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Constraints on the atmospheric CO_2 deglacial rise based on its $\delta^{13}CO_2$ evolution

A. Lourantou (1), J.V. Lavrič (1), P. Köhler (2), J.-M. Barnola (1), E. Michel (3), D. Paillard (3), D. Raynaud (1), and J. Chappellaz (1)

(1) CNRS-LGGE, Grenoble, St Martin d'Heres, France (lourantou@lgge.obs.ujf-grenoble.fr), (2) Alfred-Wegener Institute for Polar and Marine Research, Bremerhaven, Germany , (3) Laboratoire des Sciences du Climat et de l'Environnement (IPSL/CEA-CNRS-University of Versailles-St Quentin), Gif-Sur-Yvette, France

The analysis of air bubbles trapped in polar ice permits the reconstruction of atmospheric evolution of greenhouse gases, such as carbon dioxide (CO_2), on various timescales. Within this study, the simultaneous analysis of the CO_2 mixing ratio and its stable carbon isotope composition ($\delta^{13}CO_2$) over the last two deglaciations allows us to better constrain the global carbon cycle. Based on the different isotopic signatures of the ocean and the terrestrial biosphere (major reservoirs responsible for the CO_2 oscillations on a glacial – interglacial scale), $\delta^{13}CO_2$ contributes in distinguishing the major sources of CO_2 for the studied periods.

The new LGGE analytical method applied to samples from the EPICA / Dome C ice core provides a 1-sigma uncertainty over 3 measurements on the same extracted gas of 0.98 and 1.87 ppmv for CO_2, for the last and penultimate deglaciation respectively, accompanied by an averaged 0.1‰ 1-sigma for $\delta^{13}CO_2$ for both periods. This allows us to reveal significant changes in the signal through time.

The time resolution of our results (~250 and ~730 years, for last and penultimate deglaciation) allows us to divide Terminations (T) into sub-periods, based on the different slope of CO_2 rate of changes. The ~80 ppmv CO_2 increase throughout TI, coherent with previously published studies, is accompanied by a ~0.6‰ decrease of $\delta^{13}CO_2$ with additional clear trends during the different sub-periods. TII shows similar trends as for TI but of a larger magnitude: we therefore observe a ~110 ppmv rise associated with an overall ~0.9‰ decrease. In addition, $\delta^{13}CO_2$ appears overall lighter during TII than TI.

The two datasets are jointly evaluated using two C cycle box models. We conclude that oceanic processes involving stratification breakdown of the austral ocean, combined with reduction of sea ice cover and biological pump, can explain a large part of the signal. In addition, continental biosphere buildup during the Bolling/Allerod and thermohaline circulation fluctuations could have imprinted our signals in the second half of TI.