Nitrate isotopic constrains on nutrient supply to global ocean pycnocline

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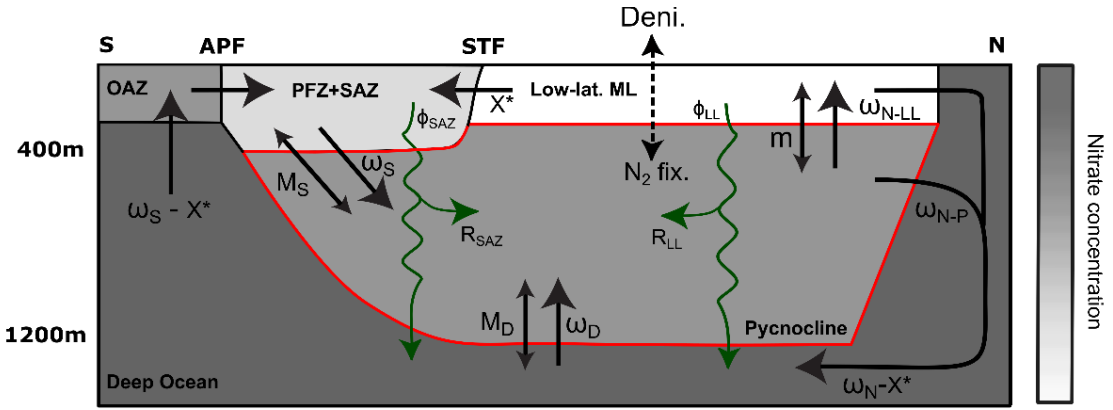
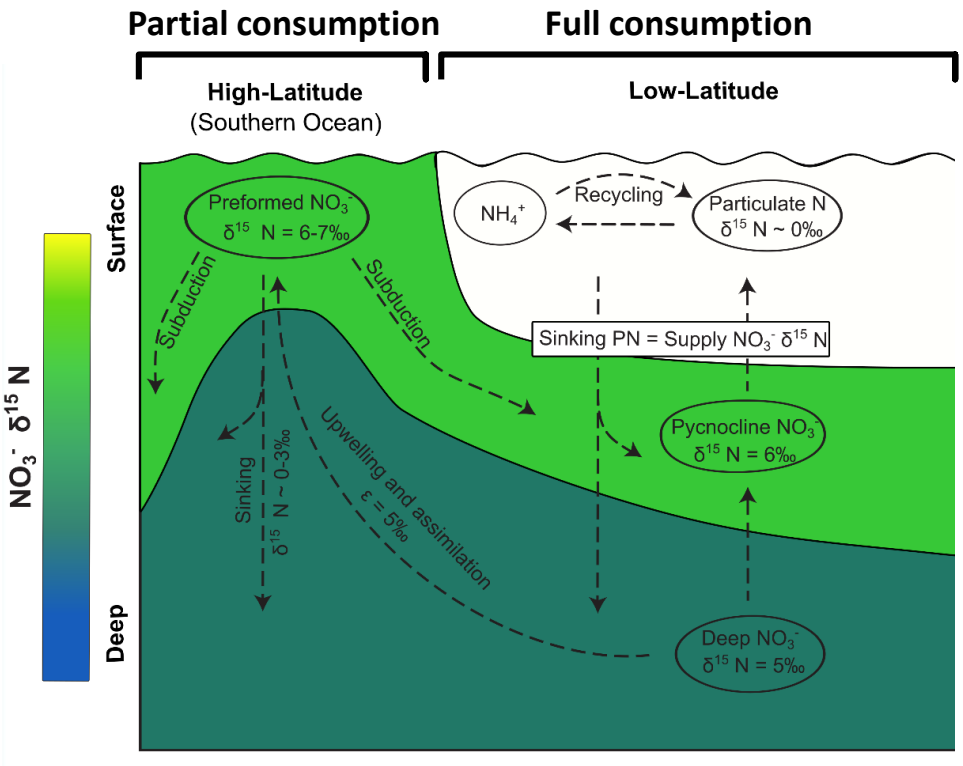
Goal of the Study

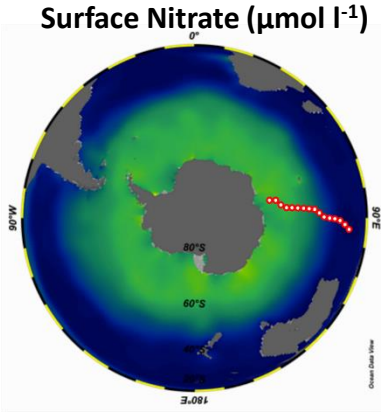
New geochemical tracer for the percentage of gross water transport into the global pycnocline from the Southern Ocean surface as opposed to directly from the deep ocean

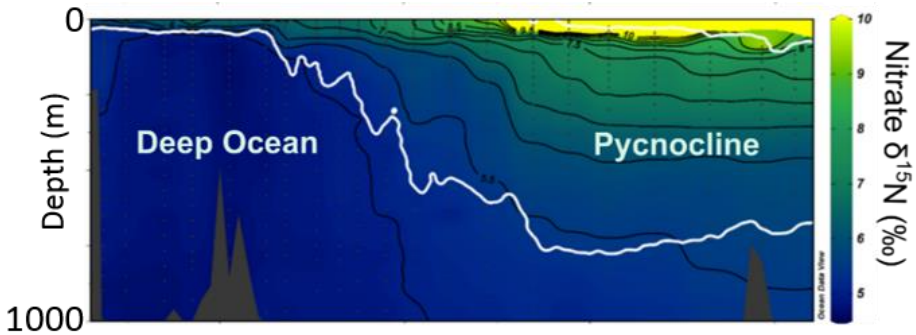
Pycnocline recipe = $(\omega_S+M_S)/(\omega_S+M_S+\omega_D+M_D)$



Southern Ocean's imprint on low-latitude nitrate $\delta^{15}N$



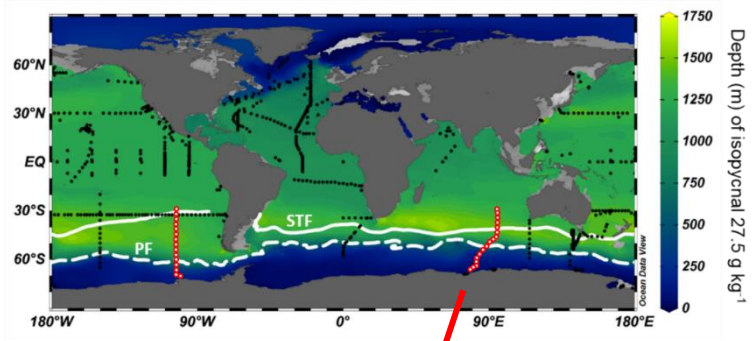




Sigman and Fripiat, 2019, in Encyclopedia of Ocean Sciences

Mean pycnocline nitrate $\delta^{15}N \propto$ **pycnocline recipe**?

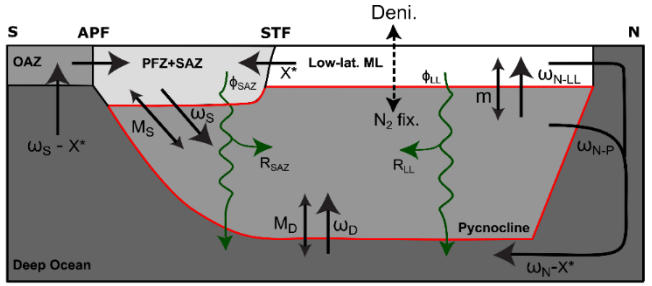
Observations



Weighted properties

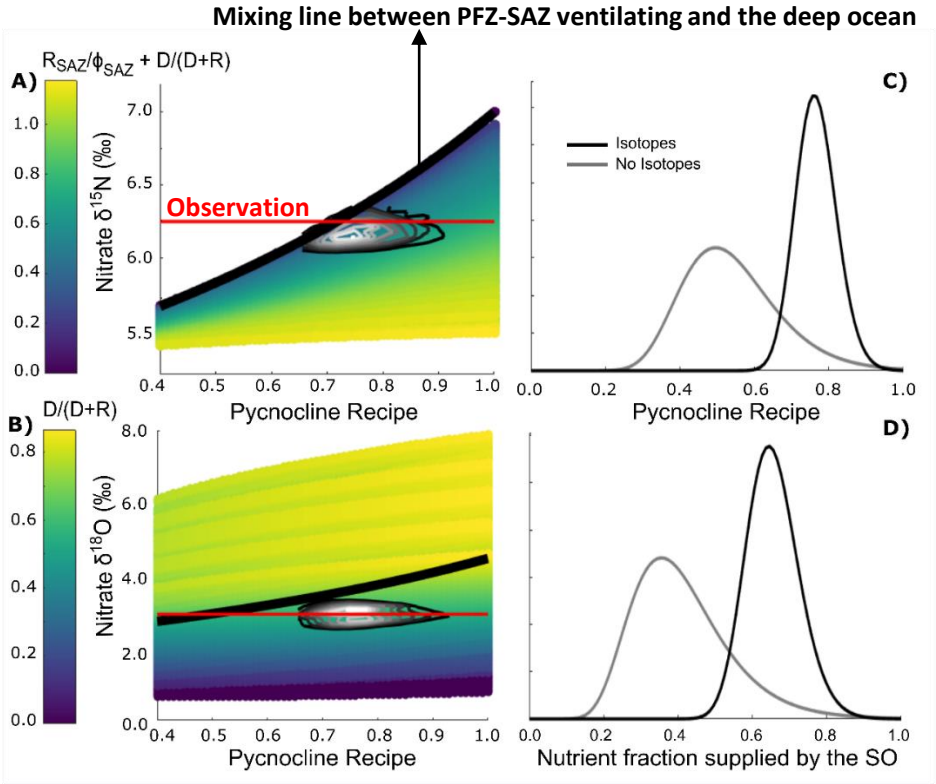
Optimization

1-Box model for the pycnocline

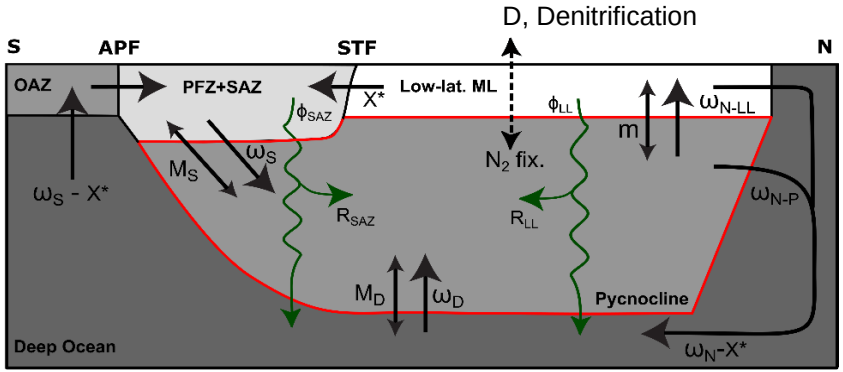


T°C, Salinity, Nutrients, Oxygen, Nitrate isotopes

Mean pycnocline nitrate $\delta^{15}N \propto$ **pycnocline recipe**?



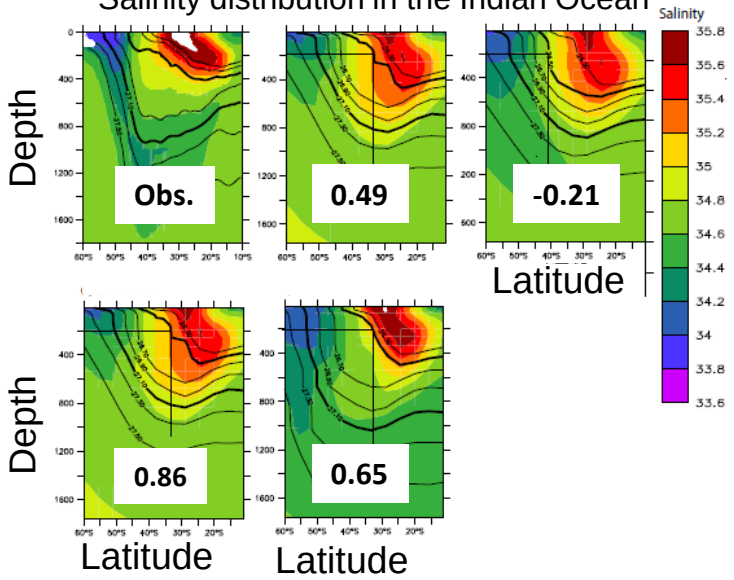
Pycnocline recipe *vs.* NO_3^- $\delta^{15}N$ *(A) and* $\delta^{18}O$ *(B) given by the model. The contour of the density function for the best fits is shown with the grayscale. (C,D) Density function of the model best fits for the pycnocline recipe (C) and the* ***fraction of nutrients in the pycnocline supplied from the Southern Ocean*** *(D). The black and dark gray lines are with and without the constraints given by* NO_3^- *isotopes, respectively.*



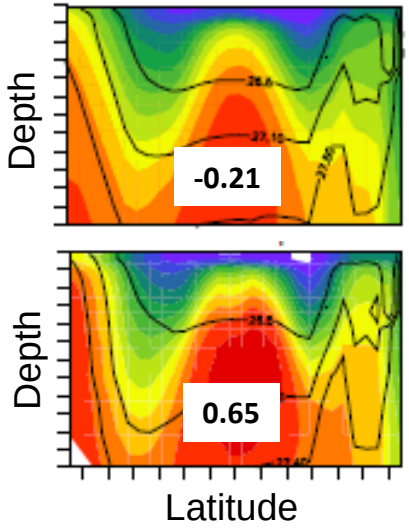
New geochemical tracer for the pycnocline recipe

Models with different physics (number = pycnocline recipe) give **similar tracer fields**

Salinity distribution in the Indian Ocean



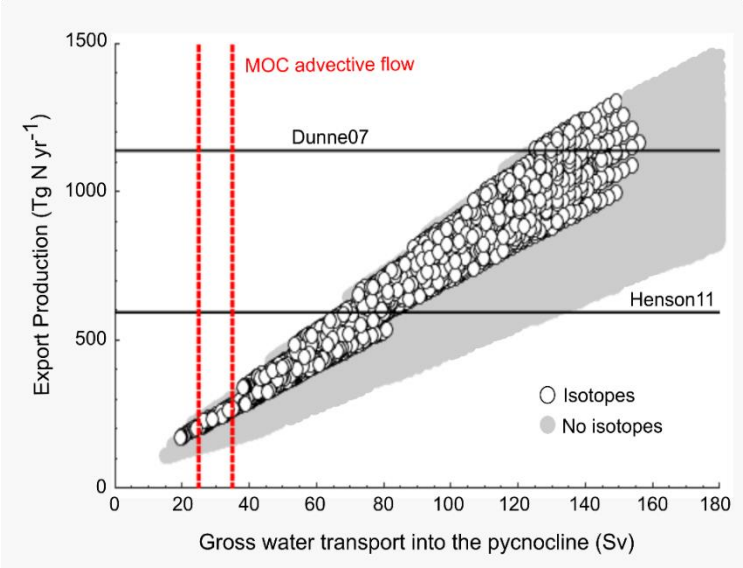
Nutrient (phosphate) distribution



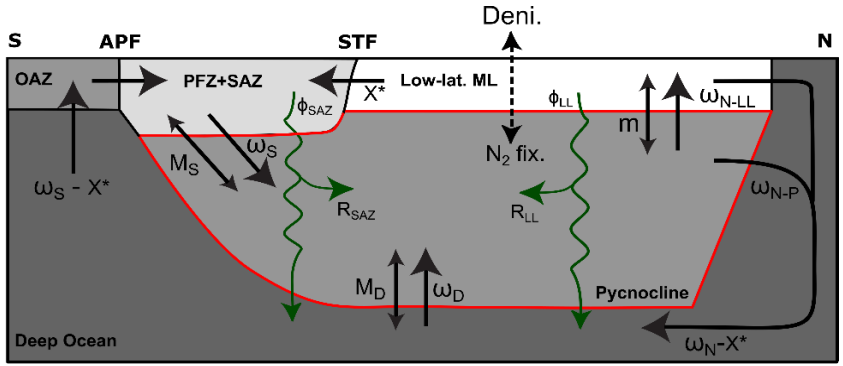
Pycnocline recipe$_{\text{Nitrate Isotopes}}$ = 0.76 ± 0.06

Gnanadesikan et al., 2007, Geophys. Monograph Series 173; Sarmiento et al., 2004, Nature; Palter et al., 2010, Biogeosciences

Importance of mixing to ocean circulation and nutrient supply

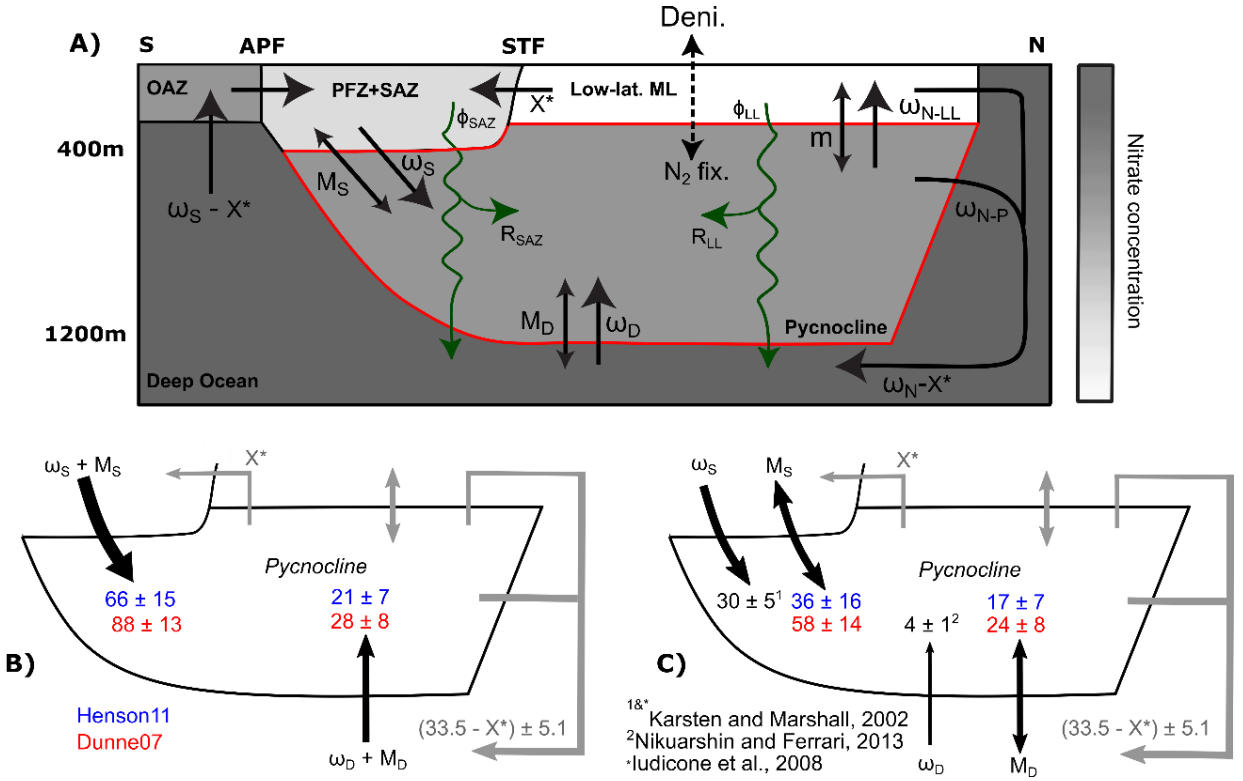


Use of observations of export production to partition the gross transport of water between their advective (ω) and diffusive (M) fluxes. Gross water transport into the pycnocline (Sv) *vs*. export production (Tg N yr^{-1}) for the model best fits (black circles). The dark gray envelop is without the constraint given by nitrate isotopes. Independent estimates of export production are indicated with horizontal black lines. The range of estimates for upper MOC advective fluxes are shown by the red dashed vertical bars.



Karsten and Marshall, 2002, J. Phys. Oceanogr.; Dunne et al., 2007, GBC; Henson et al., 2011, GRL; Nikuarshin and Ferrari, 2013, GRL

Importance of mixing to ocean circulation and nutrient supply



Pycnocline advective-diffusive balance

For the mixing-driven upwelling in the interior (ω_D), advective/diffusive (ω_D/M_D) ratio = 0.15-0.20

Similar to the advective-diffusive balance as described in Munk (1966, DSR) = 0.14-0.27

For the Southern Ocean upwelling (ω_S), advective/diffusive (ω_S/M_S) ratio = 0.52-0.83

Indicates the importance of air-sea fluxes of momentum and buoyancy