Geophysical Research Abstracts
Vol. 14, EGU2012-6852, 2012
EGU General Assembly 2012

Testing metrics of mixing using a chaotic advection model

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This study describes an evaluation of different dynamical measures and their ability to diagnose horizontal transport and mixing in atmospheric flows. This quantification can then be used to select optimal measures which can be applied to satellite and re-analyses data to identify likely regions where the indirect effect of Energetic Particle Precipitation (EPP) is important.

As a "test bench" for mixing measures a two dimensional idealized atmospheric model has been developed (Pierrehumbert et al, 1992 , Shuckburgh et al 2003). It is completely defined by a set of only five parameters. Although it is an oversimplification of real atmospheric flows, it exhibits the main dynamical characteristics of the stratosphere near the polar vortex. At the same time, it's simplicity gives us the opportunity to make detailed investigations on the quality of the mixing measures. By using this analytical model with a Lagrangian trajectory model we can examine the impact of the flow on the distribution of any trace gas.

We have chosen to examine two mixing measures, namely finite time Lyaponov exponents (FTLE) and the Renyi entropy (RE). The former is a numerical realization of the Lyapunov exponent (Wolf et al, 1984), a measure of the amount of separation of nearby trajectories of a dynamical system. The FTLE has been used in studies before as a measure of mixing (i.e. Pierrehumbert et al, 1992; Shuckburgh et al 2003; Garny et al, 2007). The Renyi entropy is a measure originating from information theory and has also been studied before in the context of atmospheric mixing (Krützmann et al, 2008).

Initial analysis seems to show a relatively strong anti-correlation between these mixing measures. In particular, high FTLE (which relate to strongly divergent regions) identify mixing barriers and are generally linked to low values of RE. Results from an analysis of a range of model realizations with varying amounts of prescribed mixing will be performed to robustly quantify the relationship between the two mixing measures.