INTERNAL WAVE EXCITATION BY TURBULENT CONVECTION

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Convection near a stably stratified region can excite internal gravity waves. This occurs in a wide range of geophysical settings, including the Earth's atmosphere and core, as well as in astrophysical systems like some gas giants like Saturn, and most stars including the sun. Internal waves excited by convection are thought to play an important role in the atmosphere, for instance, driving the quasi-biennial oscillation. Water's density maximum at $4°C$ makes it well suited to study this problem: an increasing temperature profile is unstable to convection below $4°C$, but stably stratified above $4°C$. We present numerical simulations of a water-like fluid near its density maximum in a two dimensional domain (Fig. 1, [1]), inspired by the experimental study of [2]. The simulation is run using the flexible, open-source pseudo-spectral code Dedalus [3].

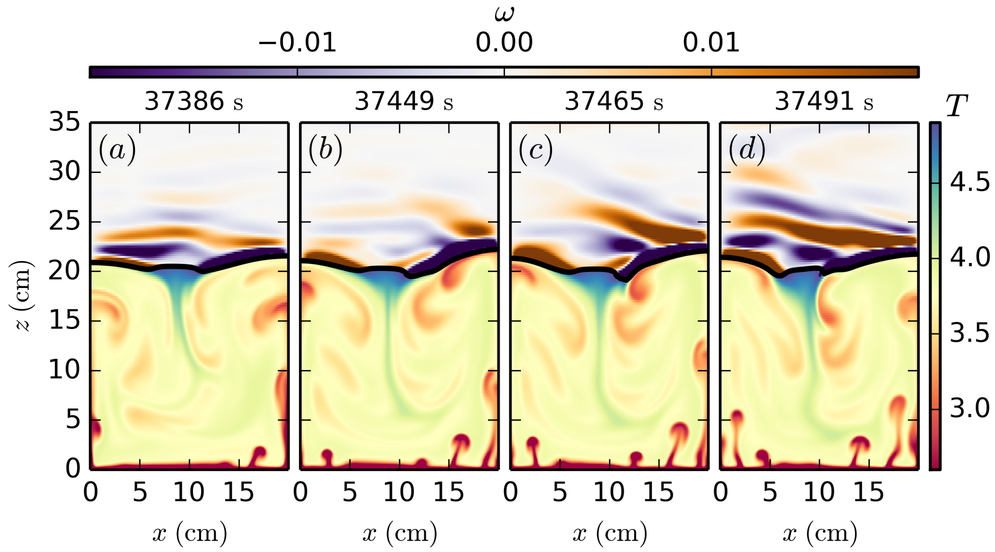

Figure 1. Four simulation snapshots. The bottom part of the domain (below the thick black line) shows the temperature field. Recall that below $4°C$, cold water (red) is less dense than hot water (blue). The thick black line is the $5°C$ isotherm and shows the boundary between the convective region (below) and the stably stratified region (above). The top part of the domain (above the thick black line) shows the vorticity field associated with internal gravity waves.

To isolate the physical mechanism exciting internal waves, we use data from the full simulation as source terms in two simplified models of internal-wave excitation by convection: bulk excitation by convective Reynolds stresses, and interface forcing via the mechanical oscillator effect. We find excellent agreement between the waves generated in the full simulation and the simplified simulation implementing the bulk excitation mechanism.

References

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[3] The code is available at `dedalus-project.org`.