Interplay of physical and biological processes in the Southern Ocean and deglacial CO_2 variations

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The mechanisms that account for the increase of atmospheric carbon dioxide (CO_2) during the last deglaciation (~18 thousand to 11 thousand years ago) are still debated, with ice core evidence suggesting distinct phases of gradual, millennial scale increases and hiatuses, interspersed by three rapid, centennial scale jumps. It has long been thought that the Southern Ocean plays an important role because of its both physical and biological effects on the global carbon cycle. However, high-resolution Southern Ocean marine paleoclimatic records with age control sufficient to test the relevant hypotheses are still challenging to produce, holding back a comprehensive understanding of the relative importance of different processes. Here, we present new high-resolution deglacial records of radiocarbon and nitrogen isotopes recovered from uranium-thorium-dated solitary deep-sea corals from the Drake Passage. The unprecedented spatial and temporal resolution of these records enables us to capture the variations of the ventilation state of different water depths in the Southern Ocean and link them to the surface biological activity during the last deglaciation. These results suggest that physical and biological processes in the Southern Ocean were highly coupled during the last deglaciation. Most remarkably, we find that the centennial CO_2 rises at 14.8 and 11.7 thousand years ago were associated with major ventilation of the deep/intermediate ocean coupled with reduced efficiency of surface nitrate consumption, consistent with rapid release of oceanic carbon to the atmosphere. Combined, our results provide compelling evidence for connection between physical and biological processes in the Southern Ocean and atmospheric CO_2 variations during the last deglaciation, allowing a more nuanced understanding of the interaction between ocean circulation, biological activity, and the global carbon cycle.