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Interactive comment on "Ensemble hindcasting of wind and wave conditions with WRF and Wavewatch III® driven by ERA5" *by* Robert Daniel Osinski and Hagen Radtke

Anonymous Referee #1

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Review comments for "Ensemble hindcasting of wind and wave conditions with WRF and Wavewatch III ® driven by ERA5" (os-2019-76) by Robert Daniel Osinski and Hagen Radtke

The authors present a results where different methods to produce ensemble wind hindcasts (to be used for wave hindcasts) are compared. They conclude that varying the starting time of the hindcast/forecast, or a single grid cell shifting, leads to quite a small spread. The stochastic perturbation of the ERA5 EDA field lead to the largest spread in the ensemble.

General comments: I like this paper, and I can recommend it for publication after some

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minor alterations. It is within the scope of Ocean Science, the topic is of interest for the scientific community, it is timely, and well executed. It is obvious that the authors have a solid expertise in atmospheric modelling and ensemble forecast compilation. It does, however, seem that they might not bee completely familiar with wave modelling efforts that has already been done in the Baltic Sea. This doesn't diminish the relevance of this paper, but I will provide a few references at the end. Not all of these need to be included in the paper, nor is it meant to be exhaustive. They are more intended as a friendly starting point to aid in finding some relevant research to put this study into better context.

Major comments:

Major comment #1) The introduction is well written from the point of view of ensemble modelling, but it totally lacks material on Baltic Sea waves and the relevant research. Please see my list of references in the end as a starting point. Also the discussion of the results needs to be tied better to what we as a community know about Baltic Sea wave conditions.

Major comment #2) While I can get on board with using only one storm in this study, I think it is very unfortunate that the authors have chosen the 2002 storm when no data from the NBP wave buoy is available. For example the 2004 Rafael storm would have wave buoy data available for validation. It might be unreasonable to redo the model runs (I will leave that to the authors), but at least the authors should discuss how realistic the highest values (Hs>11 m) are by comparing to what we know about the Baltic Sea wave climate (again, see the list of references at the end).

Specific comments:

#1) The wave model is "WAVEWATCH III", not "Wavewatch III".

#2) page 1 line 25:

Perhaps have a paragraph break at "In principle"?

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#3) page 3 line 23 “The ERA5 dataset was used in this study to drive the atmospheric model WRF, a coarse Wavewatch III ® wave model to provide lateral boundary conditions for a Wavewatch III ® wave model with higher resolution and for comparison with the model results.“

This is a bit unclear and should perhaps be rewritten.

#4) page 5 line 3 “UERRA/Harmonie-v1 was used for calibration and validation of the setup against one month of data from buoys available from the Copernicus Marine environment monitoring service 12 (CMEMS) with the previous Wavewatch III v5.16 version.”

This is unclear. What buoy data exactly was taken from the CMEMS database? Was the validation done with a different version of WAVEWATCH III than the actual results? What does “calibration” mean? Was some of the source terms calibrated specifically for the Baltic Sea? Was the validation metrics similar to those of previous modelling efforts in the Baltic Sea?

#5) Please add some kind of Table of the different type of ensembles. As written, it is a bit hard to follow.

#6) Fig 2: "results shown at 19.39°E, 56.17°N"

Show this point in Fig. 1.

#7) Fig 3.

There are a lot of subplot. Would it be sufficient to just use max difference to the mean, or to reduce the number of panels in some other way?

#8) page 10 line 24: A shortcoming of this procedure

A bit unclear what is meant by “this"

#9) page 11 lines 1-2:

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Baltic Sea not really swell dominated, so this shouldn't be an issue in your results, and the discussion seems a bit off key, especially in the middle of the paper concentrating on the Baltic Sea. It is up to the authors if they want to keep it. Just thought I would point out how it looks from a Baltic Sea perspective.

#10) page 13 line 2.

Perhaps start a new paragraph with "Figure 8 shows..."?

#11) page 13 line 19 "The time step of a high resolution ocean or wave model is normally below one hour."

This is slightly misleading, since one hour is a typical time resolution for the output of a wave model. The time step of a wave model can be counted in seconds (typical for explicit numerical schemes) or minutes (typical for implicit numerical schemes). The wave model therefore need updated wind information e.g. every 30 seconds. This is done by interpolation from the wind forcing that is provided e.g. every hour or every third hour.

#12) page 14 line 9-10: "Systematic differences cannot be found based on the small sample, but it indicates that the choice of the 15 minutes resolution is a reasonable compromise between a good representation of the extreme values and file size."

I think one could argue that a 60 minute resolution is reasonable, since a difference of 2 cm is under 1%. This is small compared to the sampling variability (roughly 5-10%) that is present in measured significant wave height data that we routinely use to validate the models. Still, 15 minutes is clearly also a reasonable choice, so I'm not arguing with that part of your conclusion.

#13) page 14 line 15-16: "For this reason, a difference in the spatial pattern can be assumed."

Do you mean that a difference can be expected?

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#14) last paragraph on page 14:

It think it is worth noting that the operational products typically used to force Baltic Sea wave models are already close to the higher resolution (0.063 deg). While this sensitivity test is very welcome, it could easily be read as if the wave modelling community is currently using insufficient wind forcings is no context is provided. It might also be worth noting, that separate high-resolution wave model implementations might benefit more from higher resolutions in the wind forcing than what is seen in a 1 nmi Baltic Sea wide wave model. This kind of sensitivity tests for coastal wave models have been done in the Baltic Sea (see e.g. Tuomi et al., 2014).

#15) page 16 line 1-2: "As the first twelve hours are not used, because of the model spin-up, this is not really a shortcoming."

This will not be true for operational wave forecasts that get their starting conditions from the previous run. Will it be a shortcoming then?

#16) page 16 lines 11-13 "To achieve a comparable robust estimate of the uncertainty, the ensemble size for the here presented approach must be larger than the one of operational local area model ensembles."

Just to be clear, is the "here presented approach" choosing the members at random? In other words, is your conclusion that choosing random members requires more members in the ensemble than if they are "screened" in advance using a coarse model, or are you trying to make some additional point?

#17) page 16 line 16-17: "For a strong event, the difference between a 5 and 60 minutes temporally resolved wind forcing is only on the order of 2 cm."

I think it is a bit questionable to give an absolute difference without knowing the significant wave height. This doesn't really provide that much useful information.

#18) In e.g. Figure 2: are you using the wave product of ERA5, or are you using WAVEWATCH III forced with ERA5 winds?

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#19) If you are only simulating the wave field in the Baltic Sea, then there is not really a need to nest it outside of the Danish straits, since no significant amount of wave energy will penetrate. It's not wrong, just pointing out that it is not really necessary.

#20) The figures are sometimes very hard to read. Please prepare them according to the guidelines of the journal (fonts sizes, labeling of subpanels etc.)

List of (potential) references:

Tuomi, L., Pettersson, H., Fortelius, C., Tikka, K., Björkqvist, J.-V., and Kahma, K. K., 2014: Wave modelling in archipelagos. Coastal Engineering 83, pp. 205-220. https://doi.org/10.1016/j.coastaleng.2013.10.011

Coastal wave modelling in the Baltic Sea with different atmospheric models using different resolutions and time steps.

Björkqvist, J.-V., Tuomi, L., Tollman, N., Kangas, A., Pettersson, H., Marjamaa, R., Jokinen, H., and Fortelius, C., 2017: Brief communication: Characteristic properties of extreme wave events observed in the northern Baltic Proper, Baltic Sea, Nat. Hazards Earth Syst. Sci., 17, pp. 1653-1658, https://doi.org/10.5194/nhess-17-1653-2017

Comparing wave forecasts with different lead time against wave buoy measurements from a storm.

Soomere, T., Behrens, A., Tuomi, L., and Nielsen, J. W.: Wave conditions in the Baltic Proper and in the Gulf of Finland during windstorm Gudrun, Nat. Hazards Earth Syst. Sci., 8, 37-46, https://doi.org/10.5194/nhess-8-37-2008, 2008.

Comparing different wave forecasts against measurements from a storm.

Tuomi, L., Kahma, K. K., and Pettersson, H.: Wave hindcast statistics in the seasonally ice-covered Baltic Sea, Boreal Environ. Res., 16, 451–472

Basic wave statistics for the Baltic Sea.

Olga Vähä-Piikkiö, Laura Tuomi, Vibeke Huess, 2019, Baltic Sea Wave Analysis and Forecasting Product BALTICSEA_ANALYSIS_FORECAST_WAV_003_010,http://cmems-resources.cls.fr/documents/QUID/CMEMS-BAL-QUID-003-010.pdf

Information about a currently running wave forecast

Nikolkina, I., Soomere, T., and Räämet, A.: Multidecadal ensemble hindcast of wave fields in the Baltic Sea. In: The 6th IEEE/OES Baltic Symposium Measuring and Modeling of Multi-Scale Interactions in the Marine Environment, May 26–29, Tallinn Estonia. IEEE Conference Publications, 9 pp., https://doi.org/10.1109/BALTIC.2014.6887854, 2014.

WAM simulations in the Baltic Sea with different wind products

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