Response to Reviewers

Storm-Modulated Submesoscale Dynamics over Sloping Topography in a Wind-Driven, Non-Tidal Basin

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We are grateful to the Editor and the two Reviewers for their thoughtful comments and constructive feedback, which greatly helped us improve our manuscript. In the following, the reviewers' comments are given in black and our responses in blue. *New* or *modified* manuscript text is given in *italics.*

Reviewer #1

The manuscript presents a numerical study of wind-driven submesoscale dynamics at depth in the Baltic Sea. The major result is that the ocean dynamics at depth, and specifically above topographic slopes, responds to strong wind events in generating submesoscale instabilities and flows that are sheltered (uncorrelated) from the surface dynamics. The manuscript is rather descriptive but well-written and easy to follow. Most results are demonstrated with thorough diagnostics. Nonetheless, I have two major concerns that I think prevents the manuscript from being published in the present state. Major and minor comments are listed down below.

Major comments

1. The link between winds and deep submesoscales is unclear. I agree that deep submesoscales are transient, depend on the low-frequency current orientation with regard to the topographic slope, and that this changes over time (Figs. 3 and 4). However, the dynamical link between the wind and the circulation is not obvious. The response to similar wind events can be qualitatively different. For example, northwards winds could lead to different current patterns and orientations (Fig. 5). I think this might be because typical wind events are very short (~1-3 days) and the deep circulation does not have time to reach a steady state after the onset of such event. Hence, the circulation might always be in a transient, unbalanced state, with the specific response to local winds (probably nonlinearly) interacting with a background or residual circulation. Also, this ambiguity might come from how wind events are defined (Fig. 1c). The wind time series shows some gradual variability and I cannot pick specific "events" such as the ones highlighted in grey shadings. For example, on 21st Oct and 27th Oct, the winds are equally strong as in the first event. **So, I would recommend to first try to draw some qualitative and quantitative links between**

winds (direction, intensity) and the deep (alongslope) currents, and then elaborate on EPV, instabilities, etc. The authors could lean on the literature on upwelling systems (e.g., Gilcoto et al., 2017) to infer time scales of the response.

We thank the reviewer for these helpful comments. We will go through the points one by one:

- To better highlight the specific storm events indicated by the grey shading, we have added an additional time series showing wind speed magnitude to Fig. 1 (panel d) and Fig. 6c. The three storms, defined as episodes with wind speeds exceeding 13 m s^{-1}, are now more clearly identified. For completeness, the wind magnitude over an approximately two-month period is also shown in the Appendix (Fig. A1, purple line). Fig. A1 not only demonstrates that strong wind events occur frequently during autumn, but also illustrates the longer-term variability of Ro, providing insight into the decay timescale of Ro following wind events.

- The dynamical link between wind forcing and circulation has been shown in previous Baltic Sea studies. As a simple model for the Baltic Sea, Krauss and Brügge (1991) and later Lehmann and Myrberg (2008) described the response of a stratified, elongated basin to constant alongshore wind forcing. Specifically, based on Ekman theory, Krauss and Brügge (1991) showed that the dominant wind-produced circulation in the Baltic Sea consists of coastal jets in the wind direction and countercurrents in the deep central areas, deflected by bottom topography. Zhurbas and Vali (2022) also demonstrated that strong wind-driven circulation is dominant in the deep layers of the Baltic Sea. Moreover, Liblik et al. (2022) showed that frequent wind reversals are followed by current reversals in the deeper layers during autumn (see their Fig. 14), indicating that the deep circulation responds rapidly to wind forcing. Previous work has further revealed that the dynamical connection between surface wind forcing and deep-water currents is mediated by baroclinic processes, including basin-scale topographic Rossby modes, near-inertial waves, and a variable rim current (Holtermann and Umlauf, 2012; Holtermann et al., 2014). To account for the aforementioned studies, we have substantially revised the Introduction section and further added the following:

  L258: *The roughly two-layer flow in the interior and the emergence of coastal jets aligned with the wind direction at both coasts suggest that the flow exhibits features indicative of Ekman dynamics (see Introduction), as described by Krauss and Brügge (1991).*

  L264: *During the prolonged final storm event, however, the along-slope currents reverse direction, accompanied by a corresponding reversal in the sign of the vorticity, consistent with the snapshots shown in Figs. 4d–i. Such current reversals following wind reversals in the deeper layers have been reported in previous studies, indicating that the circulation rapidly responds to the atmospheric forcing (Liblik et al. 2022; Zhurbas and Vali, 2022; Lips et al. 2026).*

L275: *...wind reversals frequently followed by current reversals (see also Liblik et al., 2022)…*

L324: *Such along-slope flows may be either directly wind-driven, as described by Krauss and Brügge (1991), or indirectly mediated by….*

- Motivated by the reviewer's insightful remark that typical wind events are short (~1–3 days) and may not allow the deep circulation to reach a steady state, we performed a cross-correlation analysis between the wind forcing and the deep-water currents to estimate the response timescales of the deep circulation. The analysis reveals a maximum correlation of r = 0.69 at a lag of approximately 14 h, indicating that the deep-water currents rapidly adjust their direction and strength in response to the wind forcing. This explains the extreme temporal and spatial intermittency in the deep-water submesoscale processes and generation sites, which is one of the main results of our study. Consistent with this interpretation, an even stronger correlation is found between Ro and the along-slope velocity (|r|=0.84 at zero lag), indicating that Ro is tightly linked to the interior flow. A detailed description of the cross-correlation analysis is provided below (see Comment 2 raised by Reviewer #2 and the associated text in the revised manuscript). Overall, our results show that variable winds can generate rich submesoscale activity, extending previous studies focusing on major current systems (e.g., Gula et al., 2016) to wind-driven basins with more transient circulation, as noted by the reviewer.

- As noted in the reviewer's comment, the response to wind events can be qualitatively different. While storm-driven changes in the interior flow can influence the development of submesoscale features, the magnitude of this response depends on both the intensity and duration of the wind episodes (Figs. 5 and 6). Moreover, during wind reversals, the pre-existing flow conditions also play an important role, as explained in detail below (please see Comment 1 raised by Reviewer #2). These effects are illustrated in Figs. 5 and 6, which show how successive wind events affect the interior flow and submesoscale activity, resulting in changes in the magnitude and sign of Ro and in the locations of the mixing hotspots. To clarify these points, in addition to the changes described above, we have added the following text to the manuscript:

  L269: *Wind reversals do not necessarily result in an immediate reversal of the current, as the pre-existing flow first needs to adjust to the new wind forcing. The response of Ro therefore depends on the pre-existing flow conditions but also on wind intensity and storm duration.*

2. Figures 5, 6, 7 and associated text: Oscillations are huge, they are of similar amplitude as time-averaged variables. **Are these near-inertial oscillations?** (2pi/f=14.3h at 57N and the manuscript title says that the basin is non-tidal) I guess they have a signature in velocity, which should impact vorticity. Given the large amplitude of these signals, they would deserve to be specifically studied. I suggest the authors to show time series of variables at time intervals allowing to resolve near-inertial frequency, and assess whether or not these near-inertial oscillations impact the dynamics.

These are indeed near-inertial oscillations and, as shown in Fig. 5, they have a distinct signature in the along-slope velocity (Fig. 5a) and consequently in the vorticity field (Fig. 5b). However, as mentioned in the Introduction (Lines 67-70), earlier work (Holtermann et al., 2014; Holtermann and Umlauf, 2012) has consistently shown that near-inertial waves only provide a small contribution to boundary mixing in the Gotland Basin (see also our response to comment "L70" raised by Reviewer #2). Nevertheless, to clarify this point, we have added the following:

L269: *Near-inertial waves are also evident (Fig. 5b), with previous studies (Holtermann and Umlauf, 2012; Holtermann et al., 2014) demonstrating that in our study region they play a relatively minor role in boundary mixing (see Introduction).*

Minor comments

Line 4: remove "primarily" as surface processes are equally important
Changed to: *Since interior submesoscales typically arise through flow-topography interactions…*

L30: glider observations have routinely revealed submesoscales, e.g., Bosse et al. (2017).
We have added the reference but have retained the original text, as we believe that observations revealing <u>interior</u> submesoscale motions and instabilities—particularly within the BBL or near sloping bottoms—remain relatively scarce, especially when compared with their surface counterparts.

L34: the routes to dissipation are reviewed in a book chapter (Gula et al., 2022).
We have added the reference.

L43: see global survey of submesoscale coherent vortices in McCoy et al. (2020).
This is a very relevant reference, and it has now been incorporated into the revised manuscript. Thank you for the suggestion.

L46-49: this mostly repeats the end of the previous paragraph, it should be merged or simplified.
Changed to: *The aforementioned studies have explored the emergence of interior submesoscales by focusing particularly on the vicinity of strong current systems (Molemaker et al., 2015; Dewar et al., 2015; Gula et al., 2016), coastal jets (Capot et al., 2023) and dense water outflows (Vic et al., 2015).*

L52 and elsewhere: I am confused with the use of "deep water" since the study does not go deeper than 100 m.

The terms "deep" and "deep-water" are relative, of course. Based on the reviewer's comment, we considered replacing them with "stratified interior region" or "sub-surface region", but these terms are less appropriate: the BBL, which plays a central role in our study, is not part of the "interior region". Similarly, the term "sub-surface region" could also define a region above the halocline. So we still think the term "deep-water" most precisely describes the region near and below the permanent halocline that we are interested in.

L62: remove "region"

Done.

L70: near-inertial waves are mostly generated by transient winds but in the sentence, they appear to be decorrelated.

Changed to: … *by wind-driven topographic waves and, to a lesser extent, by near-inertial waves generated by transient wind forcing.*

L72: I would remove the last sentence of the paragraph.

Changed to: *At present, however, the processes governing the exchange between mixed boundary-layer waters and the weakly turbulent interior of the Baltic Sea remain poorly understood, and the potential role of subsurface submesoscale motions has not yet been investigated in detail.*

L78: At this stage of the manuscript, I would use "hypothesis" instead of "finding"

Done.

L127: Fig. 3b should not be referred to before Fig. 2.

We have replaced "see Fig. 3b" with "*see Section 4*".

L129 (see also Major Comment): how are the wind events defined? I would recommend to drop the strategy of studying specifically these events and look more carefully at the continuity of the oceanic response.

We agree that it is important to consider the continuity of the oceanic response rather than focusing exclusively on individual wind events. Our analysis therefore considers both aspects. The time series plots capture the temporal variability of the oceanic response over several days, while the snapshots focus on a few selected periods of strong wind forcing (see also Major Comment). Furthermore, as requested by the reviewer, we performed additional model runs to explicitly investigate conditions without strong wind events. Please see our response to comment "L190" below for further details.

L163: remove "most"

Done.

Figures 2 and 3: There is no projection on a map (the grid seems regularly spaced in lon,lat) and the fields appear very distorted. 1 degree of lon = 60 km but 1 degree of lat = 111 km, there is an aspect ratio of almost 2.
We have updated Figures 2 and 3.

Fig 2: extend the colorbar range to [-1,1] to better see where the instability criterion for zeta<-1 shows up.
Since Ro < -1 regions are rare and the range [-0.8, 0.8] better highlights the eddy-like and filamentary features, we would like to keep it.

Fig 2: I do not see the point of showing maps at 80 m and 100 m as these depths are roughly within the same T,S,rho range (Fig 1b). Why not showing 150 m instead of 100 m ?
Here, we use the 80 and 100 m maps to highlight the eddy-like features in the lower halocline region and further demonstrate their vertical extent. The comparison shows that some of these features are substantially modified at 100 m (compared to 80 m depth), with some becoming stronger (e.g., Fig. 2c, black arrows) and others becoming almost absent (e.g., Fig. 2b, black arrow). However, as noted in the manuscript, the main aim of this figure is to demonstrate that the interior features are not spatially correlated with their surface counterparts.

L190: "ubiquitous at the peak of the storm" → how about non-stormy conditions?
Considering that during our study period, three successive storm events passed over the study site—and that autumn is generally a stormy season (Fig. A1)—it is difficult to assess, based on this period, whether such strong submesoscale features could develop in the absence of storms. However, by using a similar simulation that focuses on summer conditions (for details, see Chrysagi et al., 2022), we were able to briefly examine whether enhanced-Ro patterns are present in the deep regions also under calmer weather conditions. As shown in Fig. R1, relatively large-Ro features appear at 80 m depth both during calm weather conditions (08 July 2012) and after a moderate wind event (20 July 2012). This quick assessment suggests that submesoscales might be active during all seasons, even in the absence of severe storm events. Nevertheless, the large-Ro structures in Fig. R1 are weaker and less abundant than those observed under the stormy autumn conditions examined in this manuscript.

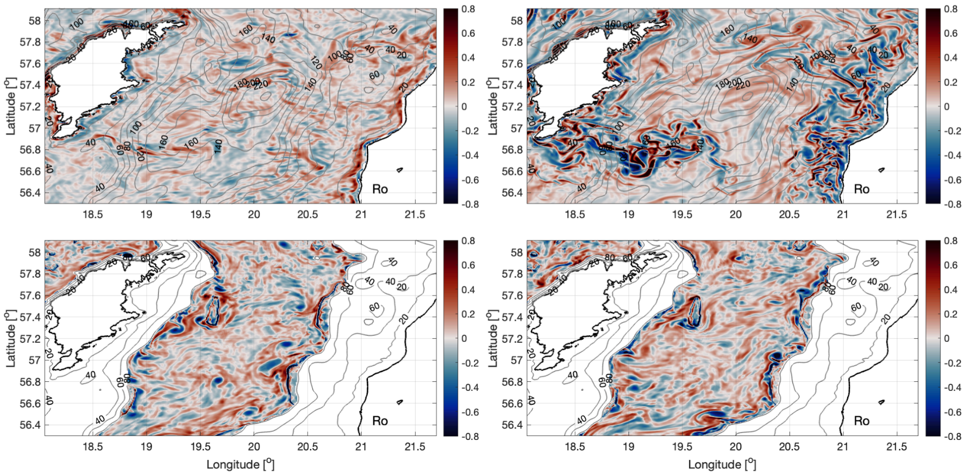

Figure. R1: Rossby number (Ro) maps at the surface (first row) and at the interior (80 m depth) of the basin (bottom row). The left panels are snapshots during calm weather conditions (08 July 2012), whereas the right panels indicate conditions after an upwelling event (20 July 2012).

L192: On the coexistence of submesoscale "disconnected patterns" between layers, this is not very new, it has been shown in many open ocean studies (Bosse et al., 2017; Vic et al., 2018).
We believe that the emergence of interior submesoscales directly beneath their surface counterparts is a noteworthy result. This has not previously been documented in the Baltic Sea and may also be relevant for other semi-enclosed, strongly stratified marine basins and limnic systems.

L216: I do not understand the sentence starting with "Fig. 3 shows…"
Changed to: *Fig. 3 shows (as will subsequent sections) that this mechanism is also at work in this semi-enclosed basin where ephemeral wind-driven currents largely dominate.*

L228: remove "waters"
Done.

L236: remove "vertically"
Since the "...EPV vertically negative…" refers to Eq. 5 and the associated instabilities, we would prefer to keep it.

Fig 4: extend a bit deeper? 150 m? it would be nice to see the bottom edge of typical submesoscale structures.
Since our focus is primarily on the region near and below the permanent halocline, we prefer to keep Fig. 4 in its current form, as the selected depth range better highlights these layers.

L281: How do you define “interior”? away from topographic slopes? How far?
Changed to: … *in the interior (depth >100 m)*, …
Here, the term “interior” refers to the stratified region away from the topographic slope and outside the turbulent bottom boundary layer. We use this term primarily to distinguish the relatively low values of Ro in the interior from the enhanced values observed near sloping topography, thereby highlighting the importance of boundary processes.

L288: Watch out with the use of O(x). It defines orders of magnitude (0.1,1,10,…) and does not mean “approximately”. The threshold of 0.5 is very large. Quasi-geostrophy applies for Ro<<1, so in O(0.1). I would use a smaller threshold to distinguish between balanced mesoscales and unbalanced submesoscales.
We agree with the reviewer that care is needed in the use of O(1), which denotes orders of magnitude rather than approximate values. We, therefore, modified the text as follows:
L288: …*By considering only the strong Ro (|Ro|>0.5), we illustrate in Fig. 6c the fraction of the boundary occupied by such strong ageostrophic features*…

As noted by Siegelman et al. (2020), who investigated submesoscale dynamics in the ocean interior, “commonly accepted values for Ro in an ageostrophic regime start at ~0.3–0.5”. We would therefore prefer to retain the criterion of Ro > 0.5 for consistency.

L298 and within the section. To me, there is no clear link between wind events and the prevalence of instabilities.
We are not sure if we understand the reviewer correctly here. Fig. 7a shows that only about 2-3% of the BBL region exhibits a negative EPV (condition for instability) if averaged over the days **before** the wind event on Oct 25-26. However, **during** the wind event, the percentage of the BBL region with negative EPV increases to 15-20%, corresponding to an (at least) five-fold increase. This percentage further increases to 25% at the end of the final wind event on Oct 29-31. Overall, this is an order of magnitude increase compared to the percentage before the wind events (Oct 20-25). This seems to support our claim that the wind events strongly expand the near-bottom regions amenable to SI and other instabilities quite clearly.

L301: towards northerly directions → northward
Done.

L332: This is not shown in the manuscript (Ekman transport, etc.)
As noted in the manuscript, the role of Ekman transport in PV destruction has been examined in detail in previous studies. Although it is not the focus of this study, we have included this point in the “Discussion” section, as it provides further insight into the destruction of PV near the boundaries, which is particularly pronounced during storm episodes.

Fig 7: I think it would be nice to show a map of epsilon, and perhaps link it to EPV patterns.
Following the reviewers' suggestion, we added maps of ε and PV (Fig. R2). However, we find that these maps do not provide substantial additional information beyond that already captured by the existing time series. We therefore prefer to retain Fig. 7 in its current form.

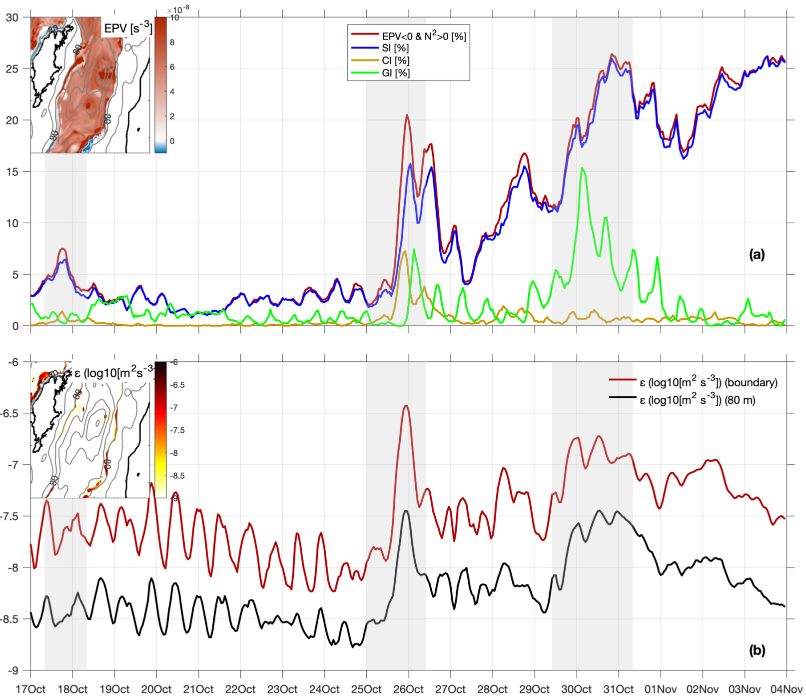

Figure R2: As in Fig. 7, but showing snapshots of (a) PV and (b) ε at 80 m depth on 31 October 2017 at 09:00 UTC (storm conditions).

L374-375: I disagree with this statement, again, the link between winds and the oceanic response at depth is not obvious.
Please see our reply above (Major Comment #1).

References

Bosse, A., Testor, P., Mayot, N., Prieur, L., d'Ortenzio, F., Mortier, L., ... & Raimbault, P. (2017). A submesoscale coherent vortex in the Ligurian Sea: From dynamical barriers to biological implications. *Journal of Geophysical Research: Oceans*, *122*(8), 6196-6217.

Gilcoto, M., Largier, J. L., Barton, E. D., Piedracoba, S., Torres, R., Graña, R., ... & De la Granda, F. (2017). Rapid response to coastal upwelling in a semienclosed bay. *Geophysical Research Letters*, *44*(5), 2388-2397.

Gula, J., Taylor, J., Shcherbina, A., & Mahadevan, A. (2022). Submesoscale processes and mixing. In *Ocean mixing* (pp. 181-214). Elsevier.

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Vic, C., Gula, J., Roullet, G., & Pradillon, F. (2018). Dispersion of deep-sea hydrothermal vent effluents and larvae by submesoscale and tidal currents. *Deep Sea Research Part I: Oceanographic Research Papers*, *133*, 1-18.

Reviewer #2

The authors report findings from a high-resolution modelling study of the Baltic sea, with an emphasis on uncovering the connection between rapid wind variability and submesoscale dynamics below the pycnocline. Based on the description provided, I am satisfied that the simulations and analysis are robust. The qualitative maps largely support the authors' arguments for a topographic origin of vorticity and BBL instabilities in the subsurface layers. In my reading, the only weakness of the manuscript is that the argument for a causal link between wind events and deep submesoscales hinges somewhat heavily on snapshot comparisons. My concerns are elaborated below. The authors should address these in a revised submission before the manuscript is accepted for publication.

Major comments

- The finding that the sub-surface Baltic sea is teeming with submesoscale eddies is interesting, although perhaps not entirely unexpected. That said, I wonder if the authors might do a better job fleshing out the connection with storms. The snapshots comparisons are great for a qualitative overview, but provide an incomplete view of the dynamics. Since the mechanisms at play are likely common to other enclosed basins, some questions that are of rather broad interest include: (i) What is the typical lag time between 'wind events ' and submesoscale outbreaks at depth? (ii) What is the role of upwelling in driving the subsurface baroclinic current whose interaction with bathymetric slopes the authors demonstrate to be a major generation mechanism of submesoscales? (iii) What influence does the slope Burger number exert on the dynamics and in particular on occurence of negative EPV? I'm not saying the authors need to pursue all these lines of analysis, but rather pointing out that the present simulations and findings offer a nice opportunity to examine broader questions.

  Thank you for these helpful comments.

  (i) As storms seem to indirectly influence the submesoscales by modulating the along-slope flow (see also Comment #1 raised by Reviewer #1), we believe that the "lag time between wind events and submesoscale outbreaks at depth" is largely determined by the "lag time between winds and interior currents". Consistent with this interpretation, a cross-correlation analysis between winds, currents, and Ro revealed that the strongest correlation is between the along-slope velocity and Ro in the boundary region, occurring at zero lag (see below for more details).

  The response to individual wind events also depends on the pre-existing flow conditions. For example, the wind event on 25 October triggers strong northward surface-layer velocities. Therefore, during the initial phase of the subsequent wind event (end of October), the reversal to southward winds first acts to decelerate the pre-existing flow before the current can reverse. This is briefly mentioned in the Appendix (Lines 371–373), but to further emphasize this point, we have added the following text:

L269: *Wind reversals do not necessarily result in an immediate reversal of the current, as the pre-existing flow first needs to adjust to the new wind forcing. The response of Ro therefore depends on the pre-existing flow conditions but also on wind intensity and storm duration.*

L286: *This is partly because the winds should first act to decelerate the pre-existing northward flow before the current can reverse, suggesting that the response to individual wind events also depends on the pre-existing flow conditions.*

L375: *Wind reversals do not necessarily result in an immediate reversal of the current, as the pre-existing flow first needs to adjust to the new wind forcing (e.g., following the 25 October wind event). The response of Ro therefore depends on the pre-existing flow conditions but also on wind intensity and storm duration.*

(ii) The role of upwelling in driving boundary currents was studied by Krauss and Brügge (1991) and further discussed by Lehmann and Myrberg (2008). To account for the aforementioned studies, we have substantially revised the Introduction and made corresponding changes throughout the manuscript (for details, please see Comment #1 raised by Reviewer #1).

(iii) We agree with the Reviewer that the slope Burger number most likely exerts a significant influence in modulating the occurrence of negative EPV as currents flow along the Baltic Sea's boundaries. However, slope Burger numbers in the Baltic basins vary broadly and often abruptly. For example, by focusing on the eastern boundary of the basin (red-shaded area in Fig. 7b), during the last storm event we found that $1.15\times10^{-4} < Bu < 3.64$, with a mean value of Bu = 0.37. Given this variability, isolating the influence of Bu on near-boundary dynamics and negative EPV generation would likely require accompanying idealised modelling work. For this reason, we have opted not to pursue this analysis within this manuscript, although we have now added the following to comment on the potential significance of this parameter:

L352: *For the Baltic Sea, future work could assess the influence of the slope Burger number (Bu) in modulating the occurrence of negative EPV along the basin's boundaries. As Bu in the Baltic Sea varies broadly and often abruptly, idealized modelling work (e.g., Masini et al., 2025), including sensitivity experiments with different slopes and stratification conditions, could shed light on the nature of instabilities (Wenegrat et al., 2018) that emerge as wind-driven flows interact with sloping boundaries.*

- To show that the selected wind events are reponsible for increase in Ro, the authors overlay these on time series plots of Ro at different depths (Figs. 5 and 6) and infer correlation based on the observed increase of Ro during these events (e.g. lines 280–282). It would be useful to better understand how this occurs. For example, would a cross-correlation analysis provide more insight into the time scales of the response to changing wind direction and speed?

  Following the reviewer's constructive suggestion, we performed cross-correlation analysis between winds, currents and Ro and have added the following to the text (and added the new Fig. A2):

  L290: *Focusing on the eastern boundary (red region in Fig. 5a), cross-correlation analysis between the along-slope velocity and Ro shows a maximum correlation at zero lag ($r = -0.84$), confirming that Ro is tightly linked to the current. Consistent with Fig. 5, the negative correlation indicates that the sign and magnitude of Ro follow the direction and strength of the current, becoming increasingly negative as the northward current strengthens and positive when the current is southward (see Appendix, Fig. A2). Moreover, a maximum correlation of $r = 0.6$ at a lag of approximately 13 h was found between Ro at the eastern boundary and the meridional wind component, suggesting that changes in wind forcing are followed by a response in Ro on a timescale comparable to the local inertial period. Note that we use the meridional wind component here because the storm events are predominantly oriented in the north–south direction, and the meridional component is approximately aligned with the alongshore direction at the eastern boundary. Focusing on the entire Eastern Gotland Basin, the wind field and the interior current were strongly correlated ($r = 0.69$) at a lag of 14 h. Similar results were obtained when correlating the current magnitude specifically in the boundary region (blue shading in the inset panel of Fig. 6) with the magnitude of the meridional wind component ($r = 0.8$, lag = 16 h) and the magnitude of the meridional wind stress ($r = 0.82$, lag = 15 h). Overall, our analyses indicate that storms indirectly influence the magnitude and, most importantly, the sign of vorticity—by reversing the interior currents, providing new insights into the dynamics of submesoscale phenomena in wind-driven basins.*

  L323: *The most energetic submesoscale features appear during storms, with wind forcing indirectly modulating these motions by altering the interior circulation. Strong correlations are found between wind forcing and deep-water circulation, as well as between Ro and along-slope flow.*

  L375: Based on the cross-correlation analysis, we added a new figure (Fig. A2) in the Appendix.

Minor comments

- 'Since submesoscales primarily arise through flow-topography interactions '. The word 'primarily 'is debatable. There are other processes such as mixed-layer instabilities, fronts and instabilities that are arguably more important.
Changed to: *Since interior submesoscales typically arise through flow-topography interactions…*

- Line 64–65: '. . . anoxic deeper layers of this globally largest anoxic marine system 'is a little awkward. Try 'The strong halocline acts as a natural lid, isolating the oxygen-rich surface water from the typically anoxic deeper layers of what is one of the globally largest anoxic marine systems. '
Done.

- Line 70: Contrary to this assertion, Figs. 5, 6, and 7 seem to show large NIW oscillations which I would presume would substantially influence vertical mixing. Calculating the near-inertial wind work would be useful to quantify how much of the wind energy is expended in near inertial pumping.
Previous observations (see Fig. 6 in Holtermann and Umlauf, 2012) and high-resolution numerical modeling (see Fig. 4 in Holtermann et al., 2014) have consistently shown that near-inertial waves only provide a small contribution to the deep-water kinetic energy and boundary mixing in the Gotland Basin. Most of the kinetic energy can be attributed to basin-scale topographic waves with periods of 3-5 days. We therefore believe that an additional analysis of the near-inertial wind work would distract too much from the main topic of our paper.

- Lines 256–260: It is not obvious what two layer vorticity structure is being referred to in Fig. 4h,i.
Changed to: *Close to the eastern margin, this roughly two-layer flow (more pronounced at the peak of the wind event) generates vorticity with opposite signs above and below the mixed layer (Fig. 4h, around 20-21°E).*

- Why is |Ro| in Fig. 6a almost twice the magnitudes seen in Fig. 5b along either boundary?
The difference arises from the different averaging procedures used in the two figures. In Fig. 6a (blue line), we first calculate the absolute value of the Rossby number, |Ro|, and then average it over the entire boundary region, including both the eastern and western boundaries (red and green regions in Fig. 5, respectively). In contrast, Fig. 5b shows the signed Ro, averaged separately over the eastern and western boundary regions. Because Ro takes both positive and negative values, these can partially cancel in the mean (Fig. 5b). No such cancellation occurs in Fig. 6a because the absolute value is taken before averaging. Consequently, the mean |Ro| shown in Fig. 6a can be substantially larger than the magnitudes of the mean signed Ro shown for either boundary in Fig. 5b.

The two figures therefore highlight different aspects of the Rossby number. Fig. 5b is intended primarily to show how storms can modulate the sign of Ro through changes in the direction of the along-slope flow. In contrast, Fig. 6a focuses on the magnitude of Ro and shows that storms can also modulate its strength.

- Fig. 7b: What is the dissipation rate ε being computed here – mean or eddy? Is it averaged over the entire BBL? Please include these specifics either in the text or caption.

  We modified the figure caption as follows: *(b) Temporal evolution of the dissipation rate, ε, spatially averaged at 80 m depth over the entire domain (black line; including the boundary region shown by the blue shading in the inset panel of Fig. 6a) and over the eastern boundary only (red line; red shading in the inset panel).*