Geophysical Research Abstracts
Vol. 13, EGU2011-7858-1, 2011
EGU General Assembly 2011

Modelling the Greenland Ice Sheet through the last glacial-interglacial cycle: climatic constraints and climatic uncertainties

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Recent growing interest in consequences of global warming lead us to more and more sophisticated ice sheet models and to the finest climate forcing. Nevertheless ice sheet modellers still are faced with one major problem regarding initial conditions. Uncertainties remain with the present state of the ice sheet prognostic variables, in particular internal temperature field. The typical time scale of thermal processes are up to 20 000 years, so ice temperature still remembers the last deglaciation. To account for this past evolution, paleoclimatic simulations over the whole last glacial-interglacial cycle (125,000 years until today) are generally conducted. Even if the climate history needed to conduct such an experiment is certainly very badly constrained, ice cores bring us still underestimated information.

We used a 3D Ice Sheet Model (ISM), GRISLI, to investigate the Greenland Ice Sheet (GIS) behaviour through the last glacial-interglacial cycle, performing transient simulation forced by the GRIP anomaly temperatures. It is an hybrid model mixing shallow ice approximation for slowly moving ice and shallow shelf approximation for ice streams and ice shelves. It is thermo-mechanically coupled, meaning that velocity, as a diagnostic variable, is directly dependent only on the temperature field and some dynamical parameters. We added a semi-Lagrangian tracer module to compute ice age and origin given past history of accumulation rate and computed velocity field.

Due to computational limitations, coupled approach between a General Circulation Model (GCM) and an ISM for running such long simulation is impossible. Considering the fact that GCMs are nowadays unable to well represent past climate (e.g. temperature amplitude at the last glacial maximum), we chose a temperature anomaly perturbation method rather than GCM snapshots forcing. In this approach, the adjustment of precipitation to temperature change is usually represented by a single constant parameter for the whole ice sheet. We investigated more deeply this relationship existing between precipitation change and temperature change and in particular how a spatially varying relation can affect the simulated topography.

We calibrated dynamical parameters, as flow enhancement and basal sliding, using the most recent information on present-day observed topography and surface velocity field. The climate history forcing and downscaling were validated with a comparison between Greenland deep ice cores information to the synthetic ice cores provided by the ice sheet model, in particular vertical depth-age profiles. We also made some sensitivity tests of simulated topography to a possible change of the summer insolation change during the Holocene, corresponding to a probable seasonality change at that time. We pretend to provide valuable information for both climate modellers and ice sheet modellers.