

## ***Interactive comment on “Ensemble hindcasting of wind and wave conditions with WRF and Wavewatch III<sup>®</sup> driven by ERA5” by Robert Daniel Osinski and Hagen Radtke***

**Anonymous Referee #2**

Received and published: 30 August 2019

This manuscript provides an interesting insight into possibilities of the construction of a large ensemble of hindcasts of wave properties in the Baltic Sea region. On the one hand, this approach is thought-provoking in itself as the pool of similar studies is very limited in this area. On the other hand, it is not clear beforehand how large is the potential of this approach to improve the hindcast as most of the discrepancies of the wave field reconstructions seem to stem from uncertainties of the driving wind fields. In particular, even small variations in the trajectories of low pressure systems may lead to large changes in the wave properties in the study area. It is thus important to understand how the possible uncertainties in wave reconstruction can be “distributed” between the variations in the driving fields and the specific ways of the description of

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wave physics. The topic thus clearly fits the scope of Ocean Science.

It is a pity that the approach is applied to an event in February 2002 for which essentially no ground truth about wave properties is available in the area of high waves. While the wave buoy of the Finnish Meteorological Institute was removed because of possible ice impact, the bottom-placed device at Almagrundet (Broman et al., 2006) did not provide any data in February 2002. However, as it is said both in Abstract and Conclusions that the event “provoked a severe storm surge in February 2002” it is necessary include at least some numbers and locations to substantiate this information. For example, nothing specific happened in Latvian waters.

The method for the construction of the ensemble is rational and interesting. It is reasonable from the viewpoint of wind fields but seems to run into problems in terms of wave properties. It is of course worth of trying to construct as large ensemble as possible in order to examine the spread. However, it is not a good sign that some members of the ensemble lead to unrealistic wave heights. Both Fig. 2 and Fig. 3 indicate that maximum wind speeds in the northern Baltic proper are mostly in the range of 20–22 m/s and only for a few members reach the level of 25 m/s. Such winds speeds only cover a small part of the northern Baltic Proper. Even though the wind direction was favorable for the generation of high waves in this area, it is unlikely that significant wave heights substantially exceeded 7 m in this storm. Wave heights exceeding 8 m are very infrequent in this region. Even in the extreme storm Gudrun/Erwin (January 2005, 10-min wind speed >28 m/s in large sea areas) wave heights most likely did not exceed 10 m anywhere in the Baltic Sea (Soomere et al., 2008).

Therefore, I guess that wave heights between 11 and 12 m in Fig. 6 are completely unrealistic for the February 2002 storm. It seems that the entire ensemble severely (by almost 2 m on average) overestimates wave heights in the northern Baltic proper. Thus, I recommend to extensively comment this feature and to include a short insight into measured or modelled wave heights in this area for storms of comparable properties. Ideally, I would recommend to include a paragraph or two about extreme wave

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properties in the study area, following either (Tuomi et al., 2011) or (Björkqvist et al., 2018).

In particular, I recommend extending the message on page 5, line 5–6 towards a sound explanation that the model is essentially uncalibrated for the Baltic Sea conditions. This is mentioned in the last sentence before conclusions on page 14. The point of this sentence should be made very clear from Abstract to Conclusions. I stress that such a bias in the evaluated wave heights does not undermine the validity of most of the results but it should be made clear to the reader that single values of wave height (and even the ensemble average) do not necessarily match the wave properties in this storm.

For the listed reasons I recommend moderate to major modifications to the manuscript. It is essential that the reader is informed (i) about some basic features of wave climate and extreme waves in the Baltic Sea and also (ii) that the simulations probably strongly overestimate wave heights and (iii) are performed specifically to study the spreading properties of ensembles, with no exact relevance to the actual wave heights during the simulation interval. An absolute must is to inquire the modelled data from a properly calibrated run (e.g., from the authors of Björkqvist et al., 2018) for the underlying location of Fig. 6 to give a minimum flavor of the possible bias.

The text is written in fairly good English but reveals slight German accent in the form of very long sentences at places and missing of some articles in the text. It is mostly clear but still needs extensive polishing, especially closer to the end of the manuscript. As I am not native speaker, I only include a list of clear typos below.

#### Minor comments

The paragraphs are at places very long. For example, the first paragraph of Introduction extends over 28 lines. It is recommended to split long paragraphs into shorter ones.

The style of calendar days ("21. February 2002" on page 6, line 4 and "22nd to 24th of

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February" on the next line) should be unified.

The first two sentences of Abstract seem unnecessary.

Page 1, line 17: probably should be "and is described".

Line 23 and some other locations: some journals require comma after "e.g."

Page 2, lines 32–34: the sentence does not make sense; possibly because of too strong German accent.

Page 3, line 13: C3S has already been explained on page 2, line 22.

Line 20: probably full stops are not necessary in "21. February 2002" and similar expressions.

Line 23 it is better to say that 0.36deg and 1deg denote the resolution of the relevant grid. Please do so also in several locations below where the size in degrees is given without any explanation.

Page 4, line 10: please specify the meaning of "writing 15 minutes output".

Line 12: please explain what is meant under "the temporal impact" (probably the dependence of the solution on the time step).

Line 17: please specify the meaning of "Eta layers".

Line 18–19: consider replacing the jargon-like expression "until fine scales develop" by a more explanative one. Please do so also in several occasions below to avoid clash in the meaning of, e.g., "finer scales are not represented" on page 6, line 9.

Page 5, line 1: to avoid misinterpretation, I suggest to mention that nesting of the wave model to the Baltic Sea is not really necessary for the hindcast of wave properties in the central and northern regions of this water body because very little wave energy penetrates through the Danish straits.

The reasoning on lines 2–6 is only partially relevant for the conditions of the Baltic Sea.

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Line 7: while most of the model setup is obviously fine for the Baltic Sea, please comment on the adequacy of the use of the chosen frequency range for this water body. Wave modellers usually substantially extend the frequency space here. The team of the Finnish Meteorological Institute normally uses 35 frequencies (Laura Tuomi et al., many papers) and some research in subbasins of the Baltic Sea even 42 frequencies (0.0418–2.08 Hz, Soomere, 2005). It is probably not necessary to cover such an extended range. However, insufficient coverage of short waves may lead to too slow wave growth under rapidly increasing wind conditions.

Lines 14–16: the message of the entire sentence is technically clear but seems misplaced or even irrelevant.

Page 7, line 7: “these”.

Page 10, lines 19–20, the sentence “Compared to ERA5, the overall spatial pattern is comparable” does not make sense to me.

Page 11, lines 2–5: the reasoning is almost irrelevant for the Baltic Sea conditions and should be left out. Instead, it should be emphasized that strong swells are infrequent in the Baltic Sea (see, e.g., Broman et al., 2006; Soomere et al., 2012) and thus deviations in the hindcast or forecast driven by the accuracy of the representation of swells are usually not very large in this water body.

Page 12, line 14: something is wrong with “500 choose N possibilities exist”.

Page 13, line 10–12: the sentence is unclear.

Line 13: “developed”; also, the entire sentence remains partially unclear starting from “why”.

Lines 16–17: the concluding sentence of the subsection should be made clearer.

Line 18: use “on” instead of “onto”.

Page 14, line 7: please specify what is meant under “The higher temporal resolutions

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do not differ so much.” Also, the subsequent sentences contain too much jargon.

Line 14: “orography of the coastlines” sounds weird as the height of the coastline is just zero; also: use “Baltic Sea”.

Line 15: spatial pattern of what?

Line 5 or another appropriate place: please stress that an uncalibrated (for the Baltic Sea conditions) wave model was used but still the results about the spread are valid.

Page 16, line 1: remove “by this fact”.

Lines 1–2: the message of the sentence “As the first twelve hours are not used, because of the model spin-up, this is not really a shortcoming.” remains unclear.

Line 14: correct “atmospheric”.

Line 20: correct “possbile”.

References:

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Soomere, T., Weisse, R., Behrens, A. 2012. Wave climate in the Arkona Basin, the Baltic Sea. *Ocean Science*, 8(2), 287–300, doi: 10.5194/os-8-287-2012.

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Interactive comment on *Ocean Sci. Discuss.*, <https://doi.org/10.5194/os-2019-76>, 2019.