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The effects of increased carbon storage in frozen soils on the carbon cycle in a coupled Earth-system Model of Intermediate Complexity for the glacial and deglaciation timescales

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Mechanisms within the Earth System that contributed to the rise in atmospheric carbon-dioxide (CO_2) from the Last Glacial Maximum (LGM, $\sim$ 21,000 years before present) to the Pre-Industrial period are still subject to uncertainty. The 13C/12C stable carbon isotopic ratio has been measured in ocean sediment cores since several decades, and more recently the atmospheric 13C/12C of atmospheric CO_2 has been measured from ice cores. So far, the proposed mechanisms that contributed to CO_2 rise since the LGM have not been able to fully explain both the full rise in atmospheric CO_2 and the atmospheric 13C/12C record during deglaciation. One carbon cycle component currently neglected from coupled-model studies of the glacial-interglacial timescales is the effect of permafrost on soil carbon storage. This work describes a simplified permafrost-carbon accumulation mechanism implemented into the CLIMBER-2 intermediate complexity Earth system model and presents the first results of the effects of this mechanism on the carbon cycle in the course of a deglaciation. This simplified permafrost mechanism reduces soil respiration, and so creates higher soil carbon in permafrost effected regions. First results indicate that the inclusion of increased carbon stored in permafrost soils during glacial periods, combined with ocean mechanisms results in a better agreement with atmospheric 13C/12C of CO_2 data than when considering ocean mechanisms alone. The increased terrestrial carbon storage at the glacial maximum also contributes to the total drop in CO_2 concentration during glaciation. The permafrost-carbon mechanism results in a drop of only 100 to 300GtC in total terrestrial biosphere carbon from interglacial to glacial conditions, with vegetation carbon decreasing and soil carbon storage increasing. These values are tuned to agree with estimates of total Carbon storage at LGM by Ciais et al 2011. The effects of different rates of carbon uptake and release by the permafrost-carbon mechanism are also looked at for their effect on the transient deglaciation. Preliminary results show that when most of the carbon is stored and released in a fast or labile carbon-pool, better agreement with data is obtained. The implication of these results is that the ocean mechanisms does not necessarily need to fully explain the CO_2 change from glacial to interglacial conditions, and that the carbon release from a deep ocean reservoir could have been of a lower magnitude than previously thought.