EGU24-16901, updated on 13 Feb 2025
https://doi.org/10.5194/egusphere-egu24-16901
EGU General Assembly 2024

Community structure matters: diverse ecosystem structure shapes carbon dynamics in a model system.

Rebecca Wright, Joe Guest, Tereza Jarníková, Marie-Fanny Racault, Erik Buitenhuis, Nicolas Mayot, Philip Townsend, and Corinne Le Quéré
University of East Anglia, United Kingdom of Great Britain – England, Scotland, Wales (rebecca.wright@uea.ac.uk)

Understanding how climate variability and climate change affects marine ecosystem dynamics and its cascading implications for the carbon cycle is a “known-unknown” that was highlighted in the past four Assessment reports of the IPCC. We present results from a novel set of global ocean biogeochemistry model branches which were designed to explore the role of marine ecosystem structure for carbon dynamics both globally and regionally, with a focus on the Southern Ocean.

PlankTOM12 is a global ocean biogeochemistry model based on the representation of marine microorganisms grouped into twelve Plankton Functional Types (PFTs) as a function of their importance for the carbon cycle. PlankTOM12 uniquely represents explicitly heterotrophic bacteria/archaea, six types of phytoplankton , and five types of zooplankton . We build three distinct branches of PlankTOM12, with identical ecosystem framework and identical physical environment, but each branch with its own set of ecosystem parameters allowing different ecosystem formations. Branch 1 (called GCB) is the historical branch that underpinned much prior research on the carbon cycle using this model and contributed to the Global Carbon Budget 2023. Branch 2 (ECO) is optimised to reproduce the observed mean, seasonal cycle, and interhemispheric distribution of surface chlorophyll-a (Chl*a*). Branch 3 (CO2) is optimised to reproduce the observed mean and seasonality of the partial pressure of surface ocean carbon dioxide (*p*CO2). Even though the parameterisations are optimised globally, many of the substantial differences between the three branches occur in the Southern Ocean. In particular, it was not possible to reproduce a good mean and seasonality for both Chl*a* and *p*CO2 simultaneously in the Southern Ocean. Strikingly, each of the three PlankTOM12 model branches offers a different perspective on marine ecosystem dynamics. The branches differ most distinctly in the relative fraction of biomass that is distributed among PFTs: the GCB branch distributes most of its biomass in small phytoplankton PFTs and large zooplankton PFTs, the ECO branch distributes its biomass relatively evenly among PFTs, and the CO2 branch is intermediate with most biomass in the small phytoplankton PFTs and large zooplankton PFTs, but also substantial biomass in the medium-sized PFTs for both phyto- and zooplankton. We show how the differences in these ecosystem structures transfer through to differences in carbon dynamics, including primary and secondary production, sinking fluxes of organic carbon, calcium carbonate, and silica, and how they propagate to carbon export to the deep ocean and export efficiency. We present the response of the three branches to recent climate change and variability using hindcast simulations over

1948-2022, and discuss model evaluation based on available biogeochemistry and ecosystem observational data. Finally, we suggest future applications and questions which may be best addressed by each model branch.