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Three-dimensional radiocarbon modeling: A tool to assess glacial–deglacial radiocarbon chronologies

M. Butzin (1,2), M. Prange (1), G. Lohmann (1,2)

(1) University of Bremen, MARUM - Center for Environmental Sciences, Bremen, Germany (contact: mbutzin@marum.de),
(2) Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

A critical factor in radiocarbon dating is the spatial and temporal variability of marine ^{14}C reservoir ages. Although there is observational evidence for considerable changes of marine ^{14}C reservoir ages during the last deglaciation most ^{14}C chronologies have not included this effect. Here, we discuss a method to assess the evolution of marine ^{14}C reservoir ages during the last deglaciation by iterative numerical modeling. The basic idea is to infer atmospheric $\Delta^{14}C$ from existing marine reconstructions by back and forth model calculations. The iteration scheme starts with a prescribed atmospheric $\Delta^{14}C$ chronology derived from marine data assuming a certain inverse reservoir age correction, and uses a three-dimensional ocean circulation model to diagnose the corresponding evolution of marine $\Delta^{14}C$. If there are differences between model results and reconstructions, the atmospheric chronology is adjusted by applying a modified reservoir age correction, and the simulation is repeated using this new atmospheric ^{14}C input curve. The iteration stops when model results and reconstructions converge, which implies that atmospheric $\Delta^{14}C$ values and marine ^{14}C reservoir ages are consistent with marine reconstructions. An example considering marine ^{14}C data from the Cariaco Basin points to reservoir ages of about 200–700 years during the last deglaciation. Correspondingly, the simulations increase the variability of re-adjusted atmospheric $\Delta^{14}C$ by about $\pm$25 per mille, and increase the mysterious drop of atmospheric concentrations between 17.5 and 14.5 cal kyr BP.