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Mixing and Vorticity Structure in Stratified Oceans

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Several series of experiments in stratified and in rotating/stratified decaying flows after a grid is used to stir the two layer stable fluid brine and fresh water set up. (Matulka 2009). We measure by comparing the gained potential energy with the available kinetic energy AKE, the relative efficiency of mixing. The experiments in stratified rotating flows with grid driven turbulence were both periodic (quasi stationary) and non-monotonic (decaying) forcing(Matulka et al. 2008).

A complex Parameter Space Using Ri, Ro, Re is used to compare field, experimental and numerical observations on the mixing structure and Topology(Redondo 2004, Redondo et al 1996) of the Stratified Rotating Flows. The horizontal spectra changes appreciable with slopes from 1.1 to 5, but relevant to dispersion, vorticity and local circulation, not only the spectral slope is important, but also the initial topology and forcing of the AKE (in Elliptical, vortex core regions) or in hyperbolic regions dominated by shear). Using multi-fractal geometry as well, we can establish now a theoretical pattern for the turbulence behavior that is reflected in the different descriptors (volume fraction, velocity and vorticity and thus obtain a certain classification relating D3 and the sum (integral) of the different fractal dimensions D2 for different levels of scalar (volume fraction intensity or temperature). Vorticity evolution is smoother and different than that of scalar or tracer density. The correlation between the local Ri and the fractal dimension detected from energy or entropy is good. Using multi-fractal geometry we can also establish certain regions of higher local activity used to establish the geometry of the turbulence mixing, that needs to be studied in detail when interpreting the complex balance between the direct 3D Kolmogorov type cascade and the Inverse 2D Kraichnan type cascade.

A large collection of SAR images obtained from three European coastal areas (Gade and Redondo 1999) analyzed and compared with other Satellite images in the frame work of the CLEAN SEAS European Union project (more information is available in Redondo and Platonov 2001) The use of routine satellite information by SAR or other sensors seems very important to build seasonal databases of the dynamic conditions of ocean mixing conditions.

We identify when intermitency is important or can be ignored, by measuring local power spectra, as time-scale and length-scale driven are important and we apply the ideas of "fossil" turbulence as they play a valuable role in the scale to scale mixing cascade.

The eddy diffusivities in the ocean exhibit a large variation and show a marked anisotropy, not only horizontal values are much larger than vertical ones but there is a strong dependence on the spatial extent of the tracer dye or pollutant and at larger scales the topology of the basic flow is very important. These are strongly influenced by the buoyancy and horizontal diffusion depends on ambient factors such as wave activity, wind and currents, in particular we compare 2D spectra both in the laboratory experiments and in SAR ocean surface satellite observations, using the Rossby deformation radius as fundamental scaling scale.

Using multifractal analysis we devise a method of deriving eddy diffusivity maps from image information should give more realistic estimates of the spatial/temporal non-homogeneities (and intermittency obtained as spatial correlations of the turbulent dissipation, or from structure functions) and these values may be used to parameterize either sea surface turbulence or atmospheric turbulence at a variety of scales. Different fractal dimensions are related to different levels of intermittency (and thus also different spectra, which are not necessarily inertial nor in equilibrium). These techniques are helpful in providing more realistic estimates of spatial and temporal variations of the horizontal dispersion in the environment; which reflects the influence of spectral energy distribution on local diffusivity in terms of a Generalized Richardson's Law.

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