Validating, Improving, and Assessing Marine Nitrification under Climate Change in GFDL’s Earth System Model 4 (ESM4)

Weiyi Tang¹, Fabien Paulot², Charles Stock², John Dunne², Bess Ward¹

¹Department of Geosciences, Princeton University, Princeton, NJ, United States
²Geophysical Fluid Dynamics Laboratory, National Ocean and Atmospheric Administration, Princeton, NJ, United States

Nitrification, the microbially mediated oxidation of ammonium to nitrate, controls the availability of different forms of nitrogen to support primary production. It also results in the formation of nitrous oxide, a potent greenhouse gas. Therefore, constraining the distribution of marine nitrification is important to evaluate the role of the ocean in the Earth’s climate system. The ocean biogeochemical component of GFDL-ESM4.1, COBALTv2, is one of the few biogeochemical models that include nitrification. However, the proposed functional form to estimate nitrification in COBALTv2 has not been comprehensively compared against the field observations. In this talk, I will discuss how we 1) compiled a database of nitrification rate measurements over the global ocean to validate the current nitrification parameterization in COBALTv2 and 2) developed new parameterizations of relationships among reaction rates and environmental variables using both the mechanistic model and machine learning algorithms. Ammonium was identified as the most important environmental predictor of in situ rates, followed by oxygen, temperature and light intensity. The new mechanistic model and machine learning algorithms outperform the nitrification parameterizations in COBALTv2 and in other biogeochemical models against the observations. 3) Next we plan to assess the sensitivity of marine nitrification to climate/anthropogenic change including warming, ocean acidification and increasing N deposition. We welcome any feedback on the model validation, development and application.