Atmospheric Chemistry and Physics Discussions

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

Anonymous Referee #2

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The paper presents an application of the computation of Lagrangian Coherent Structures to the PREDICT experiment to help gain a better understanding of the transport of moist and dry air that are of major importance to the problem of tropical cyclone formation. While the methods and techniques for computing LCS has seen a growing number of applications in recent years, the use of these methods to the more complicated velocity fields considered here which are relevant to the specific problem of tropical cyclogenesis is in my opinion an important application of these methods. The study also provides an important first step towards a more thorough analysis of the problem that can ultimately lead to computation of fully 3D LCS.

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While the application of the method to the chosen problem is an important contribution, the authors need to address a number of technical comments listed below before the paper can be recommended for publication.

Specific comments:

- 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 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 $R(\tau)$) for the velocity field to see whether this separation does indeed exist in the flows being considered here.

- 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 interpolation 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.

- 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.

- In a number of places throughout the text (e.g. p. 33293, line 17; p. 33294, line

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5; p. 33295, line 21; etc.), the authors comment on how particles 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 flow features to avoid any confusion.

• 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.

• 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.

• 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.

Minor Corrections:

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

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

- p. 33278, line27: "The Eulerian methods .....". It was not clear to me what was meant by this sentence. Perhaps could be rephrased or made clearer.

- p. 33281, line 25: ξ not defined until later in Section 2.2.1. Should define at this point.

- p. 33282, line 1: It is argued that hyperbolicity is defined by $\nabla_x(x_h)$ but this does not make sense. I assume the gradient of the velocity field evaluated at the fixed point x_h is what the authors mean.

- p. 33282, line 22: reference to velocity field being small is ambiguous as it is not clear small relative to what.

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

- p. 33283, line 8: The authors argue that DHTs can be computed from the intersection of the two set of manifolds but in general there are many of these intersections not all of which are DHTs. Should clarify which intersections correspond to DHTs.

- p. 33283, line 12: Sentence unclear. Perhaps should state that "The initial positions of the Lagrangian tracers are assigned the values x_0".

- p. 33284, line 14: insert "respectively" after "stable and unstable manifolds".

- p. 33284, line 21: FSLE is discussed in the literature and the authors should provide a relevant reference.

- p. 33285, Eq. (5): put factor $1/T_D$ in front of log to make it clear it is not under the log function.

- p. 33286, line 4: insert ", say U," after "the trajectories maintain the scalar quantity".

- p. 33286, Eq. (6): σ_i 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.

- 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 $R(\tau)$ depends on τ only and not on t. Also, why position when U is a general scalar quantity?

- p. 33286, Eq. (7): the integration variable is not stated in the integral.

- 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.

- p. 33287, line 16: insert "when" after "integrations which are far simpler".

- p. 33288, line 18: change "independent" to "independently".

- 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?

- p. 33293, 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

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make sense to say that it is not possible to compute streamlines in the Lagrangian frame.

- 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.

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

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

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

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