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Earth System Dynamics Discussions

Interactive comment on "Climatology of Lyapunov exponents: The influence of atmospheric rivers on large-scale mixing variability" *by* Daniel Garaboa-Paz et al.

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We would like to thank the Referee for his/her valuable comments and critics that we tried to take into account in the revised version of the manuscript. Hopefully, all the major and minor corrections pointed out by the reviewer have been corrected now. A detailed answer follows below. We provide replies to the reviewer' comments in bold. As well, corrections included in the manuscript are marked in red.

Answer to Referee 1

This paper studies mixing and Lagrangian transport properties for a period of 35 years, 1979-2014, of the wind field reanalysis from the ECMRWF by computing trajectories of

a large number of tracers placed in a grid of 0.35 degrees. Lagrangian simulations are carried out using the wind data as input and FTLEs are calculated for each tracer on a time horizon τ. Potential connections of FTLEs maps with baroclinic instability, ENSO, storm tracks, etc are discussed. Some of these connections/correlations are clearer than others, some are put in firmer grounds than others, and some are no more than a conjecture, but the paper has potential to be interesting.

The paper has however some scientific issues that should be addressed: 1) The FTLE definition in Eq.(2) cannot be correct. The deformation tensor C must C1 depend on t0 and τ explicitly. I guess the authors mean C is the product of deformation tensors evaluated along the trajectory of the tracer from t0 up to t0 + τ at every time step in the integration. Ideally, one should write the explicit equations that go from the motion equations to λ to make the paper accessible to a wider audience– namely, those who are not specialists in Lagrangian flows. In any case, the formula (2) must be corrected and the correct meaning for C must be given.

We agree with the referee on this insight. We rewrite the methods section to make clear the FTLE calculation; also we included the explicit dependences. The Cauchy tensor is not evaluated each time step. It is just evaluated when particles reach their final position at t0+τ.

2) Below line 25, the paragraph that begins: "Figure 4 ..." discusses ARs (atmospheric Rivers) the authors mention they use some detection criteria by Guan and Waliser and nothing else is explained. Well, I don't think this method is that well known to a general audience so that everyone should know how ARs were actually detected. One does not know why this method is used and no others or how would that change detection. The explicit details of how this detection works, why is favoured by the authors here, etc should be provided.

The AR-Detection Database provided by Guan and Waliser is the most widely used database nowadays. We didn't just follow the detection criteria, but we directly used the database, which is public. We have included more information about the AR-detection method in the paper. Specifically: We have changed “using daily-AR landfall detection criteria provided by Guan and Waliser (2015)” by:

The AR landfall detection has been carried out using the AR-Database provided by Guan and Waliser (2015). This database identifies ARs by complex considerations on the continuity and coherence of the integrated water vapor column and water vapor flux. Since it is able to identify ARs throughout the year and worldwide, this database provides, to the best of our knowledge, the most complete AR database published nowadays [Waliser and Guan (2017)].

3) I do not know how periods with land falling ARs are calculated and I fail to fully appreciate the validity of Fig. 4. What does it mean λ_AR ? You mean the FTLE is only computed during those episodes of AR events? Does this mean the whole interval (t0 , t0 + τ) must be within the event? Or only the starting time t0?

The AR periods are calculated based on the true detection method coming from the database (Guan, 2015) mentioned previously. The procedure is the following: 1. Using the Guan database, we build a true-false time series based on the presence of ARs over the region of interest. 2. We use this mask to select the FTLE maps time steps with a true AR detection. 3. We apply the mean over the true elements (2) obtaining λ_AR. To avoid misunderstandings we have added new sentences in the text to clarify this point.

4) The last sentence of the paper is intriguing. When the authors say: "... and could be used forecast precipitation events in those regions where persistence of coherent transport structures has a great impact", do they really mean to say FTLEs can be used to forecast precipitation events?

This method cannot replace the weather forecast simulations. As we comment in the methods section, the FTLE can be obtained in forward and backward direction. To compute the FTLE in backward direction we just need information from the wind field,

from the past to the present. Performing, backward advections, we can estimate the presence of attracting coherent structures in the wind field. If an attracting coherent structure starts to develop and there are precedents of a similar dynamical behaviors (like ARs), this information can be used to estimate how the deformation of air masses will be transported in the following days.

Typos: 1) In the first sentence of the paper I think "the conversion of" is better than "the conversion between" 2) In Page 3, line 8: It should be Eq.(1) instead of (2) 3) Page 3, line 18: "stable (unstable)" shouldn’t it be "unstable (stable)"?

Thank you to indicate us these typos that we have corrected. With respect to the last comment, repelling coherent structures can be thought as stable manifolds and vice versa.

Please also note the supplement to this comment:
http://www.earth-syst-dynam-discuss.net/esd-2017-1/esd-2017-1-AC1-supplement.pdf

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