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Time-lapse Volumetric Seismic Imaging of Water Masses at a Major Oceanic Front

Xiaoqing Chen[1], Nicky White[1], Andy Woods[2], and Kathryn Gunn[3]
[1]Bullard Laboratories, Department of Earth Science, University of Cambridge, Cambridge, United Kingdom of Great Britain – England, Scotland, Wales (xc325@cam.ac.uk)
[2]BP Institute, University of Cambridge, Madingley Road, Cambridge CB3 0EZ, UK
[3]CSIRO, Battery Point, Hobart, Tasmania, 7004, Australia

Oceanic fronts play a key role in modulating water mass transfer. Nevertheless, detailed information about frontal structure on appropriate temporal and spatial scales is difficult to obtain. Here, we investigate the structure of a dynamic frontal system associated with intense mesoscale eddy activity at the Brazil-Falkland Confluence of the South Atlantic Ocean using a time-lapse volumetric seismic reflection (i.e. acoustic) survey. This survey was processed by adapting standard signal processing techniques. A sequence of eleven calibrated time-lapse vertical sections from this survey reveals the detailed evolution of a major front. It is manifest as a discrete planar surface that dips at less than two degrees and it is traceable to a depth of almost 2 km. The shape and surface outcrop of this front are consistent with sloping isopycnal surfaces of the calculated potential density field and with coeval sea surface temperature measurements, respectively. Within the upper 1 km, where cold fresh water subducts beneath warm salty water, a number of tilted lenses are banked up against the sharply imaged front. The biggest lens has a maximum diameter of about 35 km and a maximum height of about 800 m. It is cored by cold fresh water which is associated with an acoustic velocity anomaly. Time-lapse imagery suggests that it grew and decayed within eleven days. On the southwestern side of the advecting front, large numbers of deforming lenses and filaments with length scales of 50 to 100 km are swept toward the advecting front. Spatial patterns of diapycnal mixing rate estimated from vertical displacements of tracked reflective horizons show that the front and associated structures condition turbulent mixing in significant ways. Finally, cross-correlation techniques are used to track the dynamic movement of frontal structures on timescales of minutes to days. This unprecedented imagery has profound implications for a fluid dynamical understanding of water mass modification at frontal systems.