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Transport and mixing properties of observational datasets from finite-size Lyapunov exponent calculations

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The finite-size Lyapunov exponent (FSLE) calculation is a simple Lagrangian technique able to detect various characteristics of transport and mixing in two-dimensional geophysical flows. Regions of high FSLEs corresponds to manifolds of hyperbolic points and allow to locate transport barriers and fronts of tracers. Moreover, the combined use of forward- and backward-in-time calculations can be used in various ways for the analysis of stirring properties. Here the robustness of the FSLE calculation is discussed in some case studies of oceanographic and atmospheric applications. For the case of the North-Atlantic POMME region and the Algerian basin, we use the FSLEs to compute the unstable manifolds of hyperbolic points from sea surface heights (ERS and TOPEX/Poseidon altimetric data). We show that the manifold calculation is a complementary technique in respect to Eulerian methods (like the Okubo-Weiss parameter) and allows to predict mesoscale fronts and filaments observed in patterns of chlorophyll and sea surface temperature. Moreover, the convolution of the manifolds can be used to evaluate the role of chaotic transport in submesoscale structures of tracer patches. For the case of the atmosphere, we combine forward and backward FSLEs and define a mixing measure that takes into account the stretching of the field and the gradients of passive tracers. Such diagnostic is applied to isentropic layers in the upper-troposphere/lower-stratosphere region using winds of the European Center of Medium-range Weather Forecasting (ERA-40 dataset) and shows the modulation and breaks of mixing barriers in connection with ENSO.