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Impact of remineralization depth on the intensity of oxygen minimum zones in the Arabian Sea and Bay of Bengal

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The combination of high primary productivity and weak oceanic ventilation in the Arabian Sea and Bay of Bengal in the northern Indian Ocean generates vast areas of depleted dissolved oxygen at depth, known as Oxygen Minimum Zones (OMZs). The Arabian Sea OMZ is the world's thickest and contributes by up to 40% to the global ocean removal of biologically available nitrogen via a process known as denitrification. In contrast, the OMZ in the Bay of Bengal is weaker and is denitrification free. The underlying mechanisms explaining these contrasts remain poorly understood. In the present study, we demonstrate that the deeper remineralization depth (RD) in the Bay of Bengal that results from organic matter aggregation with mineral particles from rivers contributes to weaken its OMZ relative to that in the Arabian Sea. To this end, we conducted a series of eddy-resolving simulations of the Indian Ocean using the Regional Oceanic Modeling System (ROMS) model coupled to a NPZD type ecosystem model. When the RD is set uniformly across both seas, the model fails to reproduce the observed intensity contrasts between the two OMZs, irrespective of the chosen RD value. In contrast, when the RD is allowed to vary spatially between the Arabian Sea and Bay of Bengal, the contrasting distributions of oxygen and nitrate are correctly reproduced between the two seas, and water column denitrification is simulated exclusively in the Arabian Sea, in agreement with observations. Our findings highlight the need for a dynamic representation of RD in global models that explicitly accounts for spatial variations in organic matter export efficiency. Finally, our study exemplifies how contrasting the biogeochemical conditions in the Arabian Sea and Bay of Bengal can be used to improve our understanding of the dynamics of OMZs and the drivers of their variability.