Mixing efficiency in turbulent plumes and fountains

G. O. Hughes*, M. Copeland, Y. Dossmann, R. W. Griffiths, , R. Kamitakahara, R. C. Kerr, M. Rosevear-Gamble, X. Qin

Research School of Earth Sciences, The Australian National University, Canberra ACT 2601, Australia

We describe a series of experiments designed to measure the amount of mixing produced by either a turbulent plume or a turbulent fountain in a box. The ratio of the potential energy increase in the box to the energy supplied to the plume or fountain is used to characterise the efficiency of the mixing.

The efficiency is necessarily a function of the box geometry and is observed to become relatively insensitive to the continued evolution of the density field in the box after an initial box ventilation timescale. The mixing efficiency typically takes values between 40 and 45% for plumes, and less than 10% for fountains, with little observed dependence upon the governing parameters for high enough source Reynolds number.

These results are compared with theoretical and physical descriptions of turbulent entraining plumes and fountains. In the case of a plume filling box, we predict that the efficiency is 50%, and that this relatively large value occurs because the buoyant plume fluid releases kinetic energy and induces mixing as it traverses the depth of the box. The efficiency in a fountain, however, is much smaller because density anomalies are rapidly diluted with distance from the source, resulting in only a minimal increase to the overall potential energy in the box.

*corresponding author: graham.hughes@anu.edu.au