PLIOcene TRANSient Climate Modelling: Towards a global consensus between ice volume, temperature and relative sea level for the Late Pliocene

Reporting

Project Information

PLIOTRANS
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Periodic Reporting for period 1 - PLIOTRANS (PLIOcene TRANSient Climate Modelling: Towards a global consensus between ice volume, temperature and relative sea level for the Late Pliocene)

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Summary of the context and overall objectives of the project

The Antarctic and Greenland ice sheets will be significant contributors to sea-level rise during and beyond this century. An increase in sea level will have considerable impact on ecosystems, the vulnerability of the coast and on society. It will increase the risk of flooding, accelerate coastal retreat and erosion and damage coastal infrastructures around the globe. A better understanding of the
responses of the ice sheets to a warming climate is evidently needed to make more rigorous predictions of the impact of regional sea-level variations. The Late Pliocene (3.264 to 3.025 million years before present) was a warm interval in the history of the Earth that can be used to gain a better understanding of the response of the ice sheets to a warming climate with CO2 levels close to or higher than present.

For this project we performed experiments with ice-sheet models forced with multiple snapshot experiments of the HadCM3 climate mode. The climate model simulations used Pliocene boundary conditions such as topography and an atmospheric CO2 level set to 405 ppm, similar to that what it is today. For these simulation, we specifically focused on two short warm intervals of each 40,000 years during the Late Pliocene, for which each period a set of climate model simulations were performed varying the orbital parameters, leading to differences in received warmth from the Sun (Prescott et al, 2014).

For these 40,000 yr simulations the ice-sheet models for Antarctica and Greenland where run simultaneously forced by temperature and precipitation from the climate model. Our simulations indicate that for one particular interval the response is rather stable, in line with the small variations in received warmth from the sun. On the other hand, the other interval shows a much stronger and opposite change in Solar warmth over Antarctica and Greenland. Hence the ice sheets show a strong asynchronous response to the same climate. This response is shown to be a key factor for interpreting the global change in sea level. In particular, simply summing the maximum individual contribution of the Greenland and Antarctic ice sheets to sea-level rise is shown to be larger than then actual synchronous sum of the sea-level contributions.

References:

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

Model development (WP 1)
In the first months, I have been mainly working on model developments to improve the physical representation of the ice-sheet model. This work has been partly presented in the IGS conference in Cambridge (September 2015). Furthermore, ongoing work also focusses on speeding up the model, such that the computational time of simulations is reduced. These updates are included in a invited review article in Quaternary Science Reviews (currently under review).

Setting up coupling framework (WP 1)
The first set up of the modelling framework has been tested with using a 40,000-year simulation of FAMOUS from 3.225 to 3.185 million years ago and force the ice-sheet model ANICE of Antarctica and Greenland with monthly temperature and precipitation. First results were presented at the EGU General Assembly in Vienna in April 2016. Additional tests have been performed using the HadCM3 climate forcing (Prescott et al., 2014) over
two time periods of 40,000 years during the warm Pliocene. Multiple HadCM3 simulations are used to assess the change in ice volume of the Antarctic and Greenland ice sheets during these time periods. A suite of sensitivity experiments are performed to assess model uncertainties. Results will be included in a paper on simulation transient climate and sea-level, to be submitted early 2017.

Pliocene ice-sheet modelling intercomparison
Following on earlier work (De Boer et al., 2015) new simulations with the ice-sheet model for Antarctica have been performed using different climate model outputs from the Pliocene Modelling Intercomparison Project (Haywood et al., 2013). Results show the dependency of the Antarctic ice sheet on this output and a comparison with other ice-sheet models. This work has been presented at the AGU Fall Meeting in San Francisco (December 2015) and at the EGU General Assembly in Vienna (April, 2016) by my collaborator Aisling Dolan.

References


Progress beyond the state of the art and expected potential impact
(including the socio-economic impact and the wider societal implications of the project so far)

The main result of the project thus far is that the response of the two ice sheet can be asynchronous to a warming of the climate, largely depending on the insolation forcing by changes in the orbital parameters of the Earth’s position relative to the Sun. Hence, care should be taken when projection long-term changes in ice volume for which changes in insolation should be considered as well.

The outcome of PLIOTRANS can be used as a benchmark for climate scientists and policy-makers in further reducing uncertainties in future targets for greenhouse gas emissions and the impact of ice-sheet melting within future climate projections.
Pliocene climate and model simulations from 3.25 to 3.05 Myr ago. From top to bottom, obliquity (bla

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