An extension of SURFER to study tipping cascades on multiple time scales

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INTRODUCTION

SURFER is a reduced complexity box model for estimating the climate response to anthropogenic CO_2 and aerosols emissions (Martínez Montero et al., 2022). Recently, we extended the model by adding sediments and weathering feedbacks in the carbon cycle submodel, and an additional set of coupled tipping elements.

SURFER is understandable, fast and easy to modify and calibrate. Therefore, it can be used as an emulator and/or as an exploratory tool. Here, we :

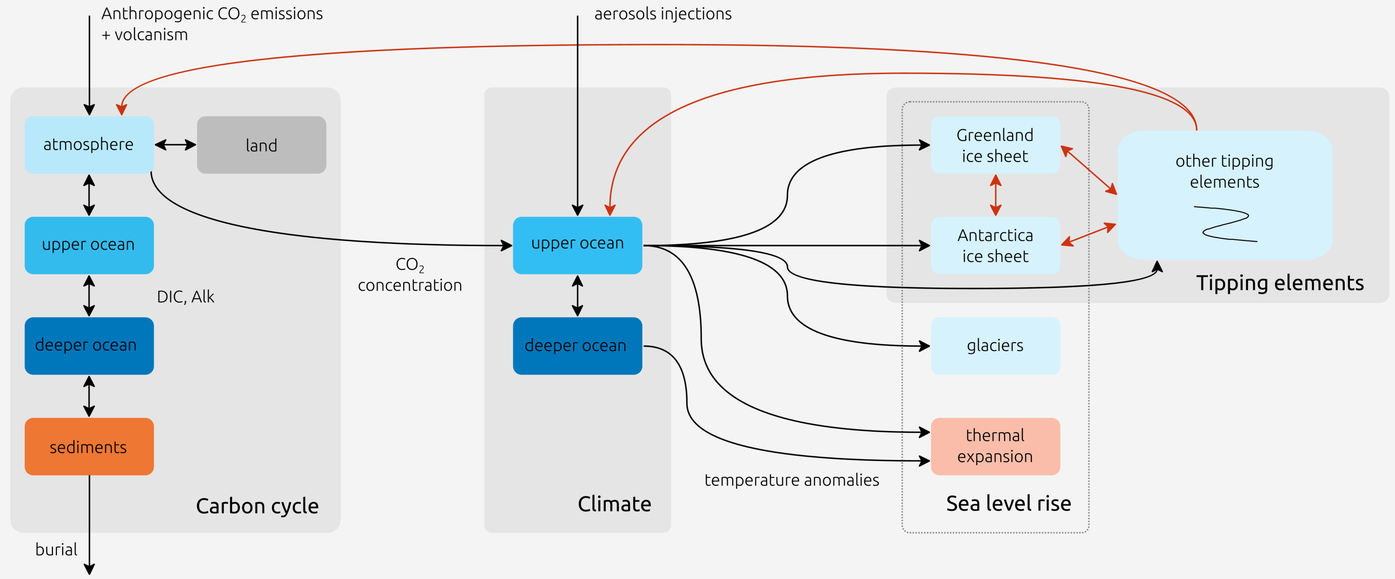
1. show the fate of anthropogenic carbon emissions,
2. tune the ice sheets to 3D models and perform long-term sea level rise experiments,
3. study tipping cascades and their causal structure.

SURFER is **UNDERSTANDABLE** and transparent.

SURFER is **FLEXIBLE**, easy to adapt and easy to calibrate.

SURFER is **FAST**. Runs of ~100 kyrs typically take less than a second on a labtop.

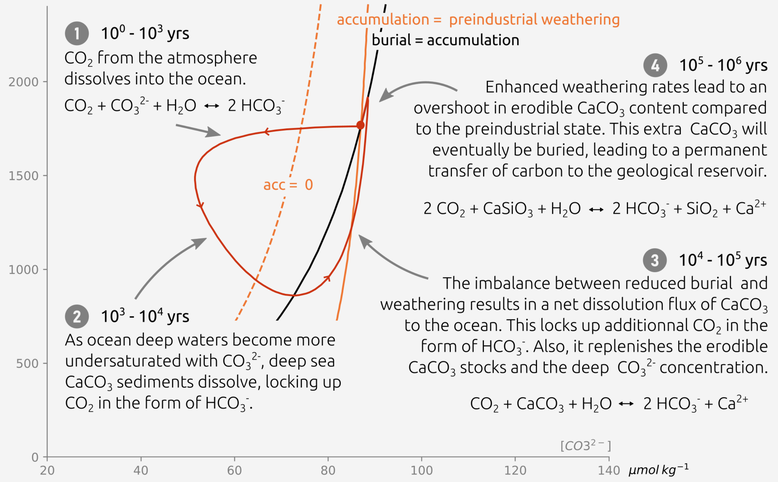
THE MODEL



1. CARBON CYCLE DYNAMICS

The extended version of SURFER includes and models carbon cycle processes on multiple time scales, based on Archer et al., (1998) and Lord et al., (2016).

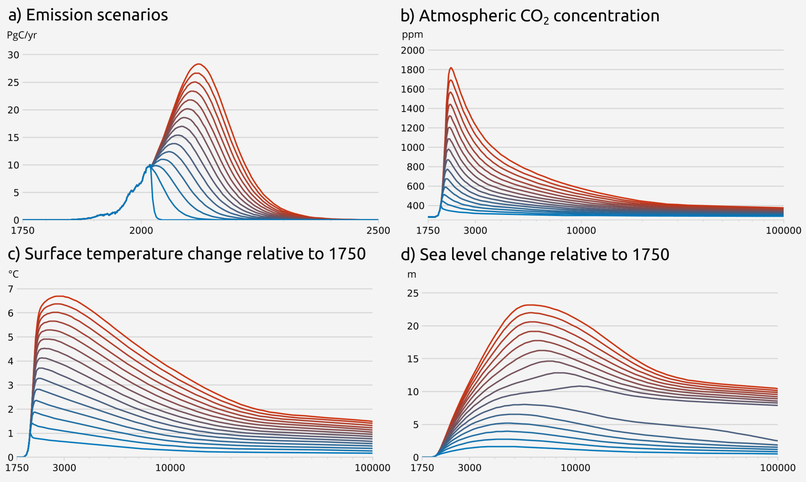
Simulated evolution of deep ocean CO_3^{2-} and erodible $CaCO_3$ sediments after 2500 PgC of CO_2 emissions



2. LONG TERM SEA LEVEL RISE

Tipping points in ice sheet dynamics lead to a separation of the sea level rise trajectories.

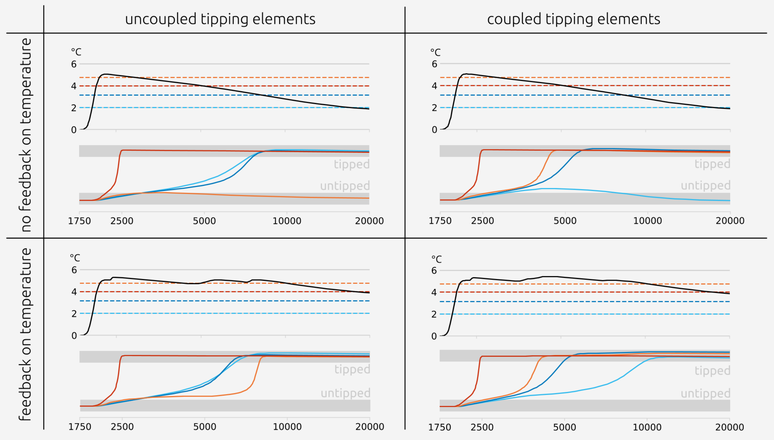
Simulated sea level rise for different scenarios with cumulative CO_2 emissions ranging from 500 PgC to 5000 PgC



3. TIPPING CASCADES

Tipping cascades can be mediated through local interactions or through global variables such as temperature.

Simulated temperature evolution and state of the West Antarctic ice sheet, the Greenland ice sheet, the AMOC and the Amazon rainforest , for cumulative CO2 emissions of ~ 3000 PgC*.



*Parameters for the tipping elements are taken from Wunderling et al., (2021).

REFERENCES

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Icons used in the introduction are from Flaticon.com

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