Rotating stratified turbulence at the tropopause

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The Global Atmospheric Sampling Program (GASP) provided data on the horizontal kinetic and potential energy spectra near the tropopause [1]. While the steep large-scale part of the energy spectrum agrees well with QG theory, its break to a shallower $-5/3$ slope in the mesoscale is still a subject of controversy.

Several homogeneous turbulence studies tackled the issue, among which [2] presented numerical simulations of decaying triply-periodic rotating-stratified Boussinesq turbulence. It was found that the steep geostrophic spectrum eventually crosses the shallow ageostrophic spectrum at large enough Rossby numbers so that total energy spectrum exhibits a slope break similar to that observed in the GASP data. However, while the vertical periodicity assumption is sensible far from boundaries, the abrupt jump in stratification N^2 observed at the tropopause limits its validity.

In fact, a similar slope break can occur within the QG framework, so free of ageostrophic motion, when vertical boundaries are taken into account [3]. A discontinuous N^2 jump indeed generates a delta sheet of potential vorticity (PV) that is mathematically analoguous to a regular QG boundary, thereby enabling temperature variance to cascade downscale along a shallow $-5/3$ spectrum [4]. Despite the fact that QG theory becomes inconsistent with a shallow spectrum, since the Rossby number must then increase algebraically with decreasing scale, this mechanism suggests a pathway towards the breakdown of balance that would not be present in classical triply-periodic turbulence simulations.

In order to reconcile these *a priori* mutually exclusive perspectives, a numerical model solving anelastic equations [5] in a non-periodic vertical domain was constructed, thereby allowing for both general dynamics and a realistic vertical structure. The purpose of this talk is to shed light on the dynamical effect of the N^2 jump at the tropopause. Following [6], the jump is assumed to be sufficiently abrupt so that the term involving the derivative of N^2 initially dominates PV. Full non-QG and corresponding QG runs will be presented.

References

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