A model-based interpretation of low frequency changes in the carbon cycle during the last 120,000 years and its implications for the reconstruction of atmospheric $\Delta^{14}C$ — AGU2006 Poster ID: PP33A-1781

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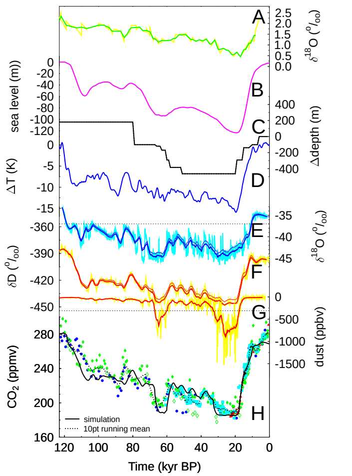
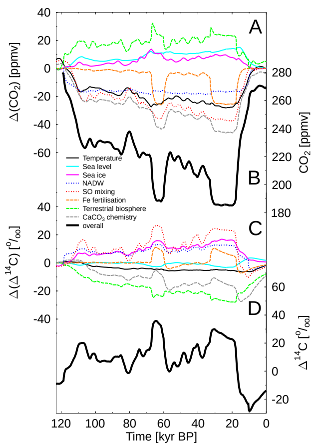
A main caveat in the interpretation of observed changes in atmospheric $\Delta^{14}C$ during the last 50,000 years is the unknown variability of the carbon cycle, which together with changes in the ^{14}C production rates determines the ^{14}C dynamics. A plausible scenario explaining glacial/interglacial dynamics seen in atmospheric CO_2 and $\delta^{13}C$ was proposed recently (Köhler et al. 2005). A similar approach and expanding its interpretation to the ^{14}C cycle is an important step towards a deeper understanding of $\Delta^{14}C$ variability (Köhler et al. 2006). This approach is based on an ocean/atmosphere/biosphere box model of the global carbon cycle (BICYCLE) to reproduce low frequency changes in atmospheric CO_2 as seen in Antarctic ice cores. The model is forced forward in time by various paleo-climatic records derived from ice and sediment cores. The simulation results of our proposed scenario match a compiled CO_2 record from various ice cores during the last 120,000 years with high accuracy ($r^2 = 0.89$). We analyze scenarios with different ^{14}C production rates, which are either constant, based on ^{10}Be measured in Greenland ice cores, or the recent high-resolution geomagnetic field reconstruction GLOPIS-75 and compare them with the available $\Delta^{14}C$ data covering the last 50,000 years. Our results suggest that during the last glacial cycle in general less than 110‰ of the increased atmospheric $\Delta^{14}C$ are based on variations in the carbon cycle, while the largest part (5/6) of the variations has to be explained by other factors. Glacial atmospheric $\Delta^{14}C$ larger than 700‰ cannot not be explained within our framework, neither through carbon cycle-based changes nor through variable ^{14}C production. Superimposed on these general trends might lie positive anomalies in atmospheric $\Delta^{14}C$ of ~50‰ caused by millennial-scale variability of the northern deep water production during Heinrich events and Dansgaard/Oeschger climate fluctuations. According to our model the dominant processes that increase glacial $\Delta^{14}C$ are a reduced glacial ocean circulation (+~40‰), a restricted glacial gas exchange between the atmosphere and the surface ocean through sea ice coverage (+~20‰), and the enrichment of DIC with ^{14}C in the surface waters through isotopic fractionation during higher glacial marine export production caused by iron fertilization (+~10‰).

Keywords: carbon cycle, ^{14}C cycle, ^{14}C production rates, glacial/interglacial, modeling, box model, radionuclides

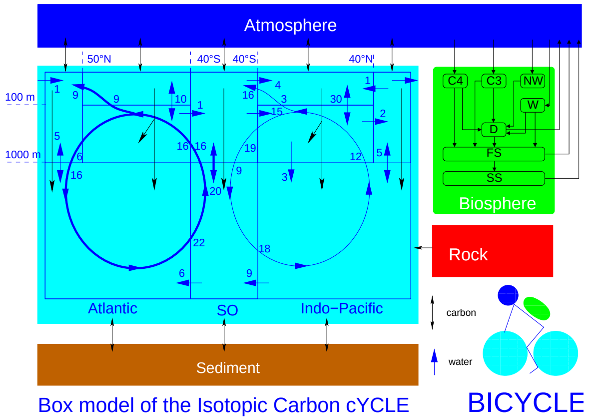
⇐ Forcing ⇓Simulation Results

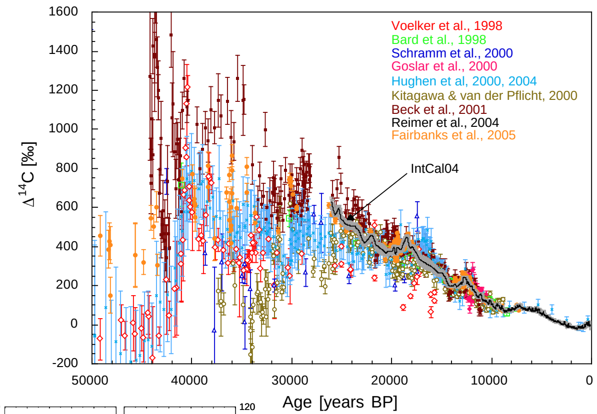




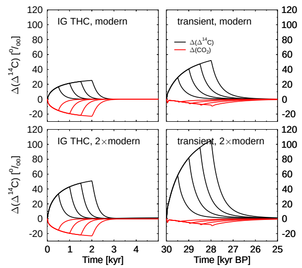
Left: Different data sets forcing the model (A: equatorial SST proxy, B: sea level; C: lysocline; D: northern hemisphere temperature; E: North Atlantic SST proxy; F: Southern Ocean SST proxy; G: dust input in Southern Ocean; H: Data and simulation results for pCO_2. **Right:** Simulation results. A: Process contribution to $\Delta(pCO_2)$; B: pCO_2; C: Process contribution to $\Delta(\Delta^{14}C)$; D: $\Delta^{14}C$ with constant ^{14}C production rate.

Model — $\Delta^{14}C$ data — Results





Top: Data based reconstruction of $\Delta^{14}C$.



Top: Shutdown of the NADW from interglacial (IG) THC or transient experiments (30–25 kyr BP) with constant ^{14}C production rates (modern or 2 × modern level), length of shutdown: 500, 1000, 1500, 2000 years.

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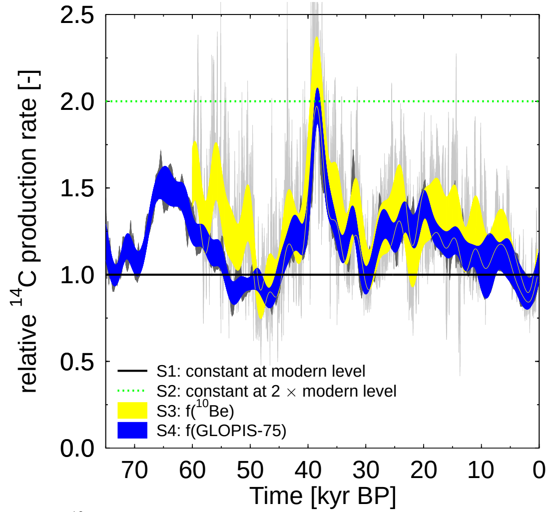
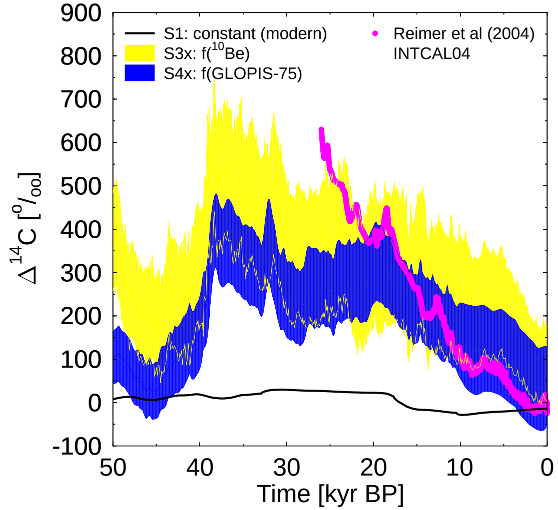
Variable ^{14}C production rates



^{10}Be from Muscheler et al. (2005) and GLOPIS from Laj et al. (2005). yellow/blue: 1/3000 yr^{-1} cutoff frequency.

Simulated $\Delta^{14}C$ based on variable ^{14}C production rates



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The content of this poster is published as Köhler et al. (2006) in GGG.

(Bard et al. 1998; Voelker et al. 1998; Goslar et al. 2000; Hughen et al. 2000; Hughen et al. 2004; Kitagawa & van der Pflicht 2000; Schramm et al. 2000; Beck et al. 2001; Reimer et al. 2004; Fairbanks et al. 2005; Köhler et al. 2005; Köhler et al. 2006; Muscheler et al. 2005; Laj et al. 2005)

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