The joint impact of ocean circulation and plate tectonics on the glacial South Pacific carbon pool

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To understand the whereabouts of CO_2 during glacials and its pathways during deglacial transitions is one of the main priorities in paleoclimate research. The opposing patterns of atmospheric CO_2 and $\Delta^{14}C$ suggest that the bulk of CO_2 was released from an old and therefore ^{14}C-depleted carbon reservoir. As the modern deep ocean, below ~2000 m, stores up to 60-times more carbon than the entire atmosphere, it is considered to be a major driver of the atmospheric CO_2 pattern, storing CO_2 during glacials, releasing it during deglacial transitions.

We use a South Pacific transect of sediment cores, covering the Antarctic Intermediate Water (AAIW), the Upper Circumpolar Deep Water (UCDW) and the Lower Circumpolar Deep Water (LCDW), to reconstruct the spatio-temporal evolution of oceanic $\Delta^{14}C$ over the last 30,000 years.

During the last glacial, we find significantly ^{14}C-depleted waters between 2000 and 4300 m water depth, indicating a strong stratification and the storage of carbon in these water masses. However, two sediment cores from 2500 m and 3600 m water depth reveal an extreme glacial atmosphere-to-deep-water $\Delta^{14}C$ offset of up to -1000‰ and ventilation ages (deep-water to atmosphere ^{14}C-age difference) of ~8000 years. Such old water masses are expected to be anoxic, yet there is no evidence of anoxia in the glacial S-Pacific.

Recent studies showed an increase of Mid Ocean Ridge (MOR) volcanism during glacials due to the low stand of global sea level. For this reason, we hypothesize that the admixture of ^{14}C-dead carbon via tectonic activity along MORs might have contributed to these extremely low radiocarbon values. With a simple 1-box model, we calculated if the admixture of hydrothermal CO_2 has the potential to lower the deep Pacific $\Delta^{14}C$ signal.

We show that if the oceanic turnover time is at least 2700 years, an increased hydrothermal flux of 1.2 μmol kg^{-1} yr^{-1} has the potential to reproduce the extreme radiocarbon values observed in our records.