Ocean physics and ecology: satellite and climate model data analysis

Ethan Lior, SEAS 2024
Jonathan Tran, SEAS 2024

Mentors EES Dept: Dr. Irina Marinov and Ekaterina Kochetkova

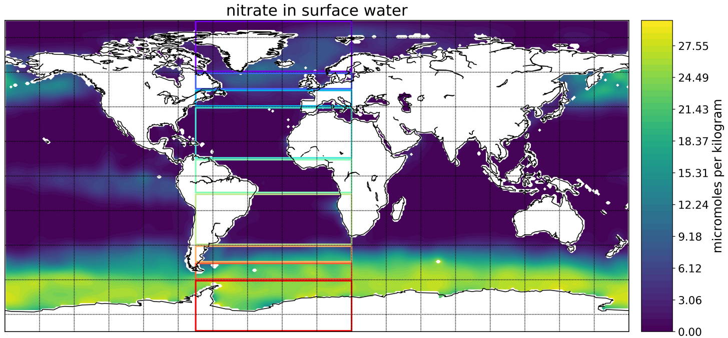
Introduction

During the 10 weeks, we have worked on transitioning from the older CMIP5 models to the new CMIP6 models. To begin, we spent around a month alternating between reading about biogeochemical processes in the ocean and studying previously written code. Gaining a strong understanding of the research content as well as the methods of research was critical in helping us develop plots later in the summer that will assist in our understanding of the ecology of the ocean.

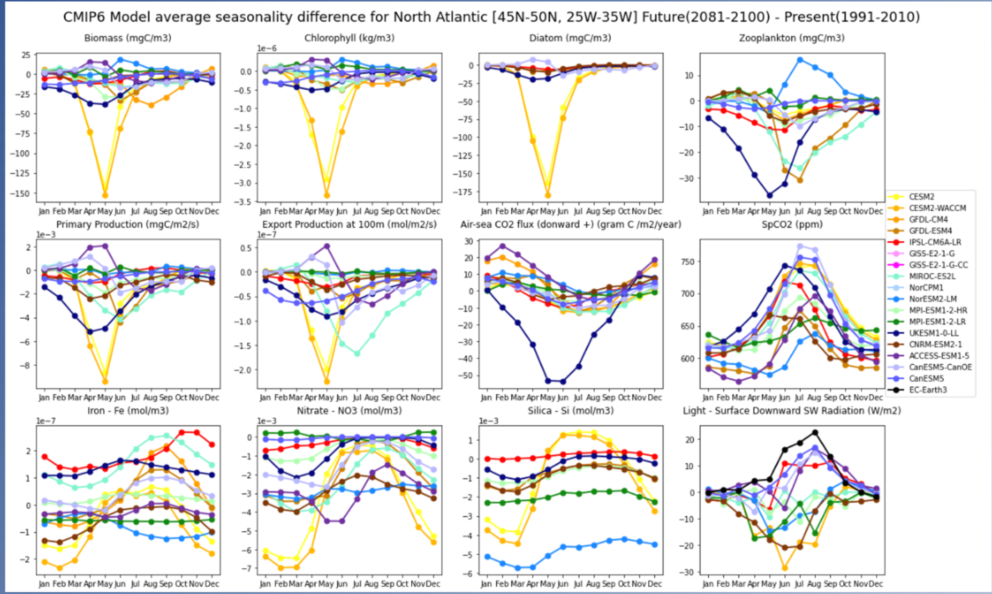
Our main research was focused on phytoplankton and their interactions with nutrients found in the ocean. Phytoplankton are critical as they account for around 50% of the total photosynthesis on Earth and our research aims to explore how their populations are affected by climate change.

Materials and Methods

The team primarily used Coupled Model Intercomparison Project Phase 6 (CMIP6) data along with the latest World Ocean Atlas Data (WOA 2018) to model variables in Python. The group used the period 1991-2010 for modelling the past and 2081-2100 for future models. The plot shown below is a model of phytoplankton biomass at different boxes in the Atlantic. We used 18 of the CMIP6 models for this plot in order to help understand possible errors and inaccuracies in specific models for when we do comparisons between different periods of time.



This plot shows surface nitrate levels from WOA 2018 Data which can be used to compare against CMIP6 model data



These plots show the average seasonal difference in twelve variables from 1991-2010 to 2081-2100.

Summary and Conclusions

From these plots, we are able to analyze present (1991-2010) ocean data and future climate model projections (2081-2100). In doing so, we were able to confirm the seasonal cycle of phytoplankton (biomass) and zooplankton. Zooplankton populations peak in the summer months after phytoplankton bloom in the spring- an expected result, as zooplankton graze on phytoplankton.

We also compared subpolar Atlantic (*above*) and Pacific boxes. For the CESM2 subpolar box in the North Atlantic, we see that observed nitrate (NO3) is in the middle range of all modeled NO3 in winter and spring. In the summer, however, observed NO3 goes to zero, while model NO3 goes to zero in only half of the models. Biological uptake by phytoplankton is too weak in the summer in some models. On the other hand, at ocean station PAPA in the subpolar North East Pacific, the opposite is observed. In the summer, NO3 is higher than in most models. In most models, phytoplankton growth is too high during the summertime at PAPA. This is explained by phytoplankton not being iron limited enough compared to reality. We can therefore deduce the iron cycle is not correct in most models here.

Furthermore, we were able to study differences in present and future data. We found that across multiple models, phytoplankton populations and the nutrients they rely on (eg. nitrate) are projected to decrease.

Phytoplankton are responsible for 50% of photosynthesis performed on Earth. Drops in phytoplankton population would affect climate on a global scale. Projections like these demonstrate the need to take action to prevent further climate change.

In future work, we are interested in studying various ratios such as grazing rate/primary production, biomass/chl ratios, zoopl/total biomass, and Si/NO3. Understanding the relationship between such variables will ultimately allow us to draw further conclusions on future climate projections.