Geophysical Research Abstracts, Vol. 9, 05110, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-05110

A method for the estimation and analysis of transport process based on a spatio-temporal scale interaction

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We present a new method built on the dynamical systems approach for the estimation and analysis of transport processes. The method can deal with transport of not only fluid particles but also flow properties such as temperature and salinity in the ocean. The method uses a spatio-temporal integration of the instantaneous flux induced by the interaction between the mean and variability of the flow. The method can be viewed as a hybrid of the Lagrangian and Eulerian methods because it efficiently estimates the (Lagrangian) transport across a(n Eulerian) boundaries that are kinematically defined by the streamlines of the mean flow. For a special case where particle transport is evaluated along a separatrix of the flow, our method yields to the Melnikov function that is used to measure the distance between the two invariant manifolds of the Lagrangian lobe dynamics up to leading order

Using this method, we also present a framework for the analysis of transport processes. The framework proceeds after first carrying out a sequence of setup steps that link the flow dynamics to the transport processes. It is followed by a spatio-temporal analysis in which transport processes can be studied by tracing the scale-dependent signals of the instantaneous flux field. This tracing also reveals how the variability of the flow contributes to the transport processes. The spatio-temporal analysis can also assess the efficiency of the flow variability in transport. We demonstrate the transport method and the analysis framework through an application to the double-gyre ocean circulation.