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A model-based interpretation of low frequency changes in the carbon cycle during the last 120,000 years and its implications for the reconstrucion of atmospheric Δ^{14}C and the ^{14}C production rates estimates

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We use the ocean/atmosphere/biosphere box model of the global carbon cycle BICYCLE (Köhler et al., 2005) to reproduce low frequency changes in atmospheric CO_2 as seen in Antarctic ice cores during the last glacial cycle ($\sim$ 120,000 years) (Köhler et al., 2006). We force the model 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 with high accuracy ($r^2 = 0.89$). The processes that contribute most to the glacial/interglacial changes in CO_2 are variations in the sedimentation and dissolution rates of $CaCO_3$, ocean circulation, ocean temperature and glacial iron fertilization of the marine biota in the Southern Ocean. The BICYCLE model includes also calculations for the carbon isotopes ^{13}C and ^{14}C and we assess what changes in atmospheric Δ^{14}C might be based on variations in the carbon cycle. Our results suggest that during the last glacial cycle in general less than 120$^o/_{oo}$ of the increased atmospheric Δ^{14}C are based on variations in the carbon cycle, while the largest part of the variations has to be explained by changing ^{14}C production rates. Processes acting on the global carbon cycle that increase glacial Δ^{14}C are a restricted glacial gas exchange between the atmosphere and the surface ocean through sea ice coverage, a reduced glacial ocean circulation, 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.

From the available $\Delta^{14}C$ data covering the last 50,000 years and our carbon cycle-based simulation results we can infer changes in the ^{14}C production rates, which are then compared with two other estimates based on ^{10}Be and geomagnetic field reconstruction. The agreements and discrepancies between these three independent approaches to estimate the ^{14}C production rates are discussed and highlight the limitations and possible uncertainties in all three approaches.

References:

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