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Four-Dimensional Seismic Reflection Imaging of Thermohaline Circulation: Brazil-Falklands Confluence

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The southwest Atlantic Ocean is characterized by circulation patterns and exchange processes that are important to regional oceanographic and biological systems. Two near-surface currents dominate this circulation: southward flowing warm Brazil Current, >26 °; and northward flowing cold Falklands (Malvinas) Current, <7 °. Both currents meet to form the Brazil-Falklands Confluence, recognized as one of the most energetic confluences in the oceanic realm. An understanding of processes within this region remain elusive (e.g. water mass characteristics, eddy production, cross-frontal movement of water properties). Here, we investigate this circulation using the seismic reflection imaging technique. This methodology exploits multi-channel seismic equipment to image the water column with a resolution of $\sim$10 m. A four-dimensional industrial dataset was acquired in water depths of 500–2000 m along the Uruguayan margin. This dataset is greater than 20 Terabytes and has a footprint of $>$7000 km^2. An airgun array of 8480 cubic inches and 10 towed streamers, each of which is 6 km long, was deployed. Seismic records were analyzed by adapting standard signal processing techniques such as three-dimensional geometry, filtering, noise attenuation, normal move-out, and stacking. The resultant calibrated acoustic images are sets of vertical slices through the water column which reveal sharp changes in temperature ($\sim$80 %) and salinity ($\sim$20 %). Water masses of differing properties can be mapped out in two-, three-, and four-dimensions. Complex themohaline structures can be identified and traced throughout the volume. The frontal interface of the confluence is clearly imaged as a thin band of northward dipping reflections, that extend to depths of 1800 m. The interface is imaged over a period of one week across an area of $\sim$2800 km^2. There is south-westward migration across the survey of 4-17 km per day. These high resolution observations are calibrated using satellite sea-surface temperature data. The properties and characteristics of the frontal interface are analysed quantitatively in two-, three-, and four-dimensions. Sub-meoscale to mesoscale eddy-like and slab-like structures are observed at all depths throughout the volume and we map their evolution through time.