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High resolution acoustic imaging of frontal dynamics and thermohaline finestructure in the Southwest Atlantic sector of the Southern Ocean

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The Southwest Atlantic section of the Southern Ocean is a highly energetic confluence zone where Pacific and Antarctic waters flow via the Antarctic Circumpolar Current (ACC) to merge with waters from the Atlantic Ocean and contribute to the global overturning circulation. However, there is an insufficient understanding of sub-mesoscale variability in the region. Such processes are known to play an important role in the vertical and lateral exchange of water masses, along with tracers such as carbon, atmosphere-ocean exchange, ocean productivity, and the mixing budget necessary to complete the overturning circulation. In particular, observations of the subsurface structure of frontal systems on high spatial scales are currently lacking, with typical hydrographic transects being too coarse to resolve sub-mesoscale processes and ACC filaments.

Here we present the first multichannel seismic images of ocean finestructure to the north of the North Scotia Ridge in the Southern Ocean, which cross several frontal systems and bathymetric features. High-resolution (O(10m)) sections of sub-surface thermohaline structure are revealed and analysed by combining the acoustic information with hydrographic (CTD, XBT and ARGO floats), current velocity (VMADCP) and satellite altimetry data. In addition, diapycnal mixing and potential vorticity estimates are generated from acoustic data. The sections reveal an intricate and complex pattern of oceanic finestructure: very high thermohaline gradients are present in shallow and intermediate waters of up to 700 m depth associated with Subantarctic Surface Water, Subantarctic Mode water and a mix of Antarctic Intermediate Water and Antarctic Surface Water; curving features, lenses and filaments with length scales of 100m-10km are found at the Polar Front and Southern ACC front; and steep continuous gradients with separate filaments are typically present in deeper sections (up to 2000 m) associated with Circumpolar Deep Water. Furthermore, acoustic reflections provide evidence that bathymetric features like the Maurice Ewing Bank or the Northeast Georgia Rise disrupt the flow of intermediate and deep water in the region and enhance diapycnal mixing.