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EXPLORING THE ROLE OF SMALL-SCALE THERMOHALINE STRUCTURE ON MIXING AND TRANSPORT IN THE OCEAN

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Salt and heat are two ocean properties of vital importance. Their mean distribution, their advective transport and their diffusive redistribution control ocean dynamics by setting the density of seawater and its spatio-temporal variability. In this thesis, we investigate two aspects of the mixing and transport of salt and heat: the role of double diffusion, a consequence of the slower molecular diffusion of salt relative to heat; and the impact of small-scale density gradients on the poleward heat transport of the ocean.

In the first part of this thesis, double-diffusive interleaving is examined as it progresses from a linear instability towards finite amplitude. We examine the finger and diffusive instability types and ask whether a steady state is possible. We find that the strength of the fluxes across the diffusive interfaces must be many times stronger relative to the corresponding fluxes across the finger interfaces than is indicated from existing flux laws as derived from laboratory experiments. The total effect of the interleaving motion on the vertical fluxes of heat and of salt is calculated for the steady-state solutions. It is found that both the fluxes of heat and of salt are up-gradient, corresponding to negative vertical diffusion coefficients for heat, salt and density. These results are reported in [1].

The remainder of the thesis addresses the limited spatial resolution of ocean models. Unresolved spatial correlations between horizontal velocity and tracer fields contribute to the actual horizontal fluxes of heat and other scalar quantities but are not accounted for by state-of-the-art ocean models. A method of estimating these unresolved fluxes is proposed, based on calculating an additional nondivergent velocity to advect all scalar variables. The sum of the Eulerian-mean velocity and the extra advection calculated

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here we call the horizontal residual mean (HRM) velocity. The calculation of the extra advection is based on the depth-integrated horizontal transport from the seafloor to the density surface whose spatially averaged height is at the height of the calculation. Incorporating the HRM velocity into an ocean model improves the effective spatial resolution and the representation of poleward heat transport.

Reference

[1] Y. Li and T. J. McDougall, 'Double-diffusive interleaving: properties of the steady-state solution', *J. Phys. Oceanogr.* **45** (2015), 813–835.

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