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How well does radiocarbon record deep-ocean ventilation changes? A coupled climate model study of the last termination.

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Ocean circulation plays an essential role in Earth's climate and the global carbon cycle. A prerequisite for improving confidence in future climate projections is the accurate numerical modeling of past deep ocean circulation changes. Unfortunately our understanding of such changes in terms of transport pathways and transit times is impeded by ambiguities in data-based reconstructions which heavily rely on radiocarbon. Interpreting the evolution of the deep-sea radiocarbon signal is indeed far from straightforward since this evolution might result from individual or concomitant changes in atmospheric levels, air-sea exchange rates, and ocean circulation.

Here, we investigate how deep-sea radiocarbon ages scale to the actual ventilation timescales during transient experiments over the last termination.

For this purpose we take advantage of a set of transient simulations performed with the Max Planck Institute Earth System Model (MPI-ESM) including the newly developed adaptative bathymetry and river routing components. The experiments, starting at 26 ka BP, are constrained with prescribed time varying ice sheets and topography. Changes in ice sheet volume naturally result in freshwater surges which affect the Atlantic Meridional Overturning Circulation (AMOC).

Ocean radiocarbon is included in the model. The atmospheric ^{14}C follows the INTCAL13 reconstruction while the impacts of varying wind speed, sea-ice cover, and atmospheric CO_2 on air-sea exchange rates are explicitly included. The model also includes a set of age and dye tracers documenting the role of specific surface areas in the deep ocean ventilation as reported by radiocarbon and ideal age, respectively.

We investigate the sequence of events in the deep ocean during periods characterized by significant changes in the AMOC. We particularly focus on the potential departures of radiocarbon based ages and transit times from the actual ventilation time scales.