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# *Interactive comment on* "Variability of distributions of wave set-up heights along a shoreline with complicated geometry" *by* Tarmo Soomere and Katri Pindsoo

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We are thankful for the very detailed and professional insight of the Referee into our manuscript and the comments on the results that we consider interesting for the marine and coastal science community. The suggestions of the Referee are very much appreciated and following them will indeed improve the manuscript.

1. We agree that our results may reflect certain specific features of the study area and may not be directly extendable to other types of coast. One of the major conjectures is that the (empirical) probability density function of wave set-up heights may have an unusual shape in some coastal sections. This feature is obviously unlikely on relatively



straight and basically homogeneous shores where the properties of the local wave climate, refraction and shoaling change slowly along the shoreline, and therefore the properties of wave set-up are also mostly uniform in the alongshore direction. In the light of this comment we feel that an inclusion of some examples of the distribution in question, in typical Baltic Sea conditions (e.g., on the Baltic proper shores of Latvia and Lithuania) would clarify which kind of distribution of wave set-up heights is usual on the coasts of this water body. It is also a good idea to single out and describe in detail the features of coastal segments in which a Wald distribution of wave set-up emerges.

2. The core message of the manuscript is that wave set-up heights may follow a qualitatively different distribution from the "standard" ones that describe properties of other drivers of high local water levels and the reach of large waves (Gaussian for the water volume of the Baltic Sea, exponential for storm surges, Weibull for different significant wave heights, Weibull or Rayleigh for wave run-up). The wider problem here is that a comprehensive description of water levels would need the inclusion of one more type of distribution in the relevant analysis. We agree that the chosen level of statistical significance (that the leading coefficient of the quadratic approximation to the exponent is nonzero) is overexploited and does not guarantee that the distributions in question substantially deviate from exponential or Gaussian. We are happy to add estimates of the frequency of emergence of a Wald distribution that rely on different levels of statistical significance.

3. We intentionally focused on the analysis of the shape of probability density functions of set-up heights. A cumulative distribution function is, in essence, an integral over the probability density function (pdf) and thus potentially suppresses possible irregularities of the pdf. Our conclusions are based on the shape of this pdf for relatively frequently occurring set-up heights. The analysis discards the very large occurrences of this height. This approach is intentional because very large values are scarce (and thus the shape of the pdf has large uncertainty for these values) and because these values may follow another (generalized extreme value) distribution. We will expand the material to

include some examples of empirical cumulative distribution functions but we think that the analysis of extreme set-up heights is the subject of another study.

4. The highest values of set-up heights that have the same (very low) probability have occurred only once during the considered time period. As the entire simulation contains 103 498 single instants of wave properties, one occasion corresponds, theoretically, to 10ˆ(-3)%. As we exclude the cases with zero set-up heights (e.g., waves propagating offshore), the number of instants of wave properties varies between 40 000 and 70 000 for different coastal segments.

Most of the data points with the smallest frequency of occurrence thus correspond to one, two or three occasions of the relevant set-up height classes with a step of 1 cm. As strong wave storms usually last less than 5–6 hours in the Baltic Sea, different data points at a 0.001% or comparable level mostly represent different storms. The level of serial correlation of single wave set-up heights is implicitly minimized by using a non-traditional approach for the reconstruction of wave properties that is based on the sequence of wind properties once every 3 hours and contains a minimum amount of "memory" of wave fields. In the context of our analysis, the possibility of serial correlation should have no impact on the results as we focus on probability density functions and do not carry out any analysis in which serial correlation may have a role (e.g., sequences of events, block maxima or similar).

5. Wind data gaps are always a problem in reconstructions of marine hydrodynamic fields. As our conclusions rely on the shape of the probability density function for relatively frequently occurring set-up heights (and we even exclude the most infrequent, equivalently the highest, set-up events), it is likely that the impact of gaps in the recordings of the strongest winds have very little impact on our conclusions. We will explain this aspect in the revised manuscript.

6. Thank you for the comments. We shall try to reshape Fig. 4 for better readability. Figure 6 is meant to demonstrate how different are the shapes of various distributions



and where the basic difference between Gaussian, Weibull and Wald distributions is. The underlying set-up data are just for illustration (but still represent the most frequent case of exponentially distributed set-up heights). The panels of Fig. 7 are presented for coastal segments with different orientation. As numbers of coastal segments are hardly visible in Fig. 2, we will add a scheme with the location of these segments.

7. We meant gaps in the calculated empirical distributions, not in the time series of wind or wave properties. It is natural that some specific set-up heights in such empirical distributions (in our case with a resolution of 1 cm) simply do not occur. This happens for very large values of set-up heights that are populated by a few events. We interpret the presence of such a gap as showing that the number of occasions for the relevant set-up height (and for the higher values of set-up) is too small for the use in the estimates of the shape of the entire distribution.

On the one hand, it is generally necessary to use as wide a range of data points as possible of the probability density function in order to adequately evaluate its shape. On the other hand, the use of data points that correspond to very large and infrequently occurring events is questionable because these data points may have relatively large uncertainty (as they reflect only a few events) and, more importantly, they may follow another distribution (e.g., an extreme value distribution). For this reason we limited the values of set-up heights to 40 cm. As implicitly demonstrated in Fig. 6, higher than 40 cm set-up events do not occur at all in some coastal segments. If they occur, the number of such events is usually a few dozen, and only in a few segments exceeds 100. Therefore, such events form less than 0.1% of all set up events. In this context we would like to emphasize once more that our aim is to understand the basic properties (such as the shape) of the probability density function of set-up heights.

As discussed on p. 7–8, we employed the numerically evaluated wave properties from the standard WAM model. The angle of incidence of waves is evaluated based on the mean approach direction of waves at the centre of the model grid cell and a piecewise linear approximation of the shoreline. Doing so led to some problems at the ends of some peninsulas that were poorly represented even at this resolution (470 m). We will describe this procedure in detail in the revised manuscript. The phase and group velocities were calculated from the standard finite-depth dispersion relation based on the peak period and water depth.

We also appreciate the list of technical corrections that we will address in full in the revised version. Also, we shall definitely consult with a native speaker, expert in the field, to bring the use of English to a much better level.

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