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Nitrate isotopic constraints on routes of nutrient supply to global ocean pycnocline

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The circulation of the ocean plays a fundamental role in restoring the surface nutrients necessary to maintain global ocean biological production. However, our quantitative understanding of the physical mechanisms that return deep-ocean water and nutrients to the upper ocean is currently limited. The nitrate isotopes are investigated here as a new data constraint on the percentage of gross water transport into the global pycnocline that derives from the Southern Ocean as opposed to the deep ocean (which we term the “pycnocline recipe”). Based on a comparison between large-scale observations of nitrate isotopes and the output of a box model, we estimate that the pycnocline recipe is 75 ± 10%; this result implies that ~ 64% of the nutrients supplied to the low latitude pycnocline pass through the Southern Ocean. Our simulations also highlight the shortcomings of a purely advective view of the ocean’s transport of water and nutrients, confirming that mixing with both the deep ocean and the Southern Ocean ventilating area are key to the exchange of water and nutrients between the pycnocline and higher-density deep and polar surface waters. Our calculations support a pure advective-diffusive balance in the deep ocean. In contrast, in the Southern Ocean, our findings provide independent evidence for the importance of air-sea fluxes of momentum and buoyancy in driving the circulation.

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