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The effect of atmospheric nitrogen deposition on marine nitrogen cycling throughout the global ocean

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The rapidly increasing rate of anthropogenic nitrogen deposition has the potential to perturb marine ecosystems and biogeochemical cycles because nitrogen is one of the major limiting nutrients in the ocean. We use an Earth System Climate Model that includes ocean biogeochemistry to assess the impact of atmospheric nitrogen deposition. Experiments are conducted where we artificially add nitrogen to nearly all locations individually throughout the global surface ocean using a nitrogen deposition rate of 700 mg N m-2 yr-1, which is consistent with modern estimates near industrial areas. We identify oceanic "biomes" that respond differently to atmospheric nitrogen deposition. (1) When nitrogen is deposited near oxygen minimum zones where water column denitrification occurs, locally increased primary production stimulates additional denitrification. Since water column denitrification removes 7 mol N for every mol N of newly formed organic matter respired, the global oceanic nitrogen inventory declines in response to nitrogen deposition in these areas. This slow, but steady decline persists for at least 1,000 years. (2) When nitrogen is deposited above shallow continental shelves where benthic denitrification occurs, our benthic denitrification model predicts an increase that is nearly equal to the nitrogen deposited and thus no net change in the global nitrogen inventory. (3) When nitrogen is deposited into the high latitude open ocean far removed from nitrogen fixation and denitrification, all of this deposited nitrogen initially accumulates in the ocean. This nitrogen eventually circulates into the tropical oxygen minimum zones where it fuels additional primary production and denitrification, which removes nitrogen at a rate equal to the deposition after 1,000 years and leads to a stable, but increased nitrogen inventory in our model. (4) When nitrogen is deposited into the open ocean where nitrogen fixation occurs, nitrogen fixation decreases due to less nitrogen limitation. This leads to a small net decrease in the nitrogen inventory during the first couple decades in some areas. After this initial nitrogen fixation response, water column denitrification then decreases, which leads to an increase in the global oceanic nitrogen inventory that persists for $\sim$700 years, until balance is once again maintained with a larger net global oceanic inventory. This balance occurs at a shorter timescale compared the high latitude locations because here is located in the tropics/subtropics that is closer to the oxygen minimum zones where water column denitrification occurs. Overall, the nitrogen deposition experiments show that the marine nitrogen cycle responds differently depending on the local biogeochemical processes taking place as well as the spatial proximity to oxygen minimum zones.