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Buoyant mixing modifications by plume arrays

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The turbulent mixing is a very important ussue at the study of geophysical phenomena. The reason is that the greatest part of the fluxes deriving from geophysic fluids are turbulent. In many of the physical phenomena ocurring in nature the diffusion of physical quantities is governed by the mixing generated by turbulence.

The study of the turbulent mixing due to gravitatory convection makes use of an experimental model with two fluids of unequal density under an unstable density distribution. The mixing process is generated by the evolution of a bidimensional array of forced turbulent plumes.

The global conclusions of the first experiments are related to the mixing efficiency and the volume of the final mixed layer as functions of the Atwood number, which ranges from 0.010 to 0.134. The mixing efficiency has an upper limit of 0.18 and this efficiency is about 20% of the maximum mixing efficiency (0.5) in comparable experiments. We propose a theoretical explanation to understand this difference: the distribution of the array of plumes modify the overall mixing efficiency, so it depends strongly on initial conditions.

The reduction of the overall mixing efficiency when the flow starts as an array of plumes may be explained because there is less volume where contact may exist at molecular level. The regions of higher local mixing would be the cones of the plumes - using Turners plume entrainment hypothesis-. More, the outer region of the cones-plumes will never contain heavier fluid and once the potential energy is lost by a falling plume no mixing may take place locally above the Ozmidov scale. This initial dilution and the horizontal entrainment is crucial as less plumes and it affects in a non-linear fashion the overall mixing efficiency.

To verify these hypothesis, we performed new experiments with a line of plumes – from one to nine plumes- with an Atwood number of 0.03. Measurements of the height of the final mixed layer as functions of the number of plumes are made to verify that the less the number of plumes the lower the mixing efficiency.

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