

Global modeling of sea level extremes during the Last Interglacial

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Learning from the past

Coastal risk are increasing due to the warming of the climate resulting in rising mean sea levels and changes in storminess. Besides relying on global climate models forced with greenhouse scenarios, we can look at past climates to enhance our understanding of coastal flooding in a warmer world. The Last Interglacial (~127,000 years ago) is considered a partial analogue to a future warmer climate. During the Last Interglacial the global temperature was warmer than the present, especially in the Northern Hemisphere, and the sea level may have been 6-9 meters higher. Such high sea levels imply substantial contributions from the melting of the Greenland and Antarctic ice sheets. In addition, a better understanding of tides and storm surges during the LIG may help to provide constraints to regional sea level reconstructions and to address questions such as what propelled giant boulders up Bahamas' cliffs.

We analyze extreme sea levels during the Last Interglacial, to understand what coastal storms in a warmer world looked like, and to help reconstruct past sea levels.

Global modeling of extreme sea levels

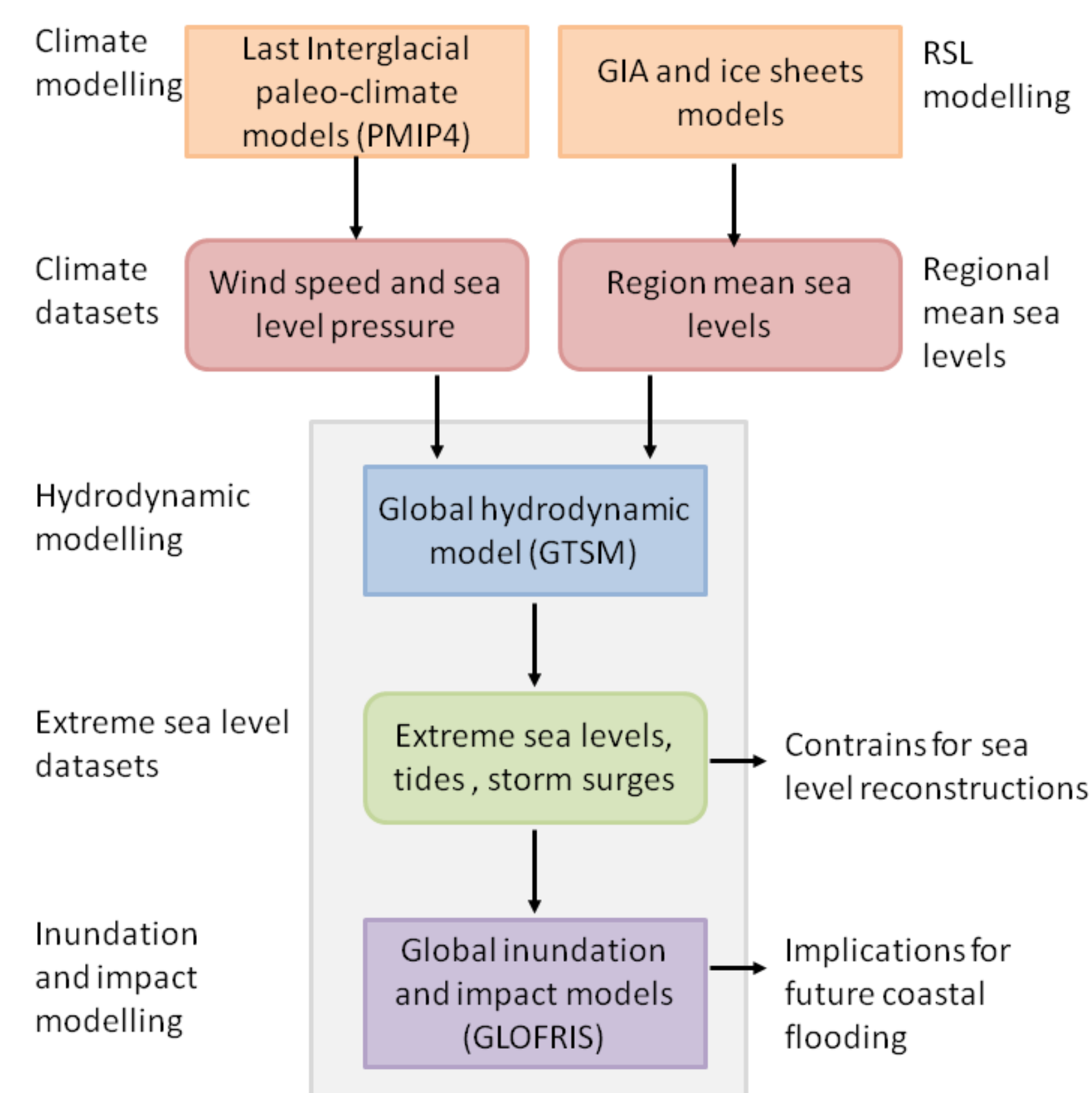


Fig. 1: Flowchart of the main model approach.

Modeling of tides and storm surges

- Global Tide and Surge Model (GTSM), global hydrodynamic model that makes use of the Delft3D Flexible Mesh software
- Unique high resolution near the coast (<2.5 km), and coarser resolution in deeper oceans (25 km) to enhance the computational efficiency
- Its high resolution and accuracy makes it possible to compute changes in mean sea levels, astronomical tides and storm surge dynamically, including non-linear interaction effects.

General approach

In this project, we use the Global Tide and Surge Model (GTSM) to simulate extreme sea levels, which are defined as the sum of mean sea level, tides and storm surges. To model storm surges we force GTSM with 3-hourly wind and pressure fields from LIG simulations by PMIP4 climate models (i.e., CESM1.2 and EC-Earth) with high resolution (~1 degree). Relative sea level (RSL) is taken from a glacio-isostatic adjustment model combined with glacio-eustatic responses of Greenland and Antarctica.

We produce time-series of storm surges, astronomical tides, and total sea levels. Based on these time-series, we will compute several indicators (e.g. tidal range, return periods of extreme sea levels). This will be analyzed against the climate in the pre-industrial.



Fig. 2: Computational grid of GTSM.

Storminess during the Last Interglacial

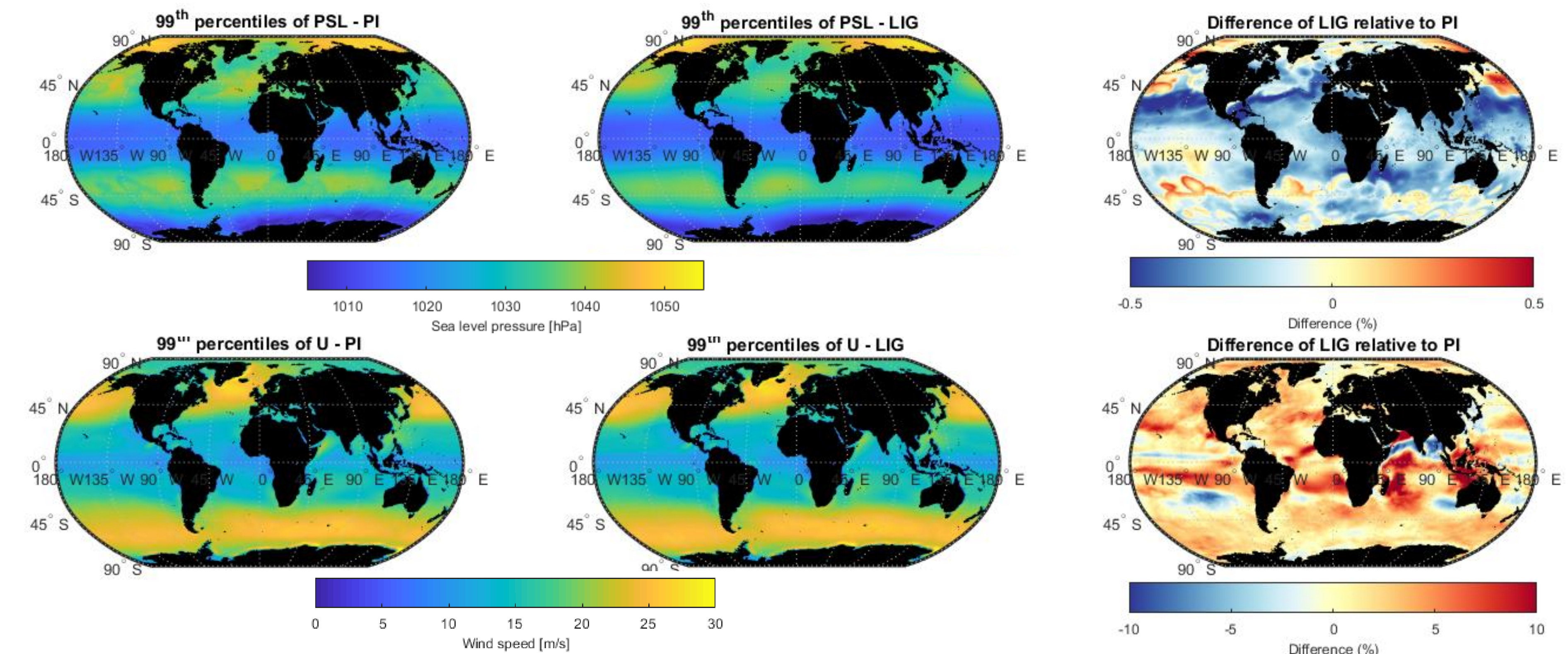


Fig. 3: Extreme sea level pressure (PSL) and wind speed (U) from the Last Interglacial (LIG) and the Pre-Industrial (PI) CESM1.2 simulations.

Figure 3 shows the anomalies in extreme sea level pressure and wind speed from the Last Interglacial with respect to the Pre-Industrial. First results suggest a general decrease in sea level pressure, except over the North Pacific and at Southern frontal boundaries. Wind speeds generally

increase, but decrease in isolated regions over the northern Indian Ocean and near southwest Australia. In Indonesia, Oman and Madagascar wind speed increase exceed 10%. Overall, results suggest that storminess in the Last Interglacial was higher.

Including regional mean sea levels

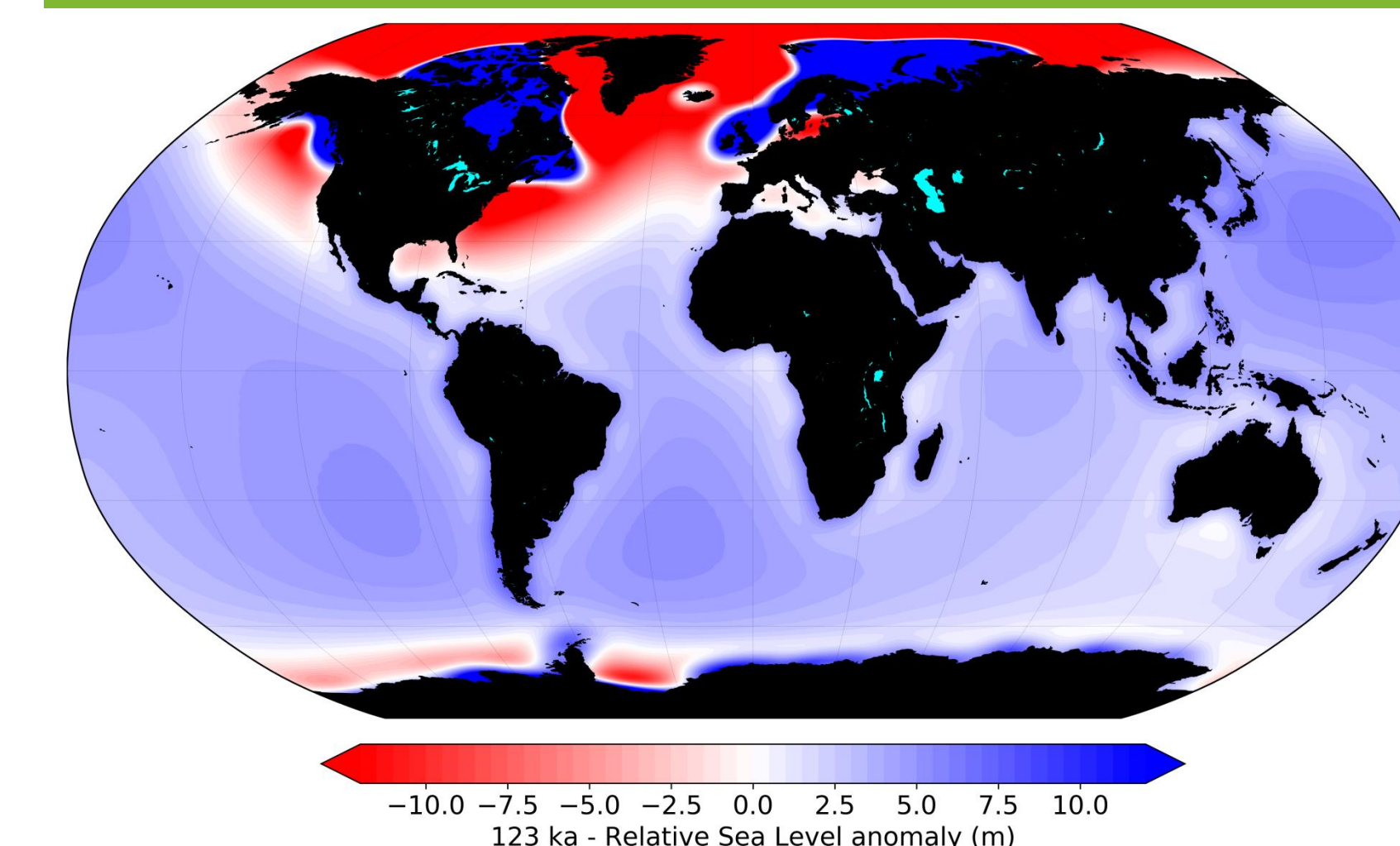


Fig. 4: Last Interglacial RSL anomaly (compared to present) from one scenario of the ANICE-SELEN coupled ice-sheet/sea-level model.

Outlook

We present a new project to assess extreme sea levels and coastal flooding during the Last Interglacial, using a global hydrodynamic model. Next steps include running the model using PMIP4 climate simulations, assessing sensitivity of storm surges and tides to changes in mean sea levels, and to changes in the global coastline. Results of these simulations will try to answer how storm surges and tides may have looked like during the LIG and how that differed from the PI. We will then investigate implications for coastal flooding, and compare our results to future scenarios from the IPCC. In addition, our results will provide insights and constraints for the interpretation of RSL proxies.