Project: 1103
Project title: AWI-CM with carbon cycle
Project lead: Judith Hauck (AWI)
Allocation period: 01.01.2020 – 31.12.2020

Progress in 2020

This project is about an interactive carbon cycle with CO_2 exchange between ocean and atmosphere. For this aim, we are coupling the ocean biogeochemistry and ecosystem model REcoM2, developed at AWI, to the AWI Climate Model AWI-CM to allow for an interactive carbon cycle with CO_2 exchange between ocean and atmosphere, within the framework of the Helmholtz Young Investigator Group 'Marine carbon and ecosystem feedbacks in the Earth System' (MarESys).

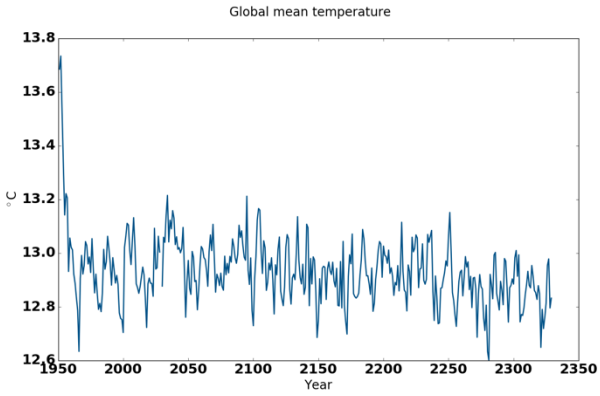

Figure 1 Time series of the global mean near surface (2m) air temperature (SAT) as annual mean values for the spin-up simulation (1950-2329)

We have by now a 400 year spin-up simulation (from ba1103 and ab1095 resources), which we have evaluated and found to be reasonable in atmospheric temperature (Figure 1), ocean and ice physical parameters (e.g. ocean temperature and salinity, ice area and thickness – Figure 2, transport: Drake Passage transport ca. 130 Sv, and ocean biogeochemistry (CO_2 flux – Figure 3, primary production (ca. 30 PgC/yr), carbon and nutrient distributions). We plan to branch off a set of simulations after reaching

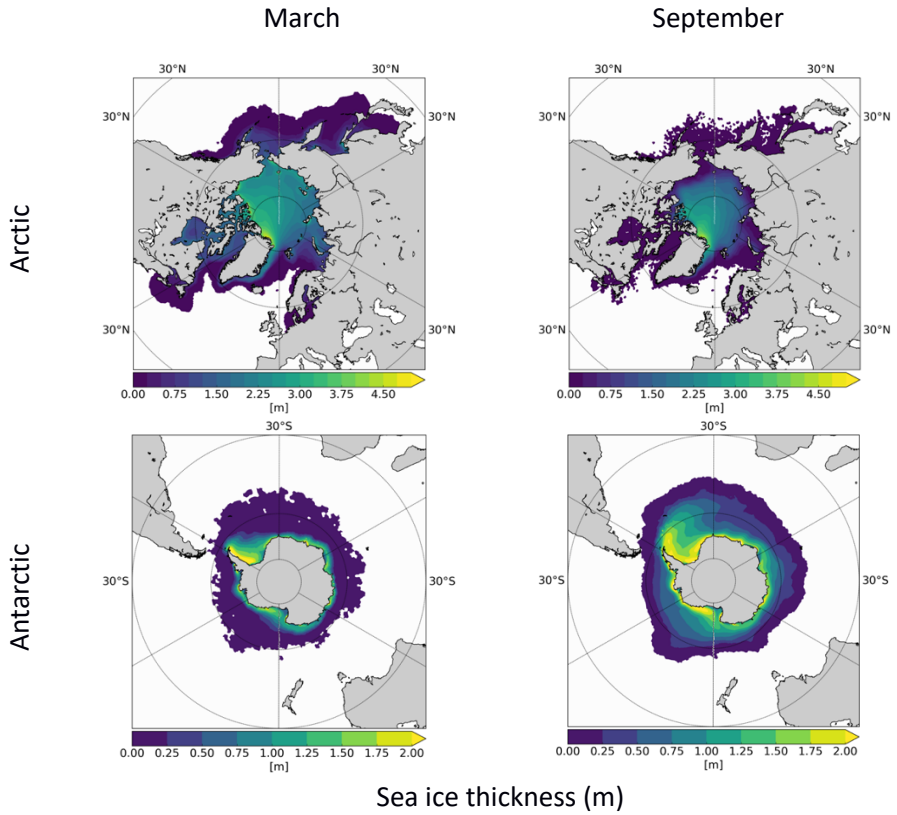

Figure 2 Sea-ice thickness in March and September, averaged over years 100-150 of the spin-up simulation. (top): Arctic, (bottom): Antarctic. (Left) March. (Right) September

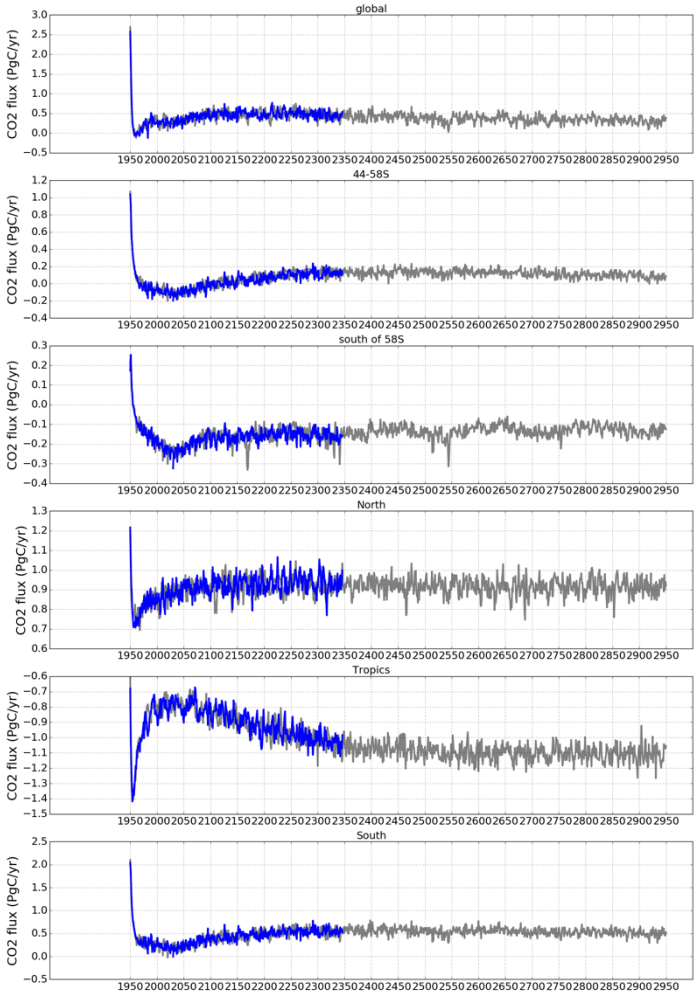

Figure 3 Time series of the air-sea CO_2 flux (PgC/yr). Positive numbers: flux into the ocean. Blue: updated 400 year spin-up. Grey: Previous 1000-year spin-up used to analyse drift. Subpanels show the global, Southern Ocean (44-58S, south of 58S) and large scale regions (North, north of 30N; Tropics, 30S-30N; South, south of 30S) as indicated in the panels.

600 years of spin-up before the end of the year. We consider 600 years of spin-up sufficient after analysis of an earlier 1000 year spin-up (see also Figure 3) which, however, had issues with a too cold atmosphere. Earlier AWI-CM simulations (Semmler et al., 2020) were performed with a 500 year spin-up. We monitor the performance of the fully coupled system of AWI-CM-REcoM2 constantly. The model spinup should be completed in the next two months.

In 2020, we performed tuning experiments to the reduce the bias in the air-sea CO_2 flux. These experiments resulted in reducing the Gent-McWilliams parameter to almost half of its previous value. This resulted in steeper isopycnals, hence stronger Antarctic Circumpolar Current (ACC) and associated reduction in CO_2 uptake in the Southern Ocean. We expanded our code with the addition of oxygen as a new tracer. After solving technical challenges and ambiguities in model setup we have started our spinup simulation forced by constant atmospheric CO_2 concentration of 278 ppm.

An inspection of the time series of globally averaged near surface air temperature revealed slight negative drift in the system (Figure 1). The magnitude of global mean temperature is consistent with the results of control runs performed by other groups at AWI. After retuning the Gent-McWilliams parameter, the air-sea CO_2 flux in the spin-up (Figure 3) equilibrates at roughly +0.4 PgC/yr (ocean uptake), in the same range as other Earth System Models (e.g. CNRM -0.9 PgC/yr, IPSL +0.35 PgC/yr) and outgassing between -0.1 and -0.2 PgC/yr in the Southern Ocean south of 58°S.

References

Jones, et al. (2016), doi:10.5194/gmd-9-2853-2016.
Semmler, et al. (2020). Doi:10.1029/2019MS002009