# Response to review comments from Referee #1 to the manuscript “Swell hindcast statistics for the Baltic Sea” (OS-2021-62)

Jan-Victor Björkqvist et al., 25.10.2021

The referee comments are marked in blue italics, while our responses are in normal font.

*I appreciate the efforts of the authors to improve the manuscript and to adequately respond to the comments and suggestions by all three referees.*
*There are still a couple of issues that need attention plus a few mostly technical aspects and typos.*

**Our response:** Thank you for following up and reviewing the updated version of the manuscript. Please find our comments to the suggestions below.

*Issues that may affect the content:*

*Line 138: It would be definitely correct to say that the largest swell HEIGHTS were expected at the eastern coastlines; however, the outcome that the highest swell WEIGHTS are also there is quite unexpected – at least to my eyes. This result to a large extent relies on the difference of translation speed of cyclones in this area. This is one of the main conclusions of the work and is explained much later in the manuscript.*

**Our response:** You are right that we probably drew too quick conclusions here. The stated fact does require some additional explanation. Since this is in the results section, and the entire mention is not central, breaking up the flow of the text with a detailed analysis is probably not a good trade off. We have therefore simply dropped this claim altogether, with the two sentences now reading:

*“In the Baltic Proper the highest swell weights were along the eastern coastlines. Nonetheless, also a short coastal section in southeastern Gotland had mean swell weights exceeding 0.6.”*

This now connects the two relevant pieces of information in two following sentences instead of separating them with a long “parenthetical” statement.

*Line 173–174: To my eyes, the use of “erratic statistics” is misleading here. The image shows mismatch between the two data sets and a two-peak structure of one of these. Also, probably it is meant that the cases shown on the image are from two (or more) different populations with possibly different distributions. Finally, please adjust “a results”.*

**Our response:** Thank you for pointing this out. We have reformulated this sentence and it now reads

*“The distribution at Kalajoki (f) in the Bay of Bothnia forms an exception, which we surmise is because the ice-cover changes the fetch geometry; the data are thus essentially not from a single population.“*

We have removed the mention that it is near a sandy beach, since it is not relevant. The relevant part is that it is located in the Bay of Bothnia (because of the ice-cover).

*Lines 192–193: the sentence "The negative correlation of the open-sea areas were indicative of decaying winds turning existing wind-sea into swell in a zero-sum fashion" is cryptic, grammatically incorrect ("were") and conceptually inexact. The negative correlation may also stem from rapid changes in the wind direction (see Eq. (2)). In other words, it may be associated (at least to some extent) with small size of high-latitude cyclones. The windsea doesn't turn into swell, it is just interpreted as swell based on Eq. (2). It is done so that the total energy of the wave system remains constant. "Zero-sum" is simply wrong in this context as only the partitioning changes.*

**Our response:** We have added the mention that it might also be caused by turning winds (i.e. decaying projected wind speeds). The new sentence (which also addresses the other parts of your comment) now reads:

*"The negative correlation of the open-sea areas was indicative of decaying or turning winds that caused existing wind-sea to be reclassified as swell."*

*Lines 254 and 256: It is incorrect to only mention erosion as swell waves are one of the major drivers of beach recovery after strong impact of windseas. Please use: entrainment, transport, motion, or even all three aspects.*

**Our response:** We have changed this to the more general *"sediment transport".*

*Line 257: As there seems to be no large difference between swell and windsea properties, I strongly recommend adding an explanation, such as "Therefore, differently from the situation in the World Ocean, the partitioning [of wave field into swell and windseas] has limited physical significance in the context of coastal processes."*

**Our response:** Thank you for this comment that gave us the chance to sharpen this part of the manuscript. We have reformulated this part of the manuscript and it now reads:

*"In our results swell was dominant roughly 70 % of time in long nearshore areas. The mean swell periods were typically short, being comparable to those of the mean wind wave periods, and the wind wave heights can exceed the swell wave heights near the shore. Therefore, the physical significance of swell partitioning for coastal processes in the Baltic Sea is limited compared to the World Ocean. Nonetheless, the positive correlation between wind-sea and swell waves in coastal areas poses a challenge for quantifying wave–seabed interaction, especially if waves are estimated using simple relationships of wind speed and fetch (e.g. Isæus, 2004). These considerations – together with the challenges posed by coastal archipelagos (Björkqvist et al., 2019) – means that further studies into wave–bottom interactions in the Baltic Sea are needed."*

*Line 279: the word "spurious" is incorrect. Windseas rapidly fill with some energy the entire directional spectrum of wave components, and some of them fall inevitably into the category of swell owing to Eq. (2). Therefore, after a few steps of running WAM with any input*

*nonzero wind field you will see non-zero swell height at every grid point. This is an intrinsic property of Hasselmann's equation.*

**Our response:** We disagree on this point. In the numerical wave models a large part of the spectra can be (practically) 0. This is in part because of the way the wind-input source term is defined (being quasi-linear with respect to the spectral energy), and probably because the weakly non-linear four-wave interactions are calculated using an approximation of discrete interactions (DIA).

In Figure 1 below we show an example spectrum. The spectrum is unrelated to the wave modelling of this paper, but illustrates this very general point. The spectrum is taken outside of the Norwegian coast from a 3 km WAM wave model run (the data has been transformed into the format for WAVEWATCH III, hence the file and variable names). This spectrum was chosen because it was readily available in binary format.

The figure clearly shows that the entire spectrum is not filled with energy, since there is a remarkable difference between the max values (over 40) and the minimum values (order 10^-16). The logarithmic color scale on the right also illustrates that the very low spectral density is not an isolated point, but covers a large part of the spectrum. There therefore exists no "background" values for the entire spectrum that would result in quantifiable swell height in a general sense. The swell heights that are seen e.g. in Figure 2 of the manuscript around 22 Dec 18:00 are caused by something other than a type of energy filling the entire spectrum that was described in your comment. This is also evident from Figure 2 in another way, since there is a visible increase in the swell heights in the middle of the growth stage: a significant amount of background energy to cause measurable swell weights would be present constantly.

The small, but measurable, swell heights that we sometimes observed in the growth stage were not caused by a constant background noise. Rather, they sometimes appear in an unexpected fashion because the swell partitioning algorithm flags a small amount of the non-zero part of the spectrum as swell, even though no swell is reasonably expected in these kinds of growth situations. This can, for all reasonable intents and purposes, be denoted as "spurious", and we therefore stand by our choice of word in this context.

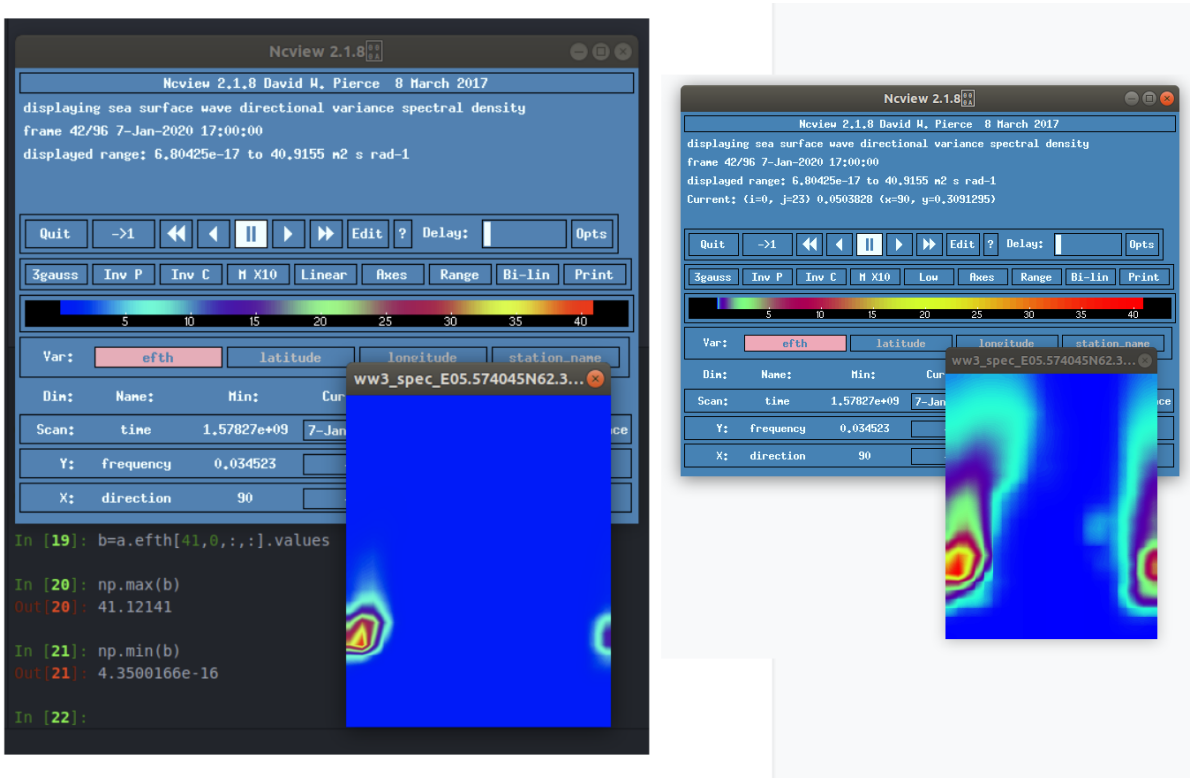


**Fig. 1** *An example spectrum that shows that the spectral density can be zero in large parts of the spectrum. Left shows the spectrum in a linear color scale, while right shows the same spectrum in a logarithmic color scale.*

*Technical details*
*The last line of Abstract: I recommend to explicitly incorporate the point that in many occasions the wave system that is considered as swell arrives with a delay after the storm has already moved further.*

**Our response:** This seems like a good idea. We have added the following sentence to the end of the abstract:

*"Namely, the highest swell typically arrives with a roughly 10 hour delay after the low-pressure system has already passed."*

*Line 135: better say "low values" or "low estimates" rather than "low numbers".*

**Our response:** This has now been corrected to "low values"

*Line 145: It is recommended to mention that swell heights are much lower in summer than in winter; just to make clear that the formal predominance of swell-dominated conditions does not mean more swell energy in summer than in winter.*

**Our response:** We have added a mention of this at the end of the paragraph:

*"We note that the higher swell weights during the summer are not indicative of higher absolute swell heights, as evident from Sect. 3.1 (Fig. 1)"*

*Line 165: use "Bay of Gdańsk", "Gdańsk Bay" or "Gulf of Gdańsk" (all three versions are in circulation) but capitalize "Bay/Gulf".*

**Our response:** Thank you for bringing this to our attention. This has now been corrected to "Bay of Gdańsk".

*Line 167: it is recommended to mention that [longer] swell waves are usually refracted more intensively in shallow coastal areas than [shorter] windseas. The use of simply "refracted" carries no information.*

**Our response:** Indeed. We have edited this part of the manuscript and it now reads:

*"Typical swell periods in the Baltic Sea are short (see Sec. 3.4), but they are still, on average, longer than the wind-sea. The relatively shallow coastal areas therefore refract swell waves more strongly compared to wind-sea waves."*

*Lines 168–169: The use of "divergence area" could lead to misinterpretation as divergence has clear physical meaning. In essence, there is no clearly defined average swell direction in this area.*

**Our response:** Thank you for pointing this out. This has been modified to:

*"In the Bothnian Sea the averaged swell directions were towards the coast, with the averaged direction not being clearly defined in the middle of the basin - a pattern already identified by Semedo et al. (2014)."*

*Line 171: please adjust "misalignment … are".*

**Our response:** This has been corrected to:

*"The misalignment between the swell direction and the wind direction is roughly similar for all the six locations [...]"*

*Table 1: empty dimensions (-) of the dimensionless W_S could be removed.*

**Our response:** We note that the similar notation is used in Figure 3. We prefer to explicitly state the empty dimensions. Nonetheless, we didn't find any stated preference in the journal's submissions guidelines for mathematical notation and terminology. We therefore keep this as is for now, but are ready to change the notation based on the recommendation of the editor or production staff.

*Line 176: adjust "follow".*

**Our response:** This has been corrected to *"follows".*

*Line 202: wind direction may also turn near the shore (as wind systems usually have a tendency to be shore-aligned), and the use of Eq. (2) results a larger share of swell.*

**Our response:** This is indeed true. We now mention this possibility and the sentence reads:

*"These longer waves are generated by the same weather system, but because the wind decays or turns closer to the coast, they are classified as swell near the shoreline."*

*Line 207: adjust "structures offers".*

**Our response:** This has now been corrected to *"structures offer".*

*Line 208: The sentence "The coastal locations are more heavily and constantly tainted by swell …" may create a feeling that swell is very heavy in some nearshore locations of the Baltic Sea. Even though, technically, the claim is correct, I suggest to reformulate the sentence to avoid misinterpretation.*

**Our response:** This has been reformulated to:

*"The coastal locations have a more persistent swell, while in the open-sea areas swell conditions are typical during the decay stage of events, leaving the growth stage free for undisturbed interaction studies."*

*Line 212: add "or wind direction turns"; see comment to line 202.*

**Our response:** We have now corrected this sentence to:

*"Namely, locally generated wind waves turn in to swell when the wind speed decays or the wind turns."*

*Line 217: adjust "duration … were".*

**Our response:** This has now been corrected to *"duration […] was"*

*Line 220: it is correct to say "the origin"; however, the wording might additionally include an expression like "alternatively, the reason why" or similar.*

**Our response:** We are slightly unsure about what is exactly meant by this comment. Since the reason for the different origin is already elaborated on in the following sentence, we decided to keep the wording here as it is.

*Line 223: it is recommended to speak about "relocation speed" or similar, to make clear difference from wind speed.*

**Our response:** We have changed this to *"translation speed".*

*Line 227: see comment to Line 223.*

**Our response:** This has also been corrected to *"translation speed".*

*Line 228 The expression "These simple calculations are in the same order …" does not make sense. Please consider saying "These simple calculations suggest the delay time that is …" or similar.*

**Our response:** Thank you for pointing this out. The sentence has now been corrected to:

*"The delay times estimated by these simple calculations are thus in the same order as the dominant 7 h and 11 h time lags found for the two coastal locations[...]"*

*Lines 242–243: similarly to the comment to Line 145: it is recommended to mention that swell heights are much lower in summer than in winter; just to make clear that the formal predominance of swell-dominated conditions does not mean more swell energy in summer than in winter.*

**Our response:** This has been modified to:

*"The swell weights in the Baltic Sea during the summer months are slightly higher than during the winter (vice versa is true for the actual swell heights), which is also the case for the North Sea and the Norwegian Sea (Semedo et al. 2015)."*

*Line 250: adjust "part" (parts?).*

**Our response:** This has been corrected to *"parts"*

*General remark: both "e.g." and "e.g.," are used.*

**Our response:** We have edited the manuscript to use *"e.g."* consistently.

*Line 276: please add that Eq. (2) also takes into account the difference in wind and wave directions.*

**Our response:** This has been amended to:

*"Classifying swell is not straightforward. We used the simplest ECMWF partitioning that only separates the wave field into wind-sea and swell based on the wave age of each wave component, also accounting for the components direction relative to the wind."*

*Line 285: adjust "artefacts … was".*

**Our response:** Corrected to *"artefacts [...] were"*

*Line 299: under "single" probably "simple" or "straightforward" or "universal" was meant.*

**Our response:** Thank you. What we meant was *"universal"* and this has been corrected to the manuscript.

*Line 312: also the difference between wind and wave direction was taken into account.*

**Our response:** The sentence has been modified to:

*“The partitioning scheme used a typical criteria based on the wave phase speed and wave direction relative to the wind (see Eq. 2).”*