Iron and its impact on primary productivity in the Southern Ocean

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The Southern Ocean (SO) is at the center of the global climate system. It accounts for ~50% of oceanic uptake of carbon and >75% of heat uptake. As such, the dynamics of the Southern Ocean have a global impact on primary productivity, biodiversity and the associated feedback mechanisms for carbon and biogeochemical cycling.

Iron is an important co-factor that is essential for marine photosynthetic organisms, assisting in the cell's ability to grow, multiply, photosynthesize and fix nitrogen. The low Fe concentrations in the Southern Ocean result from both low Fe input and the insolubility of the metal. Iron is only sparingly soluble in oxygenated seawater and has a short residence time due to precipitation reactions and significant scavenging loss onto particle surfaces. Not all Fe is bioavailable, which impacts the ability of primary producers to acquire it for diverse metabolic pathways. The distribution of bioavailable Fe reflects a balance between sources and sinks that are governed by biogeochemical processes such as chemical speciation, scavenging (particle sorption), remineralization, biological uptake and ocean and atmospheric dynamics. In the Southern Ocean, the different Fe sources and their magnitudes generate spatial variability in bioavailable Fe concentrations.

Using cores from IODP Leg 177, we reconstructed Fe reactivity by adopting a novel sediment extraction scheme designed to target diverse inputs of bioavailable Fe. We explored the relationships between the budget of bioavailable Fe (Fe_{HR}) and primary productivity as expressed in the time-varying abundances of 27 species of diatoms. Our data track relatively lower accumulation of highly reactive bioavailable Fe (Fe_{HR}) during the glacials despite enhanced dust delivery from Patagonia at those times (i.e, low Fe_{HR}/Fe_{T} ratios). The Fe_{HR} inputs increased at the beginning of the interglacials followed by increases in diatom abundance. These results imply that enrichments in bioavailable Fe occurred through processes linked to deglaciation. Those processes, although poorly known, may include delivery of Fe by icebergs, upwelling, and other coastal mechanisms. Most importantly, these data offer an alternative explanation to the conventional dust-productivity glacial model and elevate the importance of other Fe_{HR} sources also operating on glacial/interglacial time scales.