

## Review of “Statistical analysis of Lagrangian transport of subtropical waters in the Japan Sea based on AVISO altimetry data” by Prants et al.

This manuscript presents a statistical analysis of the transport processes from geostrophic velocities obtained from the AVISO SLA product. In particular the authors use Lagrangian techniques to study the northward transport in the Japan Sea of surface water masses coming from subtropical regions. This study is conducted combining trajectories of virtual particles, advected by the altimetry velocity field, and real drifters trajectories.

Some of the findings are: spatial pattern of time averages of particles reaching northern regions shows zonal dynamical features at middle latitudes that are candidates to act as gates/barriers to transport; there are small regions in the north where particles coming from the south does not arrive over the analyzed time period (“forbidden zones”); in general, particles coming from the western part are transported to the eastern; there are some intrusions of subtropical particles near the Russian coast in the northwest of the Japan sea basin; mechanism to explain the dominant northwestward transport of particles is given in relation to the presence of a quasi-permanent frontal pair-vortex system; adding errors in the altimetry velocity data do not affect significantly the results.

In general, the authors present a interesting work aimed at improving the description of surface transport in the Japan Sea in terms of Lagrangian statistic indicators. This is a good piece of work which can be of interest to some NPG readers. However a major revision has to be addressed before publication. The main issues that need to be clarified by the authors are listed bellow.

### **Major concerns:**

#### **General:**

1. Although the study has relevant results to understand the mesoscale transport dynamics at the surface of the Japan Sea, I found that some of the results are repeated throughout the manuscript, becoming redundant. For instance the information that can be obtained from Figure 4 can be deduced from the other figures.
2. Also it's really hard to follow the storyline of the study, I have found many unnecessary repetitions of descriptions and a lot of sentence and expressions that do not make sense. The manuscript needs a careful read through. A copy editing of the text would be highly appreciated to make the reading easier.
3. The authors analyze how is the northward transport in relation to zonal fronts located at the middle of the basin of the Japan Sea near 40°N. However looking at Figure 1 one can see that these fronts extends from 37°N to 42°N. In fact the authors only analyze the flux of particles at latitudes from 39.875 to 42.125 (Figure 3). Please could you clarify this choice?
4. Have the authors compared the intrusions of subtropical waters (figure 6) with Sea Surface Temperature or Ocean color satellite images? It could help you to prove with observations such dynamical features?

**Abstract:**

1. The authors repeat several times “Lagrangian indicators (line 2)”, Lagrangian maps (line 7) without specifying the Lagrangian diagnosis used in the study.
3. Sentence in lines 5-6. It is hard to understand how the eddies open the gates due to their suitable dispositions. What does “suitable dispositions” means?
2. Last two sentences: It's clear that something is happening because of the peculiarities of the advection velocity field, but which one? Please be more precise.

**Introduction:**

1. Figure 1 shows high values of northeastward velocity data in the TS (Tsugaru strait)? It means that, in average, the most of particles scape throughout this strait to the Pacific Ocean? Do the authors know if there is a relationship between these feature with the frontal-pair-vortex systems (AC-C) located at the entrance of the strait?
2. Please move to the first paragraph (where you are describing the bathymetry) the sentence in line 19 (page 1) with the reference to the figure showing the bathymetry.
3. Acronyms: The text is full of acronyms.
  - Could the authors explain what does SF mean (line 5, page 2)? Salinity fronts?
  - It could be great if the authors describe all the acronyms in the introductory part (second paragraph of introduction section) and not in the Results section (first paragraph of section 3.1) neither in the caption of Figure 1.

**Data and methods:**

1. The time step used for the Runge-Kutta integration is 1/1000. It means 0.001 days (~1.5 minutes)? Why this such short time step? Have you compared the results using a longer time step, namely, 1 day (the time resolution of the Altimetry data?)
2. It is hard to understand the sentences from line 18 and line 21 page 4: “ Trajectory of each .....in the northward transport only.” Authors say that t”he fixed the position and time of each tracers when they cross a given latitude between 37 and 43” and then they say that they “fix only the first crossing of a given latitude”. Could the authors clarify this part of the methodology?
3. line 21 page 4. Could the authors explain how a cell of AVISO can have two corners situated at land? As far as I am concerned a cell of AVISO only can be either land or ocean depending of the land mask. Maybe they mean two corners of the integration cell situated at land?
4. line 23-25. Could the authors read carefully and rewrite the paragraph? The sentence does not make sense.

5. Could the authors provide a description of the methodology used to compute and classify the fixed points of the velocity field in elliptic and hyperbolic points? The velocity field in the centers of the eddies is different to zero. Could the streamlines of saddle nodes be used to localize fronts?
6. Please specify the number of drifters used in the study?

## **Results and Discussion**

1. The description given in the first paragraph is already provided in the introductory part (line 31 page 3 and lines 1, 2 page 4).
2. First and second paragraph of this section are not results and they should be in the Introduction or in the Data and methods sections.
3. Second paragraph page 7. Eulerian (time average of northward velocities, Fig. 2b) with Lagrangian (particles trajectories crossing different latitudes, Fig. 2a) diagnosis are compared. Authors state that both diagnosis are equivalent because the transport is determined by local advection. It means that the dynamics is controlled by the local scales (“small scales”) and not by the large scales?
4. Do Fig. 3 show zonal cross-sections of Fig. 2 for four latitudes? If so, why the authors do not relate both figures in the manuscript, it could help to the reader. I do not know what does means “central part”? Authors state that “the correlation is rather good for western and eastern parts but not for the central one” (line 31-32, page 7), however, I see a good correlation between virtual and real drifters in the central part of the Japan Sea (see minima in Fig. 3 at 134°E-136°E). Moreover, this correlation is stronger in the north part (higher latitudes) than in the southern. Maybe because of the number of available drifters?. Could the authors specify the number of drifters? Have the authors values of the correlations coefficients?
5. With regard to the bad correlation with drifters (line 32-33 page 7), other explanation could be because drifters movement is due also to submesoscale features which are not provided by velocities derived from altimetry.
6. Line 2 page 8. How does the authors know that drifters have been launched randomly over the basin? Could they provide references on these drifters experiments explaining these random releases?
6. Drifters are not launched at 37°N but at least they have to cross this latitude to take them into account in the meridional transport computations.
7. Second paragraph is confused. I do not know how to differentiate gates and barriers from Fig 3. Minima and maxima of numbers of tracers?. Could the authors clarify this point?
8. It is difficult to deduce from Figure 4 the parameter chosen by the authors to define the size of gates and barriers.
9. Line 1-2, page 11. It's hard to understand what the authors mean in this sentence.

10. Line 3, page 11- This motivation has been included in the introductory sections. Please avoid repetitions.

11. Line 6, page 11. Definition of Lagrangian Maps is not clear: I really do suggest that the authors rewrite it.

12. Fig 6 correspond to maps of residence times computed backward in time. They are the incoming times and it has been already used for several authors:

- *Lipphardt, B., Jr., Small, D., Kirwan, A., Jr., Wiggins, S., Ide, K., Grosch, C., and Paduan, J.: Synoptic Lagrangian maps: Application to surface transport in Monterey Bay, J. Mar. Res., 64, 221–247, 2006.*

- *H. Gildor, E. Fredj, J. Steinbuck, S. Monismith. Evidence for submesoscale barriers to horizontal mixing in the ocean from current measurements and aerial photographs. Journal of Physical Oceanography, 39, 1975–1983, 2009.*

- *Hernández-Carrasco, I., López, C., Orfila, A., and Hernández-García, E.; Lagrangian transport in a microtidal coastal area: the Bay of Palma, island of Mallorca, Spain. Nonlin. Processes Geophys., 20, 921–933, 2013.*

13. It could be great if authors include a reference when they say that Peripheries of the mesoscale eddies in the ocean are known to be transport pathways for larvae, fish ..... (lines 5-6, page 12).

14. Sentence in line 7: “.....kind of transport for heat-loving organisms to reach the southern coast of Russia”. It means that the coast of Russia is warm?

15. The paragraph (lines 8-15) could be improved if the authors reorganize the text. Lines 11-13 (“ The red and green .....respectively”) could be move in before line 10 (“In the beginning of September .....pulled to the north.”)

16. Line 3, page 13. It seems that this is the mechanism to explain the intrusions of subtropical waters (Figure 6). The manuscript could be improved if authors are more explicit.

17. Is the displacements of the tracers (D) a Lagrangian diagnosis developed by other authors, by means of the function M, in order to obtain the Lagrangian Coherent Structures?:

- *Mendoza, C. and Mancho, A. M.: The hidden geometry of ocean flows, Phys. Rev. Lett., 105, 038501, doi:10.1103/PhysRevLett.105.038501, 2010.*

18. Line 7, page 13. “ so, the black tracers .....white ones” I do not understand what the authors mean with “displaced”. What is the difference between white and black colors? The length of the trajectory?

19. Line 14, page 13: “....pro-pulsed to the northwest”. Do the authors mean “northeast” instead of “northwest”? It seems that particles are not transported northwestward by the frontal-pair-vortex system but northeastward.

20. I do not understand the last paragraph from line 14 to line 18, page 13. Are the authors describing the drifter trajectories?

21. Line 24: Simulations with “imperfect” AVISO is compared with satellite, drifter and in situ observations. What kind of satellite product has been used to be compared with AVISO? When comparing with drifter trajectories you should take into account that drifter velocities has to be different than the geostrophic velocities derived from AVISO by definition.

22. Line 25-30. This sentence has been mentioned three times in the manuscript. Please avoid repetitions.

23. Line 31: “Nobody knows, of course true velocity field in the real ocean” This sentence is not necessary, please remove it.

24. Line 32: “The AVISO velocity field has errors as compared with an unknown “true” velocity field...”. This sentence is not logical: in my opinion anything can not be compared with things that are unknown, because they are unknown. One could say that the unknown part of the velocity field could be simulated by adding noise in the velocity data.

25. Line 34, page 13. What does “To which extent one can trust to them” mean?

26. Line 19, page 4. This study of adding errors in the velocity field to compute the trajectories has been performed for the FTLE and also for FSLE.

## **Conclusions**

1. I have found many repetitions that have been copied from the body of the manuscript. I suggest that the authors rewrite the whole conclusions section.

2. Please remove references to the Figures.

## **Technical comments:**

1. Please remove “there” (last word of abstract, line 11, page 1)

2. Why “Sea” (line 5 page 2) is in capital letter?

3. Line 6 page: 3 replace “to the coast” with “in the coast”

4. Line 10, page 3: Remove “across it”.

5. Line 11 page 3: in “ we use the altimetry data” remove “the”.

6. Line 14 page 3. Remove “based on altimetry data”. It has already been stated several times in the text. Please avoid repetitions.

7. Line 25, 26, page 7, It is not necessary to specify the longitudes for the zonal cross-section but only with the latitude the reader can localize the zonal lines.
8. Please read carefully the lines 28 in page 7 and rewrite the text: “ The number of crossing .....dashed curves” by for instance “The number of available drifters crossing the given latitudes are shown .....”.
9. There are many “to the” through the manuscript that should be replaced with “at the” or “in the”
10. Line 1 , page 9. What does “task 2” mean? Authors use “task X” throughout the manuscript to refer to the computations given in the Data and methods section. It could be great if it is stated in the methodology section that the computation X correspond to task X. (Although task is usually used in the context of a project and not in a paper).
11. There are two reference for *Prants et al, 2015*.
12. Line 1, page 12. Please remove the website of drifter data (it has been shown in Data and Methods) and also the number of the drifters.
13. Line 23, page 13. Remove “the” before AVISO and “we used” after AVISO.
14. Line 5, page 14. Please replace the sentence “ So , locations of the preferred .....are possible” with “So, locations of the preferred transport pathways are not expected to be changed significantly”.
15. Line 9, page 14. Please replace “Say” with “For example”.
16. Line 14, page 14. Replace “a plenty of” by “the presence of numerous”.
17. Line 16, page 14. Replace “As to” by “The” and remove “it”
18. Line 17, page 14. Add “by analyzing” just before “how and additional”.
19. Line 18, page 14. remove “modelling unknown corrections to the AVISO velocity field”. It has already been mentioned.
20. Line 19, page 14. Add “Finite Size Lyapunov Exponents” after “Finite Time Lyapunov Exponents”