

Review: New isoprenoid GDGT index as a water mass and temperature proxy in the Southern Ocean

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This manuscript presents a new index and calibration for GDGTs based on surface sediments in the Southern Ocean. The authors used PCA biplots to determine the main factors that influence the GDGT distribution. Furthermore, they used the new index to correlate it with water temperatures at different depths and found the best correlation at 400m. In a last chapter, they compare their new calibration with previous calibrations on five sites in the Indian and Atlantic Ocean.

Overall, the article is good, especially the PCA analysis, and I appreciate the publication, even though I think the article needs a bit more work and reorganization.

1. The introduction lacks some important information about GDGTs. For example, that the number of rings decreases with decreasing temperatures, which becomes important later in the article. I also think it would be useful to include the current debate about whether the signal is a depth signal or a surface signal, as the type of calibration (SST or subST) has an enormous influence on the results. It should be noted here that this discussion has not been adequately addressed in the SO so far. Since the authors discuss depth in detail in the later part, I would even include this in the scientific question here.
2. I also believe that the authors should compare the indices (Figure S2) with subsurface temperatures. It is not surprising that satellite data, which only reflect the top few centimeters of the ocean (and thus the cold freshwater cover), show little correlation with the GDGT indices in the SO, which occur throughout the water column. If possible, I would add a second graph here showing that the already existing indices do also not correlate with subsurface data. In this context, you could refer to the data from Kim et al. (2012), which present a TEX86L subsurface calibration based on WOA09 data. Kim et al. (2012) <https://doi.org/10.1029/2012GL051157>
3. In the last chapter - when comparing all cores - the SSTs derived from satellite data are compared with the subSTs based on the new calibration. Based on the results that GDGTs reflect a subsurface signal there, the comparison is biased from the start. I recommend two articles (Kim et al., 2012 and Hagemann et al., 2023; <https://doi.org/10.5194/cp-19-1825-2023>), which also present a TEX86L-based subsurface calibration for the SO for a TEX86L based comparison instead.

Minor comments:

Line 34: add Reference Brochier-Armanet et al., 2008, who named the phylum of the *Thaumarchaeota* <https://www.nature.com/articles/nrmicro1852v>

Line 38: write isomere instead of regioisomere.

Line 81: Change last part of the sentence and add unit e.g., „In this zone, SSTs drop below 4°C with a salinity around ~34.0 **PSU**.”

Line 83: change: “with a salinity of” to “reaching near-freezing temperatures at a continuous salinity of 34.0 PSU”

Line 88: I would split the sentence, “but” is irritating -> “...extends from ~1400 m to >3500 m depth. South of the PF, CDW upwells ...” OR “...extends from ~1400 m to >3500 m depth, with upwelling of the CDW south of the PF ...”

Line 90: Just a general comment: the upwelling event might be driven mainly by the Westerlies (haven't checked out the Carter paper yet), but the general driver of the entire ACC are the Westerlies in combination with buoyancy forcing (Rintoul, 2018 <https://doi.org/10.1038/s41586-018-0182-3>), maybe you want to mention it.

Line 96: The “are also indicated” is unnecessary. I would simply delete them. Anyway, if it is possible, I would add the long version like “Subtropical Front” to the legend, behind the shortcut STF and delete them fully of the description. And then I would write instead the Figure capture as: “Bathymetric map with sediment core location and oceanic fronts analyzed in this study.”

Line 374: Why did you compared it with Kim 2010, which was a surface calibration and not with the subsurface calibration after you figured out that it is probably a subsurface signal?

Line 388: OPTiMAL derived SSTs of MD11-3351 look to me very noisy, especially during the glacial period, with temperatures compatible to LIG. This is not a typically G-IG pattern. I would add the wording “almost every site except MD11-3357, which shows temperatures during the glacial comparable to the Interglacials.”

Table 4:

- Generally, if you do a sediment surface comparison, it is better to use WOA05 or WOA09 since global warming has less impact on the surface temperatures there.
- The placeholder characters are irritating.
- Satellite-derived temperatures at 400m? Is that possible? As far as I know it is only the surface. <https://podaac.jpl.nasa.gov/SeaSurfaceTemperature>

If you have any questions, feel free to contact me.

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