Modelling future pathways of climate change

Simulating baseline climate states for modelling ocean alkalinity enhancement

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In Short

- Simulations of future climate change scenarios are planned in earth system model FOCI to serve as baselines for experiments of ocean alkalinity enhancement.
- Model runs are planned both with a high-resolution nested configuration and the standard version to quantify potential amplification effects of biogeochemical feedbacks due to small scale processes being resolved.
- This research fits into a broader framework of evaluation of the potential, benefits and risks of ocean alkalinity enhancement

It is abundantly clear that anthropogenic emissions have caused unprecedented changes to the climate system [1]. In order to inform policies for mitigation and adaptation, understanding possible pathways of future change are essential. Integrated assessment models (IAMs) do this in a realistic way by combining physical drivers with socioeconomic influences. The latest assessment report from the Intergovernmental Panel on Climate Change [1] uses shared socioeconomic pathways (SSPs) that are a combination of projections of greenhouse gas concentrations and changes in socioeconomic factors [2]. In earth system models, these serve as baselines for mitigation strategies.

The nearly linear relationship between cumulative CO_2 emissions and global surface temperature rise have led to carbon dioxide removal (CDR) methods being on the forefront of scientific discussion to reach the agreed upon Paris climate agreement goal of limiting warming to 2°C above pre-industrial levels and pursing efforts to limit it to 1.5°C. Ocean alkalinity enhancement (OAE) has the potential to sequester large amounts of CO_2 [3] so multiple modelling studies are underway to evaluate its realistic potential. In this project, the Flexible Ocean and Climate Infrastructure (FOCI) earth system model [4] will be used to simulate baseline climate states. FOCI consists of a fully coupled atmosphere-ocean-sea-ice general circulation component and a marine biogeochemistry component. Planned are multiple runs to establish a baseline for two scenarios with high and low climate change forcing by the end of the century. The results will then be used as a control for project shk00054 where different experiments for OAE are planned along the European coastline. Scenarios SSP1-2.6 and SSP3-7.0 specifically are chosen to provide a yardstick on OAE efficacy since results from Lenton et al. (2018) [5] showed that artificial ocean alkalinisation was more effective in a scenario where emissions were low. This will be evaluated with FOCI at a later stage so contrasting baselines are planned.

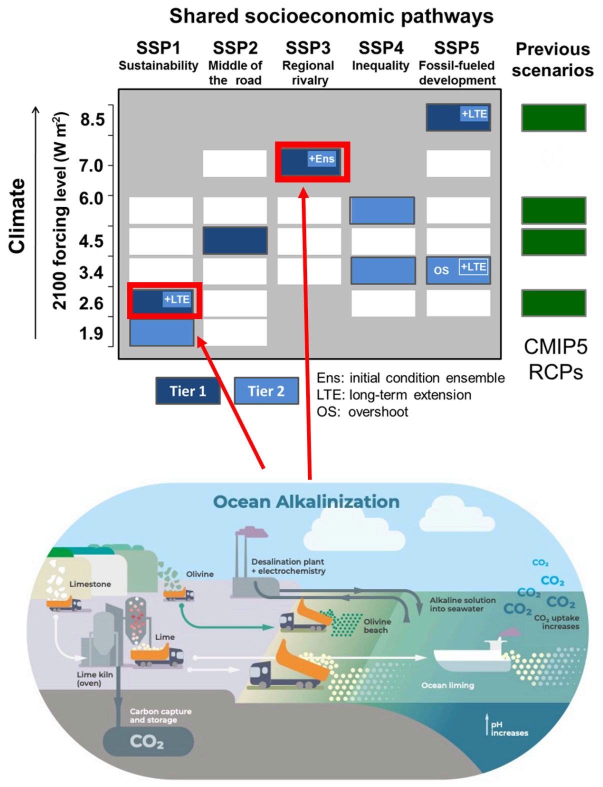

Figure 1: *Baseline scenarios for ocean alkalinity enhancement. Scenario matrix adapted from O'Neill et al., 2016. Artwork of ocean alkalinisation is by Rita Even.*

A unique feature of FOCI is the ability to selectively enhance the resolution of a particular geographical location. It is in the form of a two-way coupled nest which increases the horizontal resolution from 1/2° to 1/10° in the region of choice. In previous work, a high-resolution nest has been created for North-Atlantic waters. In this geographically relevant area for European policies, small-scale ocean components (like eddies) being resolved adds additional valuable details but also uncertainties within the carbon cycle feedback mechanism. Possible amplification feedbacks will be investigated by running both the standard FOCI configuration and the high-resolution nest with prescribed emissions for SSP1-2.6 and SSP3-7.0. These runs will also be useful for modelling groups working with regional models of the Labrador sea where deep convection occurs and eddies are essential in the restratification process. Placed in a broader context, simulations of future scenarios with a state-of-the-art model like FOCI will be useful for answering many more research questions about physical processes and mitigation strategies.

WWW

https://retake.cdrmare.de

More Information

[1] IPCC, 2021: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* https://www.ipcc.ch/assessment-report/ar6/

[2] van Vuuren et al.(2014). *A new scenario framework for climate change research: scenario matrix architecture.* doi: https://doi.org/10.1007/s10584-013-0906-1

[3] Renforth and Henderson (2017). *Assessing ocean alkalinity for carbon sequestration* doi: https://doi.org/10.1002/2016RG000533

[4] Matthes et al. (2014). *The Flexible Ocean and Climate Infrastructure version 1 (FOCI1): mean state and variability* doi: https://doi.org/10.5194/gmd-13-2533-2020

[5] Lenton et al. (2018). *Assessing carbon dioxide removal through global and regional ocean alkalinization under high and low emission pathways* doi:https://doi.org/10.5194/gmd-13-2533-2020

Funding

BMBF / DAM Forschungsmission / CDRmare