Recent and ongoing climate modeling activities at UCL-ASTR

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Two simulations of the 21st century climate have been recently carried out at UCL-ASTR using, on the one hand, the UCL-ASTR climate general circulation model and, on the other hand, the same model coupled to a thermomechanical model of the Greenland ice sheet [*Huybrechts et al*., 2002]. Both simulations display a gradual global warming up to 2080. In the experiment that includes an interactive ice sheet component, a strong and abrupt weakening of the North Atlantic thermohaline circulation occurs at the end of the 21st century. This feature is triggered by an enhanced freshwater input arising mainly from a partial melting of the Greenland ice sheet. As a consequence of the circulation decline, a marked cooling takes place over eastern Greenland and the northern North Atlantic (Figure 1). This result underlines the potential role of the Greenland ice sheet in the evolution of climate over the 21st century. Further details about this study can be found in *Fichefet et al.* [2003].

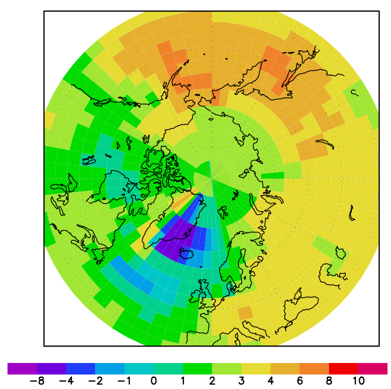

Figure 1. Changes in annual mean surface air temperature (in °C) by the end of the 21st century as simulated by the UCL-ASTR climate general circulation model coupled to a thermomechanical model of the Greenland ice sheet.

In additon, long simulations have been performed with ECBILT-CLIO, a three-dimensional atmosphere–sea ice–ocean model of intermediate complexity. On the basis of these experiments, we identified an interhemispheric climate lag mechanism, involving the long-term memory of deep water masses. Warm anomalies, formed in the North Atlantic when warm conditions prevail at the surface, are transported by the deep ocean circulation toward the Southern Ocean. There, the heat is released because of large-scale upwelling, maintaining warm conditions and inducing a lagged response of about 150 years compared to the Northern Hemisphere. Model results and observations covering the first half of the second millennium suggest a delay between the temperature evolutions in the Northern Hemisphere and in the Southern Ocean. The mechanism described here provides a reasonable hypothesis to explain such an interhemipsheric lag [*Goosse et al.*, 2003].

A three-dimensional Earth system model of intermediate complexity has also been developed. This model, called LOVECLIM, consists of a quasi-geostrophic atmospheric model (ECBILT), a sea ice–ocean general circulation model (CLIO), a dynamical model of the biosphere and of its carbon content (VECODE), an oceanic carbon cycle model (LOCH), and thermomechanical models of the Greenland and Antarctic ice sheets (AGISM). This work was done in close collaboration with the Departement Geografie of the Vrije Universiteit Brussel, Brussels, the Laboratoire de Physique Atmosphérique et Planétaire of the Université de Liège, Liège, and the Potsdam-Institut für Klimafolgenforschung, Potsdam. The coupled model is being validated by conducting ensemble runs over the last 500 years driven by natural and anthropogenic forcings, and by comparing outputs to historical and proxy data available. In the future, it will be used to investigate the evolution of climate and sea level over the third millennium, and in particular, to explore the thresholds for abrupt climate change during this period. This model (without the LOCH and AGISM components) is also presently utilized to understand the climate changes that occurred during the Holocene (last 9,000 years) within the European project "Models and observations to test climate feedbacks (MOTIF)", which is part of the Paleoclimate Modeling Intercomparison Project (PMIP).

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