Nonlin. Processes Geophys. Discuss.,
https://doi.org/10.5194/npg-2020-28-RC2, 2020
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Nonlinear Processes in Geophysics
Discussions
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Interactive comment on "Ordering of trajectories reveals hierarchical finite-time coherent sets in Lagrangian particle data: detecting Agulhas rings in the South Atlantic Ocean" *by* David Wichmann et al.

Anonymous Referee #2

Received and published: 23 September 2020

The authors apply a well-known clustering method OPTICS to Lagrangian trajectory data to extract finite-time coherent sets. Two of their aims are (i) to develop a hierarchy of coherent sets and (ii) to not fully partition the entire domain into coherent sets.

Novelty: ========

There are already several clustering methods in the literature for finding finite-time coherent sets, including a density-based clustering DBSCAN by Schneide-etal'18, which is a special case of the OPTICS approach in the manuscript. The idea of a hierarchy of

finite-time coherent sets has been considered by Ma/Bollt'13. The paper Fr/Sa/Ro'19 develops a robust method to classify only those sets are that coherent, not fully partitioning the domain. In Fr/Sa/Ro'19, coherent sets at different spatial scales are also considered, similar to a hierarchy. Fr/Sa/Ro'19 also considers the Bickley jet and ocean eddies, with ocean eddies listed as a motivation in Fr/Sa/Ro'19 for developing a non-partitioning approach. Not limited to the work above, I would say there is some "up-selling" of the novelty in the manuscript, and that prior work is occasionally omitted, mischaracterized, or overly criticized.

A positive aspect is that the (standard) "DBSCAN" and "\xi" clustering outputs of the OPTICS clustering could provide potentially useful hierarchical information, and to my knowledge this is a new way of analyzing the dynamics. Unfortunately, this is not explored much, and the authors do not provide an intuitive explanation of what the "DBSCAN" and "\xi" clustering algorithms are actually doing in their dynamical context. It would be beneficial for the authors to link the algorithms more with the dynamical inputs (trajectories) and the dynamical problem being solved. As this is the main contribution of the paper, I think this needs to be expanded much more. The reasons behind the choices of which clustering algorithm is applied to the different datasets should also be explained.

Performance: ============

The (uncited) paper Froyland/Junge'18 develops a finite-element approximation of the dynamic Laplacian, which is a very accurate and robust method of finite-time coherent set extraction for low-dimensional systems of the type treated in the Wichmann manuscript. In Froyland/Junge'18 there are no free parameters, the method is unaffected by the density of the data points, and estimates are produced on the whole domain.

A comparison can be made for the Bickley example in the Wichmann manuscript because the setup is identical. Wichmann et al uses a 200x60 grid of points and particle positions at times t=0,1,2,3,...,39,40. Froyland/Junge'18 studied the same Bickley flow as in Wichmann, except that Froyland/Junge'18 used a coarser 100x30 grid of points and only particle positions at time 0 and time 40. Figure 15 in Froyland/Junge'18 shows much clearer images with fewer trajectory inputs. Thus, I think there is not a strong case for the approach in the manuscript being a better performer.

The idea to not fully partition the domain has already been treated in Fr/Sa/Ro'19. Regarding the ocean eddy example in the manuscript, Fr/Sa/Ro'19 also applied the method of Froyland/Junge'18 to ocean flow and successfully extracted a greater number of eddies than Wichmann at a higher quality. On the other hand, Fr/Sa/Ro'19 used AVISO-derived trajectories rather than model output, so it could be that Wichmann is using a rougher velocity field. Wichmann also used lower trajectory density than Fr/Sa/Ro'19 by a factor of about 4; both of these items could make Wichmann's task more difficult, compared to Fr/Sa/Ro'19.

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