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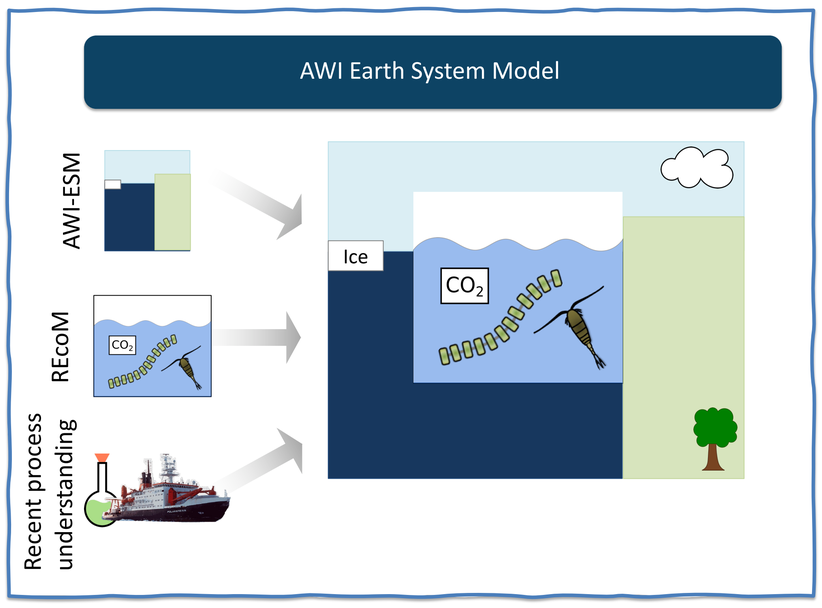
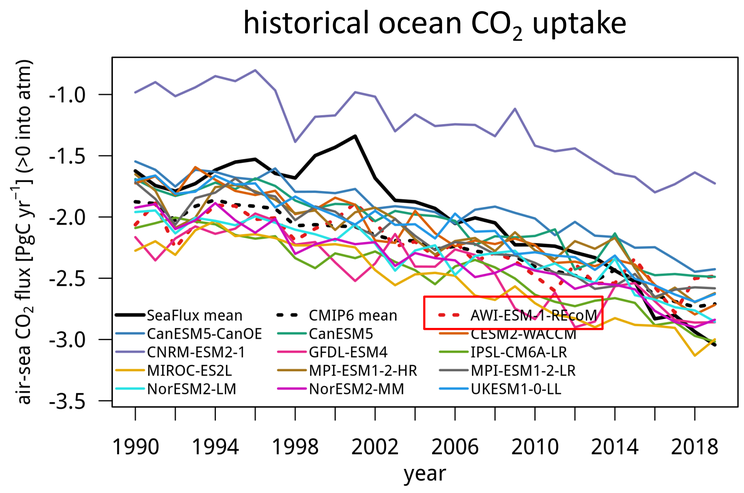
Investigating **marine carbon and ecosystem feedbacks** with the **AWI Earth System Model**

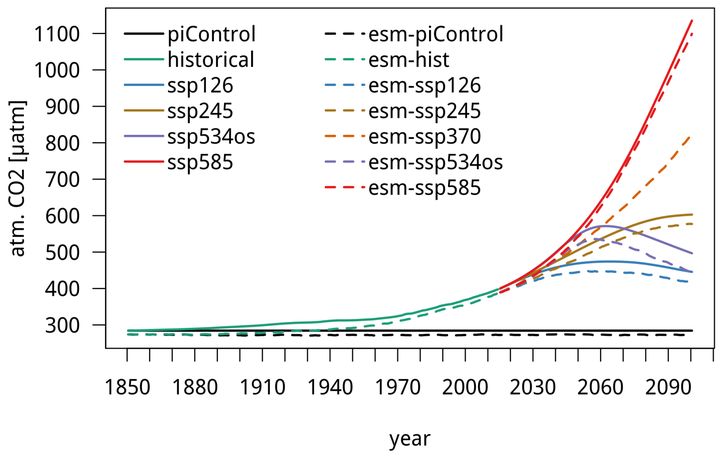
Earth System Models

- … are routinely used for future scenario projections of the carbon cycle.
- Ocean anthropogenic carbon uptake is to first a order physical-chemical process
- BUT changes in biological productivity may affect the ocean carbon cycle and ecosystems in the future under on-going climate change
- Relevant biological processes not sufficiently represented
- We tackle the representation of phyto- and zooplankton in the AWI-ESM



AWI-ESM-REcoM CMIP-type simulations available!





→ Emission-driven simulations result in lower atmospheric CO_2 (compared to concentration-driven) due to carbon-climate feedbacks

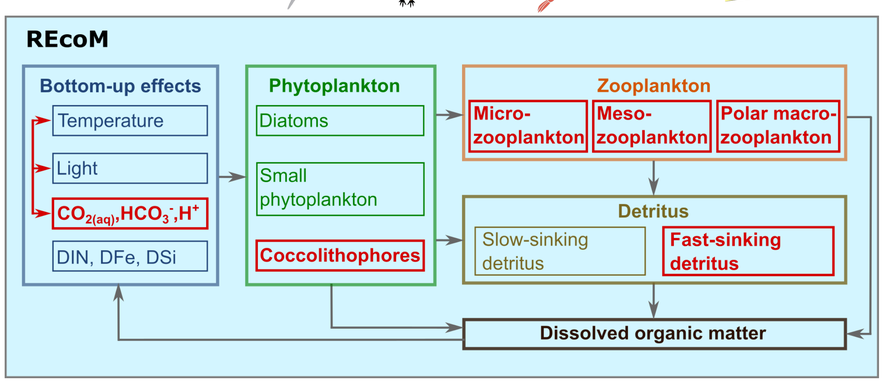
Danek & Hauck (in review)
Danek et al. in prep.

Analysis of historical air-sea CO_2 flux variability and discrepancies with data

REcoM developments

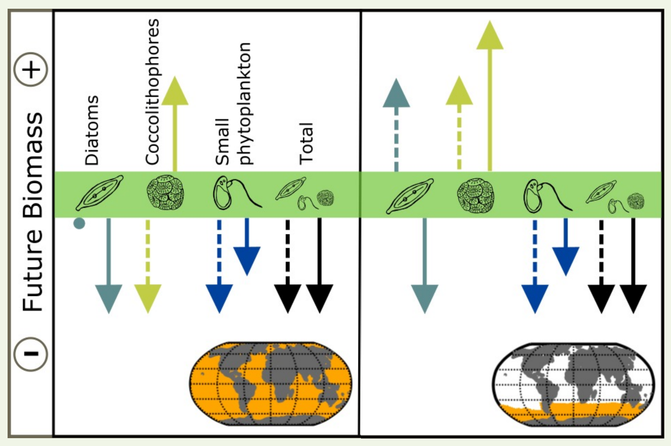
Regulated Ecosystem Model

NEXT: Quantifying effects on CO_2 fluxes



Incorporating the response of **phyto-plankton** growth to interactive effects of simultaneous changes in temperature, light and CO_2

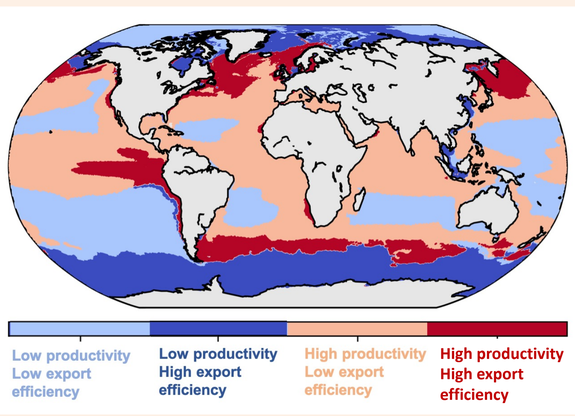
Going from one to three **zooplankton** groups and from one to two detritus groups



→ Global total bio-mass change until 2100 nearly the same (5 vs 6%)

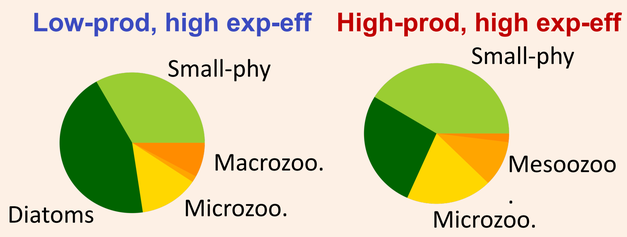
→ Important differences on group and regional level

Seifert et al., 2020, 2022, 2023



→ Increases net primary production (NPP) through nutrient recycling & thus proves the role of zooplankton for sustaining NPP

→ Plankton composition defines high export efficiency regions



Karakus et al.2021, 2022, in prep.

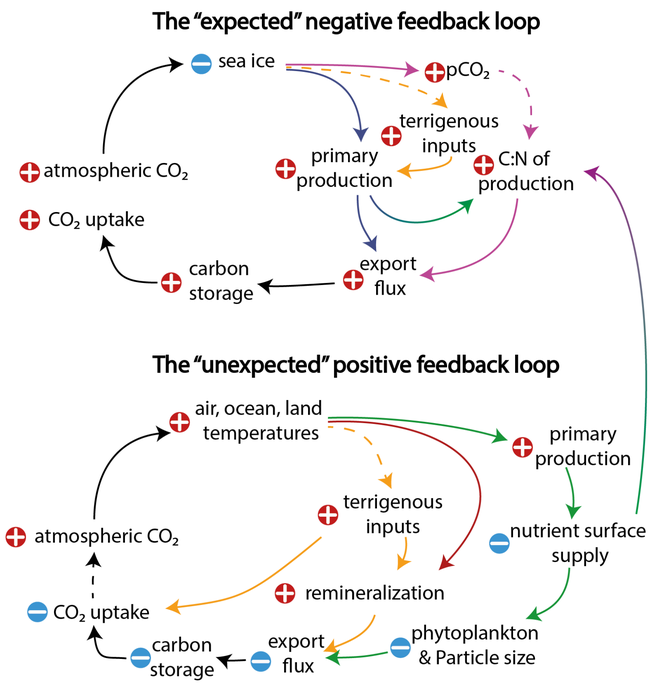
Weakening of the biological carbon pump in the future Arctic Ocean

High-resolution (4.5 km) future simulations (forced ocean model), including carbon and nutrient input from rivers/coastal erosion

→ Anticipated rise in primary production found (negative feedback loop)

→ BUT 40% reduction in the efficiency of the Arctic's biological carbon pump by 2100, (positive feedback loop)

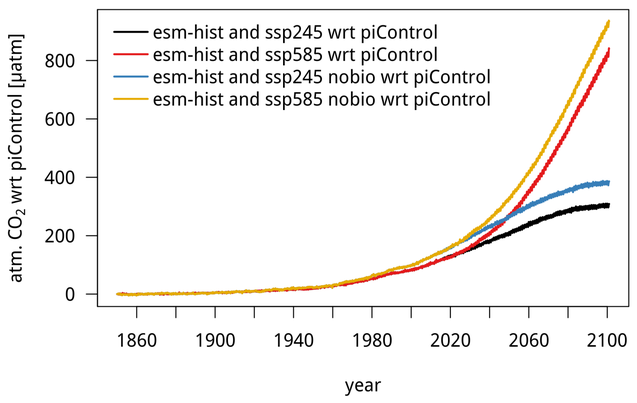
→ Terrigenous inputs also drive intense coastal CO_2 outgassing, reducing the Arctic Ocean's carbon sink by at least 10%



Oziel et al. (in review)

Role of ocean biology for anthroponic CO_2 uptake in emission-driven AWI-ESM

Commonly used numbers from very early ocean bgc models → Testing this with modern ESM

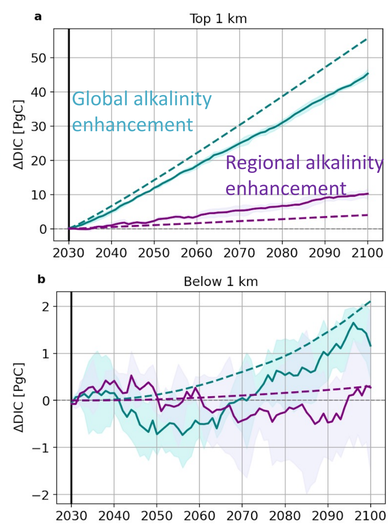


→ Difference of about 100 µatm in atm CO_2, scenario dependent (first estimate) plus about 100 µatm difference between preindustrial states (lower than previous estimates)

Hauck et al., in prep.

Marine carbon dioxide removal via alkalinity enhancement

→ Climate feedbacks/ variability may substantially perturb/reduce the expected ocean carbon accumulation → MRV challenge



Dashed line: carbon storage expected from ocean model
Solid line: carbon storage in emission-driven ESM
Difference: carbon-climate feedbacks

→ can even lead to reduced carbon storage at depth

Nagwekar et al. (accepted); Nagwekar et al., in prep.

References
Karakus et al. (2021), doi: 10.1029/2021JC017315; Karakus et al. (2022), doi:10.1029/2022JG006798; Seifert et al. (2020), doi:10.1111/gcb.15341; Oziel et al. (in review), preprint doi:https://doi.org/10.21203/rs.3.rs-3867146/v1; Seifert et al., (2022), doi:10.1525/elementa.2021.00104; Seifert et al., (2023), doi:10.1111/gcb.16799

Funding
This work was funded by the Initiative and Networking Fund of the Helmholtz Association (Helmholtz Young Investigator Group Marine Carbon and Ecosystem Feedbacks in the Earth System, MarESys; grant no. VH-NG-1301), by the ERC-2022-STG OceanPeak (Grant 101077209) and by the European Union's Horizon Europe research and innovation program under Grant 101083922 (OceanICU Improving Carbon Understanding), the European Union's Horizon 2020 research and innovation programme under grant agreement No 820989 (project COMFORT) and by the Federal Ministry of Education and Research of Germany (BMBF) in the framework of RETAKE, one of the six research consortia of the German Marine Research Alliance (DAM) research mission "Marine carbon sinks in decarbonization pathways" (CDRmare).

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