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The ocean radiocarbon reservoir age over the last termination and the calendar age uncertainty of marine samples: a sensitivity study with a coupled climate model

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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 is impeded by ambiguities in the data-based reconstructions which heavily rely on radiocarbon dating of marine samples. Central to this method is the knowledge of the reservoir age (the age difference between the surface ocean and the atmosphere). Concomitant changes in atmospheric levels, air-sea exchange rates, and ocean circulation have the potential to drive large temporal and spatial changes of this reservoir age over the deglaciation. However these changes are not well constrained by field evidence. In consequence large uncertainties affect the dating of main climate events. Model studies allow complementing field data while also providing the means of assessing the sensitivity to different processes.

Here, we investigate the sensitivity of the radiocarbon reservoir ages and reconstructed calendar ages 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) with interactive calculation of river runoff and automatic adjustment of model topography. The experiments, starting at 26 ka BP, are constrained with prescribed time varying ice sheets and topography in addition to variations of the Earth orbital parameters and reconstructed atmospheric greenhouse gases concentrations. Changes in ice sheet volume naturally result in freshwater surges which affect the global circulation and water masses distribution. 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.

Different ice-sheets reconstructions (ICE-6G_C and GLAC-1D) and model configurations (addressing vertical mixing, bathymetry and land-sea mask) provide a range of ocean responses. The impact on reservoir ages of uncertainties related to planktonic foraminifer species-specific habitat is also considered. Together with the suite of model states this provides a range of

reservoir ages over time. A calibration step allows then obtaining an estimate of the temporal evolution over the deglaciation of the time resolution of the radiocarbon dating method. Regional and global evolutions are examined and discussed.