Exploring physical and biological environmental responses to differing rates of carbon emissions

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Earth System Models (ESMs) that feature a fully-interactive carbon cycle allow for the exploration of interactions and feedbacks between the physical climate and biogeochemical systems as both respond to increasing anthropogenic CO_2 emissions. Here, we highlight past and ongoing research using CMIP5 and CMIP6-generation ESMs developed at NOAA-GFDL that explores the relationships between cumulative carbon emissions and climate sensitivity, sea level rise, and ocean acidification. Our results demonstrate that the rate of carbon emissions plays an important role in dictating the timing, magnitude, and geographic response to forcing in the context of regional sea level rise (SLR) and the Transient Climate Response to cumulative carbon Emissions (TCRE). We also find that under high carbon emission rates, rapid surface ocean acidification in the Arctic Ocean is projected to occur during the 21st century. Using results from idealized CO_2-only forcing scenarios, as well as historical and future climate projections from the Coupled Climate-Carbon Cycle Model Intercomparison Project (C4MIP), we highlight the important physical and biogeochemical controls on these high-impact ocean responses to a warming climate. We explore these features from global and regional perspectives and quantify the role of internal climate system variability with the ultimate goal of reducing the uncertainty in future climate.

Keywords: Earth System Modelling, Carbon Cycle, Projections, TCRE, Feedbacks, Cumulative Emissions

