Reviewer#1

We thank the Reviewer for thoughtful reading of our manuscript and very constructive and helpful comments. Below are our responses to the Reviewer's comments.

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

A: We thank the Reviewer for pointing us out this relevant reference. We have added the reference to Zhao et al. (2016) to this paragraph and to the reference list.

Comment #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).

A: We have changed this paragraph and noted that deep mesoscale eddies were also found in the Canadian Basin. We have also replaced the reference to *Carpenter and Timmermans (2012)* with the reference to *Bebieva and Timmermans (2016)* as it was more relevant in that context.

Comment #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.

A: We have added the suggested explanations of terms "frontal" and "rear" edges. We also have added a schematic draw of idealized eddy where we indicated the frontal and rear eddy edges for the convenience.

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

A: We have added colored marks for eddies at the top axis in this figure.

Comment #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.

A: We have added that description to Supplementary.

Comment #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.

A: We replaced these figures with new ones in which each single eddy is represented by a continuous vertical stripe for better representation and to avoid confusion of the readers. We also have added colored marks on the top axis to show average time when eddy's "pseudo center" was at the mooring site. Evident differences of the rotational speed with depth for some eddies are likely due to the contamination of eddy signal and sub-mesoscale current variability (e.g., internal waves, unfiltered baroclinic tides and others), which was not fully resolved by our MMP and ADCP records.

Comment #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.

A: We have extended the description of eddy radii estimates and moved this part to the "*Method*" section. In addition, we have also included an idealized eddy schematic (Fig. 3a) which helps the reader understand the method used. We also emphasized in the text (p. 5-6) that the applied method is insensitive to what part of an eddy passed through the mooring site.

Comment #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.

A: We have changed the structure of this section and reformulated that sentence.

Comment #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?

A: We calculated eddy polarization using the product of vector multiplication of the mean and rotational velocity at the leading eddy's edge. To ensure the identified eddy has the same polarization at the rear boundary of the eddy, we calculated an additional vector product using rotational velocities at the rear eddy's edge. In the case of conservation of the polarization, the products at the frontal and rear eddy's edges have opposite signs, indicating reversal of current direction. We have added this explanation to the text.

Comment #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?

A: We show translation speed of eddies at the M1f mooring as a separate panel in Fig. 2c. Our results of eddy source identification strongly suggest that the eddies observed at the Laptev Sea slope were advected by a pan-Arctic boundary current along the EB slope. Propagation of mesoscale eddies with the boundary currents is also suggested in several studies regarding eddies observed in the EB (e.g., Dmitrenko et al. 2009; Våge et al. 2016). The bottom slope at the site of M1 mooring is assumed to be sufficiently gentle so that the water depth varies weakly on the scale of motion, and the topographical beta-effect is of the same order of magnitude as the planetary beta-effect and thus have a small impact on the translation speed of eddies.

Comment #11. Figure 6: V_(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 Vrot or Vmean. For the relative vorticity, it would also help to show a second x-axis for the Rossby number scale (given the constant f).

A: We have changed this figure. In this plot (and in the previous version of the manuscript) we provided the mean azimuthal speed, not the long-term current speed. We have also added an additional horizontal axis to show Rossby numbers. In the revised text we have unified notations of these velocities throughout the text to avoid potential confusion.

Comment #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.

A: In the revised version, we have removed this sentence from the text.

Comment #13: It would appear from Fig. 6 (bottom left panel) that cyclonic eddies have the same sign of displacement as anticyclonic. Clarification is needed.

A: We have added the clarification that we showed amplitudes of the isopycnal displacement.

Comment #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. Also the color scale range is not well chosen.

A: We have replaced Figure 8 with a new one in which we show the uncertainties of eddy origin identification associated with differences in climatological and and in-situ temperatures (Fig. 8) and salinity (Fig. S1) inside eddy cores. We pointed out in the text that this uncertainty is significantly larger comparing to the uncertainty due to errors of the mean (shown in the previous version of the manuscript). We completely agree with the Reviewer that the method employed cannot provide the readers with an exact location of eddy sources and we never claim that statement in the text. In the revised text we extended that section describing additional uncertainties of the locations of eddy origin due to variability of the EB hydrography to make the readers more informed about quality of our analysis. We compared TS-diagrams for eddies with the climatological TS (see revised Fig. 10e). However, with the method suggested by the Reviewer we cannot identify the region of eddy formation as we did using our approach.

Nevertheless the limitations of our analysis we believe that the partitioning of eddies between the two sources - the main message of this section - is robust. We have added to the text that the contribution of salinity to the uncertainty of eddy sources is comparable to the contribution of temperature (see Table 1, and Fig. F8 and S1 for the uncertainties for every particular eddy), so we cannot rely solely on temperature anomalies inside eddies to identify their origins. In the new Fig. 8, we have changed the figure caption to make it clearer for the readers and modified the color scale range.

Comments#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. **And 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).

A: We have described salinities in cores of the EB eddies to support our discussion that eddy rotation is controlled mostly by salinity. In Supplementary we have added a new Figure S3 illustrating vertical pattern of temperature, salinity, and density anomalies inside typical EB eddy.

Comments #17: Page 13: diffusivity at neutral stratification? Lateral velocity profiles? Also, these Ri 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?

A: In our study we used Richardson numbers as proxies of mixing regime within eddies, not as a precise quantification of the diffusivity coefficients. Therefore, we think that even with a relatively coarse vertical resolution of the MMP record our conclusion that the mixing inside eddies is substantially higher comparing to the ambient water at the Laptev Sea slope is plausible. In our calculations, we used the highest possible instrumental resolution. However, we agree with the reviewer's awareness (and we pointed this out in the text) that the absolute values of diffusivity coefficients may be not completely accurate. Unfortunately, without targeted microstructure observations inside eddies (similar to those used by Padman et al. [1990] and Lenn et al. [2009]), we cannot quantify the uncertainty of the method used. In the revised Figure, we have added details about lateral structure of velocities inside the described eddy. In our calculation we used constant diffusivity at neutral stratification as indicated in Eq. (3).

Comment #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.

A: We have changed this sentence to emphasize that the previous studies used observations of temperature and salinity in eddies, but not velocities.

Comment #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.

A: We have added in the text that other baroclinic modes (not only the first mode) may be important for the generation of eddies.

Comment #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?

A: We have added a new panel in Fig. 2 with the low-frequency currents which clearly show an anomalous regime of the ACBC circulation between April and December 2009 at the M1f mooring. We noted that detailed analysis of this finding may be found in Pnyushkov et al., 2015. For the preparation of the manuscript we used a standard template (available from the Ocean Science website) where the line numbers are indicated at the left side of each page.

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

A: In the resubmitted version we have tried to improve quality of the text.

Reviewer#2

We thank the Reviewer for thoughtful reading of our manuscript and very professional and constructive comments which help us improving quality of our manuscript. Please, find our answers to the Reviewer's comments.

Q1: Main point: My main concern is about the identification of eddy origins. The authors use climatological temperature and salinity to track the origin of eddies in the Arctic Ocean. There is lots of variability in the hydrography, from short term to seasonal and interannual variability. This is however not taken into account in their analysis. In my opinion, section 4 is very speculative. It might be appropriate for the discussion part, but not as a results section. This would also affect Figures 10, 11 and 12, which show properties for the two origin areas separately. Also, the travel distance of eddies (around 1400 km from the calculated eddy origin to the mooring location, page 11 line 10) seems to be very large. Is it realistic to have these large travel distances? Are there any other studies about travel distances of eddies in the Arctic Ocean?

A: The long lifetime of eddy structures is a well known property of oceanic eddies. For example, some Gulf Stream rings and thermocline lenses are able to survive for a few years (e.g., Cheney and Richardson, 1976; McWilliams, 1985; Olson, 1991; Richardson et al., 2000) in the ocean. In the text we also provided several references that report long-lived eddies in the Arctic Ocean. For instance, Dmitrenko et al. 2009 described a mesoscale eddy approximately at the site of M1 mooring that was likely originated near the St.Anna Trough (i.e., ~1100 km away from the Laptev Sea slope). We have approached the Reviewer's concern regarding the analysis of eddy sources in two different ways. Firstly, we have replaced Fig. 8 with a new one in which we show uncertainties of eddy origins caused by differences in climatological and in-situ temperatures (Fig. 8) and salinity (Fig. S1 in Supplementary) inside eddy cores. We pointed out in the text that this uncertainty is by a factor of four larger compared to the uncertainty due to errors of the mean shown in the previous version of the manuscript. Secondly, we have provided estimates of uncertainties associated with short-term, seasonal, and interannual variability of temperatures and salinities in the Eurasian Basin. For that, we used standard deviations as the measures of variability estimated at nodes of the temperature and salinity climatology for the 2000s. The calculated uncertainties due to the variability of hydrography were comparable to those derived by the differences in climatological and in-situ temperatures inside eddy cores (see Fig. 8 and S3 for comparison). We also compared TS-diagrams for eddies with the climatological T and S (see revised Fig. 10e). Nevertheless that the uncertainty of source location for each individual eddy may be large (up to 220 km), they are substantially smaller than the distance between two identified areas of eddy formation (Fram Strait and the Severnaya Zemlya slope). This suggests that the partitioning of eddies between the two sources - the main message of this section - is robust.

Detailed points:

Q2: Section 2.2: It would be good to describe the wavelet analysis in more detail. It would be interesting to see salinity and density anomalies of eddies. For temperature, this is shown in Fig. 10. How would this look without considering the origin of eddies? How does this look for different depths?

A: We have added an additional description of the wavelet method used to Supplementary materials. We have also included a distribution of salinity to our Fig. 10 to provide additional details about properties of EB eddies and to support our discussion that eddy rotation is controlled mostly by salinity. In addition, we have calculated TS anomalies inside eddy cores without considering the eddy origin, but we note that due to very different water properties for the FS and SZ eddies their physical interpretation is very untrivial, especially for temperature anomalies. In agreement with our finding of the dominant role of salinity for density anomalies inside EB eddies, the PDFs for density (not shown) look very similar to those calculated for salinity (lower panel in Fig.1; Fig. 10c, d in the main text).

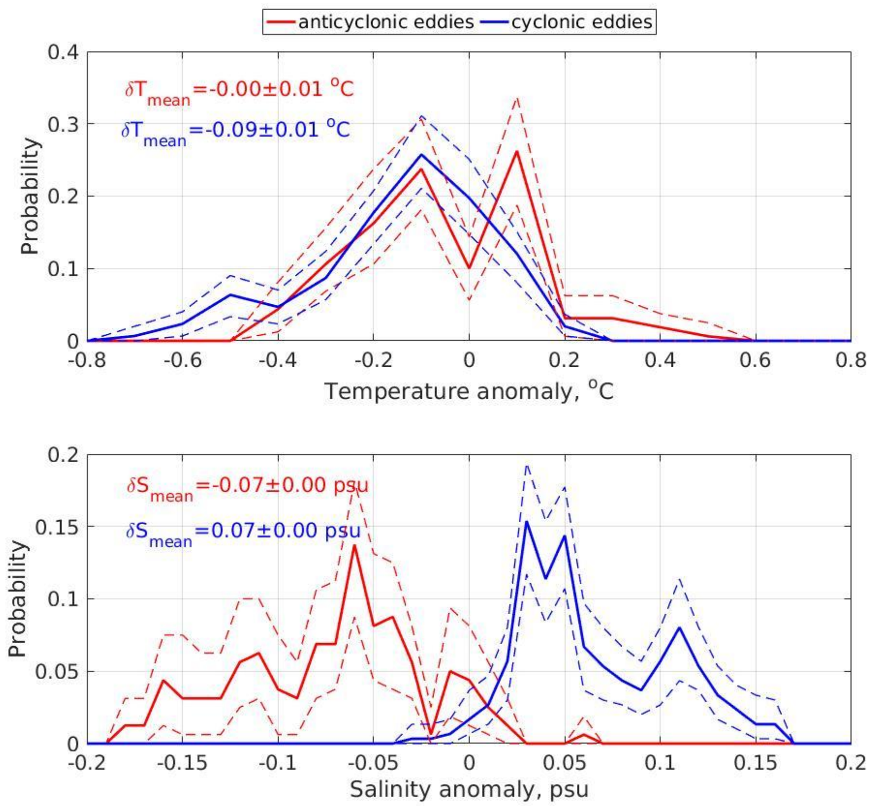

Figure 1. Probability distribution function of temperature (upper panel) and salinity (lower panel) anomalies inside cores of the identified eddies.

Q3: P2, L16: Could you reformulate this paragraph? You are jumping from a description of Fram Strait eddies to eddies in the Eurasian Basin, without introducing this region. Also, the abbreviation EB hasn't been defined before.

A: We have reformulated this paragraph and added the introduction of the Eurasian Basin to the text.

Q4: P3, L9: Is the depth range 216-800m correct? That would be the same depth range as in the time period before.

A: We have corrected these numbers.

Q5: Figure 1: distinguished -> distinguishable

A: We have corrected that word.

Q6: Figure 3: Colorbar is missing.

A: We have modified this Figure and added the requested colorbar for wavelets.

Q7: Figure 4,5,8: Labels of the colorbar are missing

A: We have added labels for these colorbars.

Q8: Figure 11: What are red, black and blue lines in Figure 11a and 11b? Also, the x-axis of plots a and b should be labeled.

A: We have modified this figure. We noted in the figure's caption that red, black and blue lines indicate frontal edge of the eddy, its center, and rear edge, respectively.