# Modelling of blue carbon

**Searching for solutions for Carbon-sequestration in coastal ecosystems. Modelling and Scenarios**

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## In Short

- Develop scenarios where vegetated areas are extended for CDR purposes.
- Develop parameterizations of CVE that can be used in the Earth system model.
- Assess CDR and climate mitigation potential of enhancing CVE and the role that this mitigation can play in different climate change scenarios.
- Assess regional- and global-scale side- and cross-boundary effects of CVE sink enhancement efforts, including impacts on pelagic biogeochemistry.

After many studies, it is obvious that anthropogenic carbon-dioxide emissions have caused massive changes in the global climate. One of the goals of the COP21 Paris agreement was to limit global warming well below 2, preferably to 1.5 degrees Celsius, above preindustrial levels. To reach this goal, such approaches were approved as using renewable energy sources, decreasing deforestation, and reducing industrial and agricultural CO2 emissions. However, the national contributions to reducing greenhouse emissions are not expected to be sufficient to reach the goals of the Paris Agreement. Hence, methods for carbon-dioxide removal (CDR) are widely considered and studied in modern research.

One of the CDR approaches is related to coastal vegetated ecosystems (CVEs). Per unit area, CVEs fix and store massive amounts of carbon. While they have been increasingly recognized for their important role in the global carbon cycle under the term 'blue carbon', their integrity and extent have been compromised by numerous human activities. CVEs continue to be lost in many areas around the world with annual losses of several percent. The potential of CVEs to decrease climate change with CDRs depends on how these systems can be maintained and expanded in different climate conditions.

One of the ways to study the influence of CVEs on climate change mitigation and CDR is to perform simulations with Earth system models (ESM). However, ESMs do not support CVE simulation because they occupy relatively small areas and cannot be dynamically modelled due to ESM resolution limitations. Therefore, the global carbon cycle, simulated by them, is not influenced by CVEs as well as the potential contribution of CVEs to CDR is not determined.
In this research, the Flexible Ocean and Climate Infrastructure (FOCI), which has been developed in GEOMAR, is used to provide a global-scale understanding of historical and current carbon sequestration and future potentials in different CVEs expansion and climate change scenarios. FOCI is a state-of-the-art $0.5^\circ$ resolution ESM [2]. FOCI has biogeochemical parts: The TRAcer Calibrated cYcles and Model of Oceanic Pelagic Stoichiometry (TRACY-MOPS) [1]. We will implement CVE parametrization on FOCI within the TRACY-MOPS compartment.

To develop new CVE parametrization, we will use the information on the historical and current spatial extent and carbon storage of different vegetation ecosystems, e.g. mangroves, seagrasses, salt marshes and macroalgae to force the model to relate to the present during spin-up and historical simulation to study the future expansion of CO2 removal CVEs. This data will be retrieved from the literature and project partners (sea4society). This parametrization will be tested by scenarios within the common guidelines for modelling and documentation which were set by the Coupled Model Intercomparison Project phase 6 (CMIP6). A matrix presenting a combination of socioeconomic develop-

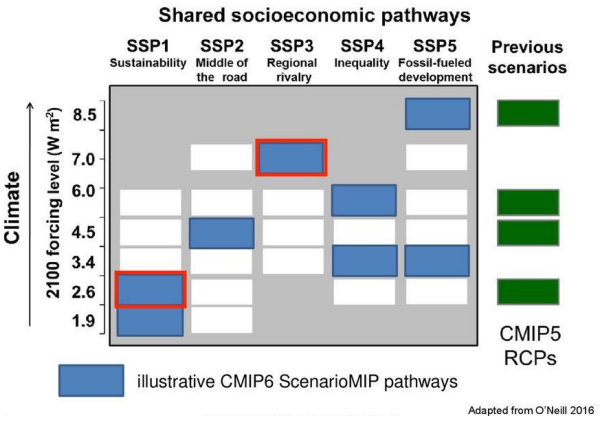


***Figure 1:** SSP-RCP scenario matrix. Scenarios used in FOCI are outlined in the red boxes. The image is adapted from O'Neill et al., 2016 [3]*

ment pathway (SSP) and climate outcome based on a particular forcing pathway (representative concentration pathways, or RCP) was provided by the Scenario Model Intercomparison Project 2016 [3] under CMIP6. In Figure 1, two outlined by red boxes scenarios with low (SSP1-2.6) and high (SSP3-7.0) anthropogenic climate forcings will be used to test CVE parametrization. Within the SSP forcing, we will develop two scenarios of CVE expansion. The idealized CVE expansion scenarios will include both an estimated maximum CDR potential scenario and one that accounts for other considerations such as sustainability and socio-economics.
This research contributes to the basis for evaluating the societal and ecological potential for ecosystem design through extending vegetated areas along the North Sea, Baltic Sea, tropical Atlantic and tropical Indo-pacific regions and delivers decision support to policy- and decision-makers. Fostering collaboration and exchange with research partners in Germany and internationally will strengthen both the efficacy and the international visibility of German Marine Sciences.

## WWW

https://sea4society.cdrmare.de/en/

## More Information

[1] C.T. Chien et al., *Geoscientific Model Development Discussions*, 1 - 58 (2022). doi: 10.5194/gmd-2021-361

[2] K. Matthes et al., *Geoscientific Model Development* **13**, 2533 - 2568 (2020). doi: 10.5194/gmd-13-2533-2020

[3] B.C. O'Neill et al., *Geoscientific Model Development* **9**, 3461 - 3482 (2016). doi:10.5194/gmd-9-3461-2016

## Project Partners

Mangrove Ecology group at University of Bremen; Earth Observation Modelling group, Marine Geophysics and Hydroacoustics group at University of Kiel

## Funding

DFG, BMBF, DAM Forschungsmission, CDRmare

## DFG Subject Area

313-02