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Evidence for enhanced mixing in the Antarctic Circumpolar Current: a natural tracer release experiment

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The Southern Ocean has recently been identified as a crossroads of two apparently contrasting paradigms for how mixing processes mediate the powering of the meridional overturning circulation (MOC) by winds and tides. In the longest-standing view, the MOC is mechanically powered by turbulent diapycnal mixing below the permanent pycnocline, which often results from internal wave instabilities and is enhanced near the ocean boundaries. In an alternative model, the MOC is chiefly driven by geostrophically balanced mesoscale eddies stirring water masses along the steep isopycnals of the Antarctic Circumpolar Current (ACC), with diapycnal transformations confined to the mixed layer and induced by air-sea interaction. A new proposition suggests, however, that the very same wind work on the circulation that sustains the vigorous Southern Ocean eddy field also supports intense internal wave activity and turbulent mixing in ACC regions of complex topography. If this is the case, the two proposed solutions to the ocean mixing problem may be interdependent, and it may not be appropriate to consider them in isolation.

Here we lend support to this hypothesis by directly quantifying isopycnal and diapycnal mixing rates in the southwest Atlantic sector of the ACC from the spreading of a stable, conservative natural tracer. The tracer is primordial 3He, which enters the deep circulation in hydrothermal fluids issued by submarine volcanic systems. An outstanding example of this process is found in the southeast Pacific, where a 3He-rich plume emanating from the East Pacific Rise flows southward at a depth of ˜2500 m along the South American margin and is injected into the 3He-poor ACC immediately upstream of Drake Passage, mimicking a deliberate tracer release experiment at the northern flank of the current. As it flows through the Scotia Sea, the 3He-rich plume dilutes and spreads (both laterally and vertically) as a result of isopycnal and diapycnal mixing with surrounding waters, at large rates that we estimate from the tracer dispersal.