Climate of the Past Discussions

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Reply on RC2

Matthew Chadwick et al.

Author comment on "Compilation of Southern Ocean sea-ice records covering the last glacial-interglacial cycle (12–130□ka)" by Matthew Chadwick et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2022-15-AC2, 2022

Reviewer 2 Comments

We thank the reviewer for their supportive and constructive comments on our manuscript. Please see below, in bold, our detailed responses to their comments.

Chadwick et al. present a valuable paper on the sea ice evolution around Antarctica, based on diatom records from a variety of previous publications. The paper is generally well written, though there are a few points that need clarifying, in my opinion. I recommend publications after these points have been addressed.

Major comments:

- Using diatoms as sea ice proxies: given that diatoms reproduce in the spring/summer, I am wondering how one the main reconstructed variable from the proxy records is winter sea-ice concentration? I think it would be good to explain this in more detail in the methodology to understand the reasoning behind this notion.

Whilst the main flux of sea-ice diatoms to the seafloor does occur during spring/summer, Gersonde & Zielinski (2000) showed that sea-ice diatoms are being exported to the seafloor throughout the year, not solely during spring/summer. As the winter sea-ice melts during spring, nutrients and meltwater are released, creating a nutrient-rich stratified surface layer, which promotes the growth of diatom blooms, including many species that are seeded directly from the sea ice. Spring blooms of diatoms in this marginal ice zone produce the winter sea-ice signal in an assemblage averaged for an entire year. The greater the winter sea-ice concentration, the shorter the open ocean season between spring melt back and autumn refreezing. In this situation, open ocean diatoms are much less competitive than sea-ice associated diatoms because they lack anti-freeze proteins (Janech et al. 2006, Bayer-Giraldi et al. 2011). Increased relative and absolute abundances in sediment traps (Gersonde & Zielinski 2000) and surface sediments (Zielinski et al. 1998) have been observed southwards, along with increased sea-ice concentrations, as a direct response of the greater relative dominance of the marginal ice zone bloom compared to purely open ocean species in the annual assemblage.

The use of diatom assemblages to reconstruct past winter sea-ice concentrations

is robust and well documented in numerous published manuscripts and therefore a detailed explanation of the justification behind this proxy is not within the scope of this manuscript.

- There is a general confusion with how many records are in this compilation. The abstract says 24 sediment cores (+ one ice core). The Materials and Methods section says 28 sea-ice proxy records from 24 sediment cores [71], but later [75] refers to 27 sea-ice proxy records. Table 1 lists 24 sediment cores and one ice core, totalling 25 records. So which one is it? Please make this as clear as possible for the frustrated reader.

We have presented 28 sea-ice records from 24 sediment cores (some cores present sea-ice reconstructions through different approaches: both qualitative – *F. curta* group, and quantitative – transfer functions) and an additional record from an ice core. We agree the different numbers given can be confusing. We will provide a sentence to explain this and we will make the numbers more consistent throughout the paper.

- How comparable are the quantitative and qualitative reconstructions? With the NaCl in the ice core, would higher values not indicate more open water rather than more sea ice?

The quantitative and qualitative reconstructions in the sediment core records are largely similar in their patterns, as is shown in Figure 2. This is not surprising, as, for the quantitative sea-ice reconstructions, the transfer function output will be strongly (but not only) influenced by the abundance of sea-ice diatoms and so should show strong consistency with the qualitative FCC abundances. The qualitative reconstruction from the EDC ice core is slightly less comparable to the sediment core records, as the Na_{ss} flux record has different sensitivities to sea-ice changes (see review in Thomas et al. (2019)). Na_{ss} flux is also a more integrated signal than marine records as the source area of precipitation/particles reaching EDC, in our case, encompasses the whole Indian Ocean (Delaygue et al. 2000). This is a point that we discuss in lines 195-200.

The sublimation of salty snow from the sea-ice surface is a major source of sea-salt aerosols to Antarctic ice cores, more so than bubble bursting in the open ocean (Yang et al. 2008, Frey et al. 2020). Therefore, increased concentrations of Na_{ss} relate to a greater extent of yearly sea ice.

Minor comments:

[lines 26-30]: sea ice is also a crucial habitat for Antarctic organisms, add this information to the paragraph

We will add this information.

[30-35]: model simulations struggle with the internal variability (stochastic nature) of the sea ice system

We will add this information.

[40] linked to

We will amend this.

[74] data ARE – data = plural

We will amend this.

[326] 'heavy sea ice' – please clarify

We will amend this to persistent or long duration to clarify.

Bayer-Giraldi M., Weikusat I., Besir H. & Dieckmann G. 2011. Characterization of an antifreeze protein from the polar diatom Fragilariopsis cylindrus and its relevance in sea ice. *Cryobiology*, 63 (3): 210-219.

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