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Simulating neodymium isotopes in a general circulation model (FAMOUS): Exploring the role of non-conservative particle-seawater interactions in governing marine distributions

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The neodymium isotopic composition (ε_{Nd}) of seawater is a widely used tracer of both modern and paleoceanographic circulation. Uncertainty in quantifying the exact processes which govern global marine ε_{Nd} cycling, particularly constraining the elusive role of particle-seawater interactions remains a challenge. Benthic flux is now proposed as a major global seafloor-wide Nd source to the ocean, alongside the suggestion for ε_{Nd} to be used as a kinematic tracer of qualitative advection rates, and a continental weathering regime tracer. Accordingly, there is a clear need to revisit sources, sinks, and transformation of this tracer into and within the ocean.

We here present the implementation of Nd isotopes (^{143}Nd and ^{144}Nd) in a coupled atmosphere-ocean general circulation model (FAMOUS). FAMOUS is designed for simulating complex feedbacks between the Earths system, and is useful for exploring marine Nd cycling on a global scale. Aeolian dust, riverine fluxes, and sedimentary release represent the major interfaces and sources of Nd to the ocean, with reversible scavenging onto biogenic and lithogenic particles coupled with physical ocean circulation governing internal marine Nd cycling. We validated our implementation against observations of both ε_{Nd} and [Nd] and quantitively evaluate the importance of different components of marine Nd cycling in governing seawater ε_{Nd} distributions. Our findings demonstrate that reversible scavenging is a key process for enhancing the ε_{Nd} basinal gradient. It is also necessary to describe the observed increase in Nd concentration along the global circulation pathway. Marine ε_{Nd} and [Nd] distributions are sensitive to benthic flux parameterisations, which represents a major simulated source of Nd to seawater. Through sensitivity simulations, we demonstrate that the bulk ε_{Nd} of seafloor detrital sediment cannot be considered representative of the ε_{Nd} composition of sediment interacting with seawater in all instances, and suggest that 'reactive' detrital components may preferentially contribute to the global marine Nd budget, particularly in the North Pacific and northern North Atlantic.

The presented Nd scheme can aid in the delivery of more robust applications of ε_{Nd} as a paleo tracer through enabling dynamic modelling under changing climatic conditions, with implications for oceanic cycling and budgets of other particle reactive elements.