

## ***Interactive comment on “Spatio-temporal structure of Baltic free sea level oscillations in barotropic and baroclinic conditions from hydrodynamic modelling” by Eugeny A. Zakharchuk et al.***

**Anonymous Referee #1**

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This is an interesting piece of research that sheds more light on the properties of barotropic and baroclinic self-oscillations of the Baltic Sea using a contemporary 3D ocean model and standard means of decomposition of velocity fields and sea level time series into Fourier components.

The description of the background and the research problem is professional. I would only recommend to (i) include reference to a generic overview of physical oceanography of the Baltic Sea (Leppäranta and Myrberg, 2009) already in the Introduction, (ii) mention an early but deep and still actual overview of the problem [Samuelsson,

C1

M., Stigebrandt, A. Main characteristics of the long-term sea level variability in the Baltic Sea. *Tellus A*, 48(5), 672–683, doi: 10.1034/j.1600-0870.1996.t01-4-00006.x, 1996], and (iii) discuss the results for the baroclinic calculations, if applicable, in the light of some recent advances towards better understanding of low-frequency baroclinic oscillations of the Baltic Sea [Kurkin, A. et al. Spatial distribution of energy of subinertial baroclinic motions in the Baltic Sea, *Frontiers in Earth Science*, 8, 184, doi: 10.3389/feart.2020.00184, 2020], with recommended focus on material on lines 398–407.

The hydrodynamic model INMOM is professional and up-to-date (although not much used as the input for international research publications). The idea is to spin up the system for a certain time interval under the impact of a strong atmospheric forcing, and then let the system run at its own, with the goal to detect the maximum number of self-oscillations over two years. To do so, the authors implement several simplifications that are not fully realistic but eventually help to detect various kinds of self-oscillations. In essence, the system of detected oscillations should be invariant with respect to the initial disturbance; however, this feature should be at least shortly discussed (and at best with some supporting evidence from other parts of the World). Also, in this context it would be important to explain why in both the barotropic and baroclinic implementations, the Baltic Sea was considered a fully enclosed basin, with no water exchange with the North Sea as stated on lines 175–177. It is also important to comment shortly on possible differences with runs that would resolve water exchange between the North and Baltic Sea. Also, it remains unclear whether river water input and ice conditions were also neglected in both the barotropic and baroclinic implementations (line 177).

On lines 182–183 it is said that “Setting the turbulent viscosity to zero for the vertical components and to the minimum values for the horizontal components allows the damping of the simulated sea level fluctuations to be reduced.” Please comment whether you did so and, if yes, how the modelled spectra relate to the actual spectra of motions. Again, I guess, the results are qualitatively invariant with respect to the par-

C2

ticular set of settings, and stronger damping would simply render some self-oscillation patterns undetectable.

The text is written in good English, with a few minor items to adjust. I recommend the manuscript for publication with minor and fairly straightforward revisions along the recommendations above and below.

Minor aspects to adjust:

Line 29: “may resonate” would be more exact.

Lines 30–31: The source “Kulikov and Medvedev, 2013” addresses generic spectrum of water level in the Baltic Sea and seems inappropriate in the context of this particular claim.

Lines 37–39: For the benefit of readers I recommend to include also a reference to (Leppäranta and Myrberg, 2009). The provided references are correct but they are not easily accessible today, and some of them are written in German or Russian.

Line 41: “a 39 h period”.

Line 42: must be “Neumann”.

Line 60 and elsewhere: I recommend using “Baltic proper” as this is not a proper name.

Lines 87–88: it is recommended to say already here that the model uses sigma-coordinates in vertical. Line 104: better say “with a spatial resolution of 2 nautical miles” or similar, and indicate the resolution also in kilometers (cf. line 115).

Line 113: capitalize: “HIROMB”.

Lines 116, 187: capitalize: “ERA”.

Lines 133–134: remove repeating information “and includes the station coordinates, sea level measurement frequency, number of sea level measurements used in this study, and percentage of missing data” that is found in the table caption.

C3

Line 138, Table 1: (i) remove the column “Period” and mention this interval in the caption; (ii) use “measurement interval/frequency” or similar instead of “span”.

Line 143: better say “standard statistical parameters”.

Line 144: define SSH for the reader.

Line 144: obviously “ratio” is meant for  $\sigma_p$ .

Line 145: the additional criteria of accuracy  $P_m$  is not defined but still used below (e.g., on line 166). Lines 146–157: please punctuate the text in formulas as part of the sentences.

Lines 152–154: I don’t think it makes sense to show the basic formulas (3)–(5) in a research paper of this type.

Line 166: please check the format the expression “ $P_m < 0.674\sigma_t g$ ”.

Line 171: “again” is redundant.

Line 175: should be “exchange”.

Line 199: the expression “ $k=0,1,2,\dots$ ” should be removed as the role of  $k$  becomes evident from the expression for  $f(t)$ ; also, the definition of angular frequency would be better placed in line with the rest of the text.

Line 201: please check the format  $a_k$ .

Line 202: “mean average” and “coefficient number” sound strange.

Line 203: please check the format  $F_k$  and  $A_k$ .

Line 203: should be Equation (8).

Lines 207, 211: why period is now  $P$ ? Does it have a specific meaning?

Lines 208–214: please punctuate the text in formulas as part of the sentences and check the format of variables in the text.

C4

Line 220: the words “are low and” are redundant.

Line 222: “principally” is redundant.

Line 229: The standard deviation appears now as ( $\sigma_m$ ); please redefine or unify with the usage above.

Line 232, 234: please show “Hailuoto Island, Ulvö Deep” etc. on some map.

Line 310: should be “Leppäranta and Myrberg, 2009.”

Line 311–312: include the classic expression for the long wave speed into the text. There is no need for a displayed equation.

Line 322: probably “phenomena” or similar are meant (instead of “observations”).

Line 336: show Narva Bay and Ellesmere Island on some map.

Line 349: “the pycnocline”.

Line 350: say “barotropic oscillations”.

Line 351: simply “broaden”.

Line 360: show Vyborg Bay on some map.

Line 378: include the classic expression for the long wave speed into the text also here. There is no need for a displayed equation.

Line 380, Figure 13: say “Number of cases” in the legend (2×).

Lines 386–387: say simply “we estimated the phase speed ...”.

Line 413, Figure 15: say “Number of cases” in the legend (2×).

Line 416: remove “estimated by (Eq. 13)”.

Line 423, the expression “the maximum dispersion of free oscillations occurs” seems to contain too much cryptic jargon. Consider saying: “the most intense free oscillations

C5

occur” or similar.

Line 429: consider replacing “moves to” by “is located in”.

Line 436, 474, 475: it is recommended to use the long expression instead of PSW and GW in this sort of discussion as some readers may omit the body part of the paper.

Line 445: use “the local”.

Line 464: should be (Nekrasov, 1975).

Line 504: (Fischer and Matthäus, 1996; Matthäus, 2006) missing from the reference list; also, should be : (Fischer and Matthäus, 1996; Matthäus, 2006).

Lines 521–522: please put the claim into more clear connection with the properties of barotropic oscillations.

Line 523: consider replacing “at the top” by some other expression.

Line 532: “may represent” seems to be more accurate.

References: (i) most doi indices are missing; please amend; (ii) the style of most references does not follow the Ocean Science style.

Line 606: should be “Longuet-“.

Line 608: the title should be capitalized according to German style: “Spektren der Wasserstandsschwankungen der Ostsee im Jahre 1958”.

Line 618: should be “Suursaar”.

Line 632: delete most of the reference and leave only: “Wilson B. W. Seiches. *Advances in Hydroscience*, 8, 1–89, 1972.”

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C6