Paleoceanographic changes in the Southern Ocean during Pleistocene glacial-interglacial cycles: Biomarker and dinocyst-based reconstructions

Lena M. Thöle[1], Francesca Sangiorgi[1], Henk Brinkhuis[1,2], Dirk Nürnberg[3], Peter K. Bijl[1]

[1]Marine Palynology and Paleoceanography, Department of Earth Sciences, Utrecht University, The Netherlands.
[2]NIOZ Royal Netherlands Institute for Sea Research, Den Burg, Texel, The Netherlands.
[3]GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany.

Expected Antarctic Circumpolar Current (ACC) and sea-ice dynamics on Pleistocene glacial-interglacials

- **Dynamics of the ACC** play a crucial role in the **delivery of heat to the marine-terminating Antarctic ice sheets**, yet large uncertainties in this relationship hamper **projections of future sea level rise**.

- Due to the **penetration of relatively warm Circumpolar Deep Water** (CDW) onto the Antarctic margin Antarctic ice shelves melt from below (**basal melt**), contributing to far more melting than at the surface due to atmospheric warming[1].

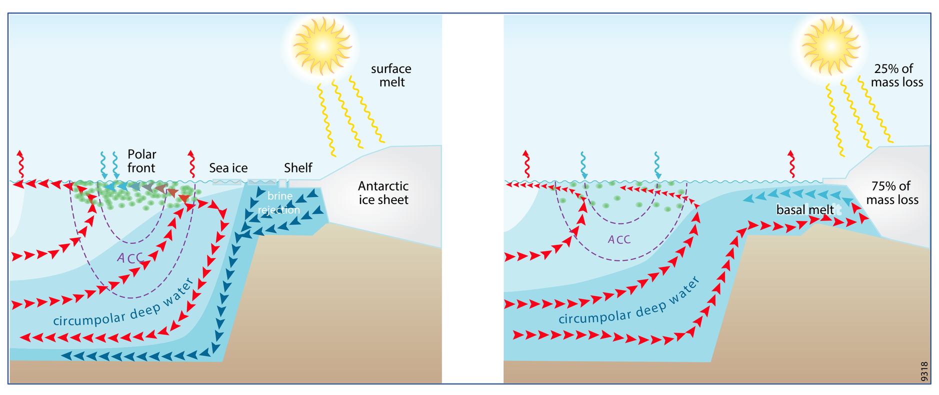

Figure 1: Conceptual cross-section of the Southern Ocean oceanography with and without sea ice.

- A better understanding of **changes in the strength and/or position of the ACC** may help to better estimate **upwelling intensities of CDW** and thus its influence on sea-ice and ice shelves.

Southern Ocean oceanography during late Pleistocene Glacial-Interglacials

- We aim to **reconstruct Southern Ocean latitudinal SST gradients, upwelling intensities and Antarctic sea-ice behavior** over late **Pleistocene glacial-interglacial** cycles.

- Although **boundary conditions and climate forcing are well-constrained** for this time period, large **uncertainties** remain about **latitudinal migration of ocean fronts**, the amplitude of **sea-ice extent and ice-proximal ocean conditions** offshore marine-terminating ice sheets.

- A main focus will lie on **terminations into interglacials** and their intrinsic dynamics. **Marine isotope stages (MIS) 5e and 11** are outstanding time intervals to be investigated and to be compared, given the **different orbital forcing and behaviors** of MIS 5e and 11[2].

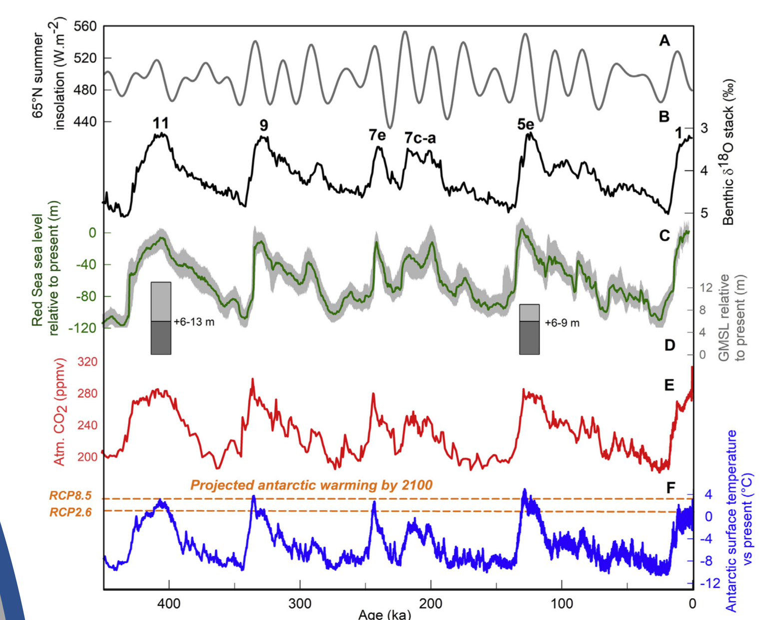

Figure 2: Key paleoclimatic records over the past 450 ka[3].

The "OceaNice" project

This **ERC project** aims at contributing to a **better understanding of past ice-proximal ocean conditions** in order to elucidate the interactions of ocean circulation dynamics and Antarctic ice loss and to **anticipate potential sea level rise under current and future climate change** conditions.

Proxy-proxy calibration for late Pleistocene surface ocean dynamics
SST, upwelling intensities and sea-ice

These findings will be integrated in **ocean circulation model simulations** → are you a **modeler?** Go talk to **Peter Bijl** for a possible **PostDoc position** ☺

Application to deeper time scales that show relevance for future atmospheric CO_2 concentrations → go see posters by Suning Hou and Frida Holm

Methods

- We apply **quantitative dinocyst assemblage-based** as well as **organic geochemical** proxies to reconstruct **SST, upwelling and sea-ice**.

- This will allow for **proxy-proxy comparison** of **SST reconstructions**, thus confirming results and/or **identifying possible shortcomings and biases** towards the interpretation of a single proxy.

- **Dinocyst assemblages** have proven to show a **strong affiliation** to ACC-associated **fronts, sea-ice proximity** and **nutrient conditions**.

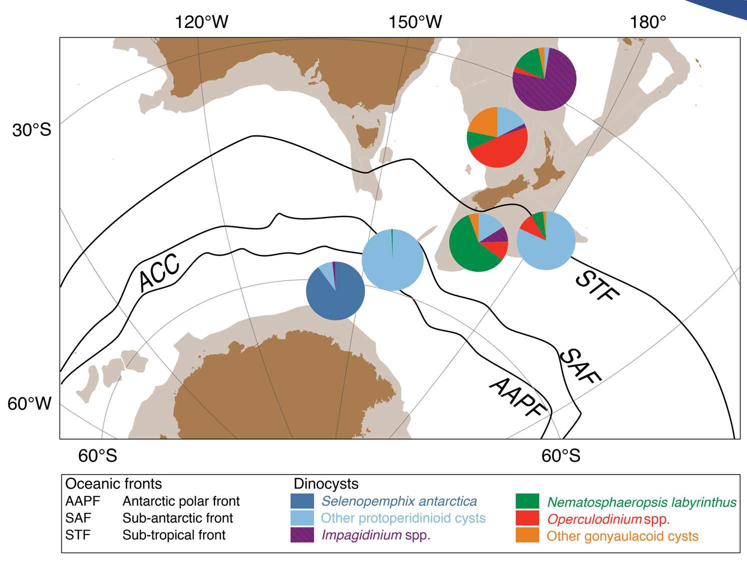

Figure 3: Modern dinocyst assemblages in the Pacific sector of the Southern Ocean[4].

- **Additional GDGT-based indices** such as the **BIT** help to further corroborate **TEX_{86}-based SST** results or recognize enhanced **terrestrial input**[5].

Dynamics in the Tasmanian Gateway

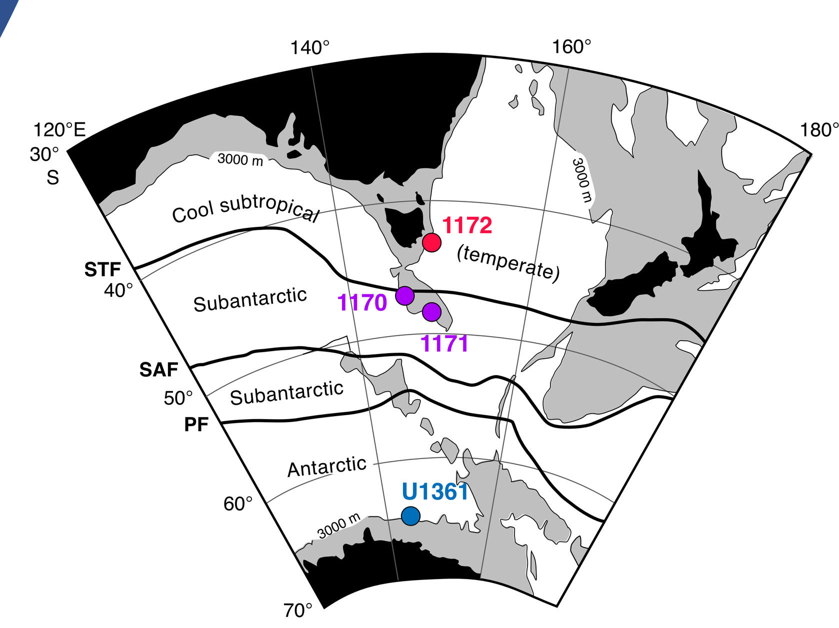

Figure 4: Core locations of ODP Leg 189[6].

- We revisit **ODP Site 1172 at the East Tasman Plateau north of the subtropical front** and ODP Sites **1170 and 1171 at the Tasman rise in the Subantarctic Zone.**

- **Previous studies** proposed a **very dynamic frontal system** over glacial-interglacials, with a general **equatorward shifts during glacials**, but **distinctly different responses**[7] during MIS 11, 9 and 5.

- As an **ice-proximal location** along this transect, we look at **IODP Site U1361** from the continental rise **offshore of the Wilkes Subglacial Basin**. We aim at further expanding on a recent study indicating **ice margin retreat and thinning during past interglacials**[8].

Challenges and Outlook

- We are confident that in open ocean conditions both of our intended proxies will lead to reliable results.

- Future projects include looking into dynamics at Totten Glacier and the South Atlantic (IODP Cruise 382).

References:

[1] Wouters et al. (2015), Science, 348 (6237), 899-903. [2] Jouzel et al. (2007), Science, 317 (5839), 793-796. [3] Capron et al. (2019), Quaternary Science Reviews, 219, 308-311. [4] Sangiorgi et al. (2018), Nature Communications, 9:317. [5] Schouten et al. (2013), Organic Geochemistry, 54, 19-61. [6] Exon et al. (2001), Proceedings of the Ocean Drilling Program, Initial Reports, 189. [7] Nürnberg et al. (2004), Climate Evolution in the Southern Ocean – Geophysical Monograph Series, 148. [8] Wilson et al. (2018), Nature, 561, 383-386.

Contact us: l.m.thole@uu.nl @lena_thole @UU_oceaNice