European ice sheet modeling initiative (EURICE)

Contact: Alexander Robinson robinson@fis.ucm.es
http://www.palma-ucm.es/people/robinson/eurice

Global sea levels are expected to increase on the order of several meters in the medium to long term under global warming, which will have large impacts on the millions of people who live in coastal areas. The largest contribution to sea level rise will come from the continental ice sheets, Greenland and Antarctica. Refining the currently highly uncertain estimates of the magnitude and timing of ice sheet mass loss is critical for adaptation strategies and minimization of losses. This project aimed to improve our understanding of the sensitivity of the ice sheets to climate change from an integrated Earth systems perspective and to reduce uncertainty in sea level rise projections.

Outcome of the project

A **flexible, user-oriented modeling framework** has been developed and tested, including a set of key generic tools that facilitate the user in coupled geophysical model simulations. To this end, several stand-alone FORTRAN and Python libraries have been developed, validated and documented. A very flexible modeling framework has been built around the above utilities that is easy to use and allows the coupling of any model components in a straightforward and encapsulated way.

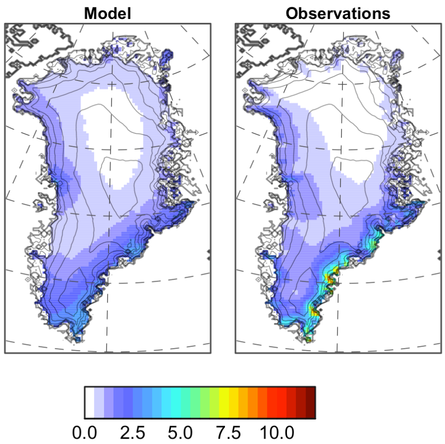

Figure 1: Modeled and observed precipitation (mm/d) over Greenland.

Significant **improvements to the regional climate model REMBO** were implemented in Work Package 1. This model is used for calculating the change in the surface mass balance of the Greenland ice sheet under climate change. A new precipitation scheme was introduced that improves both the spatial distribution of simulated precipitation compared with observations, as well as the seasonality. Furthermore, the previous empirical equation for melt has been replaced by a new full energy balance scheme. This step represents a refinement of the resolution and ability of the model to reproduce results from more computationally intensive regional climate models (RCMs), with a minimal change in computational cost.

Work package 2 consisted of investigation of the **past evolution of the Greenland ice sheet** including Marine Interglacial Stage (MIS) 11 and MIS-5, the two most recent periods when the ice sheet was expected to be smaller and the climate warmer than today, as well as the initial glaciation of Greenland about 3 Ma before

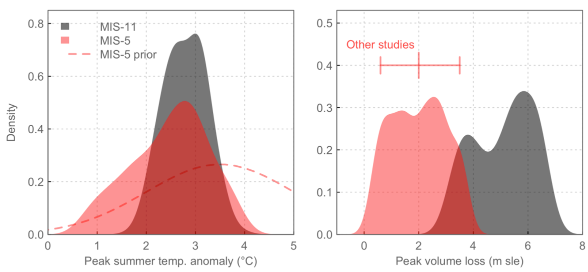

Figure 2: Estimates of regional warming and peak sea-level contribution from the Greenland ice sheet during MIS-11 and MIS-5.

today. Results show that while MIS-11 may not have been warmer than MIS-5, it was long enough to destabilize and melt most of the ice sheet. It was also shown that Greenland only originally glaciated originally after CO_2 dropped below a certain threshold. These findings have important implications for future climate change – it is critical to keep global warming to as low as possible in order to slow and/or halt the decline of the Greenland ice sheet.

In work package 3, the **future evolution of the Greenland ice sheet and its sensitivity to climate change** were studied. It was shown that the long-term consequences of melting will increase non-linearly with temperature. The melting of the Greenland ice sheet will self-amplify owing to positive feedbacks, particularly that between surface elevation and temperature. The threshold leading to complete melting of the Greenland ice sheet can be expressed in terms of cumulative CO_2 emissions, and with the newly calibrated model, we find that the threshold for melting is lower than previously believed. In addition, it was shown that current melting of the Greenland ice sheet may play role in the observed slowdown of the Atlantic Meridional Circulation (AMOC).

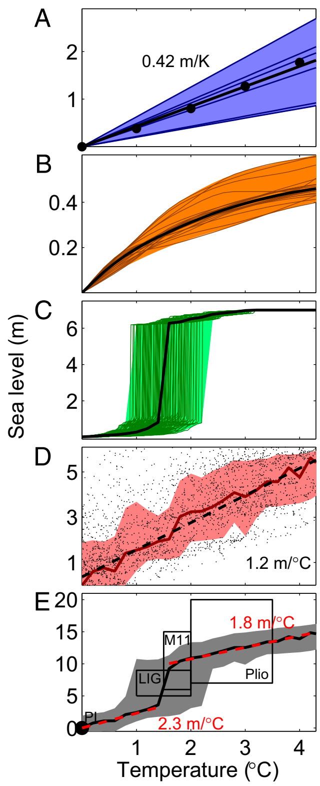

Figure 3: Sea-level commitment for different levels of global warming due to (a) thermal expansion, (b) glaciers, (c) Greenland and (d) Antarctica, as well as (e) the total commitment (Levermann et al., 2013).

Publications

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