EGU24-2748, updated on 11 Sep 2024
https://doi.org/10.5194/egusphere-egu24-2748
EGU General Assembly 2024


# Marginal sea-ice is not a major source of iron to support spring blooms in the South Atlantic

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In the South Atlantic HNLC regions, productivity limitation is largely attributed to light in combination with the unavailability of micro-nutrients, mainly dissolved iron (dFe). Many of these regions fall within the dynamic marginal ice zone (MIZ), which are highly vulnerable to future change in climate where in the past decades Southern Ocean is absorbing more heat than the polar north. It is hypothesized that sea-ice formed in winter concentrates macro- and micro-nutrients and serves as their source, on melting, to surface waters in spring to support phytoplankton blooms, where dFe concentrations can be less than 0.1 nM. For the logistical difficulties in accessing these remote areas, especially in winters, and analytical challenges, sea ice as a source or sink of micro-nutrients in these remote regions has remained understudied and only ~78 dFe usable data is available for the entire Southern Ocean sea-ice.

Sea-ice cores were collected in winter and spring from South Atlantic MIZ and analyzed for dissolved and particulate iron (pFe) along with other ancillary data. Ice-core depth profiles of dFe show a typical C-shape with higher dFe concentrations at the top and bottom of the core. dFe profiles did not follow the salinity profiles, suggesting external input of Fe at the top and bottom of the core and not brine drainage. The average concentration of dFe (0.53 ± 0.64 nmol $kg^{-1}$; n = 34) in sea-ice remained consistently lower than pFe (3.82 ± 2.42 nmol $kg^{-1}$; n = 11) and there was considerable heterogeneity even in replicate cores collected from the same floe. The measured concentrations translate into a total iron flux (TFe) of 38.05 ± 27.49 mol $y^{-1}$ (n = 45) in South Atlantic MIZ. Both measured species show regularly lower concentrations than what has been measured from other regions of the Southern Ocean, resulting in the calculated flux from the studied MIZ being 30 times lower than what has been calculated from melting of near shelf ice.

Experiments conducted in the laboratory show that majority of the dissolved iron accumulated in sea-ice is released within the first 10% of melting but with complete melting and mixing, resulting net dFe concentrations fall within the Fe-limiting conditions. pFe, although available at higher concentrations in sea-ice, had lower Fe/Al ratio compared to the typical crustal ratio. That is, a more refractory phase is released on melting of sea-ice, which is not ideal for uptake by phytoplankton.