Hot Spot of Millennial Scale Climate Oscillatory mode in glacial climate

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Last termination of ice age cycle as well as glacial periods were punctuated by abrupt millennial scale climate changes, such as Dansgaard Oeschger events, Boeling-Allerod and Younger Dryas. Although abrupt climate changes were shown to have a strong link to the shift between the (quasi) multiple equilibria of Atlantic Meridional Overturning Circulation (AMOC), modeling both together the stability of AMOC under different climate condition and observed glacial-deglacial climate change with fully coupled ocean-atmosphere GCM have been challenging. Here we present a series of long transient experiments (> 10, 000 years) with *steady*forcing under different glacial condition summarized as a phase diagram and compared them with simulation under *transient*forcing experiments following PMIP4 using a coupled ocean-atmosphere model, MIROC4m AOGCM. The simulated LGM AMOC is weaker and shallower than the modern AMOC under Pre-Industrial condition. Conventional stability diagram for varied freshwater flux as well as phase diagram showing the response of the AMOC and climate to steady forcing is first obtained. It is shown that (quasi-) multiple equilibria exist indeed under a certain range of climate condition. When a *steady*forcing under glacial condition is applied even without freshwater perturbation, however, the whole climate-ocean system shows self-sustained oscillation with bipolar seesaw pattern and changes between interstadials and stadials, whose periodicity or the return time ranges from 1000 years to nearly 10000 years depending on the background forcing of Greenhouse Gas levels and orbital parameter. Our transient simulation following PMIP4 deglaciation protocol with a gradually changing insolation, Greenhouse gas forcing and melt water from glacial to Holocene is compared with the phase diagrams for interpretation. The result shows consistency with observed sea level change and abrupt climate changes during the deglaciation in our model. It implies that the abrupt climate change during the glacial climate and deglaciation can be induced much more frequently when the coupled climate system enters the region of the AMOC oscillatory mode than outside of the region. Implication on the mechanism and the conditions of the millennial scale climate changes for the past time period is discussed.