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Simulation of climate, ice sheets and CO_2 evolution during the last four glacial cycles with an Earth system model of intermediate complexity

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In spite of significant progress in paleoclimate reconstructions and modeling of different aspects of the past glacial cycles, the mechanisms which transform regional and seasonal variations in solar insolation into long-term and global-scale glacial-interglacial cycles are still not fully understood, in particular, for CO_2 variability. Using the Earth system model of intermediate complexity CLIMBER-2, we performed simulations of co-evolution of climate, ice sheets and carbon cycle over the last 400,000 years using the orbital forcing as the only external forcing. The model simulates temporal dynamics of CO_2, global ice volume and other climate system characteristics in good agreement with paleoclimate reconstructions. Using simulations with the model in different configurations, we also analyze the role of individual processes and sensitivity to the choice of model parameters. While many features of simulated glacial cycles are rather robust, some details of CO_2 evolution, especially during glacial terminations, are rather sensitive to the choice of model parameters. Specifically, we found two major regimes of CO_2 changes during terminations: in the first one, when the recovery of the Atlantic meridional circulation (AMOC) occurs only at the end of the termination, a pronounced overshoot in CO_2 concentration occurs at the beginning of the interglacial and CO_2 remains almost constant during interglacial or even decline towards the end, resembling the Eemian CO_2 dynamics. However, if the recovery of the AMOC occurs in the middle of the glacial termination, CO_2 concentration continues to rise during interglacial, similar to Holocene. We also discuss potential contribution of the brine rejection mechanism for the CO_2 and carbon isotopes in the atmosphere and the ocean during the past glacial termination.