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Convective thermal fluxes in unsteady non-homogeneous flows generating complex three dimensional vorticity patterns

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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 convective driven mixing. We use PIV and density front tracking in several experimental configurations akin to geophysical overturning [2, 3]. We parametrize the role of unstable stratification by means of the Rayleigh and Atwood numbers and compare the scaling and the multifractal structure functions of the different markers used to visualize the non-homogeneous. 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 overall turbulent process is evaluated [4 - 6].

Diffusion is measured in the transition from a homogeneous linearly stratified fluid to a cellular or layered structure by means of Thermoelectric generated heating and cooling [2, 4]. Patterns arise by setting up a convective flow generated by a buoyant heat flux either in the base or in a side wall of the convective enclosure [1, 6]. The experiments described here investigate high Prandtl number mixing using brine or sugar solutions and fresh water in order to form a density interface and low Prandtl number mixing with only temperature gradients [7].

The set of dimensionless parameters define conditions of numeric and small scale laboratory modeling of environmental flows. Fields of velocity, density and their gradients were computed and visualized [8, 9]. When convective heating and cooling takes place the combination of internal waves and buoyant turbulence is much more complicated if the Rayleigh and Reynolds numbers are high in order to study entrainment and mixing.

The experiments described here investigate high Prandtl number mixing using salt or sugar solutions and fresh water in order to form density interfaces. The Reynolds number can be reduced adding Glicerine the set of dimensionless parameters define different conditions of both numeric and small scale laboratory applied often in modeling environmental flows. Fields of velocity, density and their gradients are computed using advanced visualization [8 9]. Visualizations are performed by PIV, Particle tracking and shadowgraph. When convective heating and cooling takes place the patterns depend on the parameter space region of the initial conditions

We also map the different transitions between two and three dimensional convection in an enclosure with several complex driven flows. The size of the water tank is of 0.2 x 0.2 x 0.1 m and the heat sources or sinks can be regulated both in power and sign [2-4]. The thermal convective driven flows are generated by Seebeck and Peltier effects in 4 wall extended positions of 0.05 x 0.05 cm each. The parameter range of convective cell array varies strongly with the Topology of the boundary conditions. At present side heat fluxes are considered and estimated as a function of Rayleigh, Peclet and Nusselt numbers, [4-6]

The evolution of the mixing fronts are compared and the topological characteristics of the merging of plumes and jets in different configurations presenting detailed comparison of the evolution of RM and RT, Jets and Plumes in overall mixing. The relation between structure functions, fractal analysis and spectral analysis can be very useful to determine the evolution of scales. Experimental and numerical results on the advance of a mixing or non-mixing front occurring at a density interface due to body forces [12] can be compared with the convective fronts.

The evolution of the turbulent mixing layer and its complex configuration is studied taking into account

the dependence on the initial modes at the early stages, Self-similar information [13]. Spectral and Fractal analysis on the images seems very useful in order to estimate dominant mixing structures as well as the basic instabilities than drive the turbulent direct and inverse cascades [12].

References

[1] Mahjoub O.B.; Redondo J.M.; and Babiano A. (2000). Hyerarchy flux in nonhomogeneous flows in turbulent diffusion in the environment Eds. Redondo J.M. and Babiano A. 249-260.

[2] Redondo J.M. (1992). Termodinámica de los procesos irreversibles, efectos termoeléctricos. Rev. Termoelectricidad2, 16-29. AIT. Pamplona.

[3] Dalziel, S. B. (1994). Perturbations and coherent flow in Rayleigh-Taylor instability in 4th International Workshop on the Physics of Compressible Turbulent Mixing, ed. P. F. Linden, D. L. Youngs, & S. B. Dalziel; 32-41.

[4] Redondo J.M.; Sanchez J.M.; Pascual I.; Noriega, G.F. (1995). Thermoelectric regulation for electric cabinets: XVI International Conference in Thermoelectrics, 02-G20. Ed. V. Vedernikov. 456-468. St. Petersburg, Russia.

[5] Mahjoub, O.B; Redondo J.M.; Babiano A. (1998).Structure functions in complex flows: Applied Scientific Research. 59, 299-313. Kluwer.

[6] Matulka A.; Redondo J. M.; and Carrillo A. (2008). Experiments in stratified and rotating decaying 2D flows, Il Nuovo Cimento 31, 5-6, 757-770. 2008.

[7] Redondo, J.M.; Tellez, J; Sotillos, L.; Gonzalez-Nieto, Pilar L.; Sanchez, J.M.; Furmanek P.,; Diez M (2014). Complex Convective Thermal Fluxes and Vorticity Structure: Geophysical Research Abstracts Vol. 17, EGU2015-14773, 2015 - EGU General Assembly 2015.

[8] Nicolleau, F.C.G.A.; Cambon, C.; Redondo, J.M.; Vassilicos, J.C.; Reeks, M.; Nowakowski, A.F. (Eds.) (2012). New Approaches in Modeling Multiphase Flows and Dispersion in Turbulence, Fractal Methods and Synthetic Turbulence: ERCOFTAC Series.

[9] Redondo J. M.; Sanchez M. A.; and Cantalapiedra I. R. (1995). Turbulent Mechanisms in Stratified Flows, Dynamics of Atmospheres and Oceans, 23, 454-462.

[10] Matulka A.; Redondo J.M.; and Carrillo A. (2008) Experiments in stratified and rotating decaying 2D flows. II Nuovo Cimento 31, 5-6, 757-770. 2008.

[11] Fraunie P., Berreba S. Chashechkin Yu.D., Velasco D. and Redondo J.M. (2008). Large eddy simulation and laboratory experiments on the decay of grid wakes in strongly stratified flows. II Nuovo Cimento C 31, 909-930.

[12] Matulka, A.; López, P.; Redondo, J. M.; and Tarquis, A. (2014). On the entrainment coefficient in a forced plume: quantitative effects of source parameters. Nonlin. Processes Geophys. 21, 269-278.

[13] Castilla R.; Oñate E.; and Redondo J.M. (2007) Models, Experiments and Computations in Turbulence. CIMNE, Barcelona, 255.