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Climate of the Past

Supplementary Material

Cosmogenic nuclide production in the Earth's atmosphere and the strength of the geomagnetic field are highly correlated (Laj et al., 1996). The weaker the geomagnetic field, the more cosmic rays enter the atmosphere and the more ^{14}C is produced. Here we investigate how the model responds to varying ^{14}C production rates over the last 45 000 years.

In order to simulate atmospheric $\Delta^{14}C$, the equilibrium ^{14}C production rate is diagnosed from the control experiment. The resulting production rate (1.18 $\frac{\text{atoms}}{\text{cm}^2\,\text{s}}$) is then multiplied by the relative production rate, based on the GLobal PaleoIntensity Stack (GLOPIS-75, Laj et al., 2004) using the conversion of Masarik and Beer (1999).

The resulting simulated $\Delta^{14}C_{atm}$ (Fig. 1) shows a reasonable match with the reconstructed values during the Holocene. Prior to that, the model underestimates the reconstructed values significantly. Similar discrepancies have been observed in other modelling studies (Beck et al., 2001; Laj et al., 2000, 2002; Hughen et al., 2004). As yet, the reason for this proxy-model mismatch remains elusive.

One possible explanation would be a glacial deep-ocean carbon reservoir that is well isolated from the atmosphere and stores radiocarbon-depleted waters (Marchitto et al., 2007). However, reconstruction of deep Pacific ^{14}C do not support this hypothesis (Broecker and Barker, 2007). Another reason might be that the rate of deep-water formation in the North-Atlantic is too large in our model. However, model simulations forced by LGM boundary conditions or freshwater discharges into the northern North Atlantic only result in an increase of $\Delta^{14}C_{atm}$ by 70‰ due to the reduced deep-water formation (Marchal et al., 1999; Delaygue et al., 2003). Accordingly, it seems unlikely that a too high value of the oceanic overturning can account for the too low values of $\Delta^{14}C_{atm}$ in the model prior to the Holocene.

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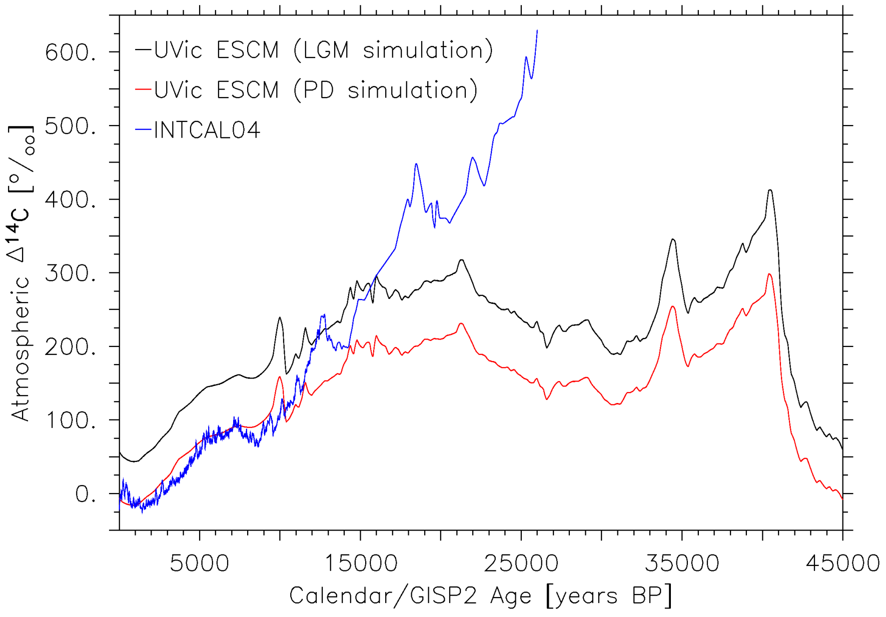

Fig. 1. Modeled atmospheric Δ^{14}C using the GLOPIS-75 based ^{14}C production rate (GISP2 age scale) and present day-like boundary conditions (red), last glacial maximum-like boundary conditions (black) and the Δ^{14}C curve based on reconstruction (blue, INTCAL04, Reimer et al., 2004).