Investigating the climate feedbacks that will determine the fate of the Greenland ice sheet

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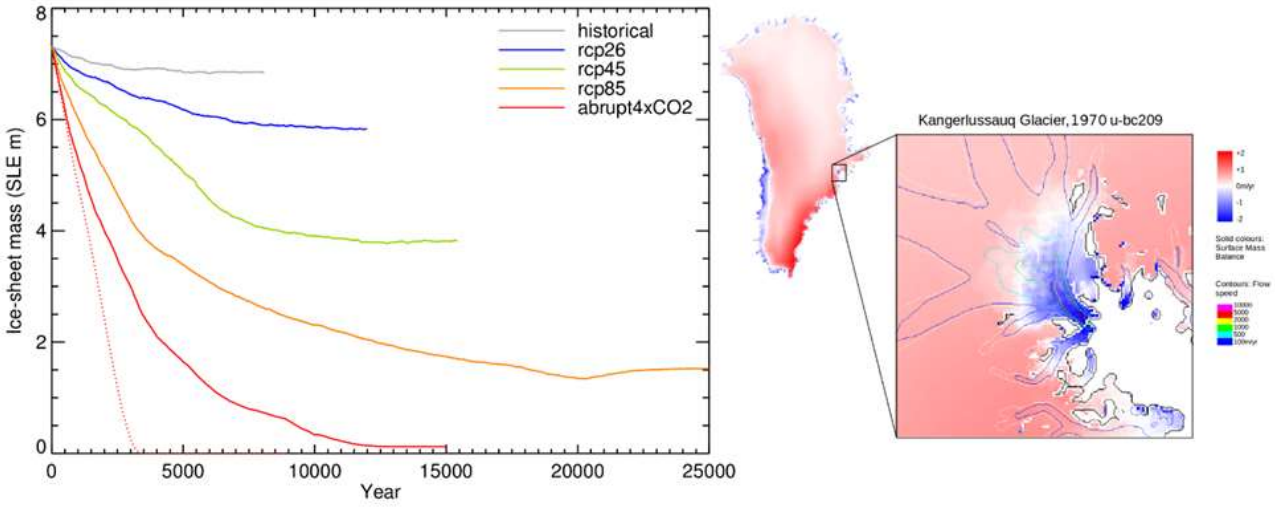
Sea level change is one of the most widely recognised and potentially serious consequences of climate change due to emissions of greenhouse gases. The contribution to sea level change from melting the polar ice sheets on Greenland and Antarctica has already raised global sea levels by around 20mm since 1993, and this rate is expected to grow over the 21st century. Ice mass loss is the most uncertain part of the sea level change budget, largely because the science of modelling how large ice sheets interact with a changing climate has been severely limited by the fact that climate and ice sheet models do not work well together.

Our group is at the forefront of the international effort to interactively model ice sheets as part of global climate projections. This project proposes to use our new and unique modelling capabilities to gain new understanding of the ways in which the atmosphere and ice sheets interact. Focusing on the Greenland ice sheet, this project will investigate the atmospheric, ocean and land surface physics that determine the sensitivity of changing large-scale surface conditions on the ice, and how changes in ice extent and height feedback on both local and regional climate and atmospheric circulation.

Studies with regional and global climate models for the coming century have shown that predictions of how much of the surface of the ice will melt ice for a given level of climate change can vary by factor of two or more. And whilst it has been appreciated for some time that warming of the surface due to its reduction in altitude as it melts is a crucial part of predicting the centennial rate of mass loss from Greenland, it now seems likely that changes in snowfall due to the changing shape of the ice sheet may be just as important. There are several interacting atmospheric, snow surface and ice flow processes involved in these large-scale feedbacks, and yet little research into the phenomena. How much, and in what way, ocean temperatures govern the calving rates of outflow glacier is also an important unknown.

This project will use a state-of-the-art model, used to make the UK's global climate projections, interactively coupled to a dynamical model of the Greenland ice sheet. A series of experiments will investigate the mechanisms of climate-ice interactions, their links to the regional climate system and what they imply for the long-term future of the Greenland ice sheet. In parallel, observational data (obtained via remote sensing and in situ) will be used to both verify the model's capabilities and improve its physical parameterisations.

Modelling climate with ice sheet systems is a new and rapidly expanding area of Earth System science. You will be well placed at the front of this field, gaining abilities in scientific and computational modelling that will enable you to work in atmospheric, land and cryospheric sciences in a number of potential roles, as well as transferrable computational and data analysis skills.



With an adaptive-mesh model of Greenland ice (right panel), our Earth System models are capable of simulating many possible futures for individual glaciers and the ice sheet as a whole under various scenarios of climate change (coloured lines, left panel). A simulation that does not model the feedbacks between the ice sheet and the climate as has usually been done until now (dotted red line) misses fundamental features of the system and predicts a very different future for the ice.

Training opportunities:
You will receive training in model data analysis and the use and interpretation of the Met Office Unified Model, used in the UK for both weather forecasting and climate prediction, the new UK Earth System Model and ice sheet models. NCAS offers training in field work appropriate for atmospheric scientists and there will also be opportunities to attend training courses related to cryosphere Earth Observation and in situ measurements.

Student profile:

This project would be suitable for students with an enthusiastic interest in the physics of the natural world and a degree in maths, physics, or a closely related environmental or physical science.

References:
Gregory, George and Smith, *"Large and irreversible future decline of the Greenland ice-sheet"*, The Cryosphere, 2020
Smith et al., *"Coupling the U.K. Earth System Model to dynamic models of the Greenland and Antarctic ice sheets",* Journal of Adv. Modeling Earth Systems, 2021

https://research.reading.ac.uk/scenario/