

Millennial and centennial CO₂ release from the Southern Ocean during the last deglaciation: A bottom-up approach

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As a critical region regulating air-sea gas exchange, the Southern Ocean has important implications for past atmospheric CO₂ changes. However, proxy data evidence is sparse to evaluate the Southern Ocean's role in affecting past air-sea CO₂ exchange due to longstanding challenges in obtaining carbonate materials to reconstruct surface conditions in this region, especially for areas south of the Polar Front where deep/intermediate waters form.

To circumvent these challenges, we propose a bottom-up approach where Southern Ocean surface-water conditions can be constrained by those of deep waters. We demonstrate that paired deep-water carbonate system variables (e.g., carbonate ion-nutrient-oxygen) can be used to derive quasi-conservative tracers (e.g., DIC_{as} and PO₄*) which allow us to constrain surface water air-sea CO₂ exchange and nutrient utilization conditions in the Southern Ocean. Application of this approach reveals distinctive features in Southern Ocean CO₂ outgassing on both millennial and centennial timescales during the last deglaciation. Combined with models, we explore mechanisms underlying the associated CO₂ releases.