Project: **1103**

Project title: **AWI-CM with carbon cycle**

Principal investigator: **Judith Hauck**

Report period: **2024-11-01 to 2025-10-31**

Maximum of 2 pages including figures. 9 pt minimum font size.

Summary

AWI-ESM-1-REcoM simulations were conducted as requested for the work packages SOFIA and Nobio. For both work packages, newly added ensemble members aid to investigate the effect of internal climate variability on modeled climate-carbon feedbacks. This is crucial as in emissions-driven coupled climate model simulations, climate change effects as e.g. an increased Antarctic freshwater runoff (SOFIA work package based on Swart et al., 2023; now registered community MIP for CMIP7: https://wcrp-cmip.org/mips/#registered-mips), or a weakened biological carbon pump (Nobio work package; revisit e.g. Maier-Reimer et al., 1996) affect both physical and biogeochemical properties. Previously, these interactions were usually excluded in scientific modeling studies as concentration-driven model setups were, and still are, state-of-the-art.

Fig. 1 shows the effect of increased Antarctic freshwater on the carbon cycle in the Southern Ocean as modeled with AWI-ESM-1-REcoM. First results of a multi-model comparison suggest contrasting model responses to freshwater forcing, indicating substantial differences in the modeled Southern Ocean water mass distribution and its effect on the carbon cycle (Jouet et al., in preparation; contribution to SOFIAMIP, Swart et al., 2023).

Ensemble sensitivity experiments on potential changes of the biological carbon pump in a changing climate show robust responses to increased/decreased sinking of particulate matter and carbon and nitrogen remineralization rates of detritus (Fig. 2; Hauck et al., in preparation).

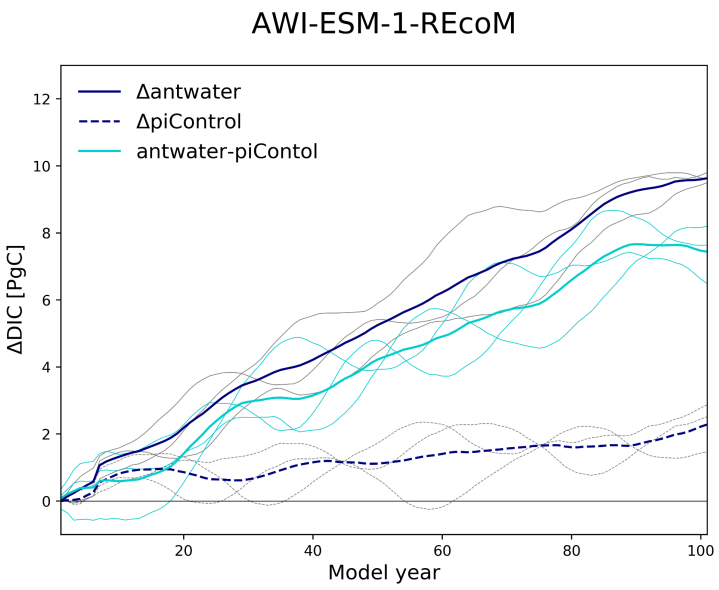

Fig. 1: DIC change (dark blue) and anomaly (antwater minus piControl; cyan) integrated over the Southern Ocean as modeled with AWI-ESM-1-REcoM following the SOFIAMIP protocol (Swart et al., 2023). Thick/thin lines show ensemble mean/members (Jouet et al., in preparation).

In addition, AWI-ESM-1-REcoM model data was used in carbon-climate feedback studies to investigate the effect of Ocean Alkalinity Enhancement (Seifert et al., 2025; Nagwekar et al., 2024; Nagwekar et al., 2025, conditionally accepted). AWI-ESM-3-REcoM model development for CMIP7 and further upcoming research activities took place as requested and is ongoing.

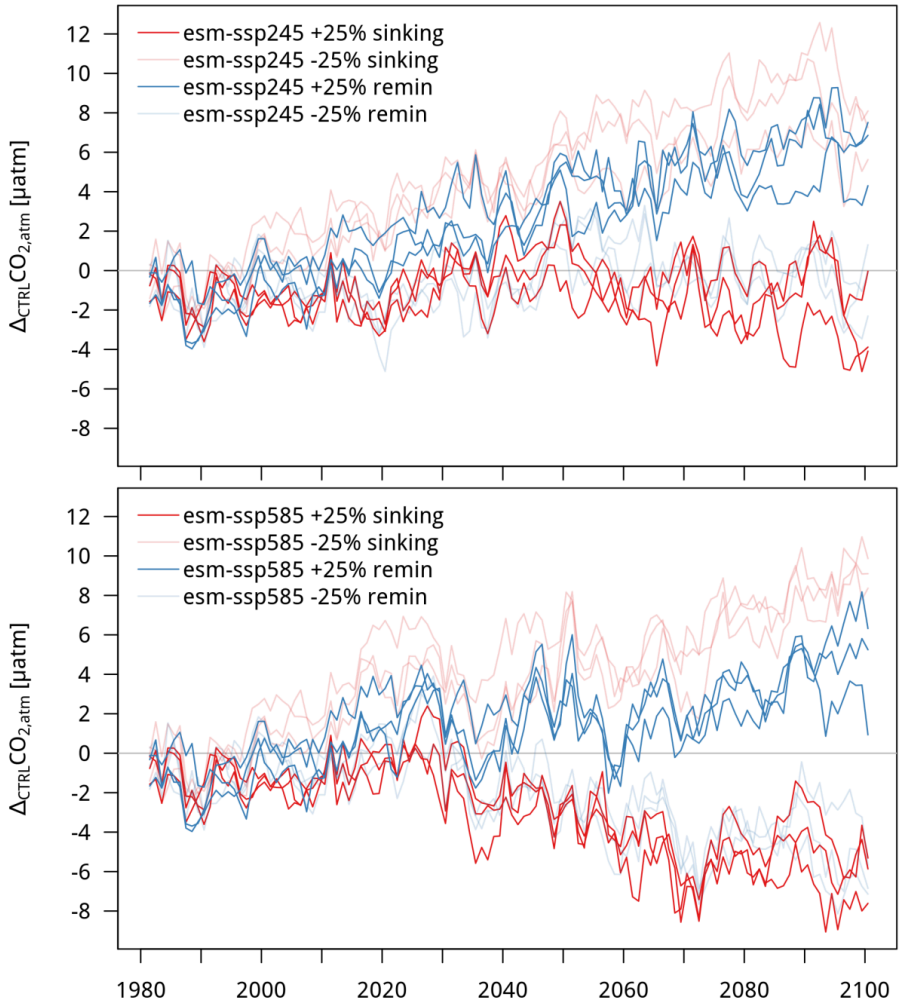

Fig. 2: Globally and annually averaged atmospheric CO_2 concentration response in emissions-driven sensitivity experiments on potential changes of the sinking velocity of particulate matter (red) and the remineralization rate (blue) with respect to default esm-SSP245 (top) and esm-SSP585 (bottom) as modeled with AWI-ESM-1-REcoM (lines of same color show ensemble members; Hauck et al., in preparation).

References

Hauck et al., in preparation: The impact of biological activity on the ocean carbon sink.
Jouet et al., in preparation: Impact of additional freshwater around Antarctica on the Southern Ocean carbon cycle: an inter-model comparison.
Maier-Reimer et al., 1996: https://doi.org/10.1007/s003820050138
Nagwekar et al., 2024: https://doi.org/10.1029/2023EF004213
Nagwekar et al., 2025, conditionally accepted (Environmental Research Letters): Alkalinity Enhancement in Subduction Regions and the Global Ocean: Efficiency, Earth System Feedbacks, and Scenario Sensitivity.
Seifert et al., 2025: https://doi.org/10.5194/bg-22-5897-2025
Swart et al., 2023: https://doi.org/10.5194/gmd-16-7289-2023