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Shallow vs Deep: Identifying the magnitude and locations of marine Nd sources with GNOM

PAIGE MIDORI WISE[1], BENOIT PASQUIER[2], SETH G. JOHN[1] AND SOPHIA HINES[3]

[1]University of Southern California

[2]University of New South Wales, Sydney

[3]Woods Hole Oceanographic Institution

Presenting Author: pmwise@usc.edu

Neodymium (Nd) isotope ratios serve as a valuable paleo-proxy aiding in unraveling the complexities of ocean circulation's impact on carbon drawdown. Nd isotopes (εNd) have the potential to elucidate the ocean's configuration during significant climate transitions, wherein the deep ocean acted as a major carbon reservoir. Despite their potential, questions persist regarding the quasi-conservative nature of Nd cycling in the ocean. To address this, we utilize the Global Neodymium Ocean Model (GNOM), a tracer-enabled transport matrix model that uses seawater data to simultaneously optimize Nd sources and sinks in the ocean, offering rapid computational insights. GNOM identifies rivers, dust, and sediments as primary Nd sources and prefers a larger sediment release at shallow depths, a topic of recent debate. Notably, our model experiments challenge this paradigm, revealing a nuanced interplay between surface and deep ocean sources. We explore the impacts of restricting specific sources, demonstrating the pivotal role of shallow sediments in shaping Nd distributions. Enhanced sediment reactivity, particularly in extreme εNd ranges, significantly influences benthic fluxes. Moreover, our findings suggest different and distinct controls on the Atlantic eNd profile and the Pacific εNd profile, with implications for paleo-tracing methodologies. By elucidating the "Top-down vs Bottom-up" debate, our study underscores the importance of sedimentary processes in modulating marine Nd cycling and underscores the necessity for cautious interpretation of εNd records, particularly in the Pacific Ocean. Through GNOM modeling, we advance understanding of Nd isotope dynamics, shedding light on crucial drivers of oceanic εNd variability.