

Global mean ocean nitrate $\delta^{18}\text{O}$ as a tracer for the supply and recycling of fixed nitrogen in the ocean

SIMON DESMETTRE¹, CEDRIC DUMOULIN¹, VIOLAINE COULON¹, DARIO MARCONI², TANYA MARSHALL², SOFIA MULLER¹, YEONGJUN RYU², TANJA WALD³, ALFREDO MARTINEZ-GARCIA³, DANIEL M. SIGMAN² AND FRANÇOIS FRIPIAT⁴

¹Université Libre de Bruxelles

²Princeton University

³Max Planck Institute for Chemistry

⁴Laboratoire de Glaciologie, Université Libre de Bruxelles (ULB)

The nitrogen (N) cycle is essential for marine productivity, as it regulates biologically available N (or “fixed”, i.e., non- N_2), a key nutrient for phytoplankton. It can be divided into an internal and open cycle. The internal N cycle does not affect the total quantity of biologically available N in the ocean but changes the distribution of its different forms – such as nitrate, ammonium and organic matter – through processes like assimilation, export, remineralization and nitrification. The open N cycle adds biologically available N to the ocean, primarily through N_2 fixation, and removes it, primarily through denitrification. However, the relative contribution of the open and internal cycles remains poorly constrained in the literature. We propose that the mean ocean nitrate $\delta^{18}\text{O}$ (hereafter MON $\delta^{18}\text{O}$) can be used to place observational constraints on the ratio between open and internal N cycles (i.e., N_2 fixation vs. export production). Using a prognostic ocean box model, we explore the sensitivity of MON $\delta^{18}\text{O}$ to physical and biogeochemical parameters. The model is calibrated using a Bayesian approach, assigning greater weights to scenarios that best match observations from a worldwide database of approximately 15,000 nitrate $\delta^{18}\text{O}$ measurements. Our results indicate that MON $\delta^{18}\text{O}$ is sensitive to the ratio of open to internal N cycles, yielding a preliminary estimate of 19% (12-26% for the 10th and 90th percentiles). Furthermore, we find that nitrate $\delta^{18}\text{O}$ in the global pycnocline (roughly the upper 1.2 km) is primarily influenced by the proportion of nutrient being trapped within the pycnocline by export production and remineralization. This suggests that a large fraction of low-latitude export production (48.1%, 37.2-57.4% for 10th and 90th percentiles) is fuelled by the recycling of nitrate in the pycnocline, with the remaining being supported by the external nutrients supply from the Southern Ocean and deep ocean.