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Turbulence and internal waves in the ACC

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We report on the first results of the Southern Ocean Finestructure (SOFINE) project, a study of the role of internal waves and turbulence in the dynamical balances, the overturning circulation, and water mass transformation in a standing meander of the Antarctic Circumpolar Current (ACC) north of the Kerguelen Plateau. We use microstructure and finestructure survey observations of the turbulent kinetic energy dissipation rate and internal wave scale flow properties to characterize the intensity and spatial distribution of turbulent dissipation and derived turbulent mixing, and consider possible mechanisms underpinning the observed distribution of turbulence in the context of the regional internal wave field and the processes governing the waves' generation and evolution. We find that the turbulent kinetic energy dissipation rate, ε, and the derived diapycnal diffusivity, κ, are highly spatially variable with systematic depth dependence. ε is generally enhanced in the upper 1000–1500m of the water column, and both ε and κ are enhanced in some places near the bottom, commonly in regions of more complex topography and/or in the vicinity of strong bottom flows. Turbulent dissipation is high in regions where internal wave energy is high, consistent with the idea that interior dissipation is related to a breaking internal wave field, however there exists a systematic discrepancy between the microstructure-based observation of the turbulent dissipation rate and the expectation for the dissipation rate from the finestructure-based observation of internal wave shear and strain variance levels and a model of wave-wave interaction physics. In particular this expectation tends to over-predict the dissipation rate near the bottom where the wave field appears to be dominated by upward propagating supra-inertia waves, while it tends to under-predict at mid-depth where the wave field above is characterized by downward propagating, near-inertia waves. Observational clues suggest that the over-prediction of ε by internal wave shear and strain variance levels and wave-wave interaction models relate to the generation of internal waves by strong near-bottom ACC flow and the interaction of these intermediate-scale upward propagating waves with the background ACC shear which, assuming linear dynamics in the typical background shear, would tend to effect an upscale energy cascade to compete with the downscale energy cascade effected by wave-wave interactions. There are also indications that wave-"mean" flow interactions play an order one role in the evolution of downward propagating waves in the upper ocean which, in this case, accelerate the downscale energy cascade. The cascade of energy to scales not well resolved by the finescale observations may be the cause of the under-prediction of the dissipation rate predicted by internal wave properties and processes at mid-depth. The take-home message is that in the region we observe an energetic internal wave field in the upper water column and near

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the bottom in regions of complex topography and strong bottom flows, however the turbulence, especially in the deep ocean, is less intense that expected based on finescale parameterization predictions. This may be due to interactions of the upward propagating waves with the “mean” flows of the ACC being of leading order importance in determining the evolution of the wave field.