UNIVERSITÄT BERN

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

Potential of Ocean Alkalinity Enhancement in Climate Stabilization Scenarios at Different Warming Levels

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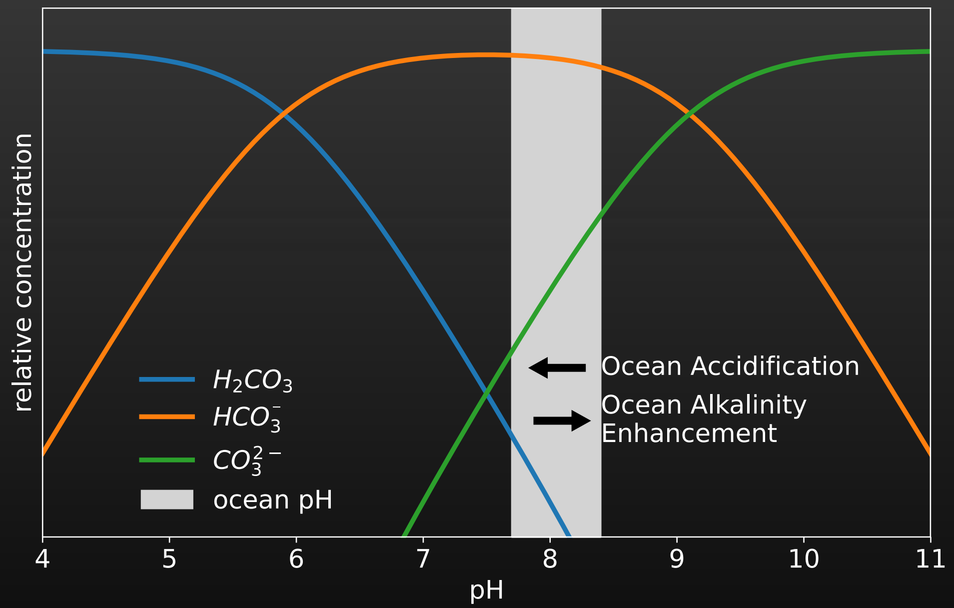
Why Ocean Alkalinity Enhancement?

- Promising marine CDR approach
- Addition of alkaline solutions or minerals to enhance CO_2 uptake potential of the ocean

What are we investigating?

- Efficiency and its dependency on the emission pathway
  - important for carbon accounting and carbon budgets
- Large-scale and long-term climate effects



$$CO_{2(aq)} + H_2O \leftrightarrow H_2CO_3 \leftrightarrow HCO_3^- + H^+ \leftrightarrow CO_3^{2-} + 2H^+$$

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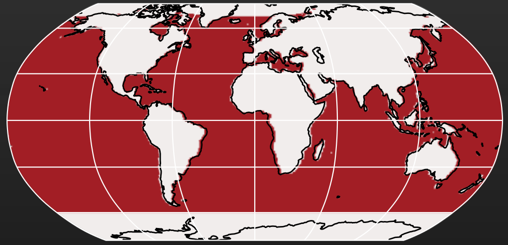
Simulation Setup

- Earth System Model GFDL-ESM2M adaptive emission reduction approach (AERA) for temperature stabilization at 1.5°C, 2.0°C and 3.0°C

- Ocean Alkalinity Enhancement with emissions from AERA runs
- Continuous alkalinity addition of 0.14Pmol per year (CDRMIP-protocol)



- OAE CO_2 concentrations but without OAE for climate feedbacks

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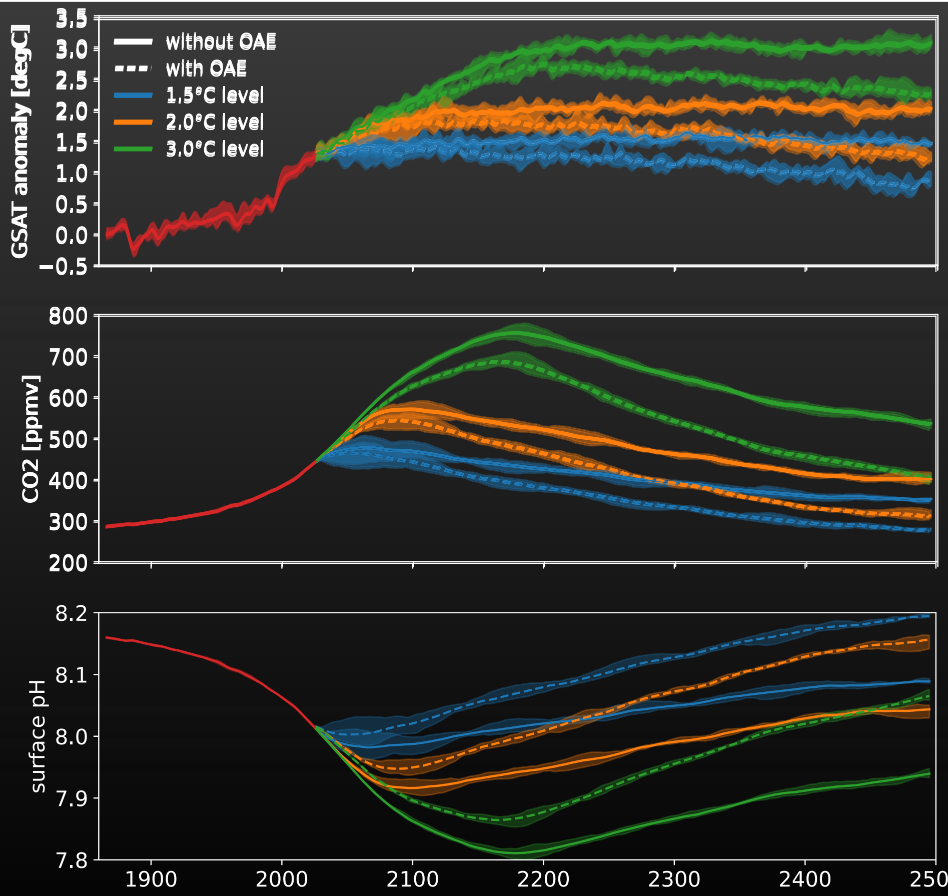
Large Scale Climate Impacts

- Global temperature reduction
- Reduction in atmospheric CO_2
- Increase in surface pH

	1.5°C	2.0°C	3.0°C
GSAT	-0.65°C	-0.75°C	-0.79°C
CO_2	-73ppm	-87ppm	-130ppm
pH	0.10	0.12	0.12



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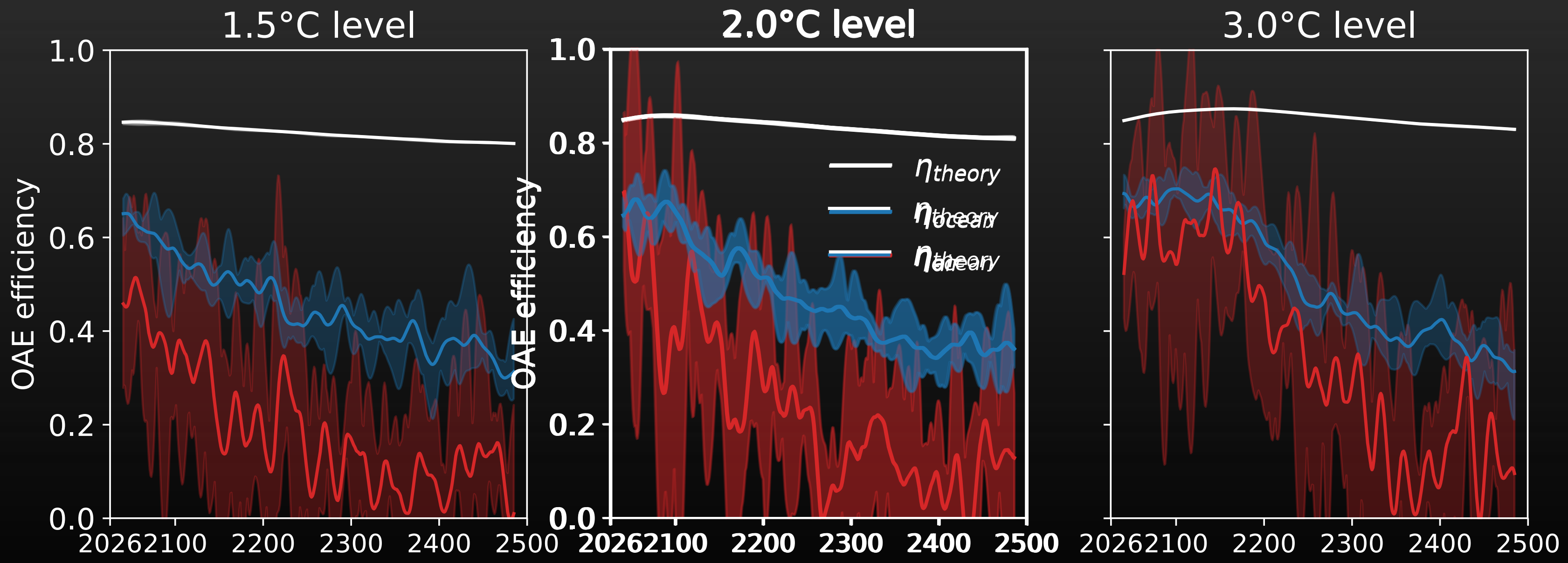
Efficiency

- Additional CO_2 due to alkalinity addition

$$\eta_{theory} = \frac{\partial pCO_2}{\partial ALK} \Big/ \frac{\partial pCO_2}{\partial DIC} \qquad \eta_{ocean} = \frac{\Delta CO_{2\,flux}}{\Delta ALK} \qquad \eta_{air} = \frac{\Delta CO_{2\,air}}{\Delta ALK}$$



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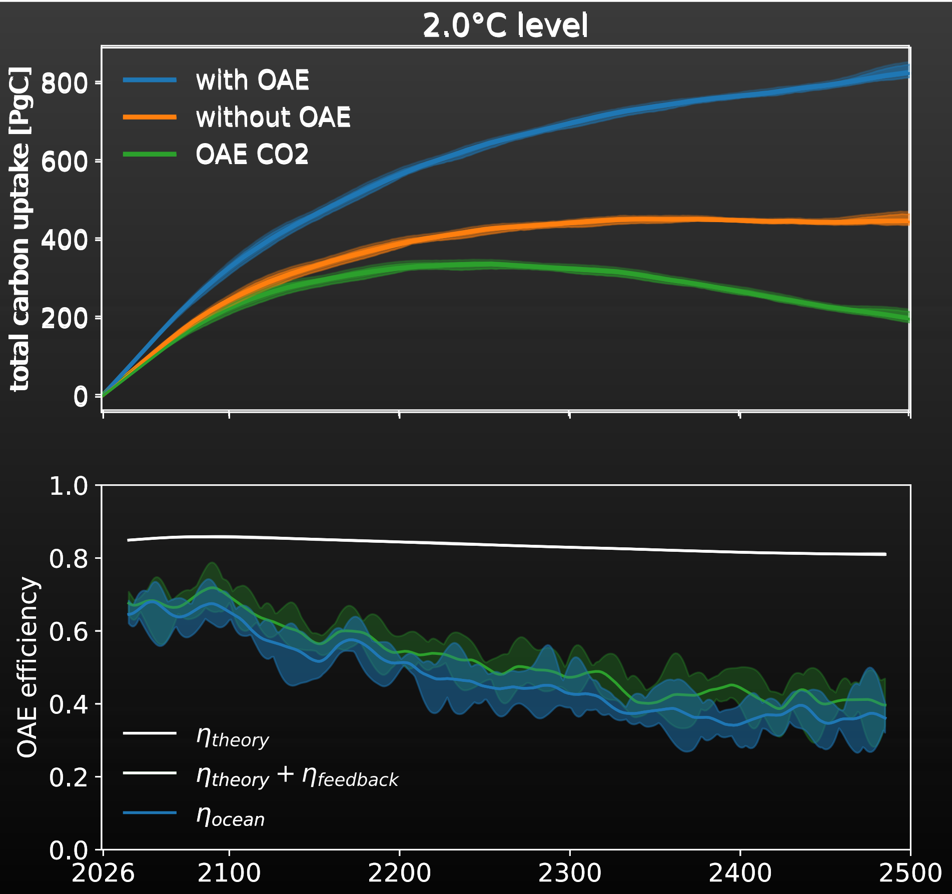
Carbon-Climate-Feedback

- Simulation with fixed CO_2 concentration from OAE simulation
  - calculate feedback effect

$$\eta_{feedback} = \frac{CO_{2\,noCDR} - CO_{2\,base}}{\Delta ALK}$$

- reduces maximum efficiency
  - explains long-term reduction in OAE efficiency



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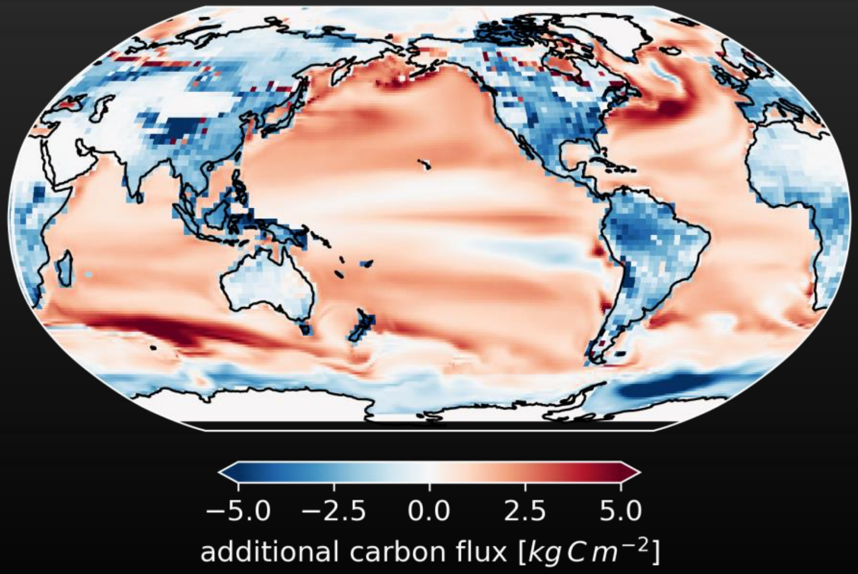
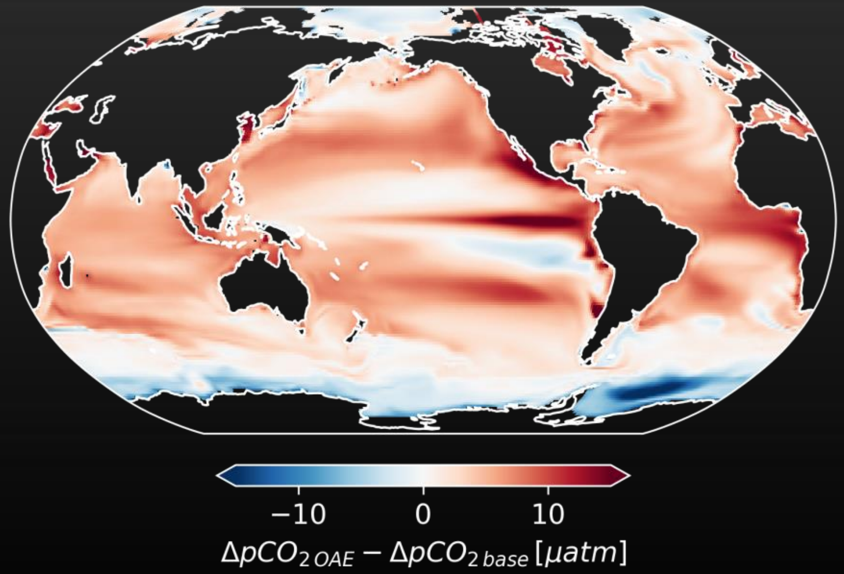
Regional Differences in Carbon Fluxes

- Most regions gain carbon, while some even loose
- pCO_2 difference due to alkalinity addition, but then uptake processes and time scales





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Conclusion

- OAE efficiency depends on emission pathway
- Carbon-climate feedback important
- Regional differences in uptake

- Good understanding of processes in our model allows for more applied questions
  - fastESM together with computing resources

Thanks for the attention

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