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Atmospheric Chemistry and Physics Discussions

ACPD

11, C16341–C16347, 2012

Interactive Comment

Interactive comment on "A Lagrangian analysis of a developing and non-developing disturbance observed during the PREDICT experiment" *by* B. Rutherford and M. T. Montgomery

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The authors would like to thank Referee 2 for the very helpful and constructive comments, which we have carefully considered to improve the quality of this paper. We will submit a revised manuscript which addresses each of the concerns. The comments are addressed individually.

One of the major difficulties in extending the analysis based on the computation of FTLE to study transport via lobe dynamics is to accurately compute the lobe geometry. An efficient way to do this is to employ methods developed by other authors (e.g. Mancho et al. (2003)) which, when used together with FTLE, can help in the extraction

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Interactive Discussion

Discussion Paper

of these important flow structures. However, these methods typically rely on the identification of DHTs which is made easier when a separation between the Lagrangian and Eulerian timescales exists in the problem (see Haller and Poje, Phys. D, 119, p352, 1998). It would, therefore, be interesting to plot the Eulerian and Lagrangian auto-correlation timescales (quantities analogous to R(τ)) for the velocity field to see whether this separation does indeed exist in the flows being considered here.

We will add a discussion that considers the possible utilities of lobe dynamics in the hurricane genesis problem, and what issues arise in this computation. We have added the suggested references for lobe dynamics and provided also the requested plots for autocorrelation. The amount and resolution of model data available for both observation and forecast data impose some limitation to the use of lobe dynamics, and we now describe these practical issues.

p., 33287, line 24: Is the linear interpolation used to advect particles sufficiently accurate for the purposes of this study. Do the authors mean bilinear inter polation in space? Other authors typically use bicubic interpolation in space and the authors should either use a more accurate scheme or explain why the method chosen is sufficiently accurate for the results presented in the paper.

In this study, we have used bilinear interpolation in space. However, we have specifically avoided simple bilinear-in-time interpolation methods. To clarify this point, we have added some additional description of our methodology for temporally interpolating the velocity fields (See third comment to Referee #1). Bicubic spatial interpolation was tried, but did not show any significant improvement over linear interpolation in trajectory locations, and LCS locations were almost identical. Bilinear spatial interpolation was chosen for pragmatic reasons since the computation of the Lagrangian fields were part of a large output of pouch products, which were computed each day with limited computing power. We now address the choice our bilinear interpolation in the manuscript.

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p. 33288, line 5: As the authors correctly point out, spurious structures can arise from the presence of open boundaries when computing LCS. In the results presented in this paper, how were particles treated when they reached an open boundary. Were they frozen? If so, how did the authors ensure that spurious structures did not 'contaminate' the results.

Particles that come into contact with the domain boundary are not frozen, but continue to move at the pouch translation speed. As a result, spurious particle separation is diminished.

In a number of places throughout the text (e.g. p. 33293, line 17; p. 33294, line ACPD 11, C15260–C15265, 2012 5; p. 33295, line 21; etc.), the authors comment on how par ticles appear to be able to pass through the manifold because of the nonexistence of LCS. However, the stable and unstable manifolds are what define the LCS. Since these are effectively material lines, particle trajectories can not cross them. My interpretation of what the authors are saying is that the particles can cross the separatrices of the streamlines which divide different regions of the flow in the instantaneous Eulerian velocity field. I would use the term "separatrices" or dividing "streamlines" throughout the paper when the authors are referring to these instantaneous ïňĆow features to avoid any confusion.

The particles do not cross the LCSs, but may cross the Eulerian streamlines. To avoid any confusion, we have clarified the differences between the Lagrangian and Eulerian structures.

P 33293, line 20. Why are FTLE values for repelling lines smaller than along attracting material lines? Is this because the flow is effectively compressible? For divergence free velocity fields, the two are expected to be equal in magnitude.

The flow is not incompressible and there is generally convergence into the pouch center during genesis.

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I found it very difficult to interpret the 3D structures in Fig. 13/ 14 and to relate what was plotted to the discussion of the results. I'm not sure how to improve these but if the authors think they are essential, perhaps including some arrows to point out the most important aspects of the plots would help direct the reader to the key features being shown.

We have changed the tilt angle of the volume-rendered plots and we have added arrows to show the key features.

The authors make the point that the flows considered essentially represent what they refer to as a cat's eye flow. In that sense the study of on the idealised problem of a barotropic meandering jet by Rogerson et al. J. Phys. Ocean., 29, 2635, 1999, with a similar flow structure appears extremely relevant. The authors should relate their results more closely to those in that paper to identify how the understanding of transport in the idealised problem considered in that work can elucidate transport in the PREDICT experiment.

We have added references to Rogerson et al. (1999), and other cat's eye studies.

P 33277, line 19: Some references here on the use of the Lagrangian reference frame would be appropriate.

Additional references have been added.

P 33278, line 18: OW is not defined until 3 lines further down. Need to define at this point.

We now define OW at this point in the manuscript.

P 33278, line 27: "The Eulerian methods .....". It was not clear to me what was meant by this sentence. Perhaps could be rephrased or made clearer.

We now specify that streamline locations are the specific Eulerian methods that have a sensitivity to time variations.

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p. 33281, line 25: ξ not defined until later in Section2.2.1. Should define at this point.

We now define zeta at this point.

P33282, line 1: It is argued that hyperbolicity is defined by nabla x (xh) but this does not make sense. I assume the gradient of the velocity field evaluated at the fixed point xh is what the authors mean.

Hyperbolicity is determined by the eigenvalues of the gradient of the velocity field at the fixed point. We have corrected this error.

P 33282, line 26: reference to velocity field being small is ambiguous as it is not clear small relative to what.

We have included brief discussions about the allowed magnitude of time derivatives and appropriate references.

P 33282, line 26: The authors should provide at least one or two references that discuss lobe dynamics.

We have added references pertaining to lobe dynamics.

P 33282, line 8: The authors argue that DHTs can be computed from the inter- section of the two set of manifolds but in general there are many of these inter- sections not all of which are DHTs. Should clarify which intersections correspond to DHTs.

We have clarified that the intersections which correspond to DHTs must have persistent hyperbolic stability and should be generally associated with a persistent hyperbolic fixed point.

P 33282, line 12: Sentence unclear. Perhaps should state that “The initial positions of the Lagrangian tracers are assigned the values x0 ”.

We will restate the sentence as suggested.

P 33284, line 14: insert “respectively” after “stable and unstable manifolds”.

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We have inserted “respectively”.

P 33282, line 21: FSLE is discussed in the literature and the authors should provide a relevant reference.

We have added references for FSLEs.

P 33285, Eq 5: put factor 1/TD in front of log to make it clear it is not under the log function.

We have reformatted the indicated Equation (5).

P 33286, line 4: insert “, say U,” after “the trajectories maintain the scalar quantity”.

We have included “say U” in the sentence.

P 33286, line 7: σi is not defined. I suspect this is nothing to do with σ appearing in Section 2.2.2. Perhaps should use a different variable name.

We now define sigma_i as the scalar variance.

P 33286, line 7: It is stated that the bar denotes mean particle position which is a little confusing. I thought the bar denotes a time average which is why R(τ) depends on τ only and not on t. Also, why position when U is a general scalar quantity?

We have clarified this sentence.

P 33286, Eq 7: the integration variable is not stated in the integral.

We have included the integration variable τ in the equation.

P 33286, line 10: I would not use the term “conserved” here as it typically means the value does not change rather than varying slowly.

We have removed the term ‘conserved.’

P 33287, lines 16, 18: insert “when” after “integrations which are far simpler”. change “independent” to “independently”.

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We have made the suggested changes.

p. 33289, line 6: I found it difficult to understand what is being meant by the last sentence.

P 33291, line 5: Has “ITCZ” already be defined?

We now provide a definition of ITCZ.

P 33292, line 2: Change sentence as streamlines are DEFINED as the particle trajectories obtained for a particular snapshot of the velocity field so it doesn’t make sense to say that it is not possible to compute streamlines in the Lagrangian frame.

We have changed the sentence as suggested.

P 33293, line 11: particle transport is in fact determined by both attracting and repelling material lines through lobe dynamics as referred to elsewhere in the text so both structures play an important role.

We will note the role of convergence in eliminating lobe dynamics for this case.

P 33294, line 21: reference is made to Eq. (8) which is not in the paper.

We have corrected this sentence to refer to equations 6 and 7.

P 33300, line 3: Sentence could be made slightly clearer for the reader.

We have broken up this sentence and attempted to clarify these ideas.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 33273, 2011.

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