Abrupt Changes in the Global Carbon Cycle Over the Past 70ka

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Two long-standing questions in carbon cycle dynamics are what caused the glacial-to-interglacial rise in atmospheric carbon dioxide (CO_2) and what is the nature of the CO_2 changes during Marine Isotope Stage 3 (MIS 3). The paradigm has been, and continues to be, that the underlying processes operate at millennial or longer time scales, and that the Southern Ocean is the primary source of the CO_2 changes, largely based on the strong covariance of CO_2 with Antarctic temperature. We will present a carbon dioxide record from 70-10 ka from the last glacial and deglacial periods from the WAIS Divide ice core (WDC) from West Antarctica, which has a sampling resolution of 25-150 years. Our work provides new evidence that a centennial scale component exists for both the rise in atmospheric CO_2 during the last termination and during the millennial scale oscillations of MIS 3. Each of the abrupt, centennial scale transitions in CO_2 was synchronous with abrupt changes in atmospheric methane (CH_4), suggesting a common mechanism driving the rapid increases. The abrupt, centennial scale increase in both CO_2 and CH_4 occur in nearly all of the Heinrich Stadials of MIS 3 and during rapid changes in North Atlantic deep water during the last termination. This provides strong support that the Atlantic Ocean overturning circulation plays a key role in the deglacial rise by modulating the timing, and possibly the magnitude, of the CO_2 and CH_4 changes. Our new data from WDC demonstrates that natural CO_2 variability can change very rapidly (100-200 years), which is not captured by existing Earth System models, requiring a refinement in our understanding of how atmospheric CO_2 behaves under natural forcings.