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Terrestrial nutrient supply, marine cycling and limitation traced through isotopes in the Eurasian Arctic

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Climate change is significantly affecting the terrestrial supply of nutrients in the Arctic Ocean. To predict the knock-on effects this will have on nutrient availability for Arctic and Sub-Arctic ecosystems, gaps in our understanding of nutrient pathways in the Eurasian Arctic Ocean need to be filled. Stable isotope measurements of key nutrients such as dissolved nitrate ($\delta^{15}N$-NO_3 and $\delta^{18}O$-NO_3) and silicic acid ($\delta^{30}Si(OH)_4$) are powerful tools to elucidate and quantify the controls on nutrient supply, distribution and cycling within the modern ocean, particularly when both isotopes are combined.

Samples collected in the 2018 summer season yield the first full profiles of $\delta^{30}Si(OH)_4$ measurements of Fram Strait and the East Greenland shelf, analysed on MC-ICP-MS, combined with nitrate isotopes measurements. Fram Strait is a gateway of exchange between the Arctic and North Atlantic basins where the pathways through which polar waters are modified in the central Arctic can be examined. In this study, polar waters are found to be isotopically heavier ($\delta^{30}Si(OH)_4$= 1.85‰) than their Atlantic counterpart ($\delta^{30}Si(OH)_4$= 1.74‰), owing to partial utilisation of Si within the Arctic Ocean. Coupled benthic nitrification and denitrification on Arctic shelves leads to the enrichment of $\delta^{15}N$-NO_3 and lighter $\delta^{18}O$-NO_3 in polar waters relative to Atlantic waters. Using newly-available pan-Arctic $\delta^{30}Si(OH)_4$ data, the enriched isotopic signatures measured in Fram Strait are traced back to isotopically light Si input by Arctic rivers and subsequent partial biological uptake and opal burial on Eurasian Arctic shelves. A similar analysis of $\delta^{15}N$-NO_3 highlights the role of N-limitation due to N-poor terrestrial nutrient supply and denitrification losses in the Eurasian Shelves, generating excess silica for export out of the Arctic Ocean and emphasizing the linkages between these two key nutrients in the Arctic Ocean.

Using $\delta^{30}Si(OH)_4$ signatures, it is estimated that ~15-40% of silica exported out through Fram Strait is of terrestrial origin. Given that the Arctic Ocean is N-limited and Siberian riverine sources of silica are increasing faster than N inputs, a larger export of silicic acid through the Fram Strait is expected in the future, with wider implications for Arctic and sub-Arctic biogeochemical cycles.