Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2020-190-AC2, 2020

Natural Hazards and Earth System Sciences
Discussions
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Interactive comment on "Wave height return periods from combined measurement–model data: A Baltic Sea case study" *by* Jan-Victor Björkqvist et al.

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Received and published: 22 September 2020

R2: The manuscript that the authors presented is overall well written and discuss an interesting and imported issue of how to compare and combine model and observational data. Further the authors use this new combined dataset to investigate return values of extreme significant wave heights in the northern Baltic Sea. I generally recommend this manuscript for publication after minor revision, I would like to encourage the authors to address the following comments.

Our response: Thank you for taking the time to review our manuscript. It is greatly appreciated. We have answered your questions and comments below.

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Discussion paper

R2: Comments on the homogeneity of the new combined datasets.

The authors stated that they construct a time series of two hindcast simulation and one observational dataset. To account for the different variability in the datasets they using a low pass filter for the observation and adding variability to the model data. They analyse and discuss the different methods and the results. I would suggest that combining datasets from different hindcasts, with different atmospheric forcing and different temporal resolution should lead to some inhomogeneity. The authors stated that there is some kind of trade-off between homogeneity and preserving the "true" wave field when merging observations and model data. The manuscript would benefit to also discuss possible effects of combining different models datasets to the analysis of extreme values.

Our response: We acknowledge that using two different data sets is not ideal. Our original thought was to use the SWAN data set (1965-2005), and only fill up the five years (2006-2010) with the WAM data set. Nonetheless, we chose to also repeat the calculations with using WAM as the primary models since it quantifies (although not perfectly) the effects of the temporal resolution of the wind forcing, the differences between the models (different physical parameterizations), and data inhomogenities.

Using SWAN as the primary model is not expected to suffer fatally from inhomogenities between model data, since WAM is only used for five years. The differences between the data sets might therefore also be as much due to the difference in model data (even if both models hypothetically would cover the period up to 2010), as to the inhomogenities caused by combining two different data sets. We will add a discussion about this issue to the revised manuscript.

R2: If correctly understand, the two data series marked with WAM and SWAN only differ between the period 1979-2010 (30 out of 55 years). On one hand, the results of the return period differ quite a bit (especially using the GEV), on the other hand, some results seem to have almost no difference. Is there any explanation of these different outcomes? Could it be the one model dominates the distribution?

Our response: 30 out of 55 years is over half of the time, so the difference is expected to be clearly visible if differences between the model data exists in the first place. We think that the most important aspect here is how the modelled extremes compare to the measured extremes. In essence, the modelled extremes are typically slightly lower in the SWAN data (see Fig. 3c), meaning that the measured maximum is more of an outlier when viewed against SWAN data (compared to if it's viewed against the WAM data).

Your observation that the GEV results differ most is important. The reason behind this is that the more parameters we have, the more risk we have of "over fitting". The curvature of the GEV distribution is determined mostly by the lower annual maxima (simply because there are more of them). A small change of the curvature can mean a large difference at the tail, where the observed maxima exists. The more exactly we fit the data (i.e. using more parameters), the more certain we have to be that the data is both reliable and homogenious. We might conclude, that if there is issues with data homogenity, the GEV/GDP distribution should be avoided because of the risks mentioned above. We will mention this in the revised manuscript.

R2: Technical comments

There is a discrepancy between the time series plotted in Figure 5, the text in section 4.2 and the colour coding in Figure 6. Whereas it is described and visible in Figure 5 that the model overestimates the observations, the coloured squares in Figure 6 indicate higher wave height for the observations (orange (8-9m) square over yellow (7-8m) area).

Our response: The discrepancy is because the time series in Fig. 5 is the original WAM-HARMONIE hindcast. The maximum wave heights in Fig. 6, again, are taken from the calibrated WAM-HARMONIE hindcast (the calibration is mentioned in the manuscript on page 12, lines 2-4). The caption in Fig. 6 mentions that is uses the calibrated hindcast, but we will add information to the caption of Fig. 4 that this is the uncalibrated hindcast.

We acknowledge that it can be slightly confusing for the reader, but Fig. 5 is meant to show the performance of the model (and motivate the need for a calibration), while Fig. 6 is meant to show the best possible estimate of the spatially distributed significant wave height. We therefore feel that the both figures are well motivated in their current form.

R2: Also, it is stated that large parts of the Bothnian Sea show a significant wave height above 8m, but the orange to red area in Figure 6 is about a third to a quarter of the Bothnian Sea area. On the other hand, it is stated that the maximum in the Bothnian Bay is above 6m, which is confirmed by the image.

Our response: This is a language mistake. We meant to communicate that the area where 8 m was exceeded is not small. We will correct the sentence to:

"Fig. 6 shows that the significant wave height exceeded 8 m in a wide area south of the Bothnian Sea wave buoy, even reaching 9 m in the southernmost part of the basin."

R2: The titles of the four panels in Figure 7 show two times "SWAN-X2" and two times"SWAN-filtered". If this is correct it is at least confusing for the reader as I would expect filtered vs X2 and annual maxima vs POT. Also it is not mentioned which buoy is represented in the Figure 7, Bothnian Sea buoy or Finngrundet buoy.

Our response: This is correct, since we use annual maxima and POT for both the filtered and the X2 data, thus resulting in four different data sets. This means that for a AM vs. POT comparison we can compare the left column to the right column, and for a X2 vs filtered comparison we can compare the top row to the bottom row. We agree that having several data sets makes it more difficult for the reader, but we felt it was necessary to present the different options because of the significant differences different methods had on the results. We tried to alleviate the possible confusion to consistently use crosses (x) for data with variability and circles (o) for data points without variability. Unfortunately, we found no way to simplify this further without removing essential information.

We will add the information that Fig. 7 shows data from from Bothnian Sea wave buoy.

R2: Finally, probably ":5(216)" are missing at the end of the DOI for reference Forristall et al. 1994, DOI https://doi.org/10.1061/(ASCE)0733-950X(1996)122:5(216)

Our response: Thank you for pointing this out. We will correct it.

NB

Dr Jani Särkkä informed us, that while the ERA-Interim had a resolution of 3 hours, the downscaled product actually had a temporal resolution of 1 hours. Nonetheless, it is evident from the spectra in Fig. 2 that the WAM data doesn't capture the same temporal scales as WAM forced with a wind forcing with a native temporal resolution of 1 hour (compared to Fig. 5.1, page 39 in Björkqvist, 2020). We will correct this to the text and amend the discussion to reflect what we stated above.

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