Geophysical Research Abstracts
Vol. 16, EGU2014-15249, 2014
EGU General Assembly 2014

Mixing and diffusion in intermittent overturning turbulence

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The improvements in experimental methods and high resolution image analysis are nowadays able to detect subtle changes in the structure of the turbulence over a wide range of temporal and spatial scales [1], we compare the scaling shown by different mixing fronts driven by buoyancy that form a Rayleigh-Taylor mixing front. We use PIV and density front tracking in several experimental configurations akin to geophysical overturning [2-7]. We parametrize the role of unstable stratification by means of the Atwood number and compare both the scaling and the multifractal and the maximum local fractal structure functions of the different markers used to visualize the front. Both reactive and passive scalar tracers are used to investigate the mixing structure and the intermittency of the flow. Different initial conditions are compared and the mixing efficiency of the overal turbulent process evaluated [6-7].
An interesting approach, relating the Multi-Fractal dimension spectra, the intermittency and the spectral exponent is to find relationships that may be used to parameterise the sub-grid turbulence in terms of generalized diffusivities [4] that take into account the topology and the self-similarity of the Mixing RT and RM flows. As an example, a relationship between the diffusivity, the exponent β, the intermittency μ, and D(i), may be found for the volume fraction or the concentration, at the same time other locally measured parameters such as the enstrophy or the gradient alignment as well as their multi-fractal structures may turn out to be physically relevant indicators of the local turbulence and the mixing.

Several methods of deriving local eddy diffusivity and local entrainment should give more realistic estimates of the spatial/temporal non-homogeneities (and intermittencies in the Kolmogorov 62 sense obtained as spatial correlations of the turbulent dissipation, or from structure functions) and these values may be used to parameterise turbulence at a variety of scales. The method involving the multi-fractal dimension measurements is much more elaborated and seems to have a better theoretical justification in the sense that it is possible that different concentrations showing different fractal dimensions may be due to different levels of intermittency (and thus different spectra, which are not generally in equilibrium as dscribed by[9,10].

Using topological descriptors we can establish now a theoretical baseline pattern for the turbulence behaviour that is reflected in the different structures (volume fraction, velocity, vorticity, helicity) we can thus obtain a classification relating D3 and the integral of the different fractal dimensions D2 for different levels of scalar (volume fraction reaction intensity or temperature). [5,8,11] Vorticity evolution is more smooth and quite different than that of volume fraction or density and these seem also different for the RT and RM instability driven mixing showing a wider range of even higher mixing efficiencies 0- 0.66

Thanks to European Union project ERBIC15-CT96-0111 Multi-scale complex fluid flows and interfacial phenomena (PITN-GA-2008-214919). ERCOFTAC and GenCat. grant 2001SGR00221.

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