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Towards reconstruction of atmospheric 14CO2 using ice core measurements

Content

Radiocarbon dating of glacial ice has been a longstanding goal in ice core science. In glacial ice, 14C is incorporated mainly through the trapping of 14C-containing atmospheric gases (14CO2, 14CO, and 14CH4). However, 14C in ice is also produced in situ, directly in the ice lattice from reactions with secondary cosmic rays. In situ 14C in ice only accumulates after bubble close-off (generally between 50-120 m) because almost all in situ produced 14C in the firn column (snow to ice transition before the close-off depth) is lost to the atmosphere via diffusion. The in situ 14C at these bubble close-off depths is dominated by production from deep penetrating muons. Understanding the muogenic 14C production rates is thus important to deconvolve the in situ cosmogenic and atmospheric 14C signals in ice cores. A new sublimation-based extraction system was developed to retrieve and accurately measure 14CO2 from ice core samples. In combination with well-established measurement systems for 14CH4 and 14CO, we use measurements of in situ 14C in ancient ice (>50 kilo-annum before present, ka BP) from the Taylor Glacier ablation site, Antarctica to obtain the muogenic 14C production rates for each 14C-containing atmospheric gases. At depths where production from muons dominates, the partitioning between the in situ 14C species appears to be constant (14CO:14CO2 ratio of ≈1:2 with small <0.2% contributions from 14CH4). With better constraints on the in situ 14C components, our results allow for future 14C studies in ice to be potentially used for a variety of applications, including absolute dating of gases in ice core and improving the radiocarbon calibration curve.

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