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Anthropogenic impacts on marine nitrogen and iron biogeochemical feedbacks and their contribution to expanding oxygen minimum zones

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Nitrogen and iron are the key limiting nutrients throughout the majority of the global ocean. These nutrient systems have important source and/or sink processes that are highly sensitive to low oxygen thresholds. In this study, we use a global ocean biogeochemical model within an Earth system model of intermediate complexity to investigate anthropogenic controls on marine nitrogen and iron cycling under warming and atmospheric pollutant scenarios. We performed sensitivity simulations to isolate the individual and combined effects of the marine nitrogen and iron internal feedbacks, as well as the impact from increasing atmospheric pollutant deposition. Our model simulations demonstrate strong negative (stabilizing) feedbacks on marine productivity from both the marine nitrogen and iron cycles when feedbacks from only one individual nutrient cycle were considered at a time. However, when the full set of marine nitrogen-iron feedbacks were activated, enhanced iron sources from the atmosphere and sediments under anthropogenic scenarios were sufficient to stimulate additional N_2 fixation by 16% globally, with much of it occurring near tropical oxygen minimum zones enhancing regional productivity there. These marine nitrogen-iron biogeochemical feedbacks driven by anthropogenic scenarios including atmospheric pollutant deposition were responsible for a projected 40% expansion in the volume of oxygen minimum zones by year 2100 in the model, whereas a sensitivity simulation with these feedbacks deactivated resulted in a 40% reduction. Our model study suggests that increasing marine nitrogen and iron sources in the Anthropocene can play an important role on future ocean biogeochemistry and productivity that significantly contribute to expanding oxygen minimum zones.