Glacial/interglacial CO2 change: Beyond the ice core record

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Decades of painstaking work on air bubbles trapped in polar ice have yielded a detailed record of atmospheric CO2 over the last 800 thousand years, demonstrating that natural CO2 change systematically amplified late Pleistocene glacial/interglacial cycles of the climate system.
In the first part of this talk I survey biogeochemical mechanisms of glacial/interglacial CO2 change as simulated by carbon cycle models, and the timing of oceanographic changes acting as the principle drivers of CO2 drawdown during late Pleistocene ice ages. In simple box models and spatially resolved GCMs alike, a handful of globally averaged parameters are excellent predictors for simulated CO2: e.g., preformed versus regenerated nutrient concentration as a metric for carbon sequestration via the biological pump, and ocean alkalinity integrating transient imbalances in the open system CaCO3 cycle. Successive activation of three ocean drivers (Polar Antarctic changes, shoaled Atlantic overturning, Subantarctic iron fertilization) does most to explain the two-stepped CO2 decline of the last glacial cycle, respectively dominated by respired carbon sequestration and ocean alkalinity increase.
The second part of this talk describes ways in which we can extend the understanding gleaned from the ice core CO2 record across the Mid Pleistocene Transition (MPT) and further back in time. For one, the ice core CO2 record is the ultimate test that helps us build confidence in indirect methods of CO2 reconstruction, such as the boron isotope pH proxy. Furthermore, CO2 data can be used to constrain model-based inversion of the diverse proxy data that record the dynamics responsible for components of CO2 change in the ice core record – and beyond. Model inversion and empirical data together suggest a powerful ice-dust-CO2 feedback, initiated during the MPT, as the driver of longer and stronger ice age cycles. In this line of thought the ice core CO2 record turns from problem to be solved to integrative constraint on the global carbon cycle as a whole: a measuring stick to our attempts to understand the coupling of biogeochemical cycles and climate dynamics.