Geophysical Research Abstracts
Vol. 13, EGU2011-7035-1, 2011
EGU General Assembly 2011

Investigating the impact of the ablation parameterization on simulated ice sheets over the last glacial cycle

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Simulating properly past ice sheets is critical to study in details climate and ice-sheet feedbacks over the Quaternary period. In early ice-sheet modeling studies, ice flow models were forced by accumulation and temperature data coming either from paleoclimatic archives or from climate model outputs. The ablation was most often determined with empirical parameterizations, such as the so-called positive degree-day (PDD) method calibrated against a few number of glaciers in Southwest Greenland for the present-day period. The physical basis of this method is that the number of positive degree-days of near-surface air temperature is converted in melt rate for snow and ice through the so-called degree-day factors (DDF) in combination with a meltwater retention and/or refreezing scheme. The main disadvantage of this method is that DDF depend on the different energy flux components and on the atmospheric structure, on surface roughness and also on surface albedo. Since about ten years, the development of coupled climate-ice sheet models allows to circumvent the use of empirical formulations by explicitly computing the snow and ice melt rates with energy balance models. However, such methods are computationally more expensive, require numerous informations (i.e. radiation components, temperature, wind speed, and wind direction, cloudiness, surface roughness, densities of snow and ice, snow temperature . . .) and may lead to technical difficulties due to the difference of resolution between climate and ice-sheet models. By contrast, the downscaling procedure is much simpler with the PDD approach and therefore this method is still widely used in the climate-ice-sheet modeling community. Moreover some recent observations over Greenland from automatic weather stations have brought new constraints for the PDD formulation. In particular, they have underlined the necessity of at least accounting for the dependency of DDF with near-surface air temperature. The net consequence is that there are a growing number of different PDD formulations in the literature. Using the climate model CLIMBER2.4 coupled to the ice-sheet model GRISLI, we investigate to which extent the simulated ice sheets are dependent on the ablation parameterization. In particular, we examine how changes in the relation between DDF and local surface conditions may impact the large-scale ice sheets at the 100 kyr time scale, as well as the role of daily and inter-annual variability parameterization. The comparison of model results with available ice-sheet reconstructions reveals that a proper calibration of the PDD method associated with a proper representation of ice dynamics leads to reasonable ice-sheet configurations at the Last Glacial Maximum.