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Ocean Science Discussions

Interactive comment on "An approach to the verification of high-resolution ocean models using spatial methods" *by* Ric Crocker et al.

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RC – Referee Comment AC – Author Comment MC – Manuscript change

RC - The paper untitled "An approach to the verification of high-resolution ocean models using spatial methods" described a really interesting method to quantify benefit from high resolution model. The paper describes in detail methodology and apply it to compare two ocean circulation forecast models on the Nordic Sea. Scientific results obtain comparing the two forecast system are poorly commented and explained but this scientific analysis is not the main topic of the paper, which is really dedicated to the description, implementation of this methodology that was not already applied for ocean forecast. That could be frustrating for readers, authors can certainly add analy-

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sis of some results, some suggestions are provided below. Nevertheless, the paper is clear and objectives are well presented and I recommend the publication of this paper if authors take into account few following remarks and comments.

AC – We thank the reviewer for their time and expertise in reviewing the manuscript. Below are our responses which we hope address the points raised along with changes made to the original manuscript.

RC - 1. Section 2, Figure 1 : this figure presents the domain and the difference of coastline between the two models. Difference of coastline is an important point discussed also latter in the paper and illustrated on fig 4. To be really interesting, I recommend to highlight the differences between the two SST fields on this figure. A more contrasted color bar, for example, can highlight difference of spatial scale, intensity of SST fronts...which are the main reasons to apply the HiRA method in this context.

AC – Agreed. We looked at several different colour palettes which were also colour blind friendly and replotted. In addition, some bathymetry contours were added to address a comment from reviewer 2

MC – New colour scheme used, and bathymetry contours added.

RC - 2. Section 3, line 187. Reference to WMO manual is useful but Authors should explained that this guide refers to Atmosphere and that ocean scales are really different. In this paragraph specificities of ocean should be described as difference of scale de-pending of the areas, open ocean vs shelf, rossby radius...This is briefly discussed later in the section (line 245) but it should appear before in the introduction of the method to justify to use it for ocean application.

AC – Thank you, the WMO reference was indeed only atmospheric, tying in the original justification and application of this method when it was applied to the atmosphere. As such we have expanded the original section to refer to ocean specific characteristics, as well as a brief addition to the introduction.

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MC –" A similar principle applies to the ocean, i.e. observations can represent an area around the nominal observation location, though the representative scales are likely to be very different from in the atmosphere. The representative scale for an observation will also depend on local characteristics of the area, for example whether the observation is on the shelf, or in open ocean or likely to be impacted by river discharge."

RC -3. Section 3, fig 3 and 4. Figure 3 and 4 are useful to understand the method and the neighbourhood concept. But it could be really useful to have, on these figures or with a new figure, a clear description (with an example) of how is computed the probability/density function especially in the coastal cases, how the observations are selected in a neighbourhood, where the coastline is different between the two models and when observations are removed from the statistics. A schematic view of this process should be really useful to understand easily some non-intuitive results as for example why there is less observation in a larger domain.

AC – We have added a schematic showing how the neighbourhood points contribute to generating a pdf. We have also expanded the description of how missing points are handled within the text.

MC – added as figure 4

RC - 4. Section 4, line 290. I suggest to use zonal and meridional instead of horizontal and vertical

AC – Accepted

MC – Changed to zonal and meridional

RC - 5. Section 4, figure 4. Unclear or a mistake in the legend. Why a) is 7x7 neighbourhood (NB4) and b) NB5? Comparison should be done between similar neighbourhood.

AC – The idea we were trying to convey was that due to the forecast grids, the kilo-

metre size of neighbourhoods becomes increasingly incorrect as the neighbourhood becomes bigger if simply assuming that multiplying 1.5 km or 7 km are accurate measures of the total size (instead of using the true grid resolution in degrees). Coupled with that is the fact that the model resolution is different in latitudinal and longitudinal directions.

MC – We have separated out and expanded the table describing the neighbourhoods to indicate why a 25x25 AMM15 is more suitable to match to 7x7 AMM7 than the 33x33 AMM15. Also modified the caption to figure 4.

RC -6. Section 5 and 6, fig 5, 7, 9, 10. It's really difficult to identify differences between each line, probably too much lines on the same figures or more important line should be highlighted (in bold or with darker color?) NB1 and NB2 are the more important, is really difficult to distinguished them especially on fig7,9,10. Uncertainty, computed for each line, is difficult to associated to the right line. Is it useful to have the "1" line for AMM15, there is no comparison with AMM7? It's also difficult on these figures to have clear relationship between the uncertainty vertical bar and the difference bar. It will be useful to have on the figure or in a table the information where the difference bars are smaller than the uncertainty. This is discussed in the text (paragraph line 420) but it is difficult to verify what is described on the figures.

AC – Agreed. We felt there was a balance to strike between showing how the scores change with neighbourhood size and the ability to see detail of the actual results. The "1" is important in this case as it shows the default result we would get if HiRA were not being used. However we have tried to make the plots clearer whilst retaining that information.

MC - In order to clarify the plots we have removed some of the larger neighbourhoods from figures 5, 9 and 10. In addition on figure 7 the main lines have been made bold. In order to help with identifying where difference bars are less than the uncertainty, an S has been added over the difference bars where the 95% uncertainly error bars of the

two equivalent lines do not overlap.

RC -7. Section 5. Discussion on the different results obtained on-shelf and off-shelf is really interesting, but in the paper it appears as a mix between feasibility and useful methodology to compare several forecasts and a clear difference due to dynamics, physical ocean process and seasonal cycle. I suggest adding more quantitative information concerning the impact of the number of observation to compute robust statistics. The sentence (line 460) explains that the model are better to forecast open ocean, but is there any impact of the number of observation in the statistics? Do you compute statistics with the same number of observations in the two domain (off-shelf and on-shelf)? Fig 12 and 13 seems to exhibit larger uncertainty in the statistic on-shelf in comparison to off-shelf. On fig 12 and 13, it's clear that main differences between the two models appears in summer. That's not really discussed in the paper, is there clear explanation, is it due to physical seasonal processes or mainly due to the number of observations?

AC – The aim of this paper was to show how the HiRA technique could be used to tease out interesting detail of the model forecasts which could then be a basis for investigation in the future. Notably in this case the apparent seasonal signal. Figure 14 indicates the numbers of observations going into the two domains, and hence the fact that this is a potential source of error. However with the underlying characteristics of the domains being different, it is quite likely that the spatial distribution of observations within the domains is as important as the number of observations. Again, as this was meant to be an investigation of the potential for the verification technique rather than a full model assessment, we did not dig further into the detail of this, but do think it is an important consideration when assessing any results produced using HiRA

RC -8. Section 5, line 479. Conclusion of this paragraph is not clear. What do you really mean by "closer look at the data"?

AC – Essentially breaking the data down and identifying underlying specific parts of the

data which may be contributing to the results counter to the general trend, and which are masked by aggregating.

MC – Edited the text to “therefore a deeper look at the data is required to assess whether this signal is consistent within shorter time periods, or whether there are underlying periods contributing significant and contrasting results to the whole-period aggregate. “

RC -9. Section 5, line 508. Last sentence concludes on differences at NB2 scale, could you add comment on this conclusion about significance and robustness of this result.

AC – Yes, as you indicate the statement is too strong given the error bars presented. We have highlighted that aspect (indicating that the error bars cross, so whilst we cannot say that the difference is significant, we cannot, with the plot provided, say they are not.) And giving suggestions as how to improve this.

MC – “At the NB2 scale, the AMM15 potentially demonstrates more benefit than AMM7 except for April and May, where the two show similar results. There is a balance to be struck in this conclusion as the differences between the two models are rarely greater than the 95% error bars. This in itself does not mean that the results are not significant. However, care should be taken when interpreting such a result as a statistical conclusion rather than broad guidance as to model performance. Attempts to reduce the error bar size, such as increasing the number of observations, or number of times within the period would aid this interpretation.”

RC -10. Section 5, fig 14. On this figure lack of observations seems to appear end of May and in the text (line 487) authors indicate that missing data are in April.

AC – The text was incorrect, there was a reduction in observations during May due to issues with the observation extraction from CMEMS. Additionally, there was a forecast reduction in April (due to separate technical issues) not indicated by the plot.

MC – The text is now correct and additionally refers to the missing forecast period.

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