Stratified flows

Stable stratification impacts geophysical and astrophysical fluid dynamics across a spectrum of space and time scales, ranging from rapidly-evolving shear layers only tens of centemeters in depth in the ocean thermocline (Woods & Wiley 1972) to residual circulation and mixing due to gravity-wave dynamics in the Earth's middle and upper atmosphere (Andrews, Holton & Leovy 1987) and in the solar interior (e.g. Fritts, Vadas & Andreassen 1988).

Unique features of turbulence in stratified environments complicate the modeling of these flows: e.g.
1) vertical mixing is impeded by gravity's restoring force, while horizontal mixing is less constrained, resulting in the formation of layers that extend in the horizontal and are confined in the vertical;
2) such layers can be subgrid-scale in the vertical direction, and in some cases nearly all of the dynamics must be modeled;
3) the persistent damping of vertical motion leads to, in the absence of continuous external forcing, eventual turbulence decay and restratification, leaving the fossil remnants of dynamically-inactive (or only weakly-interacting) 'frozen-in' flow features;
4) these fossil remnants of past turbulence events can serve to precondition future turbulence outbreaks when external forcing reappears, resulting in preferred locations where turbulence nucleation recurs;
5) gravity-wave radiation from flow over topographic or layered-turbulence features can propagate great distances before succumbing to overturning; when the wavelengths of the waves are not resolved, non-local mixing must be incorporated in the sub-grid model of such flows. The three papers included in this section individually examine aspects of stably-stratified dynamics. The first two are basic studies, involving analysis of direct numerical simulations (DNS) of turbulence in stratified environments. The paper titled "Entrainment-zone restratification and flow structures in stratified shear turbulence" by Reif et al. investigates the late-time dynamics and morphology of a stratified turbulent shear layer using turbulence budgets, single-point structure tensors, and 3D flow visualization. The paper "Waves in turbulent stably-stratified shear flow" by Jacobitz, Rogers & Ferziger explores attempts to partition flow fields into gravity-wave and turbulence components. The authors caution against the identification of gravity waves via the phase angle between density and vertical velocity, and examine the utility of projecting the flow onto the linearized inviscid equations of motion when stratification is present. Though their results (and others they cite) show some promise, the authors point out a fundamental difficulty with this approach ,and conclude that turbulence and waves in stratified environments may be inextricably entangled.

The third paper "Adriatic simulations by DieCAST" by Dietrich, Carnevale, & Orlandi endeavors to identify the root cause(s) of and influences on the cross-Adriatic current flowing from the Croatian coast to the Italian coast. At the outset of the CTR Summer Program, their study identified several influences on this current, including the topography of the Mid-Adriatic Pit and seasonal variations in stratification due to near-surface solar radiation, air-sea exchanges, freshwater river plumes and the saltier water entering through the Strait of Otranto. The work reported here focuses on the dominant influence of topography, laying the groundwork for future detailed studies of the influence of stratification.

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