

## ***Interactive comment on “Structure and dynamics of mesoscale eddies over the Laptev Sea continental slope in the Arctic Ocean” by Andrey Pnyushkov et al.***

### **Anonymous Referee #1**

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This paper analyzes mesoscale eddies as sampled by two moorings on the continental slope of the Eurasian Basin's Laptev Sea. The paper contains a wealth of interesting information relevant not only to the regional oceanography but to boundary processes in the entire Arctic. In general, it has the potential to be an excellent contribution to the literature on Arctic eddies. The manuscript, however, is poorly structured and presented. The figures are often not described well, and procedures and results can be ambiguous. It needs a major re-structuring and re-writing.

Specific comments, in order following the manuscript, not importance:

1. Page 2, paragraph 5: A relevant paper is by Zhao et al. who relate KE and

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mesoscale eddies in the Beaufort Gyre:

Zhao, M. et al., 2016. Evolution of the Eddy Field in the Arctic Ocean's Canada Basin, 2005-2015. *Geophysical Research Letters*, 43, doi:10.1002/2016GL069671.

2. Page 2, paragraph 20: Indeed such deep eddies have been observed and studied in the Canada Basin:

Carpenter, J.R. and M.-L. Timmermans, 2012. Deep mesoscale eddies in the Canada Basin, Arctic Ocean. *Geophysical Research Letters*, 39, L20602, doi:10.1029/2012GL053025.

Note that the above paper analyzes mooring data, not ITP data as stated later in the manuscript (paragraph before section 4).

3. Start of section 2.2: Re-phrase "... indicate the reversal of current rotation at the frontal and rear edges of the eddy". I assume this is referring to the first half of an eddy transit and the latter half? Or perhaps define frontal and rear.

4. Figure 2: It would help to point to the eddies (perhaps with colored notches) on the panels.

5. Figure 3 and discussion: In general, the wavelet analysis is inadequately described and unclear. This may require a supplemental description. It should be clearly explained why the wavelet transform is required in addition to simply the velocity maxima, as would appear in Fig. 3.

6. Figures 4 and 5 are very confusing. Each coherent eddy should be order tens of meters in thickness, while are we to understand that each circle is meant to represent an individual eddy? It seems strange to say "each feature is generally identified simultaneously at several adjacent depth levels" and then have them with different radii? While the reader eventually comes to understand that each vertical line of circles represents a single eddy, it is unclear why the radii and speeds can differ so greatly with depth in some cases.

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7. Estimates of the radii come too late in the text given that this is a natural question for the reader pondering Fig. 4 and 5. Further, some more careful discussion of radii estimates is required given that most eddies do not transit the mooring directly through their centers.
8. It seems that some of section 3 (e.g., Section 3.2.2) should go sooner - in the methods section. The manuscript is not well structured in places (see point 7 above). The end of section 3.1 finishes by telling us that in the next section the role of eddies in ocean dynamics will be assessed, but the next section seems to discuss properties of eddies not their role in ocean dynamics.
9. top of page 7: "For additional assurance, we controlled conservation of eddy polarization at both edges of the identified eddies." What does this mean?
10. Section 3.3: can we see advection/translation velocity somewhere? How are the authors sure that the eddies are advected by the background flow and not by some other translation mechanism? What is the topographic beta effect in the vicinity?
11. Figure 6:  $V_{\text{mean}}$ : Surely this is not the right parameter here? A large, swift eddy may have a weak mean velocity, for example. Maximum azimuthal velocity would be better. However, the first paragraph in 3.4 now confuses the issue of what is plotted with respect to velocity in Figs. 6 and 7. The authors need to make the notation between the text and the labels on the figure panels consistent. In that absence of this consistency, it's ambiguous whether the relative vorticity shown uses  $V_{\text{rot}}$  or  $V_{\text{mean}}$ . For the relative vorticity, it would also help to show a second x-axis for the Rossby number scale (given the constant  $f$ ).
12. Sentence before section 4: were these actual divergences or convergences, or associated with water column heaving? If the latter, one would not expect rotational velocities.
13. It would appear from Fig. 6 (bottom left panel) that cyclonic eddies have the same

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sign of displacement as anticyclonic. Clarification is needed.

14. Equation (1) is somewhat of a concern given that changes in salinity between two isopycnals are effectively negligible at the temperatures of interest. Can the authors quantify the uncertainty of such a technique particularly with respect to the dominant influence of salinity on density (and generally poorer salinity resolution compared to temperature)? It's reasonable to use temperature as a "tracer" on an isopycnal in the Arctic, but generally not salinity. Of course, the start of section 4.2 ought to give those high correlations because this is how the waters were mapped to each other in the first place. [please see also my point 16 below]

Further this method for identifying eddy origins is inappropriately specific. That is, the pink circles in Fig. 8 show specific locations with rather small error bars (pink circles and error bars are rarely overlapping). Rather, one expects eddies of a particular range of core T-S properties to derive from instability of a boundary current with a particular range of core T-S properties. A more appropriate analysis would place all the T-S dots from the entire EB (corresponding to red dots in the inset) in light grey on a T-S diagram, then plot core T-S dots corresponding to each eddy (colored by eddy class, for example) over top of these. Perhaps also with two mean T-S profiles (lines) plotted in color (corresponding to the colors of the dots) representing the water masses in each of the two source regions. This would give a much more intuitive, representative picture of eddy origins. With the present analysis and uncertainty checking, the authors seem to be implying that it is extremely likely that a particular eddy derived from a particular spot, which is certainly not likely to be the case.

Indeed, the last paragraph before section 4.3 points to anticipated evolution of the eddy core properties given the inferences of distant eddy origins - an additional important reason for the pinpointing of specific locations being illogical.

Figure 8 caption is not clear. There are red circles in the inset and pink circles in the main map but only red circles are referred to when I believe the authors mean pink.

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Also the color scale range is not well chosen.

15. The text and other figures would be easier to follow with examples (cross sections of temperature with salinity contours) of typical FS and SZ eddies.

16. What exactly does a salinity "anomaly" look like at the core of an eddy? One would expect the upper part of the core to have a positive salinity anomaly and the lower, a negative salinity anomaly. Profiles of ambient and eddy core (both T and S) are required here and could go with the section Figures (point 15).

17. Page 13: diffusivity at neutral stratification? Lateral velocity profiles? Also, these  $R_i$  are extremely sensitive to the vertical averaging. 2 m is probably too large to achieve reasonable estimates. Can the authors quantify this uncertainty? Certainly the statements in the top paragraph of page 14 are correct, but have they been reasonably demonstrated here?

18. page 14: What does this mean: "compared to previous studies based solely on observed density anomalies" ? Eddy T-S properties are analyzed in these papers.

19. page 14: "similar to the first baroclinic radius of deformation, suggesting generation of eddies by baroclinic instabilities" Note that the second baroclinic mode is likely important in the formation of these eddies - but this will become clear once the reader is shown ambient vs. eddy core stratification.

20. page 15, first paragraph (line numbers in a revised version would be much easier): How and where has this been shown in the manuscript?

21. Finally note that there are grammatical issues and typos throughout and the paper needs careful proofing.

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