefully re-work the mentioned parts of the manuscript to make them more concise and coherent. Specifically, we will

- inspect and screen the manuscript for long phrases with limited informational content. These will be deleted and replaced with shorter and more targeted statements.
- as suggested by the reviewer, explicitly mention examples of processes in the abstract and in section 4.
- highlight important findings making conclusive statements easier to identify.
- include maps illustrating the spatial distribution of mean and extreme sea level changes (see also reply to Referee #1).
- add to and extend the discussion on decadal variability.

The reviewer further mentions the Baltic Sea Chart datum as a common reference level for nautical charts and that the manuscript does not reflect this development. We will briefly mention and acknowledge this development in a revised version although we do not see that this has any impact on the assessment provided and the conclusions drawn.

The reviewer suggested moving the discussion of wind waves into a separate sub-chapter. This suggestion makes sense as wind waves are usually averaged out when sea level is considered. On the other hand, waves do have effects on sea level such as wave set-up and a combined discussion also makes sense from our perspective. For example, wave-driven effects create the largest danger in terms of flooding during extreme water level events where they contribute up to 1/3 of the local water level increase in some locations.

To address the point raised by the reviewer we suggest renaming the chapter into "Extreme sea levels and wind-generated waves".

Regarding section 3.3 the reviewer states that the phrase "knowledge gaps" is "often used in the case when there are policy-driven goals determined beforehand. Such goals are missing for the present review MS". The reviewer is right that such goals are indeed missing in our manuscript as they are well beyond the scope of the manuscript. We were not aware that this phrase is used in this context only. Our manuscript is part of a series of review papers, the general structure of which was agreed upon among the different groups beforehand. This also included the use of the phrase "knowledge gaps" in the specified context. To balance the trade-off between keeping the agreed structure and considering the reviewer's point we suggest using "Knowledge gaps and further research challenges" as a sub-chapter title in a revised manuscript.

The reviewer further requests that sub-chapter 3.3 should be recomposed but did not give any specific comment apart from the one discussed above. As provision and discussion of policy goals are outside the scope of this manuscript as well as of the entire series of review papers to which this manuscript belongs we, therefore, refrain from including such goals and from re-composing the entire section. However, we will carefully check the section to conclusively highlight our perspective on future research needs.

The specific points raised by the referee will be addressed as follows:

- Line 40: We will update the numbers according to the suggestion.
- Line 42: The comment suggests that our statement in the manuscript was misleading. We intended to illustrate that (from a global perspective) the Baltic Sea is small and may appear irrelevant for the global figures. We will revise this sentence to avoid this misinterpretation.
- Line 51: We will add corresponding numbers.
- Line 52-53: We will add examples to illustrate these points.
- Line 79: Thanks for the additional and useful reference. The point raised and the reference will be added.
- Line 84-85: We agree that this is misleading. In the referenced publication, it means that if we refer to the external trend; that is, at the entrance of the Baltic Sea (1.6 mm/year) as "100%", then local values may deviate by as much as 25% caused by redistribution within the Baltic Sea. We will reformulate this part to make this clear and explicit. We will further explicitly and briefly discuss freshwater discharge in the text referring to Figure 2 where these processes are present. Sea ice effects will be discussed in relation to erosion and sedimentation in section 2.3.2.
- Line 127-144: We will briefly introduce the Baltic Sea Chart Datum 2000 (see above) and correct the quotation of Bogdanov et al. (2000). The question of different reference levels is relevant as it hampers comparison and may introduce uncertainties. We think that it should be briefly mentioned but that a comprehensive discussion is beyond the scope of the paper.
- Line 129: Unfortunately we can not upload publications from other authors to the web. We will quote this publication as a presentation given at the Scientific Symposium "200 years of tide-gauge measurements in Świnoujście", Świnoujście, Poland, November 18, 2011.
- Lines 158-160: We assume that the reviewer refers to currents within the Baltic Sea. We intended to refer to currents in general. For example, if the Meridional Overturning Circulation in the North Atlantic changes, it will modify the large-scale sea level in the North Atlantic and as a result also in the North and Baltic Seas. We will reformulate and clarify the context in which this sentence is meaningful.
- Lines 165-166: The formulation was misleading. The intention was to state that tide gauges are located mostly at the coast. It will be reformulated.
- Line 187: We don't understand this comment. The results are explicitly presented in

Table 1, which is clearly referred to in the text.

- Line 196: We will follow the suggestion and briefly outline the mechanism.
- Line 197-204: We will revise this along the line suggested by the reviewer.
- Line 205-212: An additional sentence will be added describing the relation between NAO and Baltic Sea level variability. An important result is, that correlation is not stable but variable across time indicating that NAO is not the optimal pattern and/or sampling effects are important. We will make this clear and more explicit in a revised manuscript.
- Line 212-217: Yes, the link between the interannual variations of Baltic winter sea level and the NAO is spatially and temporally heterogeneous (stronger in the north, weaker in the south, stronger in recent years, and weaker in the past). The link to the Biscay-Tromsø difference is temporally and spatially more stable. This pressure difference dominated the NAO in all regions until approximately 1970. Thereafter, it does so only in the south, whereas in the north the impact of both SLP patterns is now comparable. In general terms, the Biscay-Tromsø SLP difference is a better indicator of Baltic sea level interannual variations than the NAO, although the NAO is also a good indicator for the last two decades. We will improve the description in the revised manuscript.
- Line 233: Numbers from the study will be added.
- Line 237: The reviewer is thinking of the redistribution of water mass within the Baltic Sea, but the changes in the freshwater budget affect sea level through changes in salinity. For example, if in the future the Baltic Sea becomes overall fresher, sea level will rise on average. So in total sea level change is not necessarily zero. Since precipitation is one of the variables whose change is more difficult to predict, the quantification of this effect in the future is complicated.
- Line 266: We will modify the titles as suggested above including waves.
- Line 277-279: We will rearrange the text and extend the discussion of storm surges as suggested.
- Line 284: Quotation marks were used to make a definition. We will use italic instead. In addition, the reviewer is right and the definition needs to be more specified. We will address this point as suggested by the reviewer.
- Line 288: We will change the text and refer to the study by Winsor, P., Rodhe, J., Omstedt, A. (2001). Baltic Sea ocean climate: an analysis of 100 yr of hydrographic data with focus on the freshwater budget. Climate Research 18: No. 1-2, pp. 5–15. We will also include the recent estimate from Mohrholz (2018). Major Baltic Inflow Statistics – Revised. Front. Mar. Sci. 5, art no 384. doi:10.3389/fmars.2018.00384 stating that "... the top limit of transport through the Danish straits is about 45 km^3 day^{-1}. This corresponds to a maximum mean sea level change of 12 cm day^{-1}"
- Line 296: The reference will be added.
- Line 297: To be able to address the processes individually, we prefer not to conflate them but follow the definitions used in Pugh and Woodworth (2014): Sea Level Science, Cambridge Univ. Press (see Chapter 7 and glossary). Here storm surge refers to the changes of sea level in coastal waters caused by winds and air pressures acting on the sea surface. We'll revise the text and the headlines to make this clear.
- Line 337: We will add the suggested reference and extend the discussion as suggested.
- Lines 345-347: We will cite the secondary references as the original is not available to us. To make this clear we will change the quotations to (Witting, 1911, as cited in LM 2009) and as (Defant 1961, as cited in LM 2009).
- Lines 401-405: The reviewer is right. The text will be revised making it more specific by including numbers and key messages.
- Lines 487-492: Yes, we agree and we will add some more sentences on sea ice effects.
- Lines 552-734: See our reply to the general comment on section 3.3 above.
- Comments on Lines 736-741, and 742-745:: We intended to provide the message that the Baltic Sea (i) offers a rich data set and (ii) is affected by many processes, so (iii) it represents a good laboratory to study coastal change. We will revise the text to make these points and the quotation of the Reusch et al. (2018) manuscript clearer.
- Lines 745-754: We prefer to retain this as this appears to be mostly a matter of style

but we'll remove the phrase "We argue …".

- Technical remarks: We will browse the manuscript and reduce the use of "may" wherever possible.