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Examining seasonal variability in seawater iron isotopes from the Bermuda Atlantic Iron Time-series (BAIT)

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Understanding the sources and cycling of the micronutrient iron (Fe) supplied to the ocean are of great interest, as Fe is essential for phytoplankton growth. In the North Atlantic surface ocean, atmospheric deposition is the dominant input of Fe, mostly from air masses carrying Saharan desert dust [e.g. 1, 2]. However, the impact of dust deposition on Fe isotope cycling in the surface ocean remains obscured, largely due to the highly episodic and seasonal nature of dust deposition, and a lack of mechanistic understanding of Fe isotope fractionation upon dissolution. Here, we present dissolved Fe isotope (δ^{56}Fe) data as part of the Bermuda Atlantic Iron Time-series (BAIT) program. This is the first oceanic δ^{56}Fe time series, and includes 12 depth profiles collected from stations near Bermuda during March, May, August and November 2019 (3 stations from each month). At depth, we observe remarkable consistency in dissolved Fe and δ^{56}Fe throughout the seasons. Between ~200-600 m, dissolved Fe and δ^{56}Fe are relatively constant (~0.3 nmol/kg, ~+0.8‰). Below 800 m, where Upper Labrador Sea Water dominates (previously shown to carry a sediment influence [e.g. 1]), we see a similar uniformity (~0.7 nmol/kg, ~+0.4‰). Above 200 m, however, we observe large seasonal variability in both Fe concentrations and δ^{56}Fe. Winter conditions are characterised by low dissolved Fe (<0.2 nmol/kg) and elevated δ^{56}Fe (up to +1‰). In contrast, summer shows the highest Fe concentrations (up to 1.2 nmol/kg), coupled with lower δ^{56}Fe (down to +0.3‰). This pattern reflects a transition from winter, where biological uptake and ligand complexation set a higher δ^{56}Fe, to a dust-dominated summer, where crustal Fe from Saharan aerosols (~+0.1‰) is added to the surface [e.g. 2]. May and November profiles can be interpreted as a transition between these two states. We further explore the effect of dust and uptake/complexation on δ^{56}Fe in this dataset using the PISCES Fe biogeochemical model.

[1] Conway & John (2014) *Nature* **511**, 212-215.
[2] Conway *et al.* (2019) *Nat. Commun.* **10**, 2628.