Geophysical Research Abstracts
Vol. 14, EGU2012-14014, 2012
EGU General Assembly 2012

Turbulent Diffusion in Non-Homogeneous Environments

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Many experimental studies have been devoted to the understanding of non-homogeneous turbulent dynamics. Activity in this area intensified when the basic Kolmogorov self-similar theory was extended to two-dimensional or quasi 2D turbulent flows such as those appearing in the environment, that seem to control mixing [1,2]. The statistical description and the dynamics of these geophysical flows depend strongly on the distribution of long lived organized (coherent) structures. These flows show a complex topology, but may be subdivided in terms of strongly elliptical domains (high vorticity regions), strong hyperbolic domains (deformation cells with high energy condensations) and the background turbulent field of moderate elliptic and hyperbolic characteristics. It is of fundamental importance to investigate the different influence of these topological diverse regions.
Relevant geometrical information of different areas is also given by the maximum fractal dimension, which is related to the energy spectrum of the flow. Using all the available information it is possible to investigate the spatial variability of the horizontal eddy diffusivity K(x,y). This information would be very important when trying to model numerically the behaviour in time of the oil spills [3,4]

There is a strong dependence of horizontal eddy diffusivities with the Wave Reynolds number as well as with the wind stress measured as the friction velocity from wind profiles measured at the coastline.
Natural sea surface oily slicks of diverse origin (plankton, algae or natural emissions and seeps of oil) form complicated structures in the sea surface due to the effects of both multiscale turbulence and Langmuir circulation. It is then possible to use the topological and scaling analysis to discriminate the different physical sea surface processes. We can relate higher orden moments of the Lagrangian velocity to effective diffusivity in spite of the need to calibrate the different regions determining the distribution of mesoscale vortices and other dominant features [5,2].
We present relationships used to parameterise the sub-grid turbulence in terms of generalized diffusivities that take into account the topology and the self-similarity of the sea surface environment.
Multifractal analysis can also be used to distinguish fresh oil spills and natural slicks in the ocean surface, with residence time the diference diminishes (The Damkholer number scales the time with rough weather accelerating the dilution). Modelling the Rossby deformation scale dynamics is fundamental to predict oil spill behaviour as this range is the most energetic.

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