Coupling between nutrient biogeochemical cycles in the ocean

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Marine biological production is an important component of the earth-climate system. The biological carbon pump can regulate global temperatures by removing CO_2 from the atmosphere. However, this process is limited by the availability of micro- and macro-nutrients amongst which Fe, nitrate (N), phosphate (P) and silicic acid (Si) are essential. While N, P and Fe limitations can restrict the total amount of carbon fixed by the biota in the sunlit layer of the ocean, Si availability determines the nature of the biological production (siliceous vs. calcareous) and consequently the carbon rain-rate ratio of the export production and the efficiency with which CO_2 is removed from the atmosphere. Therefore the efficiency of the marine C pump depends locally on the “cocktail of nutrients” at the sea surface and globally on the large scale interactions between nutrient cycles, in particular N, Si, and Fe.

Over the years we have used new diatom-bound proxies for Si, Fe and N biological availability along with more classical productivity tracers in recent sediments and marine archives in key regions of the ocean to explore the nature of the coupling between nutrient cycles and their impact on the carbon pump.

For instance, using diatom-bound Fe concentration in sediment cores from the tropical Pacific and Southern Ocean, we show that dust accumulation records can not be straightforwardly used to reconstruct past changes in micronutrient availability and the cycling of iron in the surface ocean because they do not account for deep, soluble sources of iron or potential variations in the biological demand by the biota. Our work also reveals that the single most important factor causing Si limitation in the ocean is the dearth of Fe in the photic zone highlighting the indirect control exerted by Fe bio-availability on the biological C pump by enhancing the removal of Si from the ocean.