Geophysical Research Abstracts
Vol. 12, EGU2010-4529, 2010
EGU General Assembly 2010

Sensitivity of a Greenland ice sheet model to atmospheric fields

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In the context of global warming, the role of the Greenland Ice Sheet (GIS) is a key issue. Numerical modeling is a major tool to assess the future behavior of this ice sheet and its contribution to sea level change. In this kind of study one must associate an ice sheet model and a climate model that provides atmospheric fields such as precipitation and temperature. However, no model can perfectly represent reality. Before embarking on next century simulations, sensitivity studies are necessary to evaluate the impact of those uncertainties on the predictions. To do so, we compare here several simulations where an ice sheet model is forced with different climate models.

The ice sheet model, GRISLI, is a 3D ice sheet model (Ritz et al. 2001). It is an hybrid model, allowing for the various ice flow regimes found in ice sheets: SIA (shallow ice approximation) for slowly moving ice; SSA (shallow shelf/stream approximation) for ice streams and ice shelves. Using mass conservation, an ice sheet model simulates the evolution of ice thickness in response to climatic conditions. Here, we perform what is usually called "steady state experiments" where a "climatology" is prescribed constant with time. The objective is to determine the steady state topography that would be consistent with this climatology used as a forcing and compare it with the observed present topography.

We performed the simulations with several sets of climatic conditions, each set being the output of an atmospheric model and supposed to represent the present climatology over the Greenland ice sheet. The atmospheric models used are the following: a atmosphere-ocean global circulation model (AOGCM) with a rather coarse resolution of aproximatively 300 km (CNRM); an AGCM with a zooming capability (LMDz) and a 60 km resolution over the Greenland ice sheet (LMDz); A regional atmospheric model (MAR) with a 25 km resolution. Finally we also force the ice sheet model with fields based on observed values and provided by CISM.

Our results indicate that the topography (extension and thickness) is very sensitive to climatological fields. Both precipitation and summer temperature are relevant. The regional model is the one that gives the best agreement between simulated and observed topography. These simulations also reveal an especially strong sensitivity in the northern part of the GIS. We also noticed that in all the simulations, the GIS is slightly shifted to the east.