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 system and ocean biogeochemical processes in the Earth system. We have been working on both ocean biogeochemical model (HAMOCC) development and investigating how climate variability and changes interact with ocean biogeochemical cycles. The HAMOCC now includes prognostic N_2 fixers [*Paulsen et al*., 2017] and numerous minor updates have been conducted (e.g. updating particulate organic matter parameterization (the Martin curve), transient dust depositions). Please note that the project is still ongoing and we are further developing the new ocean biogeochemical scheme in HAMOCC (e.g. particle aggregation scheme, river inputs). The stand-alone model (MPI-OM/HAMOCC) has also been updated including new diagnostic tracers (preformed tracers and dye tracers for tracking the water mass behaviors) to understand how ocean biogeochemical tracers are redistributed in the ocean with circulations. The model spin-up is still on-going and unfortunately, we are a little behind the schedule on spinning-up the model (because of the model bug fixing and stand-alone model adjustment takes a long-time) but as soon as the model spin-up is completed, we will continue conducting transient experiments and analyzing the model output.

Current Work: How ocean biogeochemical cycles evolve with climate change and variability?

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

[A] Light absorption by phytoplankton in the ocean redistributes heat in the water column with implications for climate mean state and variability [e.g., *Patara et al*., 2012]. In particular, nitrogen-fixing cyanobacteria are observed to strongly affect ocean surface temperature due to their surface bloom-forming behavior [*Kahru et al*., 1993; *Capone et al*., 1998]. To investigate the effects of cyanobacteria on a global scale, and further to include potential feedbacks between ocean and atmosphere, we use MPI-ESM. We expand HAMOCC by including nitrogen-fixing cyanobacteria as additional phytoplankton group [*Paulsen et al*., 2017]. We conduct experiments with and without accounting for cyanobacteria in the interactive feedback of phytoplankton light absorption on radiative heating in the ocean and assess the respective effects on climate. The model results reveal that the tropical climate system is sensitive to the spatial distribution of phytoplankton and related light absorption in the tropical and subtropical oceans. We further perform transient simulations with MPI-ESM in order to study how changes in the phytoplankton distribution under rising CO_2 feedback on climate change. We focus hereby on the evolution of cyanobacteria, which are proposed to become one of the winning phytoplankton species. We test several proposed adaptation mechanisms of cyanobacteria and assess how the evolution of the phytoplankton distribution affects climate.

[B] The internal variability of ocean biogeochemistry is one of the major uncertainties for detecting the changes due to global warming but the characteristics and mechanisms driving the internal variability are not well understood. Climate variability is one of the components that could strongly impact on ocean biogeochemical cycles and marine ecosystems in various time-scales (i.e., from monthly to centennial time-scales). Combining the analysis of observations [*Boyer et al*., 2013; *Ito et al*., 2017] and MPI-ESM's Grand Ensemble Simulations (MPI-ESM-GENS), we are currently investigating the role of internal variability on regulating ocean biogeochemical cycles [*Takano and Ilyina*, in prep]. The internal variability could change not only in time but also in space for each ensemble members, which could results in additional uncertainties on interpreting the limited observations. The MPI-ESM-GENS would enable us to quantify the internal variability in the Earth system but it is difficult to investigate how the observed climate variability could modulate the ocean biogeochemical cycles (i.e. origin of the internal variability of ocean biogeochemical tracers). Using the MPI-OM/HAMOCC with new additional tracers for further diagnostics, we are currently spinning-up the stand-alone model. Once the model reaches the steady-state, we will continue conducting the transient experiments using atmospheric forcing from the reanalysis to investigate how the observed climate variability and changes could modulate the ocean biogeochemical cycles.

References

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