Ocean Science Discussions

Ocean Sci. Discuss., author comment AC2
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Reply on RC2

Taavi Liblik et al.

Author comment on "Quasi-steady circulation regimes in the Baltic Sea" by Taavi Liblik et al., Ocean Sci. Discuss., https://doi.org/10.5194/os-2021-123-AC2, 2022

Dear Mr/Ms

We thank you for your time and constructive comments! Please find our responses, actions below.

Best Regards,

Taavi Liblik

The submitted manuscript describes the ocean circulation patterns observed in the Baltic Proper in 2020 and the forcing mechanisms behind them. The authors use extensive set of new observational data from moored instruments (two current meters plus one CTD recorder), 2 glider missions, one Argo float, several CTD profiles and back them with the numerical model results and atmospheric reanalysis data.

General comments

The major concern in this kind of study is whether the data collected in a restricted area can be representative for a larger region, such is the Baltic Proper in this case. By using the model results and a long Argo trajectory the authors convinced me that the link between the point measurements, as well as rather short glider sections and more general circulation pattern does exist here. The obtained time series are not only thoroughly processed, quality controlled and analyzed but also deliberately matched with the model outcome. Several topics/processes are analyzed. The in situ data-model output comparisons are supported by additional observations and everything is illustrated by the appreciable number of figures (15) and two tables. The complex manuscript is well written and allows the reader to familiarize well with the specifics of the area and science problems. The received results are convincingly yet cautiously discussed in the light of the previous findings and the broader/long-term perspective. The conclusions drawn by authors are interesting and motivate to further studies. Thus, I have only a few questions and some comments that can potentially improve the way of the presentation. Otherwise, I have no more concerns and I suggest a minor revision.

Response: Thank you for your time and the constructive review! We agree the major concern is an important question and there is room for improvement for next studies. Surprisingly, there is very limited current observation data available from the Baltic Proper. That was one of the motivators of the current study. To our knowledge, the

present study is backed by one of the most comprehensive current observation datasets in the Baltic Proper (compared to earlier studies): six months of ADCP measurements, 2.5 months of point current meter measurements, two months of glider measurements, and one year Argo drift. Many previous circulation studies did not use current measurements at all but relied solely on simulations.

Action: We modified the last sentence of the conclusion to better highlight the importance of observations in circulation studies. "Further *in-situ* measurements and simulations of the current regimes in various locations during the periods of quasi-steady forcing could help to reveal the causes of the discrepancy."

Specific comments

Page 2, line 52: for the pelagic ecosystem - if it concerns the deep bottom layer it probably also impacts the benthic ecosystem. Consider adding this.

Response: Yes, we agree.

Action: We removed pelagic. It reads now „The conveyor determines salinity, stratification and other important characteristics for the ecosystem."

Page 2, line 57: increase hypoxia in the Northern Baltic Proper and Gulf of Finland - why? Please add 'due to ....' that the reader does not need to look for this information elsewhere.

Response: Yes, we can do it.

Action: It reads now „Only Major Baltic Inflows (Matthäus & Franck, 1992; Mohrholz, 2018) ventilate the deep layers of the southern and central Baltic Proper (Holtermann et al., 2017) but increase hypoxia in the Northern Baltic Proper and Gulf of Finland due to the transport of former anoxic/hypoxic Eastern Gotland Basin water and creating stronger stratification (Liblik et al., 2018)."

Page 8, line 236: Persistency of the current - what does the persistence tell us? Consider adding a few words, like 'informs about… and is defined by'

Response: It can be added.

Action: It reads now: „Persistency of the current, characterizing the variability of the direction of the flow, is defined as the ratio between vector and scalar current speeds:"

Page 9, line 270: The flow resulting from the sea level gradient and due to the inclination of isopycnal surfaces are also a consequence of wind but develop slower - Nicely explained!

Response:Thank you!

Action: No change.

Page 9, line 276: 0.6 m/s - this is rather low wind speed, do not you think? Is this a mean for all months from this period? Or for Mar-Aug only? The impact of seasonality could be mentioned here, I think.

Response: This is not mean wind speed, but mean wind component towards 10-degrees. Please see the explanation in the previous section. It is a good idea to mention seasonality.

Action: We added „The w_{10} is higher in winter and smaller in summer. Considering the linear relation between the two variables, the 1979–2020 mean w_{10} = 1.1 m s^{-1} corresponds to c_{40} = 4.2 cm s^{-1}."

Page 11, line 331: a drop in SST from 21 to 15 °C – this is interesting and a bit counterintuitive. In other parts of the Baltic Sea such a fierce drop in surface temperature in summer is often a sign of upwelling, not the downwelling. What is the source of this cold water – the mentioned vertical mixing and cooling alone? I would expect that northerlies are able to cool the sea surface more efficiently than the southwesterlies unless they are much stronger. A set of SST maps from late June/early July would make it clear (possible advection path), I think.

Response: Yes, we agree, it might sound surprising. It was vertical mixing mostly behind the event. Also, some cooling probably occurred. We have checked the SST maps. It happened in a large area, not only in the study area. Important here is that 21 °C is exceptionally high SST for this region at the end of June. There was a very strong atmospheric heat flux to the sea before the mixing event. The weather was sunny and the air temperature was high. Also, the wind was very weak, see figure 4. This allowed forming a thin and warm surface layer, which however was easily mixed with colder subsurface water during the strong wind impulse event. We don't want to include heat flux etc. calculations in the manuscript as that is not the focus of the paper, but we add an explanation for such a rapid drop.

Action: We added sentence: „A precondition for such a rapid drop in SST was the formation of a thin and exceptionally warm surface layer due to atmospheric heat flux (Fig. 6a) and weak wind (Fig. 4) at the end of June."

Page 16, line 416: occasionally deviated from the measured values - no surprise, it would be strange for the model to show the same results as in observations all the time.

Response: We agree, it is not surprising

Action: We removed that part of the sentence.

Figures

Figure 4 - Are you still able to change the color palette? I think this one is not color-blind friendly.

Response: Thank you for noting.

Action: We changed the color palette to color/blind friendly.

Figure 5 - Similarly here, it would be nice to avoid red and green color together.

Response: We agree, figures should be color/blind friendly.

Action: We changed red to black and made blue lighter.

Figure 8 and 12 – Could you add the notation about geographical sites: W and E or Sweden and Estonia? It would help to grasp the bathymetry/orientation at once.

Response: Yes, that will make it easier for a reader to follow.

Action: We added W and E.

Figure 13 – What is the parking depth for this float? Slightly above the bottom or the same along the whole Argo trajectory (~100 m)? What information does the ANDRO product provide here? The same as Argo GDAC? Could you, please provide WMO for this float?

Response: It was between 105-135 m. ANDRO provides the displacement data (when and where it surfaced and parked). It was convenient to derive trajectory from the database, where the method is well documented. We did not download the data from the Argo GDAC.

Action: We added the parking depth and WMO number to the figure caption.

Technical corrections

Page 2, line 48: so called - this is an informal phrase, use another one.

Response: We agree.

Action: We removed it.

Page 9, line 278: at the Valeport location - this can be a sentence start, stressing the change in instrument being described.

Response: Yes, that would make it easier for a reader to follow.

Action: It reads now „At the Valeport location, the most frequent current direction was 350°."

Page 10, line 288: low-passed filtered - low-pass filtered

Response: We agree.

Action: We fixed it in the whole manuscript.

Page 10, line 289: reasonably well – put it at the end of the sentence

Action: We did so.

Page 10, line 299: evoked – induced

Action: We changed.

Page 16, line 405: northerly wind prevailed – should not there be a coma here?

Response: We think you are right.

Action: Added coma.

Page 16, line 412: The flow was to the south in the upper – rephrase a bit to make this sentence similar to the previous one, like 'On the contrary, a pattern typical for the upwelling ....' and continue in similar way as before. This would make things easier for the reader, because there are many directions and layers in this description and it is easy to get lost.

Response: We agree it makes it easier to follow.

Action: We changed as suggested.

Page 16, line 414: These vertical patterns - do you mean downwelling and upwelling? If yes, say it (e.g. in brackets).

Response: We agree it makes it more clear.

Action: We changed as suggested.

Page 16, line 422: Next, we analyze the vertical (Fig. 8) and horizontal (Fig. 9–11) structure - this part is somehow disconnected from the previous one. You need to clarify why do you include it. Say something like: 'To understand (what?)....we next analyze the vertical...'. Similarly, you can explain why do you want to analyze model data in this area (the Eastern Gotland Basin) that is out of the area where all of the measurements were taken (this is the major concern I mentioned in my general comments).

Response: Yes, we can introduce this section a bit better. The reason for analyzing the model data out of the measurement area is to understand the larger-scale circulation dynamics better. We showed that during the quasi-steady periods current structure is quite well reproduced by simulation. We believe this allows us to provide a trustworthy picture of the larger scale current dynamics as well. The conclusion about subhalocline current was supported by the Argo float trajectory.

Action: It reads now „Next, to understand the larger scale circulation dynamics during the periods, we analyze the vertical".

Page 17, line 437: but forced – but was forced?

Action: We fixed.