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The Southern Ocean FINEstructure project: Turbulent dissipation and mixing rates and mechanisms in a Southern Ocean mixing hotspot.

S. Waterman (1,2), A. C. Naveira Garabato (1), and K. L. Polzin (3)

(1) National Oceanography Centre, Southampton, United Kingdom, (2) Grantham Institute for Climate Change, Imperial College London, London, United Kingdom, (3) Woods Hole Oceanographic Institution, Woods Hole, USA

The Southern Ocean FINE structure project is an observational field study designed to investigate various mechanisms of ocean mixing and the roles that they play in the larger-scale circulation in a standing meander of the Antarctic Circumpolar Current (ACC) north of the Kerguelen Plateau. The region is potentially of special significance to closing both the Southern Ocean overturning circulation and the momentum budget of ACC. By presenting both a large-scale topographic obstacle and small-scale topographic roughness in the path of multiple ACC jets, it is a likely site for both enhanced adiabatic and diabatic mixing processes.

We present the first results of the project which relate to the rates and mechanisms of turbulent energy dissipation and turbulent mixing in the region. From the first-ever full-depth microstructure measurements in the Southern Ocean, we map the observed turbulent kinetic energy dissipation and diapycnal mixing rates in this mixing hotspot. We next explore some of the physical mechanisms that observations and theory suggest may underpin the observed distributions. This exploration leads us to a characterization of the internal wave field in the region, and a study of some of the processes related to its generation, evolution and eventual dissipation.

Results show that the observed turbulent energy dissipation and mixing rates are highly spatially variable. Systematic structure with depth and proximity to rough topography suggest a link with the local internal wave field, which can be characterized as consisting of near-inertial waves propagating from the surface downwards and higher frequency internal waves potentially sourced at the bottom propagating upwards, both being modified by a background shear as they propagate. Turbulent dissipation is high in regions where internal wave energy is high, however, the rates of turbulent dissipation and mixing are, in key places, generally lower than anticipated from the observed internal wave energy levels. Large background shears characteristic of the ACC result in wave-mean flow interactions that are important in determining wave evolution, and, in the case of upward propagating waves, may compete with the downscale energy cascade promoted by wave-wave interactions thereby suppressing the turbulent dissipation. The calculation of timescales and the exercise of ray-tracing support the hypothesis that the mean flow can play an order one role in modulating the generation and evolution of internal waves and, as such, the dissipation, observed.

In the big picture, these results point to the importance of the large scale flow field and its interaction with the bottom topography and the internal wave field in producing the spatially variable map of turbulent dissipation and mixing in the region that was observed. This will have important implications for the global map of energy dissipation, the dynamics of the overturning circulation, and our parameterizations of turbulent mixing processes which will be discussed.