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Ocean Science
Discussions

Interactive comment on "Better Baltic Sea wave forecasts: Improving resolution or introducing ensembles?" *by* Torben Schmith et al.

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Response to Anonymous Referee #2 with authors' replies marked by ***

OVERVIEW: This paper will serve a useful purpose in documenting performance of an operational wave forecast modelling system for the Baltic and in assessing and discussing the relative benefits of increasing wave model resolution versus a probabilistic forecast system in this specific scenario - where approximately an order magnitude increase in computing power has been available. For such a study, the authors have done a good job with being concise in their use of probabilistic verification metrics and delivered a clear set of results.

However, I would recommend that publication is made subject to a number of major

revisions. These are required in order to address a number of questions raised by the study, but which the authors have only dealt with very briefly or passed over: 1. For a wind driven wave model, the nature and quality of the forcing winds are a key consideration in the model performance. The driving wind model therefore needs to be well documented and, specifically for this paper, any differences in horizontal resolution associated with the deterministic and ensemble forecasts systems need to be provided clearly in Section 2 These were not clear to me on my read through, and I am left with the impression that the authors have compared a 10km wave model with a 5km wave model but using a similarly specified wind model for both deterministic and ensemble forecasts?

*** The HIGH and LOW deterministic models are forced with wind from 3 km DMI-HIRLAM, while LOWENS are forced with wind from 5 km ensemble DMI-HIRLAM. Note that this disfavours the LOWENS forecasts, since the ensemble runs are forced by lower-resolution wind fields.

We will modify the manuscript to make clearer which wind forcing is used for the different configurations. ***

2. If this is indeed the case, then I think the wind forcing being used, wave model resolutions chosen and available observations naturally lean the study toward favouring the ensemble. This is acceptable, but needs to be acknowledged and discussed further within the paper. From a wind perspective, if no higher resolution atmosphere model that will improve representation of the land-sea boundary layer is available then the ensemble's provision of multiple answers will generally help the verification scores from that system. Whilst a costly enhancement, the change from (LOW) 10km to (HIGH) 5km resolution may not be enough to significantly enhance wave forecast performance in the coastal zone and, besides, only one observation site is available to illustrate coastal performance. This means that it is difficult for the reader to get a clear picture of what advantages the HIGH res model is expected to yield - I'd suggest that might be improved by some visualization of model fields in order that the impact of changes

from LOW to HIGH over the wider region can at least be illustrated.

*** We do not understand why the referee thinks that our set favours the ensemble. In our opinion, the setup disfavours the ensemble, as pointed to under 1.

The Land-sea boundary problem has been accounted for using water-wind, as described in line 103.

To illustrate the performance of the different configurations, we will in the revised manuscript show forecast fields during the Toni storm, January 2017. ***

3. Although, in my view, the experiments favour the ensemble system, the paper still raises a valid point: which is that when using regular grid wave models and an order of magnitude computing resource to invest then the ensemble will likely provide a better return, in terms of improving forecast skill over the larger offshore part of the domain. However, in order to make this point the authors also need to be mindful of and discuss the study within the context of rather more of the open literature than they have done. For example, Cavaleri et al (2018) provide an exhaustive discussion of coastal processes and how wind and wave models need to improve in order to properly represent these - it would be good if the authors can set out where and how the HIGH system attempts to address these aspects of coastal forecasting better than the LOW or LOWENS systems. Similarly, there is also the question of whether an unstructured or refined grid approach would enable significant improvements in coastal regions of the domain whilst keeping the model efficient offshore and enabling a best of both worlds approach (e.g. Bunney and Saulter" 2016). So I would recommend that the authors try to address these aspects of the paper with appropriate references in both Sections 1 and 6.

*** Thanks for pointing to these aspects. We will include these in the discussion and may be also in the introduction. ***

SPECIFIC COMMENTS

Paragraphs at line 44 and 48. I think this discussion could be a bit more expansive? The authors have followed through the practical viewpoint where the wave model is scaled to the NWP and then resolution is increased if there is spare resource. This is a quite standard 'in practise' way of working, but as a motivating point it would be good if the authors could expand on what scales they believe are required for an idealised/ pragmatic wave forecasting system that dealt with both coastal and offshore areas of the region.

*** We do not believe that there is one simple model setup, performing well both for offshore and coastal conditions. One has to resort to nested configurations, unstructured mesh, or subgrid-scale representations. We will expand the discussion to include these aspects. ***

Sentence at line 64. I'm not convinced that the ensemble vs resolution increase argument is generic, rather it depends on where the model is being used and how end-users will deal with the resulting products. So I think it would be better to contextualise this argument to the situation in question - a wind-wave dominated regional sea with a mixture of offshore and coastal regimes.

*** We do not quite understand this point. At line 64 we mention two ways to spend additional computer resources: ensembles or increased resolution. We do not bring forward any arguments or analysis at this point. ***

Sentence at line 112. I'm not convinced the information about the spin-up is that useful.

*** In that case we will remove it ***

Paragraph at line 117. Around here would be an excellent place to add further detail regarding the NWP forcing.

*** We will add info on wind resolution to table 2. ***

Paragraphs at lines 247 and 255. The dependencies of RMSE/bias on SWH are to be expected when matching up deterministic forecasts since small timing errors in the

predicted wave time-series will have larger impacts on the model-observation match-up in the upper percentiles of the SWH pdf than in the lower percentiles.

*** Yes, we will do a remark on this. ***

Section 6.1. It would be useful to state the resolution of the NWP systems underpinning Tuomi et al.'s wave models.

*** We will do so ***

Section 6. For completeness it would be worth discussing the spread-skill characteristics of the LOWENS system. At the sort of short forecast ranges discussed, these systems are usually under-spread and it would be useful to know if this is also the case here (and if not, why not?). The ability of the ensemble to properly generate spread provides the difference between running a system that provides some improvements to forecast verification vs a deterministic model through a partial sampling of forecast uncertainty, and one that genuinely samples the likely observed outcomes.

*** We will show rank histograms and discuss these. An example of rank histogram is shown in Fig 1. ***

Section 6. This would be a good place to talk through the computational limits placed by using a regular grid scheme in this region and some of the other modelling options that might allow some best of both worlds solution to be achieved in future. Its fair to say that in supercomputing terms a resource increase of order 3-10 times might be the maximum expected over 1 or 2 new systems, so the problem highlighted here is important.

*** We think we have already replied to the issues of nested domains, unstructured grids etc. above. ***

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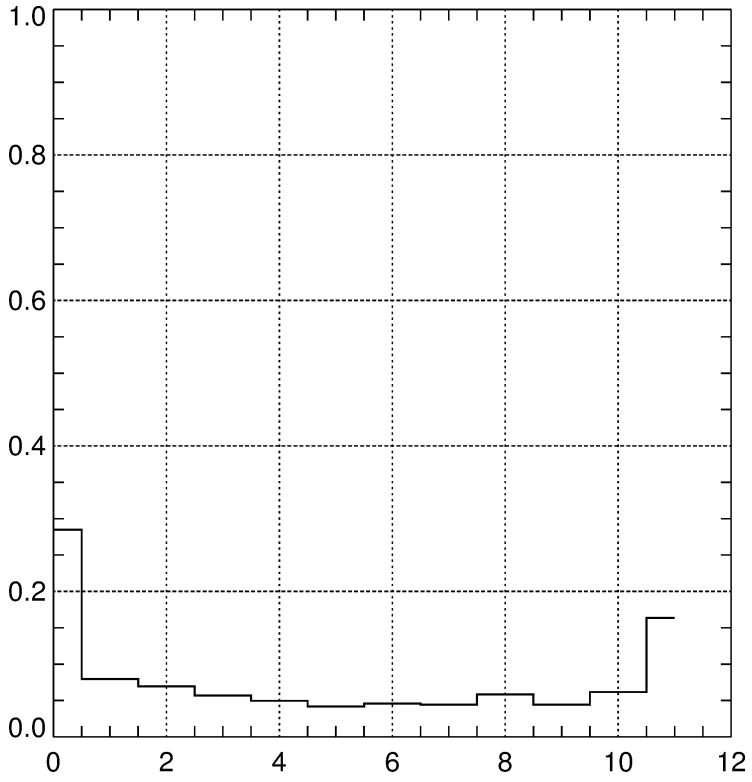

Fig. 1. Histogram over the rank of the SWH observation relative to the ensemble members. Darss Sill, 48 hr forecast time.