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Mechanistic modelling of the marine iron cycle identifies key roles of ligands and seafloor iron sources in regulating marine primary productivity

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Dissolved iron (Fe) is an essential micronutrient in the marine environment that limits primary productivity across approximately a third of the global ocean. However, many processes which govern the extent of Fe limitation, including sedimentary release, biological uptake, and the internal cycling of Fe, remain poorly understood on the global scale. To constrain these processes, we have developed a new Fe biogeochemistry model within the University of Victoria Earth System Climate Model (UVic ESCM) which includes improvements to the representation of reductive and non-reductive sedimentary Fe dissolution, the ligand cycle, and phytoplankton. Phytoplankton growth and nutrient uptake are quantified using an improved version of the Optimality-Based Phytoplankton-Ecosystem Model (OPEM) which includes variable Fe stoichiometry and cell-quota-based Fe-limitation. Using this model, we employed Latin Hypercube sampling to identify the model parameter sets which give Fe and ligand fluxes that most accurately reproduce global observations of dissolved Fe. These were subsequently used in model ensemble simulations to quantify the effect of seafloor Fe sources on surface ocean Fe concentrations, thereby identifying and constraining the processes which drive Fe-limitation across the high-nutrient, low-chlorophyll regions of the ocean. Our model shows improved performance metrics with respect to observational datasets, highlighting the key role ligands and seafloor iron fluxes play in regulating the global Fe cycle and marine primary productivity.