Nonlinear Processes
in Geophysics
Discussions

Interactive comment on "Competition between Chaotic Advection and Diffusion: Stirring and Mixing in a 3D Eddy Model" *by* G. J. Brett et al.

Anonymous Referee #3

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1 Summary

The authors study the effect of chaotic advection and diffusion in a submesoscale eddy within a surface mixed layer of the ocean. The eddy is generated using two methods, a three dimensions eddy model and a direct Navier–Stokes simulation. In both cases the flow is generated in a rotating cylinder driven by an off-center lid to break the symmetry. The analysis present three different methods:

- from the Lagrangian Scale (δ), which defines the thinnest filaments that can form from the balance of advection and diffusion, the authors show that advection dominate in the wider chaotic sea region where the layer width is larger than δ.

- from a set of trajectories evolved from the background flow affected two types of perturbation (deterministic and stochastic). Analysis of particle dispersion is presented for different magnitudes and combination of those perturbations. Stochastic perturbation takes over deterministic perturbation over time, an important factor not considered using the scaling arguments of section 1.

- using the Nakamura Effective Diffusivity and the volume integrated tracer variance, the authors give ,quantitive measure on the importance of stirring for different perturbation combinations. Both tools show similar results, when filaments are created, the tracer variance increases until diffusive mixing takes over and wipes every filament. The analysis first focus on integrated values (Fig. 7) then figs. 8-9 present in-depth structures of the flow from dye and effective diffusivity contour.

In general, the paper is well written, the analysis and the description is exhaustive, and easy to follow. The discussion around each of the 3 metrics are well linked together and create a great comparison that will be useful for future research. The topic is important to understand mixing processes in ocean flow in general and could help parametrize model sub-grid phenomena. I would recommend the publication of this paper in NPG with minor revisions. I have divided my comments into two sections, the first one regroups general comments about the analysis and the second are minor corrections and typos.

2 Comments

- The methods are really well described but I believed some of the sections are too long. I would like the authors to focus on results and maybe relayed some of the methodology details to Appendix. For example, sec. 3-3.1 and add details to the

results section in 3.2. Section 5 is also a bit hard to follow as the reader is asked to compare two figures, maybe a reorganization of the figures could improve the readability.

- l55-60: the authors should take a look at *Material barriers to diffusive and stochastic transport* by G. Haller, D. Karrasch and F. Kogelbauer, which seeks transport barriers with no diffusion of tracers across it. Those structures could help extract the different regions analyzed in figure 11.

- l575-580: is there a difference between x_0 and X_0, and later in the caption of Fig.8 there is also an ϵ ?

- l771-774: 3D dye released and tracking seem almost like an impossible task, especially when the tracers have to be followed for multiple days. Right now, none of those methods can be calculated with observation data. Is there any plan for the applications of such analysis to 3D model outputs (ECCO, HYCOM, etc.) that assimilate data from floats, drifters, CTD casts, etc. ? An analysis performed for example on a Loop Current or Agulhas Current eddy would be interesting.

3 Typos

- l140: the streamfunction is not intuitive at all, I believed a sketch of the flow in section two could improve the readability.

- l299: for a for a

- l319: Caushy-Green

- l421: move out pf

- l445: a scale with square root of time could be included in the left panels figure 7

- eq20: I believe it should be σ instead of γ ?