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The cold and warm contributions to the eastern South Atlantic subtropical gyre

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The returning limb of the Atlantic Meridional Overturning Circulation is sustained partly by the Southern waters entering from the Pacific Ocean through the Drake Passage, what is commonly referred to as the cold-fresh water route, and by the Indian waters entering through the Agulhas Current system (ACS), what is known as the warm-salty route. Here we carry out numerical simulations of Lagrangian trajectories to identify the multiple direct and indirect cold and warm intermediate-water pathways reaching the eastern South Atlantic subtropical gyre: predominant trajectories, transit times, water transformations, changes in thermohaline properties and spatiotemporal variability. These different inflows have been characterized with thousands of particles released backward in the eastern subtropical gyre along 34°S (from 10°W to 18°E, hereafter the reference section) in 2019 and tracked during 50 years, using daily velocity fields from the GLORYS12v1 reanalysis product with a 5-day resolution.

The total cold-route contribution of intermediate waters to the reference section represents 7.1 ± 0.6 %, slightly less than the 9.0 ± 1.2 % fraction reaching this section via the warm-route ACS; both contributions decrease substantially in summer: 5.9 ± 0.7 % for the cold route and 6.2 ± 3.0 % for the warm route. The cold route consists of three main pathways: direct incorporation with over 90% of particles and water particles that recirculate either in the western subtropical Atlantic or enter the Indian Ocean before flowing back to the reference section, respectively, with about 7% and 2%. Different routes can also be identified for the warm route into the reference section, largely dominated by the direct route through the ACS but also with alternative pathways characterized by recirculations within the Atlantic and Indian Oceans. We also discuss some of the water transformations, in particular the largest changes in thermohaline properties that occur in the confluence zones of Malvinas-Brazil Current and the Agulhas-South Atlantic Current. For instance, during austral summer and along their direct path from the Drake Passage, the cold-water parcels gain a mean of 0.86 ± 0.11 °C, 0.26 ± 0.01 in salt, increasing their mean density in 0.08 kg/m^3 .