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The role of climate-icesheet-carbon interaction in glacial-interglacial cycles

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Despite of the impressive amount of data from ice cores, ocean sediments and other sources, there is no widely accepted theory for the glacial CO_2 changes. Despite of the popularity of the Milankovitch theory, major challenges remain such as the 100ky problem and the causality problem at Termination II.

A mechanism is proposed in which climate, carbon cycle and icesheets interact with each other to produce a feedback that can lead to quasi-100 ky glacial-interglacial cycles. A central process is the burial and preservation of organic carbon by icesheets which contributes to the observed glacial-interglacial CO_2 change (the glacial burial hypothesis, Zeng, 2003). Allowing carbon cycle to interact with physical climate, here I further hypothesize that deglaciation can be triggered by the ejection of glacial burial carbon when a major icesheet grows to sufficiently large size after a prolonged glaciation so that subglacial transport becomes significant. Glacial inception may be initiated by CO_2 drawdown due to a relaxation from a high but transient interglacial CO_2 value as the land-originated CO_2 invades into deep ocean via thermohaline circulation and $CaCO_3$ compensation. Also important for glacial inception may be the CO_2 uptake by vegetation and soil regrowth in the previously ice-covered regions. When tested in a fully coupled Earth system model with comprehensive carbon cycle components and semiempirical physical climate components, it produced under certain parameter regimes self-sustaining glacial-interglacial cycles with durations of 93 ky, CO_2 changes of 90 ppmv, temperature changes of 6C. Since the 100 ky cycles can not be easily explained by the Milankovitch astronomical forcing alone, this carbon-climate-icesheet mechanism provides a strong feedback that could interact with external forcings to produce the major observed Quaternary climatic variations. It is speculated that some glacial terminations may be triggered by this internal feedback while others by orbital forcing. Some observable consequences are highlighted that may support or falsify the theory.