Impact of temperature dependent remineralisation in a warming ocean on the global carbon cycle (CARBOCHANGE – BMBF Project 670)

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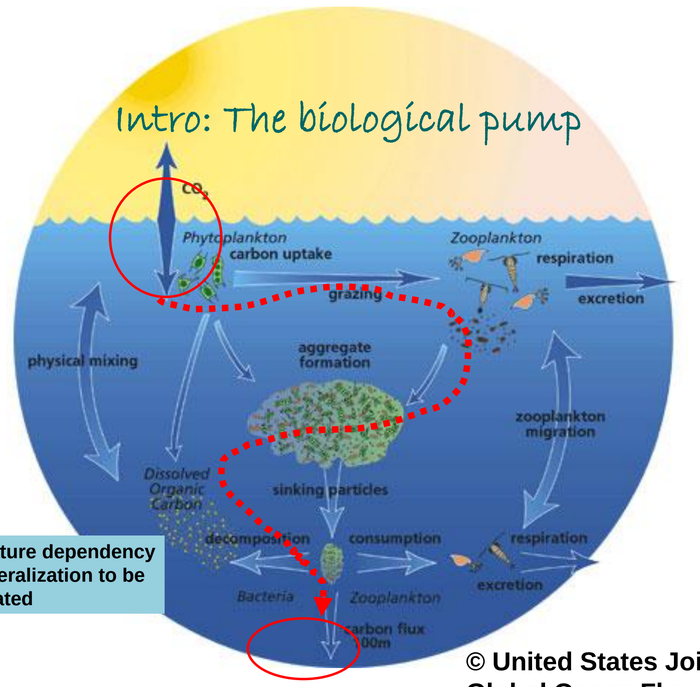
Motivation

The biological pump exports carbon from the atmosphere to the subsurface ocean (see right)

How will this change in a warming ocean?

- Observations demonstrate temperature dependency of remineralization of organic matter (Bendtsen et al., submitted) $Q_{10} \approx 2.5$
- → rise in temperature (due to climate change) will increase remineralisation rate
- but: Increased remineralisation will increase near surface nutrient levels with a potential for a negative feedback by increased production
- what is the net effect of increased remineralization on the carbon budget and air-sea exchange?

Intro: The biological pump



Temperature dependency of remineralization to be Investigated

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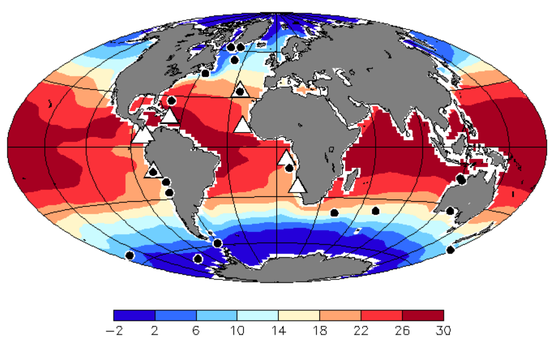
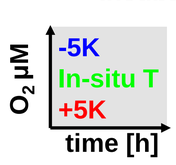
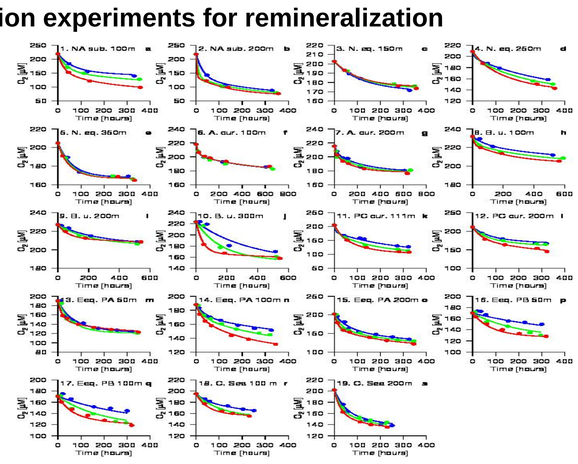
The experimental basis



Incubation experiments for remineralization



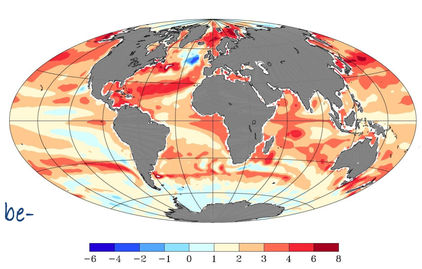


Water samples were taken at locations indicated by bullets (POC) and triangles (DOC) around the world (see map). Incubation experiments were performed at local in-situ temperature and +/- 5 ºC. Oxygen consumption was measured as indicator of remineralization and a fit was made in order to determine Q_{10} rates (lines).

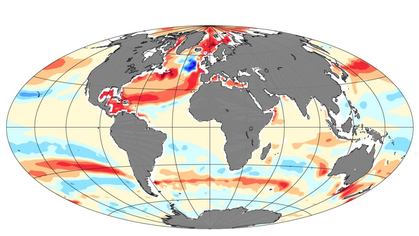
Projected temperature changes (CMIP5) and experiment setup

0-200m

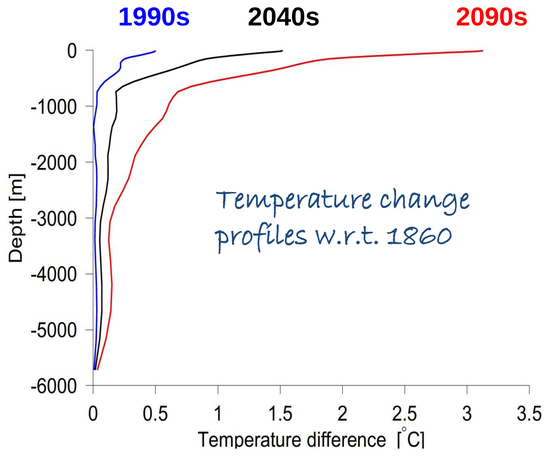
Temperature difference between 2091-2100 and 1860-1869 (RCP8.5 – HIST)



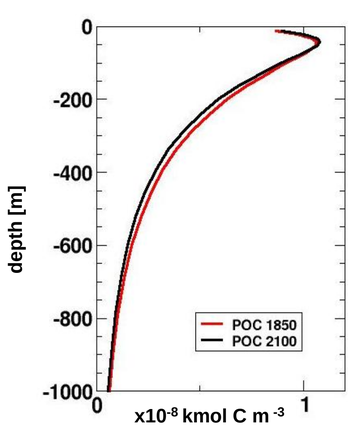
200-400m



CMIP5 HIST 1990s **RCP85 2040s** **RCP85 2090s**



Change in remineralization profile of POC

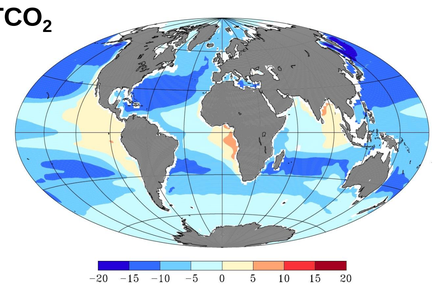


Experiment set-up

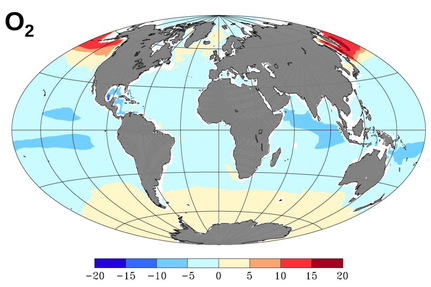
Basis: CMIP5 piControl (MPI-ESM-LR)
identical experiment set up but:
Temperature perturbation field from RCP85 2090-2100 used for remineralization only (!)
with a Q_{10} of 2 (POC and DOC)
Integrated for 100 years
Differences with identical years from piControl

Impact on biogeochemistry

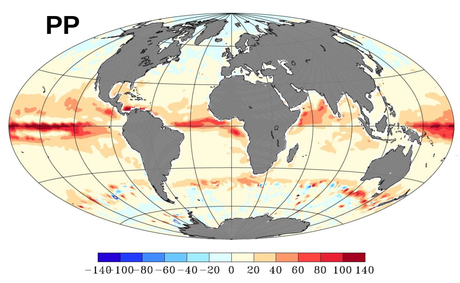
TCO_2



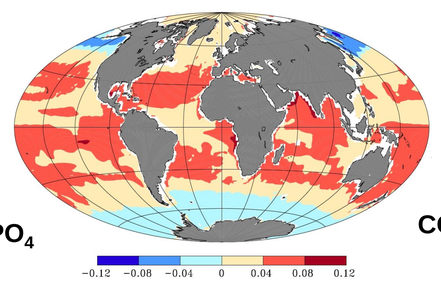
O_2



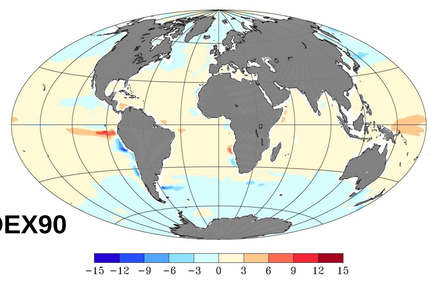
PP



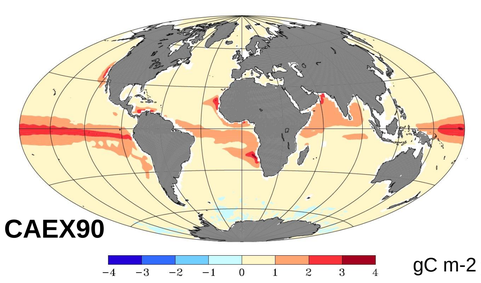
PO_4



COEX90



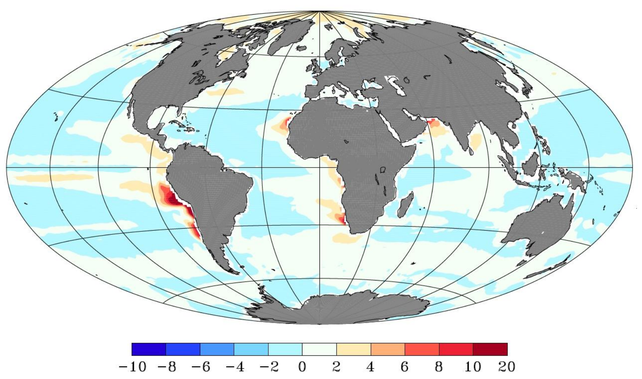
CAEX90



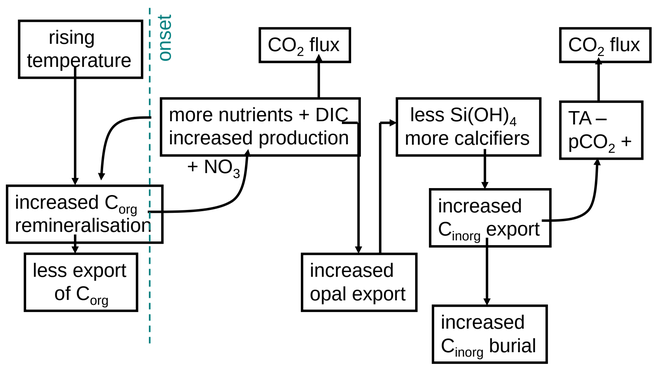
gC m-2 yr-1

Change in global inventories by year 100	[Pg C]	Accumulated change in ocean boundary fluxes by year 100	[Pg C]
TCO_2	-27.95	Air-sea CO_2 exchange	18.66
Detritus	-0.06	Sedimentation of $CaCO_3$	10.22
$CaCO_3$	0.05	Sedimentation of organic carbon	-0.87
Phytoplankton	0.02		
Zooplankton	0.03		
Dissolved organic carbon	0.27		
Total	-27.63		28,01

Impact on pCO_2 [ppm]



Flowchart of processes



- Temperature dependent remineralisation has an impact on carbon budget
- Increase of pCO_2 mainly in regions of high biological production
- Decrease in oligotrophic regions
- Net loss almost 0.3 GtC/a
- Calcite export plays significant role
- Role of alkalinity needs to be further investigated
- Going from sensitivity exp. to absolute T-dependent remineralisation requires tuning/new spinup

Max-Planck-Institut für Meteorologie

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