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Modelling the ice age termination and its implication for the future projection of sea level change

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Sea level change is a issue for the future climate change and it is inevitable to develop models that are capable of simulating the past change and predict the future. Here we overview the current status of climate and ice sheet modelling for the past and future climate change and show the prospect of our research. Mainly the simulation of the ice age cycle will be shown, while the modelling of the abrupt climate change and the future ice sheet change will be also discussed.

The glacial cycles in saw-tooth shape with 100ka cycle is investigated with the same ice sheet model and GCM used for future projection of sea level change, and the similarity and difference between the ice age termination and future Greenland ice sheet change is discussed. As sea level change during the ice age termination is well documented, it must provide a good benchmark opportunity for modeling the ice sheet retreat and investigate the factor that determines the sea level change and its rate. Many ice age models were investigated either by simple or conceptual models or forcing a three dimensional ice sheet model by scaled isotope data from ice core (GRIP/GISP) which already includes the information of the ice sheet change itself. Here, The three dimensional ice sheet model (IcIES, Abe-Ouchi et al, 2007) with the input examined by GCM (MIROC GCM) is forced by the orbital parameters (Berger, 1978) and atmospheric CO2 content obtained by ice cores (Vostok, EPICA and DomeF), whose dating is partly given by a new method using the N2/O2 ratio. The ice sheet model includes the thermo-mechanical coupling process of ice sheet with the process of delayed isostatic rebound with a typical time constant. In order to estimate the climate sensitivity to Milankovitch forcing and atmospheric CO2 indicated by ice core data we used an atmospheric GCM (part of which is also used for future projection. Within the range of possibilities of the model, ice age cycles with a saw-tooth shape 100 ka cycle, the major NH ice sheets volume and the geographical distribution at the glacial maximum are successfully simulated. Although the delayed response of Viscoelastic earth mantle-crust system as well as the role of atmospheric stationary wave feedback is found to be important to sharpen the termination, the speed of retreat of about Order (0.01~0.02m/yr) is not largely dependent on the uncertainty of those processes. On the other hand, Greenland ice sheet retreat results in at most 0.004 to 0.005 m/yr of sea level change if a similar forcing (7 to 8 deg C warming over the ice sheet) is assumed. The difference in the rate of sea level change between the Greenland and NH ice age ice sheet is related to the relation between the steady state ice sheet response to temperature change (which mainly depends on the land size and shape of ice sheet), given temperature perturbation and the ice sheet size when the warming starts (which is not necessarily in steady state).