Dear editor,

We thank the two anonymous referees for evaluating our manuscript. We are pleased to learn that both referees have found our work interesting. Their comments and suggestions helped us to improve the manuscript. Below are our replies to the referees' comments in blue. Page numbers mentioned here refer to the original manuscript published on Biogeosciences discussions.

Anonymous Referee #2

Referee's comments (RC) - The manuscript by Park et al. reports on seasonality of archaeal fluxes and GDGT- based thermometry in sinking particles based on two case studies in high latitudes. The study is based on material collected in sediment traps at different depths. This approach is complementary to the collection of surface sediments and offers the opportunity to study processes and mechanisms lying to the signal acquisition in the sediments. An interesting point is made on depths of production of OH-GDGTs. and the consequences on RI-OH thermometers. To conclude this manuscript address important issues in the paleo-proxy community and the new set of data presented is interesting. I therefore recommend the publication of this manuscript with minor revisions detailed below:

General comments

1. **Referee's comments (RC)** - A more throughout presentation of the errors associated with the temperature reconstruction based on the different indices and different calibrations should be discussed and provided.

   Author's responses (AR) - Global TEX_{86} calibrations are based on an assumption that major GDGT producers 'Thaumarchaeota' dwell mostly in surface waters and experience similar biogeochemical alterations crossed the global ocean. This greatly simplifies a diversity of ocean system. Next to analytical errors, seasonal and/or depth production of GDGTs or additional contribution of other archaeal community other than Thaumarchaeota can account for the calibration errors (Kim et al., 2010).

   The TEX_{86}^{L} calibration has a 4.0 ℃ of uncertainty (standard error of the estimate), which could be even larger than a magnitude of annual temperature variability in cold oceans (e.g. our two regions). As appeared in the eastern Fram Strait, the changes of TEX_{86}^{L}-derived temperature are largely controlled by the depth and time of GDGT production and sinking materials aggregated with GDGTs by time. Absolute estimated temperatures varied within the calibration error. In this case, the temperature error inherited from the calibration is less important than other relative changes. In the Polar Front, warm biases observed at deep traps were larger than the calibration errors, suggesting significant non-thermal effects on GDGT compositions or the unreliability of the global calibration in the region.

   To assess the analytical error, we analyzed a lab-internal sediment standard. The standard deviation of replicate analyses is ±0.01 units of TEX_{86}^{L} and 6 % for isoprenoidal GDGT concentrations.

   Author's changes in manuscript: We will add more statements regarding the differences between observed and reconstructed SST in the context of the analytical uncertainty and the calibration error as follow:

   (1) P2-Line13: 'Moreover, all TEX_{86}^{L} calibrations for temperature include a rather large scatter, resulting in a calibration error of, e.g., ±4℃ for the TEX_{86}^{L} calibration (Kim et al., 2010).' (2) Analytical error: The standard deviation of replicate analyses is reported in the section 'GDGT analyses'. (3) Calibration errors are given in the GDGT flux and indices section. (4) P11-L20: 'When the error of the TEX_{86}^{L} calibration (±4 ℃) is considered, the SST estimates are identical to the satellite-derived SSTs.' (4) P12-Line11: 'Warm and cold biases of the TEX_{86}^{L}-derived temperatures varied within the calibration error (±4 ℃) throughout the trap deployment period. It shows that the bias of the calibration occurs neither in one direction only nor to the same extent even at a given location, instead the temperature estimate is more affected by other processes discussed above.' (5) P14-Line16: 'In the eastern Fram Strait, the changes of TEX_{86}^{L}-derived temperature are largely controlled by the depth and time of GDGT production and sinking materials aggregated with GDGTs by time. Additionally, the absolute estimated temperatures varied within the TEX_{86}^{L} calibration error (±4 ℃). In this case, the temperature error inherited from the calibration is

less important than other relative changes.' (6) P15-Line23: 'Temperature residuals (~7 °C) in the deep trap, which are larger than the calibration error (±4 ℃), suggest significant non-thermal effects on GDGT compositions or the unreliability of the global calibration in this region.'

2. **RC** - Different processes of the production as well as the export of GDGTs are investigated in in two settings, even if the figures are already numerous, it would be interesting to provide the reader with a figure/sketch summarizing the mechanisms of production (seasonality/community or depth changes) and export (type of ballasts or timing) in the two settings.

   AR - We agree to have a figure or sketch summarizing all our findings. However, as you also noticed there are already 9 figures in the manuscript. We therefore chose to add a table (Table 2) rather than a figure. Additionally, we changed the format of Table1 to help the readers, who might want to compare Table1 to Table 2.

   Author's changes in manuscript: Table 1. is restructured. New Table 2 is inserted in the summary and discussion section. Tables can be found below:

Table 1. Information on FEVI16 and PF3 trap.

Trap name	FEVI16	PF3
Region	Eastern Fram Strait	Antarctic Polar Front
Location		
Latitude (° N)	79.02	-50.13
Longitude (° E)	4.35	5.83
Water depth (m)	2580	3785
Trap depth (m)	1296	614
		3196
Deployment period (dd.mm.yyyy)		
Start	23.07.2007	10.11.1989
End	30.06.2008	23.12.1990
Sampling interval (d)	10-31	21, 42*
Cruise reports	ARK-XXII/1c (Klages and Participants, 2007)	ANT-VIII/3 (Gersonde and Participants, 1990)
	ARK-XXIII/2 (Kattner and Participants, 2009)	ANT-IX/2 (Fahrbach and Cruise Participants, 1992)

*The exact sampling interval of each sample at FEVI and PF3 can be found on PANGAEA (https://doi.pangaea.de/10.1594/PANGAEA.897268).

Table 2. Summary of TEX_{86}^{L} thermometry in FEVI16 and PF3 site.

Trap name	FEVI16	PF3
Oceanographic setting	Seasonal ice cover	Winter ice edge
Main GDGT producers	Thaumarchaeota	Thaumarchaeota + Euryarchaeota
Surface ocean temperature	Satellite-SST[a]: -0.1 − 3.4 °C Ave. SST[b]: 1.9 °C	Satellite-SST[a]: 1.8 − 5.2 °C Ave. SST[b]: 3.5 °C
Shallow trap	TEX_{86}^{L} [c] T: 2.8 °C (30 − 80 m depth signal)	TEX_{86}^{L} [c] T: 4.6 °C (Thaumarchaeota + Euryarchaeota)
Deep trap	n.a.	TEX_{86}^{L} [c] T: 8.5 °C (Dominant Euryarchaeota)
Surface sediment	TEX_{86}^{L} T:2.3/2.8 at 2400 m	TEX_{86}^{L} T: 9.1°C at 3800 m
Relevant processes for GDGTs	- Export of upper ocean signal by fast settling particles - Highly ballasted with opal and carbonate - s.v. [d]: 15 m d^{-1}	- Contribution of Euryarchaeota in CDW[e] casing warm biases
Conclusions	- Linear calibration (TEX_{86}^{L}) applicable - Temporal offset due to changing ballast materials and s.v. - OH-GDGTs based calibrations applicable	- Linear calibration (TEX_{86}^{L}) unreliable - Nonlinear relationship between TEX_{86}^{L} and SST (>50° N) - OH-GDGTs based calibrations applicable

[a]Satellite-derived sea surface temperature
[b]Averaged surface temperature over the trap deployment period
[c]Flux-weighted average temperature over the trap deployment period
[d]s.v.: sinking velocity
[e]CDW: Circumpolar Deep Water