Interactive comment on* "Eddy characteristics in the Northern South China Sea as inferred from Lagrangian drifter data"** ***by J. X. Li et al.

Responses to the comments of referee #2

First of all the authors are extremely grateful to anonymous referee involved for providing his/her excellent comments and valuable advice on this paper. In the following, referee comments are in black text with actions taken following in blue.

1. I'm not certain I understand how the algorithm used leads to the isolation results shown, for example, in Figures 3 and 4. One suggestion I have is to move this section to an Appendix where additional detail of the algorithm itself can be included without distracting unnecessarily from the main results of the manuscript.
   Good suggestions. We moved section 2.2 (eddy identification method) to an appendix.

2. The data set itself is impressive and is a tribute to the multi-national Surface Velocity Program (SVP) initiated years ago as part of the World Ocean Circulation Experiment (WOCE. The data are well described in Section 2.1. However, it is not clear what statistics, exactly, is shown to represent data density in Figure 2b. The text and figure caption say "trajectory number," which is a non-standard quantity. I assume that it refers to the number of distinct trajectories (i.e., drifters or drifters that have left the box and later returned as new trajectories). If so, that measure is not as instructive as the number of buoy days, independent of drifter. At least that is true for Eulerian quantities derived from the drifter data. I concede that the analyses presented here are about eddy or curvature quantities that are intrinsically Lagrangian. At a minimum, please try to better define "trajectory number."
   Good suggestions. The phase "trajectory number" refers to the number of distinct trajectories as the referee comments. To clarify this, we changed it into "number of drifter observations" (Dever et al., 1998) in both the text and figure captain.

3. Also in Section 2.1, please comment on the winter versus summer seasonal mixed layer depths in the study region. Since the authors point to a result that the number of large eddies peaks during the winter monsoon, it is imperative that the 15m drogue depth be well within the mixed layer in both seasons.
   Good suggestions. The seasonal variation of mixed layer depth (MLD) is predominantly annual in the NSCS, where the MLD is deeper than 70 m in winter and shallower than 20 m in summer. Wind stirring and cooling convection seem to be dominant in the annual variation in the NSCS, while the effect of Ekman pumping is not negligible in summer when both wind stirring and cooling convection become weak (Qu et al., 2007). We added several sentences in Section 2.1 as suggested and added a reference.

4. At the end of Section 2.2 on page 1580 the authors describe their criterion for separating a new eddy from, possibly, multiple loops around the same eddy. They use a criterion based on the sum the radii of two successive loops. They do not, however, justify that

length scale against any independent data or theoretical behavior. How does the 2 x radius length scale compare with the distance an eddy is expected to advect westward on a beta plan over two rotation periods? (This would be roughly 5 cm/sec x Trot.)
Good suggestions. We agree with the reviewer that the criterion for separating a new eddy from multiple loops based on the radii of two successive loops seems not so convictive, since it ignores the westward movement of eddies. Based on the theoretical behavior of eddies embedded in the background flow, we used a new criterion:

$D_0 = \overline{U} \times \Delta t$, where $\overline{U}$ is the drifter-derived mean velocity, and Δt is the time interval between two successive loops (defined as t2-t1, where t1 is the time at the overlapping point of an loop and t2 is the time at the overlapping point of its subsequent loop along a drifter trajectory). Note D_0 is not constant, since $\overline{U}$ and Δt can both vary from site to site.

5. At the end of Section 3.2 on page 1582 the authors state that "The reason may be that drifters are biased toward regions of convergent flow associated with anticyclones (Chairgneau and Pizarro, 2005)." I have not looked up this particular reference, but I believe that the statement is not correct. In the northern hemisphere, surface flow in mesoscale eddies is expected to be convergent in cyclones and divergent in anticyclones. This expectation is based on the notion of frictionally driven secondary circulation that breaks geostrophic balance slightly at the surface leading to a slight high-to-low pressure flow, which is inward in cyclones (analogous to atmospheric cyclones). Please review this statement and better justify it.
Winds from the overlying atmospheric circulation patterns can produce surface currents that sometimes cause convergence (coming together) or divergence (moving apart) of upper ocean waters over surface areas several kilometers in scale. Under the right divergent conditions, cool, nutrient-rich waters can upwell (move vertically) from deeper waters to act as a seed for the formation of a cold-core (cyclonic) eddy. Likewise, warmer, nutrient-poor waters may converge, be downwelled, and a warm-core (anticyclonic) eddy can form. So in a sense, in the northern hemisphere, surface flow is divergent in cyclones and convergent in anticyclones, while bottom flow is convergent in cyclones and divergent in anticyclones. As to the atmospheric cyclones, the bottom flow is convergent and the top (analogous to sea surface) flow is divergent. The difference is because of the view of us, since we feel the surface flow (divergent) of ocean cyclonic eddies, but feel the bottom flow (convergent) of atmospheric cyclones. Some may argue that cyclonic eddies in the ocean may be under-sampled by drifters because of the diverging flow, on the other hand drifters tend to feel the convergent part of the flow associated with anticyclones. Such argument seems to be supported by both our results and the results of Chairgneau and Pizarro (2005) in the eastern South Pacific. Thus open questions still remain: how the biased drifter movements can impact on our statistics? The higher number of drifter anticyclonic loops is due to buoys trapped into the convergent flow, or is it due to a cascade of the large-scale anticyclonic vorticity toward mesoscale motion? Further investigation, including high-resolution numerical

simulations, is needed to respond to these questions. We added several sentences in the text to clarify it.

6. In Figure 10a it would be helpful to show or describe the error bars in the results based on the standard deviations. It is not obvious that the temporal fluctuations in eddy number are significant.
   Good suggestions. A figure describing the error bars in the results based on the standard deviations was added in the new version of the manuscript.

7. Minor moments:

(1) Page 1577, bottom: "drifters dataset" should be "drifter dataset".
Corrected.

(2) Page 1578, top: "avoid the energy" should be "avoid aliasing the energy".
Corrected.

(3) Page 1578, bottom: "identification method for these loops" should be "identification of these loops".
Corrected.

(4) Page 1579, top: "disturbing of" should be "disturbance of", "we need do the skip searching, not the" should be "we must do skip searching, not".
Corrected.

(5) Page 1580 and Figure 6: What is the obvious mean current at 117degE, 18degN? It is not identified yet it is a significant feature of the mean current pattern.
Good suggestions. The obvious mean current at 117° E and 18° N is the northern part of the cyclonic West Luzon eddy located off the northwest Luzon, which is controlled by both the local Ekman pumping and remotely forced basin-scale circulation (Qu, 2000). We added several sentences to make it clear.

(6) Page 1581, top and Figure 8 caption: Refers to 10 km histogram bins but the figure appears to have 5 km bins.
We have changed the “10 km” in the Figure 8 caption into “5 km”.

References:

Chaigneau, A., and O. Pizarro (2005), Eddy characteistics in the eastern South Pacific, *J. Geophys. Res.*, 110, C06005.

Dever, E. P., M. C. Hendershott, and C. D. Winant (1998), Statistical aspects of surface drifter observations of circulation in the Santa Barbara Channel, *J. Geophys. Res.*, 103, 24,781-724,797.

Qu, T. (2000), Upper-layer circulation in the South China Sea, *J. Phys. Oceanogr.*, 30, 1450-1460.

Qu, T., Y. Du, J. Gan, and D. Wang (2007), Mean seasonal cycle of isothermal depth in the South China Sea, *J. Geophys. Res.*, 112, C02020.