Simulating regionally varying sea-level changes over the past glacial cycles with a coupled ice-sheet sea-level model

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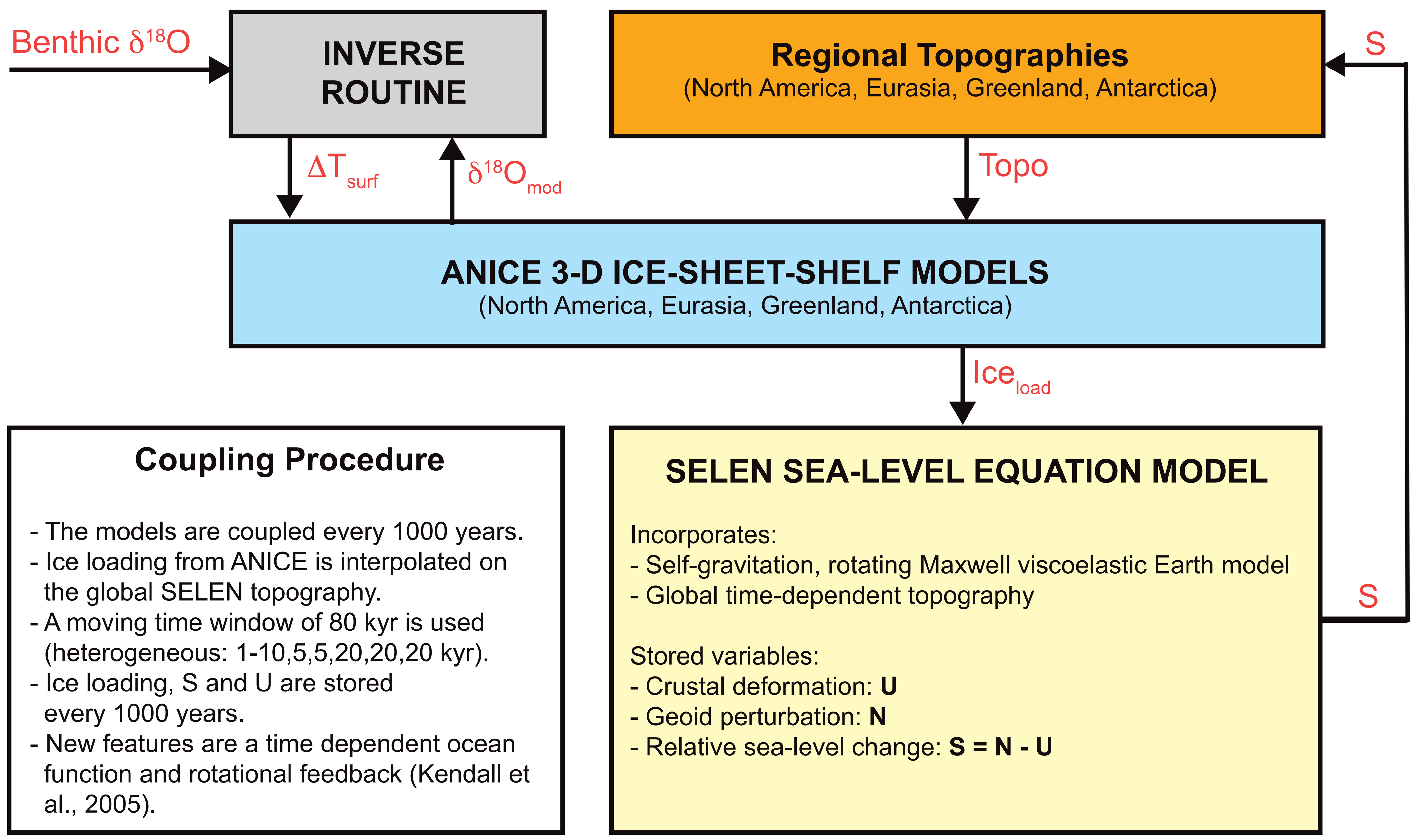
INTRODUCTION

Relative Sea Level (RSL) variations during the late Pleistocene cannot be reconstructed independently of the estimates of ice-sheets volume fluctuations. For the latter, however, the knowledge of regional and global RSL variations is necessary. Overcoming this problem of circularity demands a fully coupled system where ice sheets and sea level vary consistently in space and time and dynamically affect each other. Here we present results over the past 410,000 years from the coupling of a set of 3-D ice-sheet-shelf models to a global sea-level model based on the gravitationally self-consistent Sea Level Equation (SLE) and incorporating feedbacks from Earth rotation and coastline variations.

SIMULATING ICE VOLUME AND RELATIVE SEA LEVEL

With an inverse forward modelling approach (De Boer et al., 2012) a surface-air temperature anomaly ΔT_{surf} is derived from the benthic $\delta^{18}O$ record (Lisiecki and Raymo, 2005) to force the ANICE ice-sheet-shelf models. Every 1000 years the ice-sheets thickness variations are provided into the sea-level equation model SELEN (Spada and Stocchi, 2007) to compute the Crustal deformation (**U**) and the RSL change (**S**) for the next time steps. Runs start at 410 kyr ago (MIS 11 interglacial) and run to the present day.



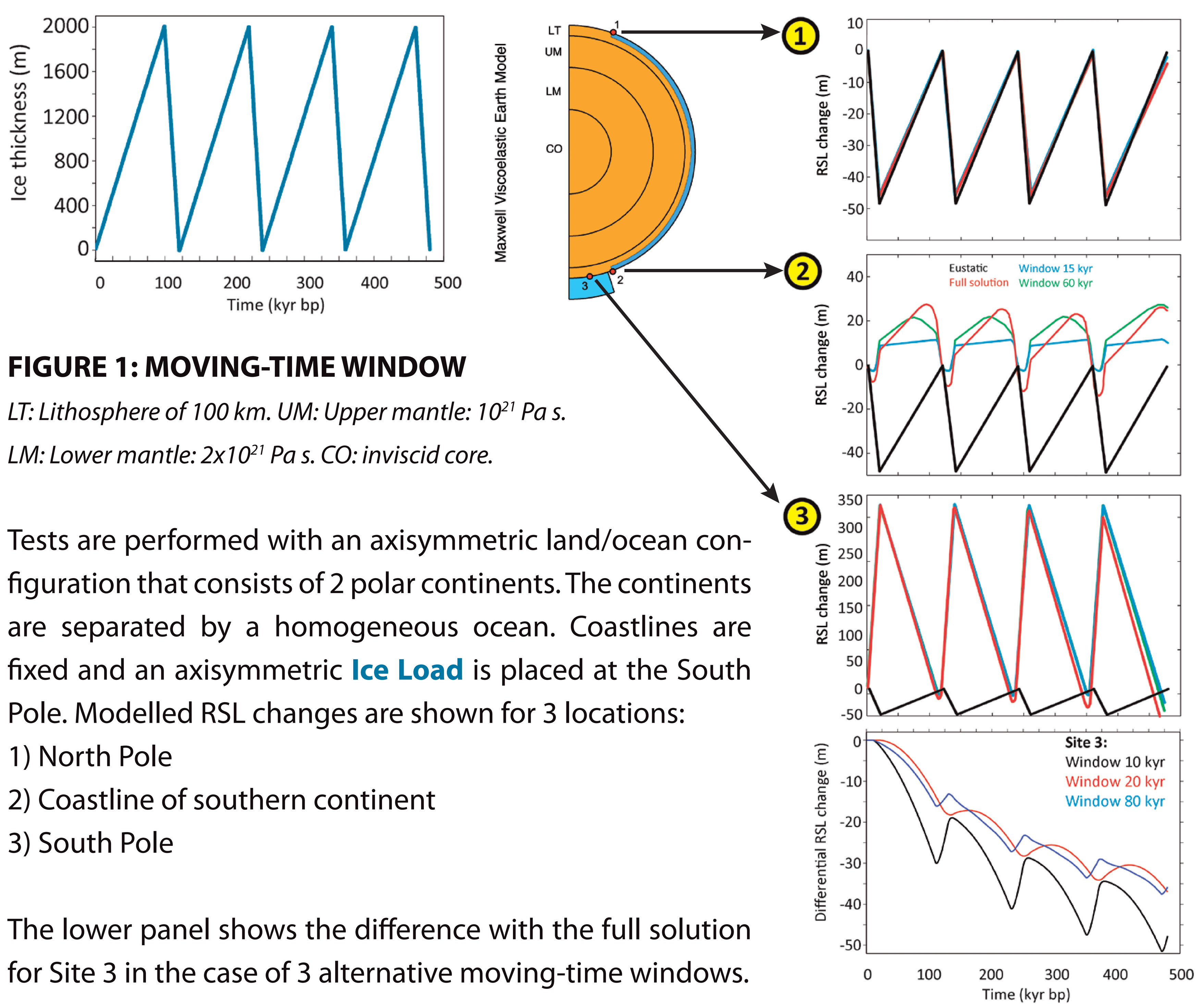


FIGURE 1: MOVING-TIME WINDOW

LT: Lithosphere of 100 km. UM: Upper mantle: 10^{21} Pa s.
LM: Lower mantle: $2x10^{21}$ Pa s. CO: inviscid core.

Tests are performed with an axisymmetric land/ocean configuration that consists of 2 polar continents. The continents are separated by a homogeneous ocean. Coastlines are fixed and an axisymmetric **Ice Load** is placed at the South Pole. Modelled RSL changes are shown for 3 locations:

1) North Pole
2) Coastline of southern continent
3) South Pole

The lower panel shows the difference with the full solution for Site 3 in the case of 3 alternative moving-time windows.

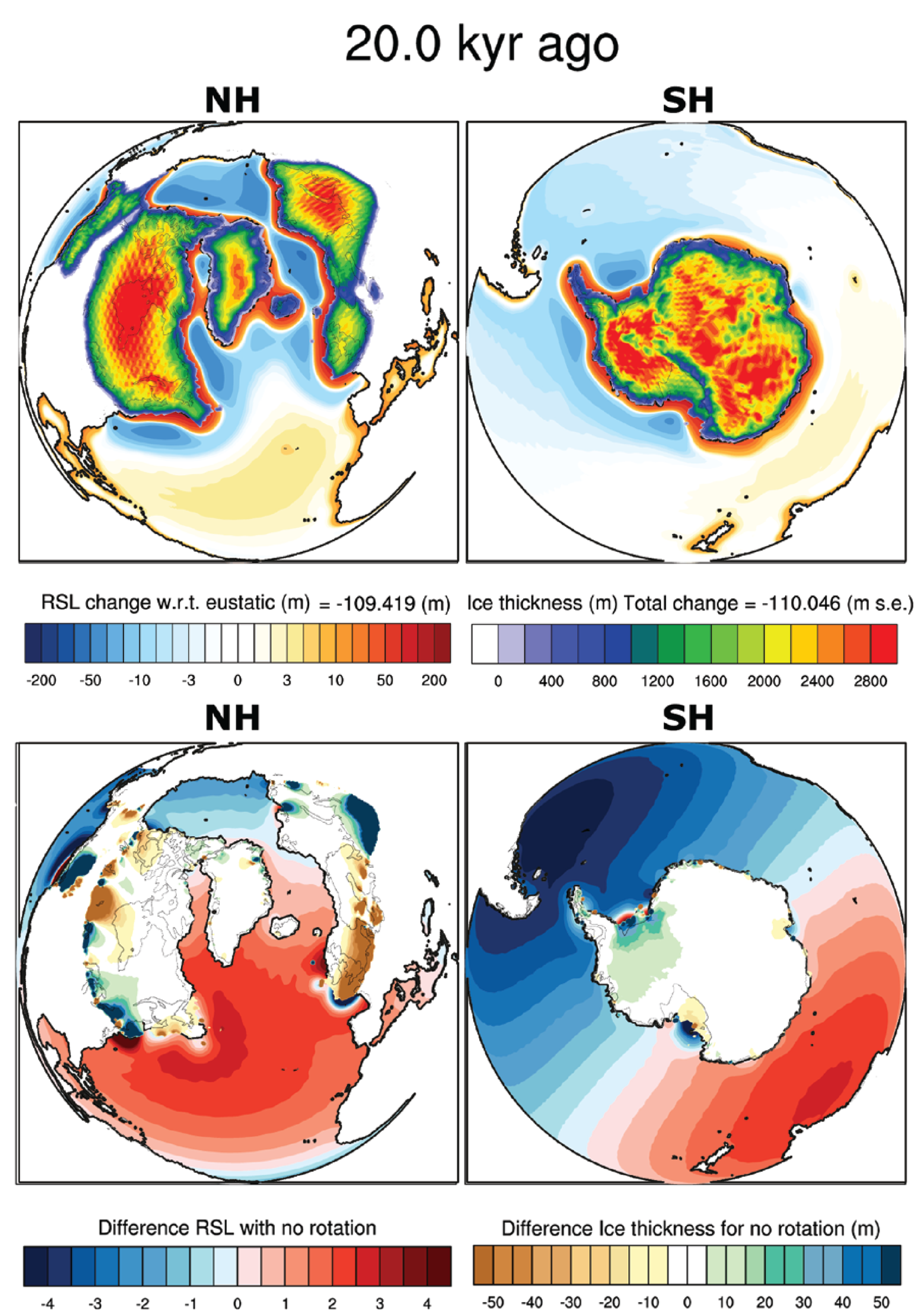


FIGURE 2: ROTATIONAL FEEDBACK

A new feature in SELEN is the use of rotational feedback in the calculation of the self-consistent RSL. The top panels show the NH (left) and SH (right) RSL change w.r.t. the eustatic with on top the total ice thickness at the Last Glacial Maximum (20 kyr ago). The lower panels show the difference between a simulation with rotational feedback included minus a run without. Difference in RSL is shown in blue-red, difference in Ice loading in brown-white-blue.

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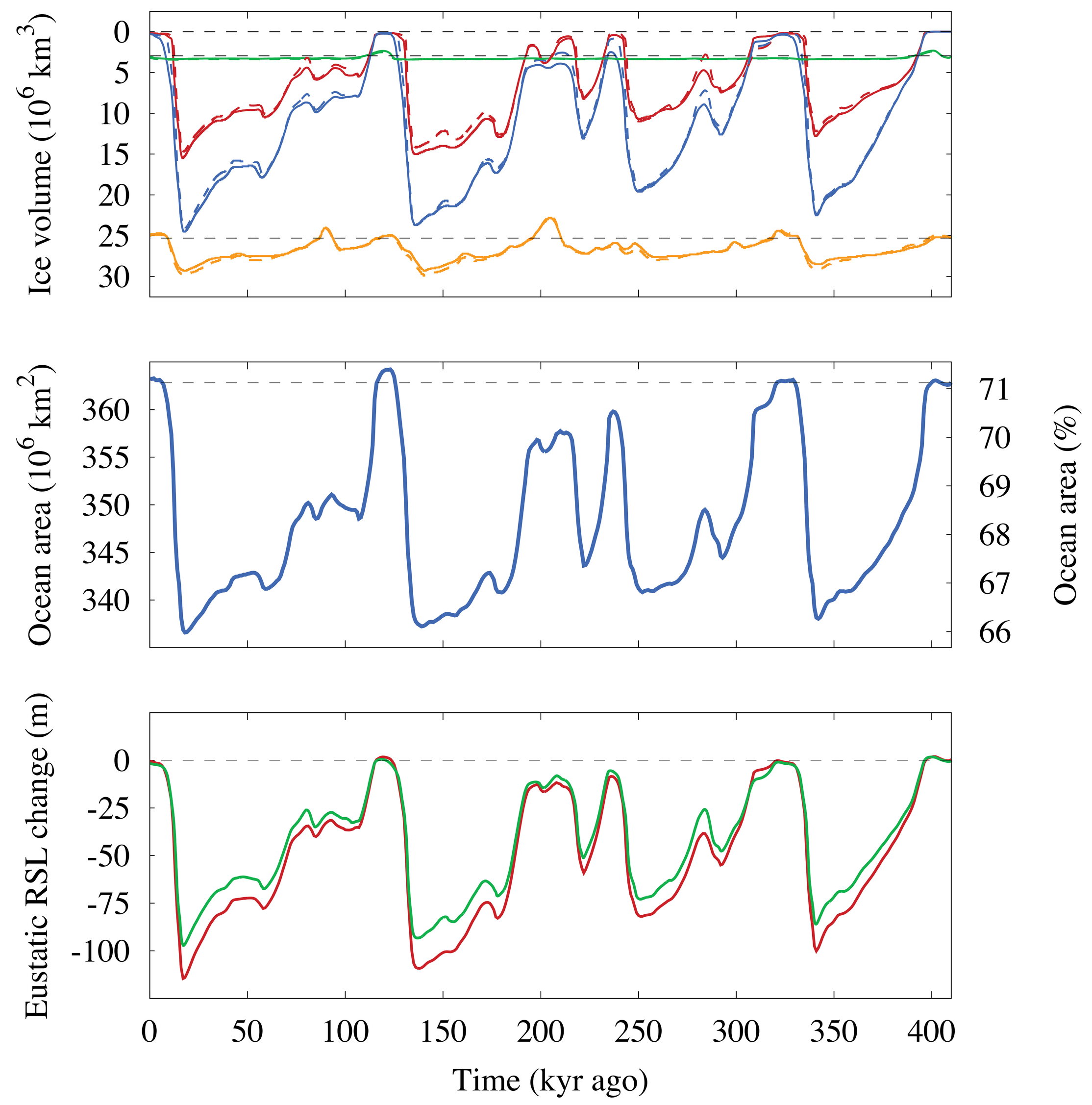

FIGURE 3: TIME DEPENDENT OCEAN FUNCTION (TDOF)

The top panel shows ice-volume evolution over the last four glacial cycles for **Eurasia**, **North America**, **Antarctica** and **Greenland**. Dashed lines indicate simulated ice volume without coupling to SELEN. The second panel shows the evolution of the Time Dependent Ocean Function (**TDOF**), on the left y-axis the total ocean area; the right y-axis shows the percentage of the total area of the world. The lower panel shows the eustatic RSL change, from a **Run with SELEN** and a **Run without SELEN**.

CONCLUSIONS

A moving-time window is needed to reduce the very long simulation time when coupling ANICE to SELEN.

Rotational feedbacks can have significant effects on local relative sea-level change.

The two-way coupling provides new insight in the interaction between ice sheets, topography and the relative sea-level change.