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Lagrangian diagnostics of transport properties, barrier effects and mixing rates for the stratospheric polar vortex through a dynamical systems approach (FSLE)

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Strong jet current systems, like the one surrounding the wintertime polar vortex in the stratosphere, may behave (or not) as dynamical barrier to Lagrangian cross-stream mixing, dependently on some flow characteristic parameters. This phenomenon can be studied in detail with the aid of simplified meandering jet models, defined in terms of a kinematic velocity field having qualitatively a similar large scale shape as the actual stratospheric polar jet. We employ analysis techniques coming from the dynamical systems theory, e.g. the Finite-Scale Lyapunov exponents, already well established as the most reliable tool when dealing with relative dispersion problems in strongly nonlinear fields. The technique is applied to a meandering jet model and to realistic Lagrangian stratospheric trajectories based on ECMWF data relative to the winter polar stratosphere, in order to obtain a climatology of the polar jet barrier features. We are in particular interested in estimating the transport rates, over advective characteristic time scales, between different parts of the flow (meandering jet model and polar jet). At this regard, the domain of the flow is partitioned in a few macro-areas, (e.g. the jet stream, the inner region, the outer region) and the elements of the transition matrix, (i.e. the average fractions of trajectories passing from one element to another in a given time interval) are computed through massive Lagrangian simulations, both for the jet model and the actual polar vortex system.