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# A Lagrangian view of the transfer of Southern waters to the South Atlantic Ocean

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The Atlantic Meridional Overturning Circulation (AMOC), a key component of the Earth's climate system, is sustained through the northward transport of Southern Ocean waters to high latitudes. This returning limb of the AMOC consists largely of relatively cold waters entering from the Pacific Ocean through the Drake Passage, what is commonly referred to as cold-water route. Here, we explore the pathways and transit times of these Antarctic waters that are incorporated to the South Atlantic, with special attention to their recirculation in the subtropical gyre and their escape northward through the North Brazil Current. For this purpose, we use daily values of the climatological GLORYS12v1 velocity field, as obtained using data for 2002-2018 and track the trajectories with the help of the OceanParcels software. We trace the particles transiting through four sections in the Southern and South Atlantic Oceans: 64°W and 27°E, crossing entire Antarctic Circumpolar Current (ACC) through the Drake Passage and off South Africa, respectively; 32°S, from the African coast out to 5°S, sampling the eastern boundary current system; and 21°S, from the American coast out to 30°W, sampling the North Brazil Current.

Particles are released daily in the Drake Passage down to 1800 m during one full year, its spatial distribution and number being proportional to the transport crossing each vertical portion of the section. This represents an annual-mean of 116.3 Sv entering the Atlantic sector through the Drake Passage, split into 13.3 Sv for surface (Subantarctic Surface Water, SASW, and Subantarctic Mode Water, SAMW), 40.2 Sv for intermediate (Antarctic Surface Water, AASW, and Antarctic Intermediate Water, AAIW) and 62.8 Sv for deep (Upper Circumpolar Deep Water, UCDW) water masses. The particles are then tracked forward, with a one-day resolution, during 20 years. The simulation shows that about 83% of the SASW/SAMW transport follow the ACC past South Africa while the remaining 17% are incorporated to the subtropical gyre. Among the latter, only 13% veer northward and cross the 21°S section. Regarding the intermediate waters, AASW/AAIW, 93% of transport follows the ACC, and 7% join the subtropical gyre. Finally, for the UCDW transport, which remains part of ACC, about 97% follow eastward as the ACC and only 3% drift cross the 32°S section, and only 4% of the latter reach through the 21°S section. The median times for the Drake Passage water particles to get to the 27°E, 32°S and 21°S sections are: 1.7, 2.1 and 5.7 yr for the SASW/SAMW; 2.3, 5.3 and 6.5 yr for the AASW/AAIW; and 3.3, 6.0 and 11.7 yr for the UCDW, respectively. Long tails in the age distributions reflect a high degree of recirculation, being remarkable the high presence of mesoscale eddies around 32°S over Cape Basin.