Project: **1241**
Project title: **Carbon Dioxide Removal**
Principal investigator: **Julia Pongratz**
Report period: **2021-11-01 to 2022-10-31**

During the allocation period in 2022, the resources could not be fully utilized due to the delayed operational readiness of Levante and, hence, the delayed adaption of MPI-ESM to the new environment. Manpower could not be allocated as planned due to the pandemic which delayed the hiring process. This involved a period during which the newly hired staff members needed to familiarize themselves with MPI-ESM and DKRZ services and platforms.

CDRSynTra: In the first phase of the project, the main effort has been focused on implementing an Ocean Alkalinity Enhancement (OAE) module into MPI-ESM. The module was further modified to allow for spatiotemporally explicit applications of alkalinity (Fig.1).

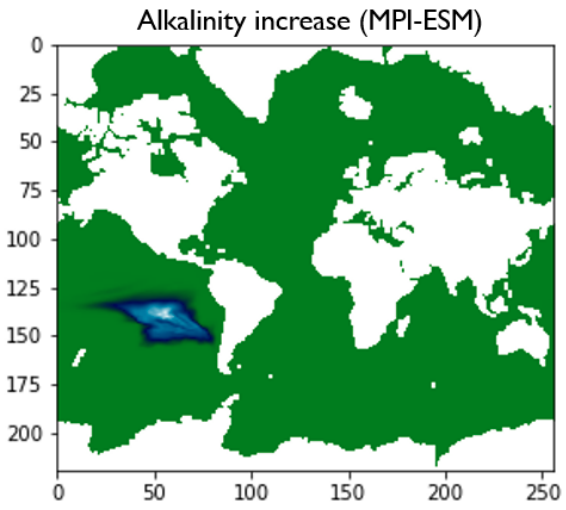

Figure 1: Alkalinity is applied over the Pacific Ocean.

In the project's second phase, multiple short model integrations of the fully-coupled MPI-ESM (2 to 10 years) have been performed to benchmark and validate the OAE module and compare results with CMIP6 MPI-ESM data.

In the remainder of the fourth quarter of 2022, the focus will be on developing a land-use scenario with a focus on CDR. This scenario shall be run with the fully-coupled MPI-ESM in 2023. We will also contribute to the global Carbon Dioxide Removal Model Intercomparison Project (Keller et al.2018), by simulating global Ocean Alkalinity Enhancement scenarios.

STEPSEC: In the first phase of the project, the herbaceous biomass plantation (HBP) branch of MPI-ESM (Mayer, 2015) was reintegrated into the recent MPI-ESM-landveg release branch. A switch was introduced to allow reading transitions between HBPs and crops from an external file. In that way, HBP transitions can be adapted from the land use harmonization project (LUH2) (Hurtt et al., 2020).

In a second phase, JSBACH including the HBP extension was tested in offline model integrations (mostly 10-30 years simulations). The necessary climate forcing for the historical period and future projections (ssp126, ssp370) stemmed from CMIP6 or ISIMIP (https://data.isimip.org/search/tree/ISIMIP3b/InputData/climate/). Several land use scenarios and patterns were tested: constant land use for 2015, LUH2 derived ssp126 and ssp370 using maps or transitions. The model was integrated without HBPs, with HBPs placed on abandoned agricultural areas as in Mayer (2015), and with a fixed fraction of HBPs based on the LUH2 data.

Results were compared to those of the Land Use Model Intercomparison Project (LUMIP) (Lawrence et al., 2016) (Fig. 2).

Accordingly, the first tests were performed with the fully coupled MPI-ESM (10-30 years).

Until the end of the quarter, the first simulations with JSBACH standalone and idealized land use (30% of forests and 30% of bioenergy plants, respectively, prescribed in each grid cell) forced by

MPI-ESM HR climate for ssp126 and ssp370 based on ISIMIP (bias-corrected and downscaled; https://data.isimip.org/search/tree/ISIMIP3b/InputData/climate/) will be run over the full simulation period (2015 to 2100) and analyzed. This includes spinups with JSBACH standalone forced by historic MPI-ESM HR climate based on ISIMIP.

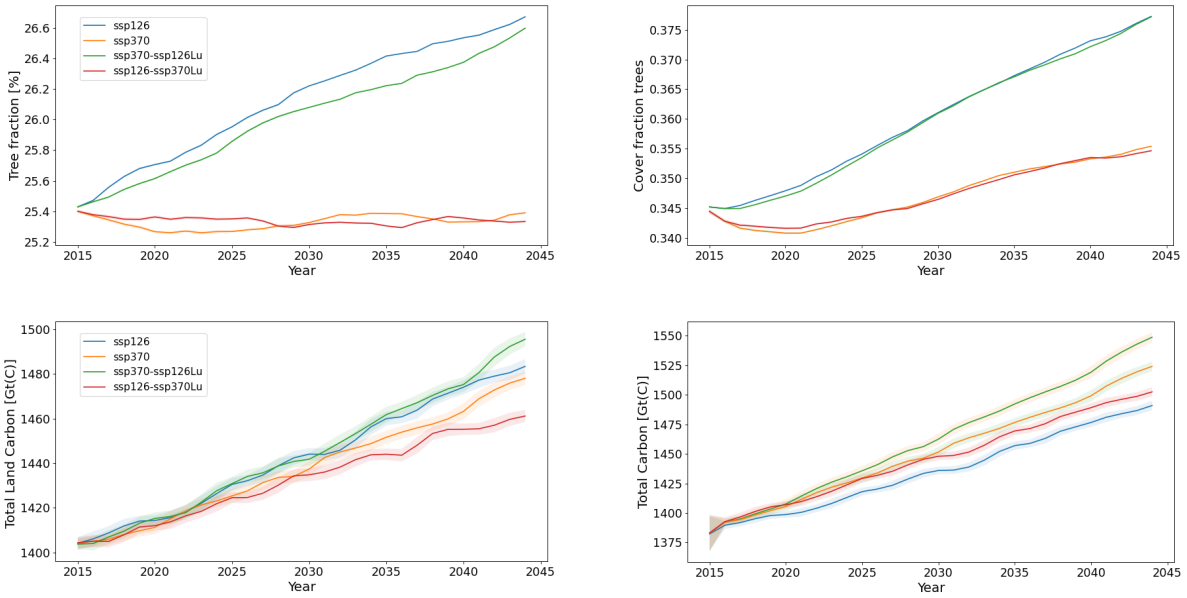

Figure 2: Total land carbon (GtC) and tree fraction from LUMIP (fully coupled run, the multi-model ensemble mean, left) and from JSBACH standalone simulations (right).