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Water-mass transformations in the Southern Ocean diagnosed from observations: contrasting effects of air-sea fluxes and diapycnal mixing

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Transformation rates of water masses in the Southern Ocean are estimated in a neutral surface framework using air-sea fluxes of heat and freshwater together with in situ estimates of diapycnal mixing. The air-sea fluxes are taken from two different climatologies and a reanalysis dataset, while the diapycnal mixing is estimated from a mixing parameterization applied to five years of ARGO float data. The air-sea fluxes lead to a large transformation of typically -59 to -77Sv, directed toward lighter waters centred at gamma=27.2. Diapycnal mixing leads to two weaker peaks in transformation acting in the interior, 8Sv centred at gamma=27.8 directed towards denser waters and -16Sv centred at gamma=28.3 directed towards lighter waters. Hence, air-sea fluxes and interior diapycnal mixing are important in transforming different water masses within the Southern Ocean, although these magnitudes are comparable to the uncertainties from a plus or minus 5Wm̂-2 in air-sea fluxes and factor 4 uncertainty in diapycnal mixing. This transformation of dense to lighter waters from diapycnal mixing within the Southern Ocean is slightly larger, though comparable in magnitude, to the transformation of lighter to dense waters from air-sea fluxes in the North Atlantic. The pattern of surface and interior fluxes responsible for these water-mass transformations partly relate to the strength of the Antarctic Circumpolar Current in density space: both the surface air-sea fluxes and the diapycnal diffusivity at a depth of 1400m positively correlate with the surface current speed.