Turbulent mixing in subglacial ocean flows

L.-A. Couston[a]

Turbulent mixing within ice-ocean boundary layers (IOBL) is investigated using Direct Numerical Simulations (DNS) in a regime close to realistic ocean conditions below Antarctic ice shelves. Turbulence in the IOBL controls the intensity of heat fluxes from the ocean to the ice, and thus ice melting, which impacts ice-shelf dynamics and ultimately sea-level rise. IOBL are special two-scalar boundary layers because the boundary conditions at the ice-ocean interface couple heat and salt fluxes, producing meltwater masses that freshen and cool along related trajectories. The interconnection between freshening and cooling in IOBL is at the heart of Gade's 1979 mixing line theory[1], which states that meltwater masses cluster on a straight line (Gade's mixing line) in a T-S diagram (temperature-salinity), connecting the oft warm and saline water masses in the far field to the cold meltwater masses closest to ice. Gade's mixing lines are used like a compass in subglacial physical oceanography. They allow identifying water masses driving ice melting and attributing cryospheric changes to oceanic changes. The 3-equation model[2], which is used by used by most regional ocean models, goes beyond the Gade's mixing line theory by parameterizing the full IOBL, relating ice melting rates to resolved ocean conditions few meters away from the ice. Gade's mixing line theory and the 3-equation model rely on assumptions of turbulent mixing in doubly stratified fluids that have not yet been validated by DNS. This presentation will present numerical results from a series of DNS that were designed to test the assumptions and applicability range of the two models. The DNS consist of two-scalar plane Poiseuille ocean flows below horizontal ice. The relationship between the turbulent diffusivities of the temperature and salt fields and the dependence of the effective heat and salt transport coefficients on the turbulence intensity and density stratification will be discussed.

---

[a] ENSL, UCBL, CNRS, Laboratoire de physique, F-69342 Lyon, France

[1] Gade, *Journal of Physical Oceanography*, ***9***(1), 189-198 (1979).

[2] Holland and Jenkins, *Journal of physical oceanography* **29**(8), 1787-1800 (1999).