Project: **976**
Project Title: **EU H2020 Project 'CRESCENDO' Marine Biogeochemical Processes**
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Project Objective and Progress

The objective of this project is to improve the representation of ocean biogeochemical processes in the model and better understand the interactions between physical climate and ocean biogeochemical processes in the Earth system. We have been working on both ocean biogeochemical model (HAMOCC) development and investigating how climate variability interacts with ocean biogeochemical cycles. Please note that the project has just started and we are still under development on new ocean biogeochemical scheme in HAMOCC. The model development is still on-going and unfortunately we are a little behind the schedule on implementing a new scheme but as soon as the model development is completed, we will continue on testing and evaluating the model.

Current Work: The impact of climate variability on ocean biogeochemistry and biogeochemical feedbacks on climate

Interactions between physical climate and ocean biogeochemical processes are still not yet well understood and we are working on this problem from two different approaches.

1. The dynamics and distribution of marine biota are strongly controlled by its physical surrounding, such as temperature, light, and ocean circulations. In turn, phytoplankton can modify the optical and viscous properties of the seawater, thereby potentially feeding back on the distribution of heat and momentum in the ocean. To study the effects of the feedbacks induced by the presence of phytoplankton on the Earth system, we implemented several bio-physical coupling mechanisms into the MPI-ESM: 1) the light absorption by phytoplankton, 2) the albedo change by phytoplankton, and 3) the increase in water viscosity by phytoplankton aggregations. Phytoplankton species that are particularly prominent in changing the sea water properties are nitrogen fixing cyanobacteria, due to their capacity to form extensive surface mats. We perform experiments with and without the bio-physical coupling included to study the effects of the bio-physical feedbacks on the climate system using the latest version of HAMOCC including prognostic N_2 fixers [*Paulsen et al*., 2016, under revision]. The preliminary results show that the light absorption by phytoplankton has considerable effects on ocean temperature and circulation, especially in the tropics. The increase in the tropical surface temperature, which is in the order of 1 K, affects the wind fields (e.g. eastward shift of the Walker circulation, contraction of the Hadley cell) with implications for the precipitation patterns (wetter in the equatorial West Pacific, drier in the subtropics and above the Pacific warm pool). Furthermore, the experiments reveal that especially the light absorption within the downwelling regions of the subtropical gyres plays a role in affecting tropical climate. We are still under further investigation on feedback processes.

2. Climate variability could strongly impact on ocean biogeochemical cycles and marine ecosystems in various time-scales (i.e., from monthly to centennial time-scales). We are now preparing and running the stand-alone ocean model (MPI-OM) with HAMOCC to conduct

transient experiments based on atmospheric reanalysis forcing. The objective of this transient experiment to investigate how the observed climate variability (such as El Niño Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO)) impacts on variability of ocean biogeochemical tracers (such as carbon, oxygen, and nutrients). Model spin-up is now undergoing and we will compare the spin-up and transient experiments based on the CMIP5 version of MPI-OM/HAMOCC [*Ilyina et al*., 2013] with the experiments based on the latest version of HAMOCC [*Paulsen et al*., 2016, under revision]. This will enable us to evaluate the performance of the model and how differences in model structures could lead to uncertainty in variability of ocean biogeochemical tracers. We will also use the results from transient experiments to evaluate the climate driven ocean biogeochemical variability simulated in MPI-ESM's super ensemble experiments. We are now analyzing the output from MPI-ESM's super ensemble experiments along with our experiments to quantify the role of climate variability on regulation the variability of ocean biogeochemical tracers under the different climate change scenarios.

References

[1] Ilyina, T., K. D. Six, J. Segschneider, E. Maier-Reimer, H. Li, and I. Núñez-Riboni (2013), Global ocean biogeochemistry model HAMOCC: Model architecture and performance as component of the MPI-Earth system model in different CMIP5 experimental realizations, *J. Adv. Model. Earth Syst*., 5, 287–315, doi:10.1029/2012MS000178.

[2] Paulsen, H., T. Ilyina., K. D. Six., and I. Stemmler (2016), Incorporating a prognostic representation of marine nitrogen fixers into the global ocean biogeochemical model HAMOCC, *J. Adv. Model. Earth Syst*., under revision.