Geophysical Research Abstracts, Vol. 8, 08027, 2006
SRef-ID: 1607-7962/gra/EGU06-A-08027

Stratified turbulence

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It remains a topic of dispute if the dynamics of stratified turbulence at low Froude number Fr is essential two-dimensional with an inverse cascade of energy or three-dimensional with a forward cascade. When $Fr \ll 1$ and $ReFr^2 \gg 1$, analysis of the governing equations suggests the scaling $l_v \sim U/N$ for the vertical length scale l_v (U is a horizontal velocity scale and N is the Brunt Väisälä frequency) if the dynamics of the flow imposes the vertical length scale and not any other externally imposed condition [1]. Because of the sharp vertical gradients in stratified flows implied by this scaling, the advection terms involving the vertical velocity are of the same order as the other terms, although the vertical velocity is much smaller than the horizontal velocity, and consequently the dynamics in strongly stratified fluids is three-dimensional[2]. A different scaling exist if $ReFr^2 \ll 1$. In this case, analysis suggests that the dynamics is two-dimensional and strongly affected by viscosity.

The aim of our study is to investigate systematically the influence of Re and Fr on the dynamics of strongly stratified fluids using direct numerical simulations (DNS) and validate our scaling analysis with the DNS. A series of DNS of homogeneous turbulence with a linear stratification is performed at a fixed Re and with varying Fr at the moment with resolutions up to $1024 \times 1024 \times 192$ grid points. The parameters will be chosen so that both regimes, $ReFr^2 > 1$ and $ReFr^2 < 1$, are covered by the DNS. Preliminary results reveal the existence of strongly anisotropic three-dimensional turbulence with a forward cascade of energy and the scaling $l_v \sim U/N$ if $ReFr^2 > 1$, and viscously dominated, predominantly horizontal turbulence with large pancake-like structures and with almost no overturning of the density field and the scaling $l_v \sim l_h Re^{-1/2}$ if $ReFr^2 < 1$.

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[1] Billant & Chomaz *Phys. Fluids* **13**, 1645 (2001).
[2] Lindborg, *J. Fluid Mech.* **550**, 207 (2006).