Poleward shift in the Southern Ocean westerlies synchronous with the deglacial rise in atmospheric CO_2

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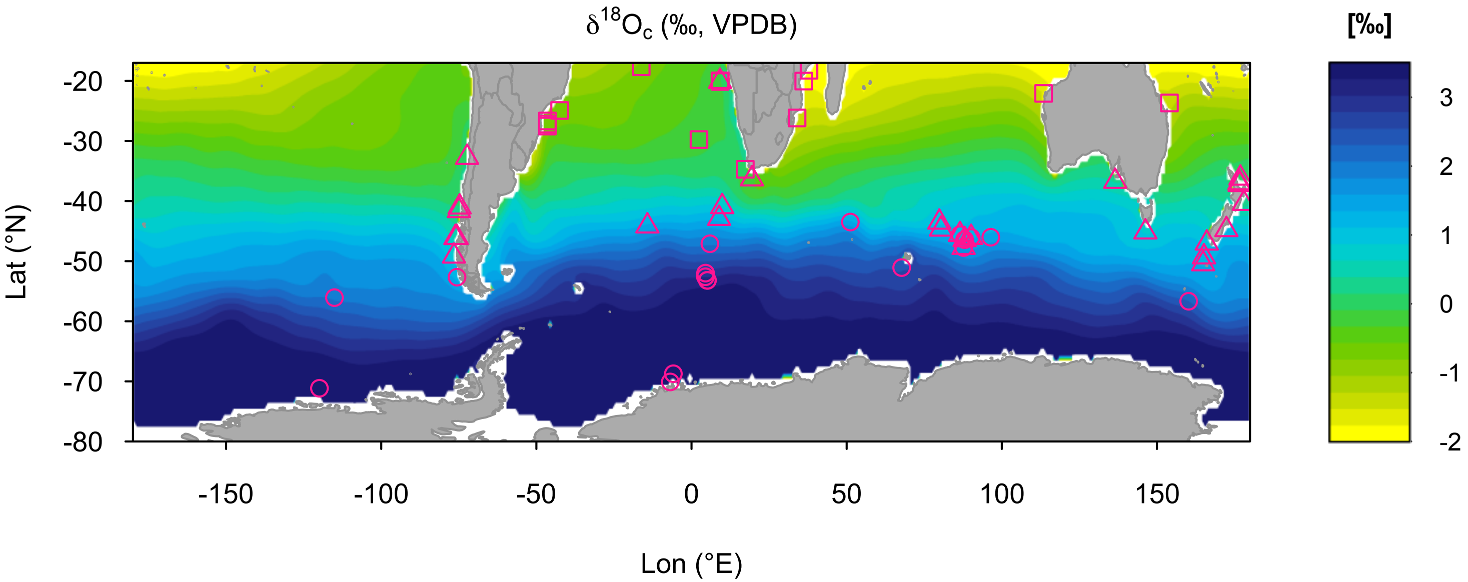


Fig.1 sites used in this study overlaid on modern climatology of $\delta^{18}O_{calcite}$

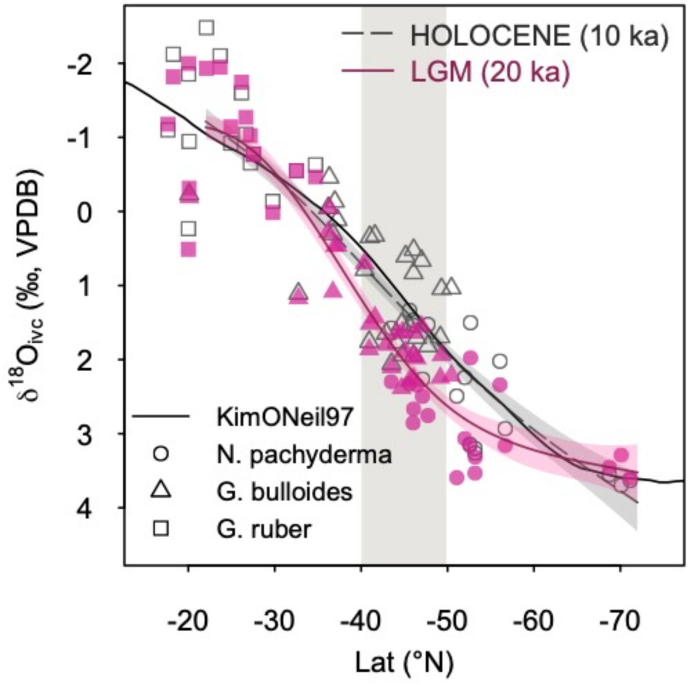
The Southern Ocean westerly winds have long been hypothesised to play a role in driving the glacial-interglacial cycles in atmospheric CO_2 (e.g. Toggweiler et al., 2006); however, past changes in their position and strength have remained allusive.

At the basin scale, temperature dominates over $\delta^{18}O_{water}$ (~salinity) in determining the spatial pattern of $\delta^{18}O_{calcite}$.

We can thus use meridional profiles of planktic foraminiferal $\delta^{18}O$ to track changes in the latitude of the maximum meridional SST gradient, which is dynamically linked to the position of the westerly winds (Gray et al., 2020).

this is preliminary/unpublished work

Methods We compiled 60 Southern Ocean records of planktic $\delta^{18}O$ spanning the last deglaciation, including 6 new records. The data are corrected for the whole ocean change in $\delta^{18}O_{water}$ and mean surface ocean change in SST ($\delta^{18}O_{ivc}$), and modelled as a function of latitude at 100yr timesteps following Gray et al., (2020).



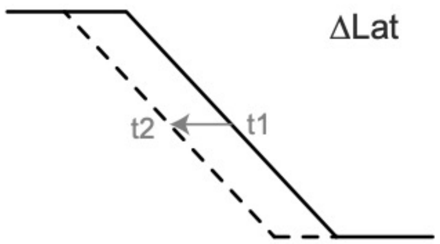


Fig. 2 Holocene and LGM profiles of $\delta^{18}O_{ivc}$ from all sectors of the Southern Ocean.

We calculate the change in position of the westerlies as the latitudinal shift that minimises the area between curves at different time steps within a specified latitudinal range (grey box above).

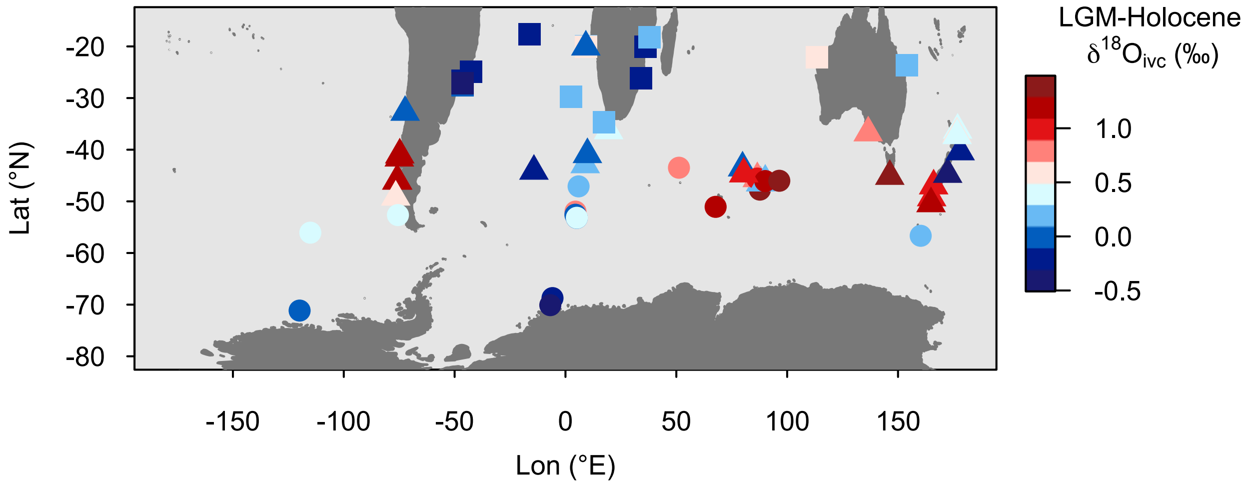


Fig. 3 LGM-Holocene $\delta^{18}O_{ivc}$ anomalies

The data indicate the westerlies shifted equatorward during the LGM. However, mapping the LGM-Holocene $\delta^{18}O$ anomalies shows the shift is only observed in the Pacific/Indian sectors, and no change is seen in the Atlantic

Effect of basin geometry restricting ACC movements?

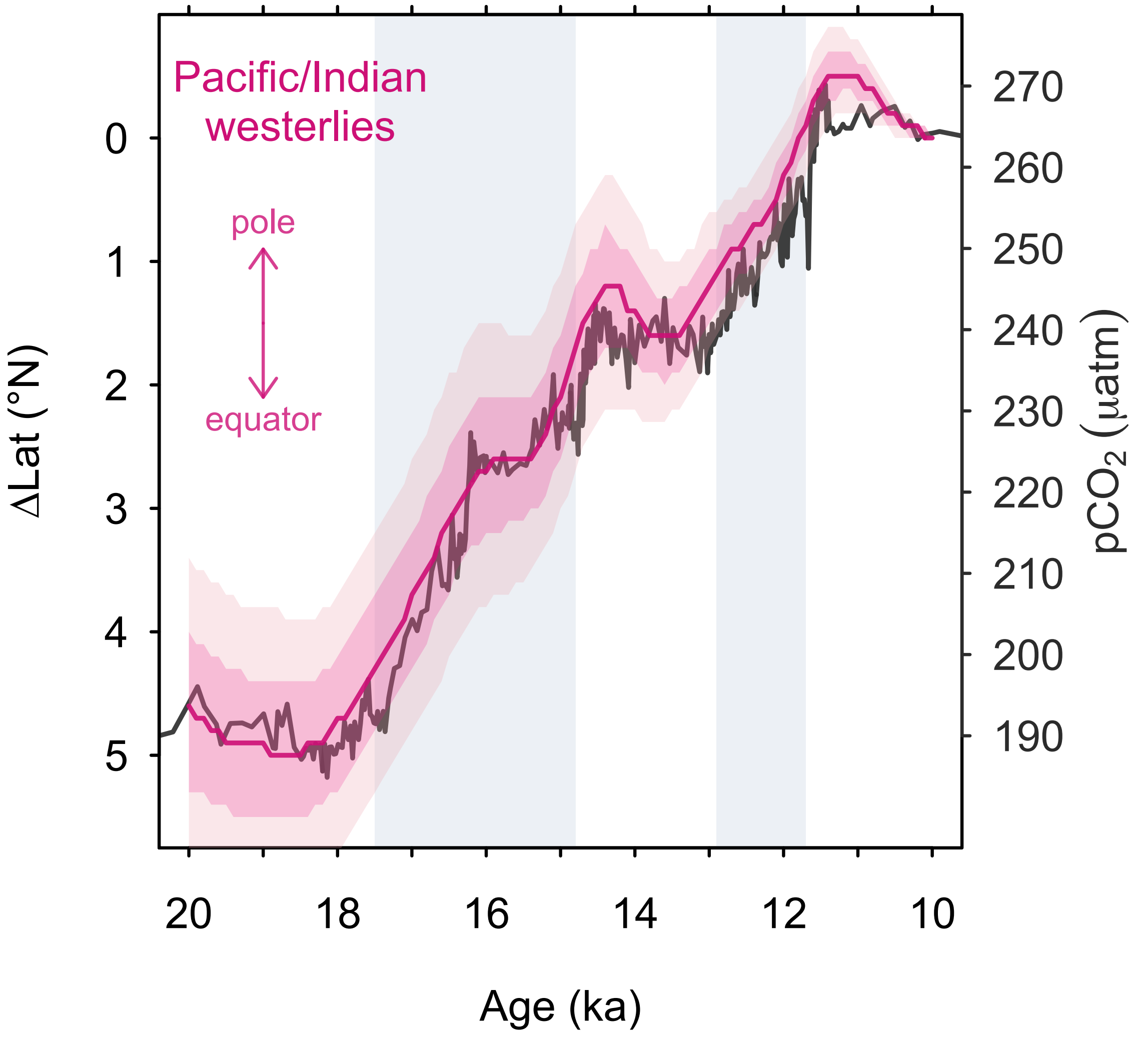


Fig. 4 reconstructed changes in the position of the Pacific/Indian westerlies (pink) and atmospheric CO_2 (black; Bereiter et al., 2005).

Our results show a ~5° equatorward shift in the position of the westerlies during the LGM (relative to 10ka) in the Pacific/Indian, but no significant change in the Atlantic.

Changes in the position of the Pacific/Indian westerlies show a tight coupling with atmospheric CO_2 over deglaciation.

The position of the westerlies may modulate CO_2 via it's influence on

i) sea ice extent, which controls both air-sea gas exchange and mixing in the deep ocean (Marzocchi et al, 2019)

ii) wind-driven upwelling

However, CO_2 may also influence the westerlies leading to a **feedback mechanism** (e.g. Toggweiler et al., 2006) which could help drive deglaciation.

advertisement for the North Pacific

If you like westerlies, please see our new paper looking at deglacial changes in the North Pacific gyre circulation and westerlies over deglaciation in GRL([Gray et al., 2020](#)).

Key points

- Planktic δ[18]O data indicate that the North Pacific subpolar gyre expanded southward by ~3° during the Last Glacial Maximum

- Climate models show that changes in gyre extent/strength are driven by a nonlinear response of the westerlies to ice sheet albedo/topography and CO_2

- Proxy data and model simulations indicate that the gyre boundary and westerlies began to migrate northward at ~16.5 ka, during Heinrich Stadial 1 driving changes in ocean heat transport, biogeochemistry, and North American hydroclimate.