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The spatiotemporal structure of diabatic processes governing the evolution of Mode Water in the Southern Ocean

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A data-assimilating, eddy-permitting Southern Ocean State Estimate (SOSE) for 2008-2010 was used to describe and quantify the relative role of surface buoyancy flux and diapycnal ocean mixing in the formation and destruction of water in the mode water (MW) density range $\sigma\theta$=26.7 – 27.2 kg m-3. All the terms in the temperature and salinity equations that the SOSE solves have been diagnosed to obtain a three-dimensional and time varying volume budget for individual isopycnal layers.
The three-year average MW formation rate in the Southern Ocean south of 30°S by air-sea buoyancy fluxes is 7.9 Sv. Formation is predominantly accomplished by wintertime surface ocean heat loss at a rate of 6.6 Sv occurring equatorward of the Subantarctic Front (SAF), and by surface freshening at a rate of 1.3 Sv occurring poleward of the SAF in spring and summer.
The formation by diapycnal ocean mixing at a rate of 8.8 Sv is as important as the surface formation. This mixing occurs within the depth range of the deepest mixed layers. Mixing of temperature warms MW resulting in MW destruction at a rate of 2.4 Sv. Mixing of freshwater forms MW from both lighter and denser waters. Notably, it is the mixing of freshwater that transforms denser intermediate waters into MW.
By charting the MW formation and evolution processes in time and space, this paper allows better understanding of the three-dimensional Southern Ocean overturning circulation with regards to the MW density class.