Data driven modelling of ocean carbon removal strategies
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In order to limit rising temperatures it is necessary for us to remove carbon dioxide from our atmospheres. The soil, atmosphere, and ocean all act as carbon stores – however, the deep ocean has the greatest capacity. Ocean carbon dioxide removal strategies (OCDR) look to make use of the potential of the deep ocean for carbon storage. Alkalinity enhancement and algae cultivation are examples of such strategies, but these strategies are costly to implement and it is challenging to measure their effect.

Ocean modelling tools provide an effective insight into the impact of OCDR strategies. Developed under the framework of Oceananigans, OceanBioME is an ocean modelling package designed to be a fast and flexible way of testing OCDR strategy.

This summer, I was part of a group project working on the development of the modelling tool OceanBioME. In particular we wanted to develop this tool to study the Kelp Blue Farm based in Luderitz Bay, Namibia. We were working towards building a 3-dimensional model of this kelp farm, incorporating physics forcing, a biogeochemistry, carbonate chemistry, and sediment model. Parameter optimisation was also an important focus of this project.

I was part of a pair and our role was to implement a new biogeochemistry (BGC) into OceanBioME. The biogeochemistry we worked with was 'PISCES' (Aumont, 2015). The complexity of PISCES means it is an accurate representation of the biogeochemistry in many ocean modelling scenarios, including being a suitable biogeochemistry for the Kelp Blue farm. Comprised of 24 compartments, PISCES details the interactions between phytoplankton, zooplankton, nutrients, and particulate matter. We spent a substantial amount of the summer understanding the model, and movement of carbon. The actual implementation of PISCES was coded in Julia, and we made several modifications to the model as was necessary to give dimensional consistency and conservation. We initially had many issues with the stability of the model, but working through the modifications mentioned above, as well as scaling certain parameters improved this. Both a 1-dimensional box model, and 2-dimensional column model are now stable on longer simulations with larger time-steppers.

We have produced an open-source implementation of PISCES that is incredibly accessible. It is easy to get started running simulations with OceanBioME. Our code can be used to investigate the effects of variable ocean conditions on phytoplankton growth. These include temperature, PAR (light) levels, nutrient limitation and initial conditions.

Although this is where we leave PISCES at the end of the summer, there is still much potential development. Implementation of variable PAR and temperature is underway, which will allow for incorporation of seasonal variance into our model. Work by other members of this group project will further be useful in optimizing parameters in this model. This continued development of PISCES, and OceanBioME is significant in improving our understanding of OCDR strategies.