

Author's response to the review

Tuomi, L., Johansson, M., Twelves, A., Rantanen, M., Lagemaa, P., Kanarik, H., Särkkä, J., Raudsepp, U., and Westerlund, A.: Record low sea levels in the Bothnian Bay in November 2024, State Planet Discuss. [preprint], <https://doi.org/10.5194/sp-2025-12>, in review, 2025.

We would like to thank the reviewer for their constructive comments and suggestions to improve our manuscript. We have revised the manuscript accordingly. Below, you will find our detailed responses to the questions and comments. The reviewer's comments are shown in *italic font*, and our replies appear in plain blue text. All changes are clearly marked in the revised manuscript.

RC1, Anonymous Referee #1, 28 Oct 2025

Summary: The manuscript presents a characterisation of an extreme low sea level in the Gulf of Bosnia in the Baltic Sea. The magnitude of this extreme was exceptional compared to the past historical record. This extreme event was linked to winds flowing from a specific direction. The study estimated the return period of this extreme and assessed the short-term forecast for it.

Recommendation: The manuscript is clearly written, and the analysis is, in my opinion, correctly conducted. I have, however, some concerns about the suitability of the topic for the journal, a decision that the editor or the editorial board should make. The manuscript presents an analysis of a very specific sea-level extreme. This assessment may certainly be relevant from the operational meteorological or oceanographic point of view, but I do not clearly see its impact as an assessment report for 'State of the Planet'

We thank the Reviewer for constructive comments and suggestions. As this paper is intended for OSR10, Chapter 4: Specific Events in the Ocean (2024), its main aim is to provide a detailed overview of the extreme sea level event that occurred in the Baltic Sea in November 2024 and to examine the factors that contributed to it. We have revised the manuscript to include information and time series of observed annual minima from the Kemi tide gauge (Figure 3). We also give more detailed description about the general forecast accuracy of the BAL MFC NRT system, allowing comparison between the accuracy of the extreme event forecast and the overall performance of the NRT system. We also discuss how these forecasts could have supported sea-level warnings issued by weather forecasting centres in this region. Please also see our detailed answers below.

Leaving this question aside, I have a few suggestions that the authors may want to consider:

1) The abstract indicates some sea-level figures to characterise the magnitude of the extreme, but these are only meaningful to researchers working specifically in this geographical area. Also, it would be more useful to indicate the magnitude in terms of standard deviations derived from some climatological period (possibly detrended to subtract the impact of the GIA)

We have rewritten the abstract to better describe the content of the manuscript with focus on the extreme event in the northern part of the region.

2) The Abstract should also mention the exact date of the extreme. This is first mentioned at the end of the introduction.

We have added the exact date of the extreme event to the abstract.

3) line 96 'We present winds measured at Kalajoki...' daily, hourly, 6-hourly..?

The wind measurements presented are hourly 10-min averaged values. We have added this information to the manuscript in Section 2.

4) The resolution of Figure 1 should be improved.

We apologise for the poor resolution of Figure 1. Something went wrong in the conversion of this Figure from the doc-version to the pdf-version. In the revised version of the manuscript we have taken care that the resolution does not change in the conversion.

5) line 170 'forecast lengths'

I think the authors mean forecast horizons. For instance, the length of a forecast be 10 days if it's continued beyond the forecast horizon of, say 1 24 hours.

We thank the reviewer for this comment and have revised all instances in the text to ensure consistency: when referring to the total length of the forecast, we use the term forecast length, and when discussing the time between the start of the forecast and the time of the event, we use forecast lead-time. We hope this change makes the text clearer and easier to read.

6) The GEV analysis is correctly conducted using detrended data. It is interesting to know whether November 21st remains a record sea level even in the detrended series

We have added time-series of observed annual minima from the Kemi tide gauge including also the detrended dataset in Figure 3. The 21 Nov 2024 event is a record also in the detrended dataset.

7) A GEV analysis of the winds, for instance, daily means, would also be interesting. It would address the question of whether the sea-level record was due solely to the magnitude of the winds, or to some combination of strong winds, the prefilling state, or sea-ice cover.

Thank you for this suggestion. Due to the small size and complex shape of the Baltic Sea, wind direction plays a key role in extreme events. Thus, the record-low sea level in Kemi was not due to the magnitude of wind speeds alone, but to the combination of strong wind speed and northeasterly direction that pushed water away from the Bothnian Bay. A GEV analysis of wind speeds would therefore be insufficient; such an

analysis would need to be restricted to winds from the northeast sector. Isolating this effect carefully would require substantial additional effort and is beyond the scope of the present study, although we agree it would be an interesting topic for future research.

8) What were the sea-ice cover conditions? Ice cover is known to modulate the amount of momentum transferred from the atmosphere to the ocean. Did a smaller-than-normal ice cover play a role? Somewhat surprisingly, ice cover is not mentioned at all in the manuscript (or I missed it). This would increase the 'climatological aspect' of the study and perhaps make it more suitable for publication in State of the Planet

We thank the reviewer for raising the issue of momentum transfer modulation by sea ice, which indeed can have a substantial effect on sea levels in the Baltic Sea. At the time of the event (21st November 2024) there was no sea ice present in either the Gulf of Bothnia or Gulf of Finland. For context, the median first-freezing date at Ajos (close to Kemi) during the 1991-2020 period was the 20th November; thus, the lack of ice in late November 2024 was not remarkable.