Comprehensive open datasets of stratified turbulence forced in vertical vorticity or wave modes

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We present new comprehensive open datasets of stratified turbulence in a periodic domain with constant Brunt-Väisälä frequency N. The forcing is either in large horizontal vortices or in wave modes. More than 80 simulations were carried out with the 'ns3d.strat' pseudo-spectral solver of the open-source CFD framework Fluidsim.

This datasets have 3 main particularities. (i) The horizontally invariant shear modes are cleanly removed from the dynamics. (ii) Large ranges of horizontal Froude $F_h = \varepsilon_K/(NU_h^2) \in [0.007, 2]$ and buoyancy Reynolds $\mathcal{R} = ReF_h{}^2 = \varepsilon_K/(\nu N^2)$ numbers are investigated, with U_h the horizontal rms velocity, ε_K the kinetic energy dissipation rate, and ν the viscosity. These datasets are adapted to investigate the different regimes of stratified flows forced with vortices, in particular the weakly stratified regime ($F_h > 0.1$) and the Layered Anisotropic Stratified Turbulence regime (LAST, $F_h < 0.07$ and $\mathcal{R} > 10$).

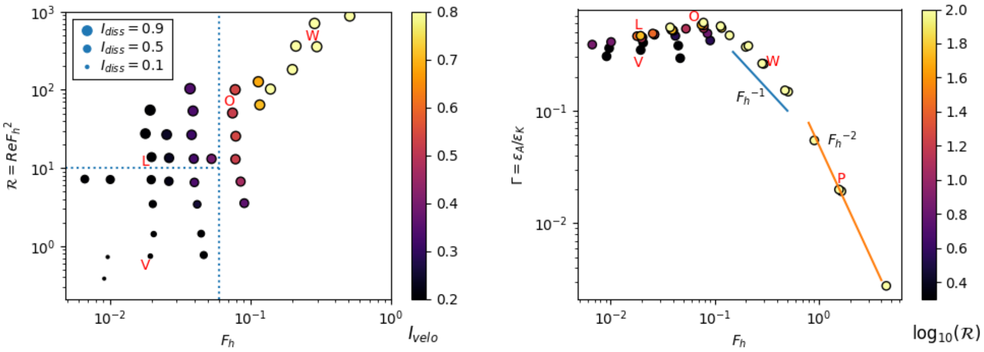

Figure 1: Isotropy coefficients (left) and mixing coefficient (right), in a space set by $\mathcal{R}$ and F_h. Each point corresponds to one simulation. (left) Colors represent a large scale isotropy and markersize a small scale isotropy (see legend). The large and dark markers correspond to the LAST regime.

(iii) Statistical quantities like (1) spatial, temporal and spatio-temporal spectra and (2) spectral energy budget are provided. We will show how it will be easy for anyone to investigate stratified turbulence with this dataset by loading and plotting these quantities with our Python library Fluidsim.

Different physical questions will be addressed in view of numerous geophysical applications. (i) Characterization of the different regimes (left figure), in particular through comparisons based on spatial and temporal spectra with theoretical results and in-situ measurements. (ii) Scaling laws for different averaged quantities like the mixing coefficient $\Gamma = \varepsilon_A/\varepsilon_K$ (right figure), where ε_A is the potential energy dissipation rate. (iii) Presence and degree of nonlinearity of internal gravity waves through a spatio-temporal analysis.

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