Geophysical Research Abstracts
Vol. 20, EGU2018-19750, 2018
EGU General Assembly 2018

The resilience of the marine nitrogen cycle to ocean acidification: how changes in seawater pCO_2 and pH induce global compensatory effects between N2-fixation and nitrification.

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Different mechanisms have been proposed in the existing literature about how the marine nitrogen cycle keeps its balance in response to external forcings. The coupling between N2-fixation and denitrification has been presented traditionally as the stabilizing mechanism of N inputs and losses over long time periods. Moreover, anthropogenic forcings such as climate change and atmospheric nitrogen deposition have been suggested to keep the global N inventory balanced through complex biogeochemical processes involving nutrient supply, export production and ocean deoxygenation.

The response to ocean acidification remains however as one of the missing measures on the supposed elasticity of the N-cycle. Changes in the spatial and temporal evolution of N2-fixation and nitrification due to ocean acidification might have implications on nutrient cycling, primary production, oxygen (O_2) concentration and N2O production on a global scale. We use a coupled global physical-marine ecosystem model (NEMO-PISCES) to explore the future response of marine N2-fixation and nitrification to increasing seawater CO_2 and lower pH. Since high concentrations of CO_2 have been shown to stimulate marine N2-fixation, and lower pH to constrain nitrification, we added new parameterizations of these effects into the model. Moreover, we also explore the response to a combined forcing of global warming and ocean acidification. In response to the increase in atmospheric CO_2 prescribed by the RCP8.5 scenario, N2-fixation is boosted by +25% in 2100 compared to our pre-industrial rate of $\sim$70 TgN yr-1. But the associated change in climate change reduces N2-fixation considerably, largely owing to stronger inhibition by nitrate and stronger iron limitation. When climate change and carbon enhancement operate in tandem, the two effects are modeled to nearly cancel each other globally, although not regionally. Nitrification experiences a significant drop of -16% in year 2100 due to ocean acidification alone. This decrease is exacerbated in combination with climate change, with an additional 5% triggered by less productivity and hence less export of organic matter to depth. Using primary production as a metric to evaluate the net effect of the changes in these processes, we observe a compensation between N2-fixation and nitrification. The resilience of the N-cycle to external forcings are of exploratory nature, given our limited understanding of the factors that ultimate control N2-fixation and nitrification processes.