We thank the reviewer for constructive comments of our submitted manuscript. The point-by-point replies to the comments of the reviewer are below. Your comments are marked in black and our responses in red.

Review on “Simulating sea level extremes from synthetic low-pressure systems” by Jani Särkkä, Jani Räihä, Mika Rantanen, and Matti Kämäräinen

The manuscript investigates sea level extremes in the Baltic Sea through numerical simulations of synthetic low-pressure systems. The authors conducted simulations based on historical records and compared the results with actual data. However, there are several areas where the manuscript can be improved before it is considered for publication:

Cyclone Model Validation

The article heavily relies on synthetic cyclones, which are artificially created. This approach introduces several assumptions, and synthetic cyclones may not accurately represent the complex dynamics and characteristics of real cyclones. This limitation raises questions about the reliability of the results. The discussion on the model's validity should be expanded in Section 2 instead of conclusion. To enhance the manuscript, the authors can:

- Justify the chosen intensity of the cyclone (pressure anomaly ΔP of -40 hPa and minimum radius R of 1000 km) by comparing it to extreme extratropical storm events observed in the Baltic Sea. What is the implication of the radius R and how is it different from the radius of the maximum wind of a tropical storm?
- Explain the characteristics of extratropical storms, compare with the model and discuss the limitation of the model
- If possible, discuss their similarities and differences compared to tropical storms and compare the synthetic cyclone model to existing hurricane models (e.g., Holland 1980).

Thank you for this comment. We agree that there are several assumptions involved in the design of synthetic cyclones. This is an inevitable issue whenever research is conducted with synthetic or artificially created cyclones.

The Gaussian shape was originally chosen for two main reasons:

1. the Gaussian shape requires red only a few parameters to describe it, and

2. the Gaussian shape characterizes the shape of the low-pressure system with sufficient accuracy.

It is clear, of course, that not all possible variations in the cyclone shapes can be described by such simplification. However, we would like to emphasize the importance of other factors in determining sea level variations.

For example, far more relevant to the simulated sea levels than the deviations of the shapes from Gaussian are (1) the depth and extent of the cyclone, and (2) the track and propagation speed of the cyclone.

The cyclone radius of 1000 km is consistent with observations, although we agree that this value is at the upper limit of the distribution. A study by Rudeva and Gulev (2007) found that the effective radius of cyclones over the ocean can be larger than 900 km, with an average of about 700 km. Thus, we argue that a radius of 1000 km is plausible in the Baltic Sea region. We present this justification in the revised manuscript.

The pressure anomaly ΔP of -40 hPa was chosen so that the resulting maximum surface wind speeds do not exceed 40 m/s. According to geostrophic wind law, larger pressure anomalies would have resulted higher wind speeds, but wind speeds higher than 40 m/s are not plausible in the Baltic Sea region.

In the revised manuscript, we discuss more clearly the limitations of the Gaussian shape and how it differs from a typical extratropical cyclone. As our method is only intended for the Baltic Sea region, where tropical storms cannot occur, we decided not to discuss the similarities with tropical storms or hurricane models.

Rudeva, I., & Gulev, S. K. (2007). Climatology of cyclone size characteristics and their changes during the cyclone life cycle. Monthly Weather Review, 135(7), 2568-2587.

Numerical Simulations

The manuscript lacks details about the numerical simulations. It would be helpful to include:

- The computational domain used in the simulations.
- The number of simulations performed, including the range of origins, speeds, and directions

Clarification on the handling of initial conditions

- Currently, the cyclone's origin at 10°E with a 1000 km radius suggests that it affects the Baltic Sea at the start of the computation. The manuscript should explain how initial conditions were handled. Also consider originating the cyclone further away from the Baltic Sea for more accurate results.

The grid size in the simulations

- The current spacing of 0.1 degrees in the meridional direction and 0.2 degrees in the zonal direction may be too coarse for predicting sea level elevations at tide gauge stations.
- The correlation between sea level prediction and grid size should be investigated, considering L159 "The higher spatial resolution Averkiev and Klevannyy (2010) use near St. Petersburg is likely the reason for the 1.5 meter difference between their simulated maximum and our result." If this statement is valid, it means that the sea level elevation may be higher at Oulu and Riga with finer grid simulations.

In the revised manuscript, we have added more information on the details of the numerical simulations, such as the computational domain. The number of simulations varied depending on the location studied. As our aim was not to find the most extreme sea levels, but only to find extremes surpassing the observed ones, the number of simulations is not essential.

We added an explanation on the initial condition, noting that the wind speeds 1000 km away from the cyclone center do not significantly affect the sea levels. Hence, it is not necessary to place the origin of the cyclone further west of the Baltic Sea. We added an explanation of the effect of the grid size, noting that in an earlier study using the same numerical model, even sea level simulations in sparser grid had correlation over 0.90 with the Finnish tide gauge observations.

It is true that finer grid simulations would likely produce higher extreme sea levels for the sites studied. As our aim was to find lower limits for the maxima, not the most extreme ones, the improved grid simulations are left as a subject for future studies.

Minor Comments

- Throughout the text, it seems that the intensity of the cyclone is fixed, but in several places (e.g. L4, L127), "various intensities" are mentioned. The authors need to correct this.

Thank you for pointing this out. We have corrected this in the text.

- Paragraph L50-54 seems unnecessary in the introduction and can be removed.

We removed this paragraph.

- Terms such as "large," "small," and "short" need to be defined more precisely, particularly in L194-197.

The text has been rewritten, L194-197 are in Section 2.2 in the revised version.

- L125 - "As we calculate only short-term sea level changes, our results represent the sea level fluctuation with respect to the sea level preceding the arrival of the cyclone.": unclear

We rewrote this sentence.

- The mention of an observation in 1984 at Oulu in L144 should include an explanation of what caused that anomaly. For example, what was the intensity (pressure and radius) of the related storm?

We added text explaining the physical background of the high sea level in 1984.

Figures

- Figure 2 should include labeled x and y axes.

Axis labeling was added

- Figure 3 does not provide valuable information

We agree. Figure 3 was removed

Tables:

- Table 1: Pressure anomaly and radius are fixed for all simulations, thus they are not necessary.

This is true. The table was updated