PROJECT TITLE: Exploring the future of the marine N_2O cycle

DTP Research Themes: Living World, Changing Planet

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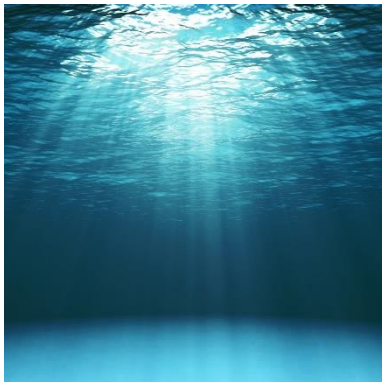
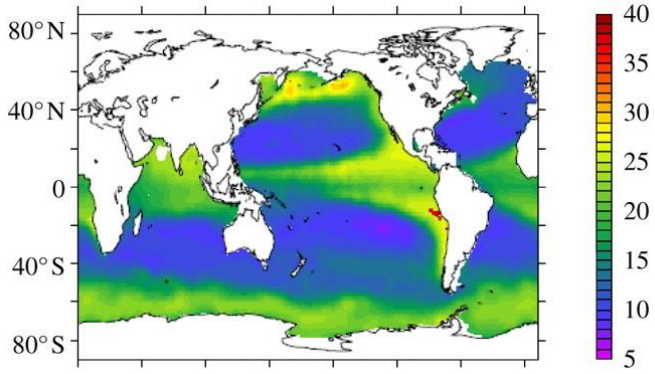
Project keywords: Ocean, Greenhouse gas, Climate change, Biogeochemical cycles, Modelling, Observations, Nitrous Oxide



The ocean is a primary source of nitrous oxide (N_2O), which is critical for our climate



Global N_2O ocean concentration (nmol kg^{-1}) at 200 m depth (Freing et al., 2012)

Project Background

Nitrous oxide (N_2O) is a major atmospheric greenhouse gas. It is the third most significant contributor to radiative forcing in our modern climate. One of the most important sources of N_2O is the ocean, which is estimated to contribute up to 50 % of the total emissions (Ciais et al, 2013). N_2O is produced in the ocean by the microbial processes of nitrification and denitrification, which occur in oxic and suboxic/anoxic environments, respectively (Freing et al., 2012). The level of N_2O production in the ocean thus closely relates to the level of oxygen present in the ocean. Besides, recent research shows that pH also regulates the production of N_2O via its influence on nitrification (Rees et al., 2016). Climate change has started to impact our environment with increases in ocean deoxygenation and acidification, which are projected to intensify under future scenarios (Ciais et al., 2013). However, due to the complex interactions between climate stressors on the sources and sinks of N_2O in the ocean, the future of N_2O production is still very uncertain (Hopkins et al., 2020).

Project Aims and Methods

This project aims to evaluate the impacts of deoxygenation and acidification on ocean N_2O cycling under climate change. Current Earth System models use simple parameterisations to represent the sources and sinks of N_2O in the ocean. However, these parameterisations are based on modern observations, and might be inaccurate for a future perturbed ocean. These parameterisations also do not account for the effects of pH changes on nitrification and N_2O production. During the project, the student will first develop a process-based model of N_2O cycle to determine the controls of N_2O production in the ocean. To do so, the student will add the sources and sinks of N_2O and a pH control on nitrification to the state-of-the-art nitrogen cycle model of Zakem et al. (2019). This new N_2O model will constitute the first ocean model to capture the complex interactions between denitrification, nitrification, and the ocean environment. This theoretical model will then be applied in a global Earth System model for modern estimates and future predictions. The student will have the possibility to either further develop a model intercomparison to consider uncertainties in future projections of marine N_2O production or to perform paleoclimate reconstruction of N_2O emissions (critical for the glacial-interglacial cycle; Schilt et al., 2010). The student will also spend a year at PML to learn to use electron capture detector gas chromatography (ECD-GC) to measure dissolved and atmospheric N_2O.

This will involve the collection of field samples by going to sea onboard a UK research vessel, as well as the development of experimental manipulations and the data analysis to directly investigate the impact of changing environmental conditions on N_2O production and consumption.

Candidate requirements

We seek a highly motivated and independent candidate interested in an interdisciplinary understanding of marine biology, ocean chemistry and climate. Candidates should have a degree in at least one of these specialities: Oceanography, Earth Sciences, Geophysics, Environmental Sciences, Geography, Biology, Chemistry, Physics or Mathematics. It is okay if you have only one of the above as we can train you in the other areas. *We also welcome and encourage student applications from under-represented groups. We value a diverse research environment.*

Indicate the opportunities provided by partners Training

Overall, the student will receive specialist training in computer model programming and data analysis. The student will learn how to use and develop models of different complexity (from ecosystem to Earth system models). Dr Monteiro and Andrews will supply modelling support on nitrogen cycling and future/paleoclimate. Dr Rees will provide training in analytical and experimental methodology alongside familiarization with ocean fieldwork. The student will spend one year with at PML with Dr Rees to learn analytical techniques and gain fieldwork experience. The student will also spend one month at the University of South California with Dr Zakem to learn about the ecological nitrogen model. The student will develop expertise in marine ecology, ocean biogeochemistry and climate (future climate change and paleoclimate).

Background reading and references

Ciais et al. (2013). Carbon and Other Biogeochemical Cycles. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press

Freing et al. (2012). Global oceanic production of nitrous oxide. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*(1593), 1245-1255

Hopkins et al. (2020). The impacts of ocean acidification on marine trace gases and the implications for atmospheric chemistry and climate. *Proceedings of the Royal Society A*, *476*(2237), 20190769

Rees et al. (2016). The inhibition of N2O production by ocean acidification in cold temperate and polar waters. *Deep Sea Research Part II: Topical Studies in Oceanography*, *127*, 93-101

Schilt et al. (2010). Glacial–interglacial and millennial-scale variations in the atmospheric nitrous oxide concentration during the last 800,000 years. *Quaternary Science Reviews*, *29*(1-2), 182-192

Zakem et al. (2019). Stable aerobic and anaerobic coexistence in anoxic marine zones. *The ISME journal*, 1-14.

Useful links

http://www.bristol.ac.uk/geography/courses/postgraduate/
http://www.bristol.ac.uk/geography/people/fanny-m-monteiro
http://www.bristol.ac.uk/geography/people/oliver-d-andrews
https://www.pml.ac.uk/People/Science_Staff/Dr_Andy_Rees

NERC GW4+ DTP Website:
For more information about the NERC GW4+ Doctoral Training Partnership please visit
https://www.nercgw4plus.ac.uk

Bristol NERC GW4+ DTP Prospectus:
http://www.bristol.ac.uk/study/postgraduate/2021/doctoral/phd-great-western-four-dtp

How to apply to the University of Bristol:
http://www.bristol.ac.uk/study/postgraduate/apply
The application deadline is Friday 8 January 2021 at 2359 GMT.
Interviews will take place during the week commencing 8th February 2021.

General Enquiries:
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