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Quantifying uncertainties in geochemical proxies ($U^{K'}_{37}$ and TEX_{86}) for seawater temperature

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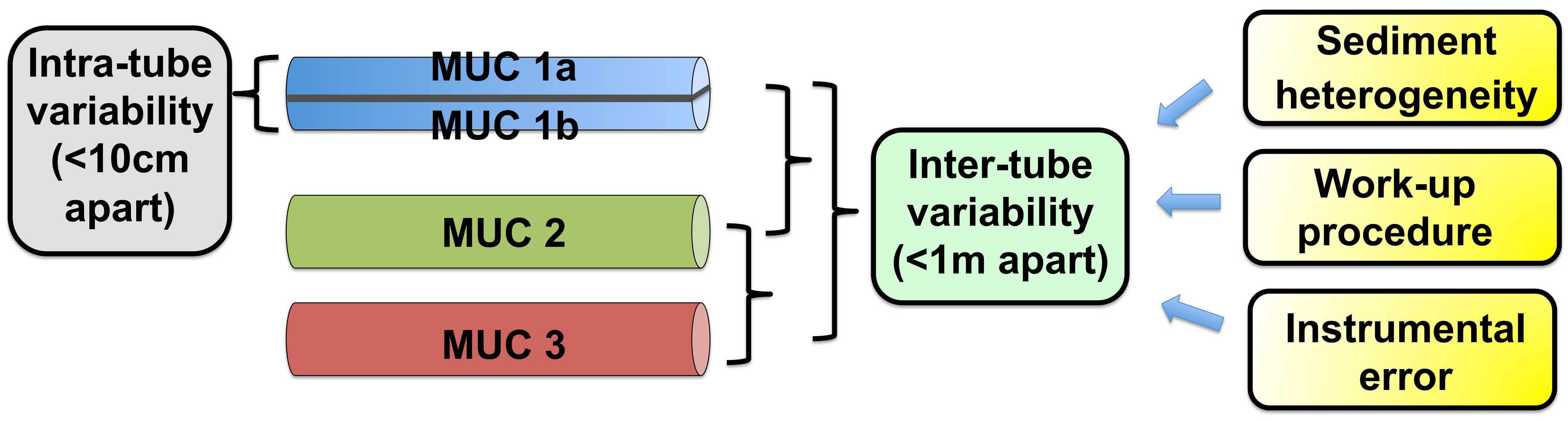
1. MOTIVATION

- Geochemical proxies such as alkenone-based $U^{K'}_{37}$ and archaeal glycerol dialkyl glycerol tetraethers (GDGT)-based TEX_{86} are often used for reconstructing sea surface temperature (SST) – but inherent noises in these proxies are not well studied.
- Comparing proxy records to model outputs for the Holocene climate show that proxy records are more variable – proxy is noisy or climate model is not sensitive?
- How well can $U^{K'}_{37}$ and TEX_{86} record Holocene climate variability?

2. APPROACH

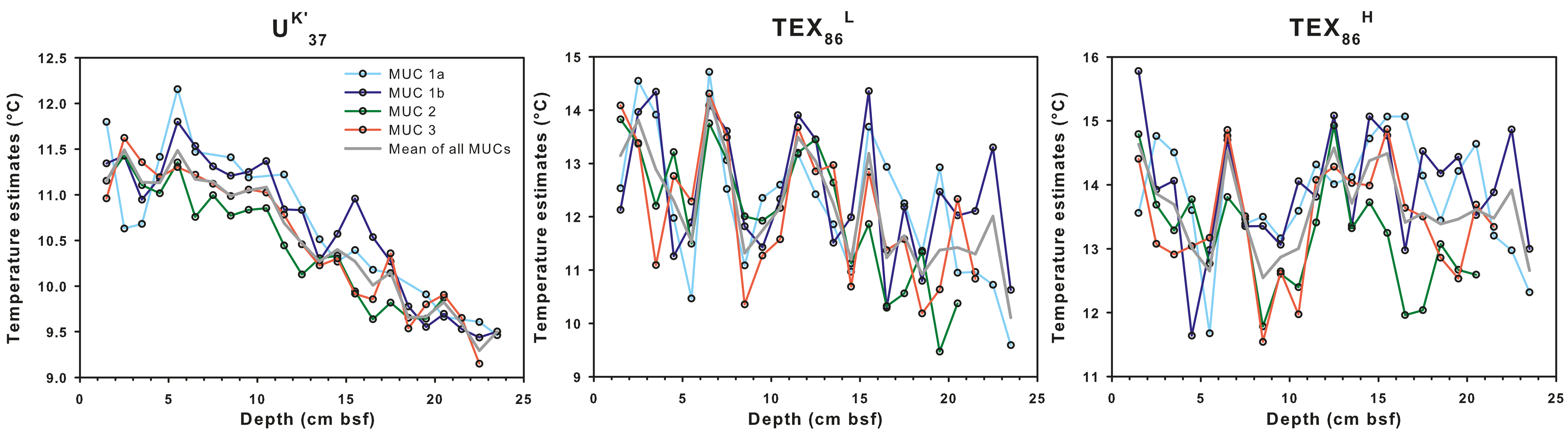


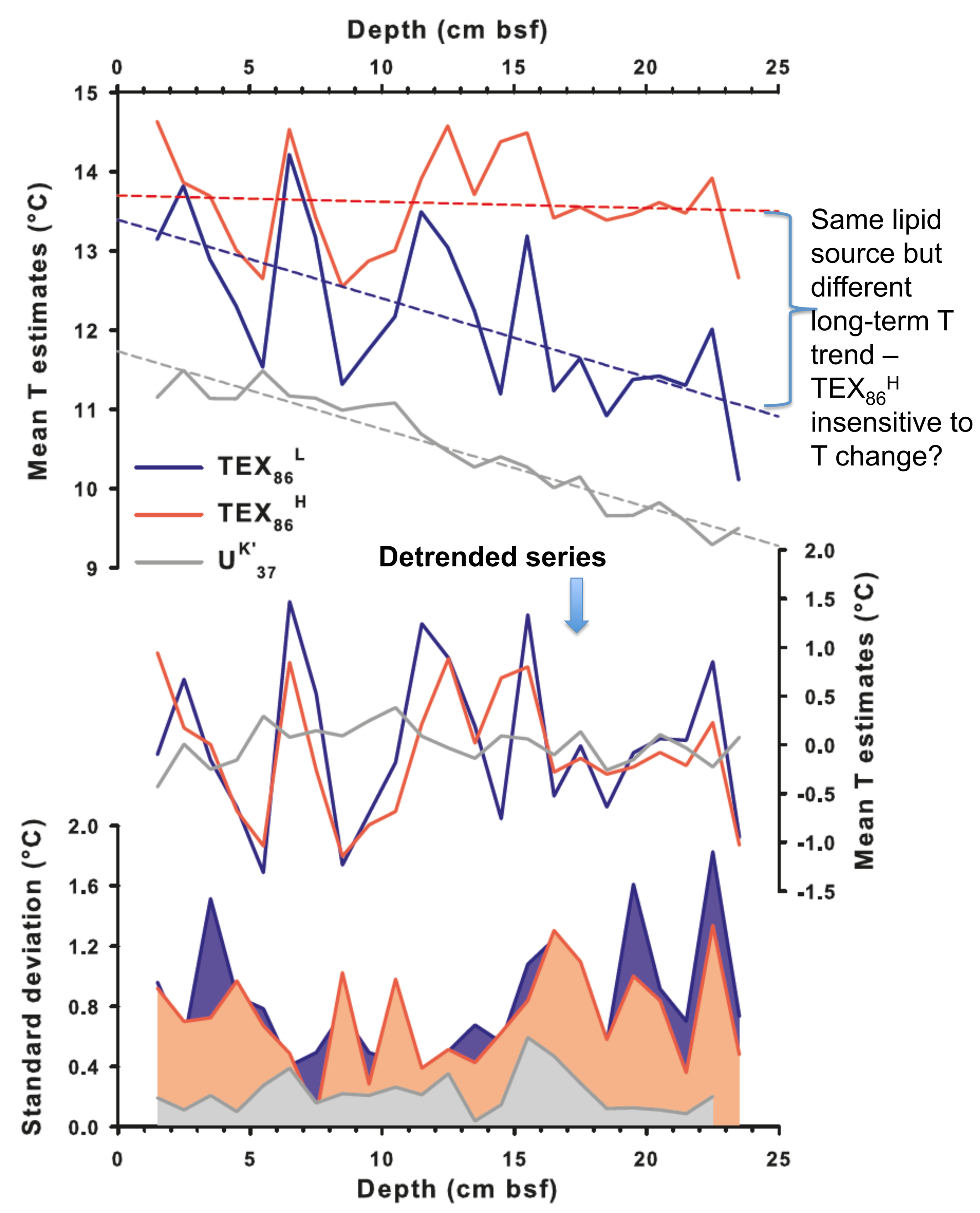
3. MATERIAL & METHODS

- We analyzed 3 multicores (MUCs) from the same deployment, retrieved off New Zealand (site SO213-84-2, 45°S 174°E, 991m water depth) during SOPATRA expedition.
- At the site, WOA09 annual mean SST = 11°C; summer SST = 14°C.
- Organic compounds were extracted via sonication (solvents (MeOH & DCM). Total extracts were partitioned into two fractions using open column SiO_2 chromatography
- Alkenones were quantified using a GC-FID. Instrumental conditions were as described by Müller et al. (1998). $U^{K'}_{37}$ values were calculated based on the index proposed by Prahl and Wakeham (1987), and converted into temperature estimates using the calibration of Prahl et al (1988).
- GDGTs were quantified using a HPLC-APCI-MS. Instrumental conditions were modified from Hopmans et al. (2000). TEX_{86}^{L} and TEX_{86}^{H} values, and temperature estimates derived from these indices, were calculated using the calibrations of Kim et al. (2010).
- Error by work-up procedure was estimated by mixing aliquots of sediments from the entire length of all MUCs, and separating them into ten replicate samples.

4. RESULTS & DISCUSSION

4.1. $U^{K'}_{37}$, TEX_{86}^{L} & TEX_{86}^{H}: Temperature estimates and residuals





- Our sediment records probably span the Holocene, judging from the sedimentation rate and two C^{14} dates of a piston core at the same site (T. Ronge, unpublished).

- $U^{K'}_{37}$ vs. TEX_{86}^{L} T records: In spite of differences in their short-term variabilities ($U^{K'}_{37}$-T records are smoother), the slopes of downcore T changes (long-term variability) for both proxies are similar → slope approximates Holocene T change?
- TEX_{86}^{L}-T vs. TEX_{86}^{H}-T records: Short-term variabilities are in agreement but the slope of T change differ significantly. Both proxies are based on the same source organism but TEX_{86}^{H} records no long-term climatic trend.

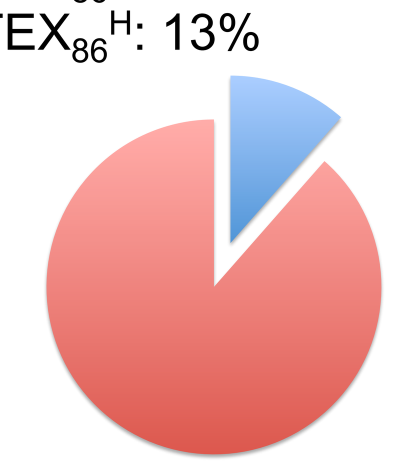
Correlations between residuals of proxies
(r^2 value; Original series; Detrended series)

	Intra-tube	Inter-tube
$U^{K'}_{37}$ vs. TEX_{86}^{L}	0.06 (0.06)	0.05 (0.05)
$U^{K'}_{37}$ vs. TEX_{86}^{H}	0.00 (0.00)	0.03 (0.04)
TEX_{86}^{H} vs. TEX_{86}^{L}	0.29 (0.28)	0.33 (0.35)

- Residuals of $U^{K'}_{37}$-T vs. residuals of TEX_{86}^{L}-T & TEX_{86}^{H}-T: no correlation suggests that the residuals are not due to heterogenous climate signals; and different underlying causes for the spatial variabilities (intra- and inter-tube) between alkenone-based $U^{K'}_{37}$ and GDGT-based TEX_{86}^{L} & TEX_{86}^{H} → different extent of mixing, seasonality in proxy signals?

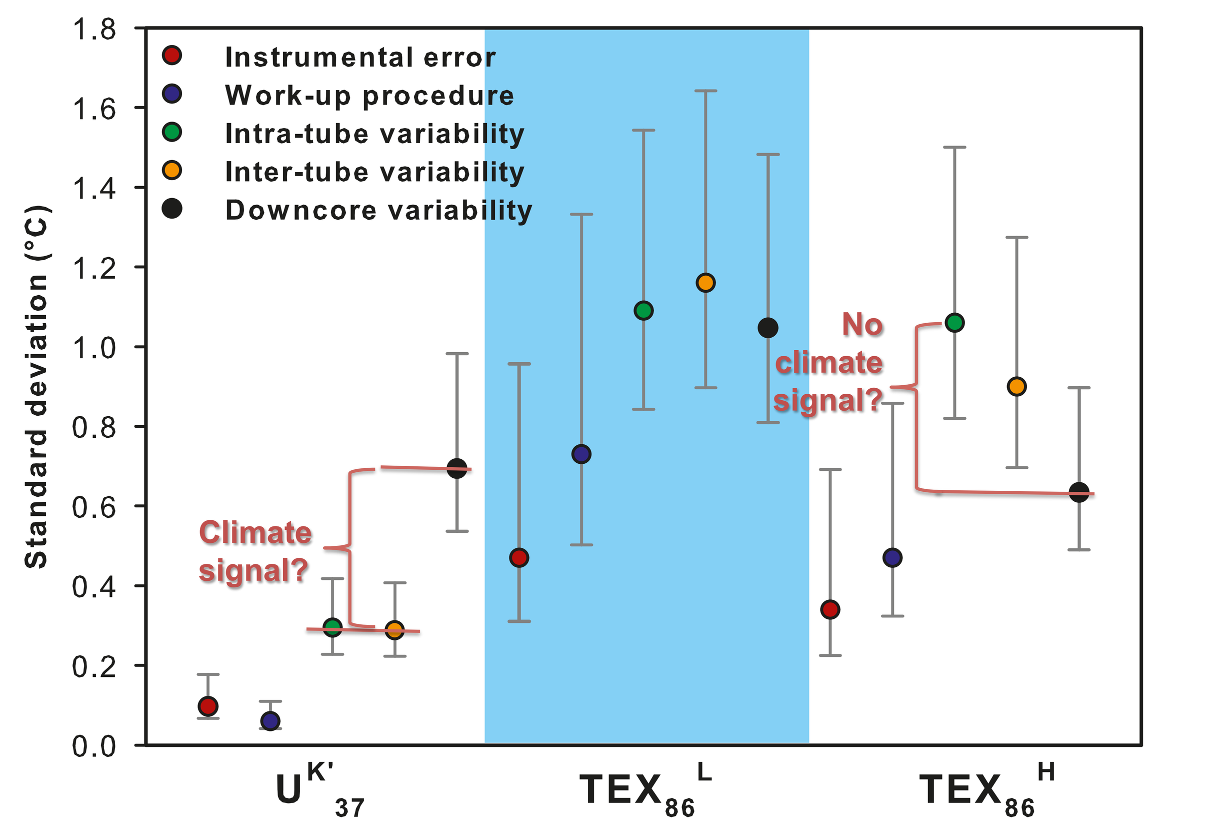
Contribution of spatial heterogeneity in proxy signal to standard error of calibration

- $U^{K'}_{37}$: 7%
- TEX_{86}^{L}: 8%
- TEX_{86}^{H}: 13%



Standard error in proxy calibration
($U^{K'}_{37}$: 1.1°C, TEX_{86}^{L}: 4°C, TEX_{86}^{H}: 2.5°C)

4.2. Climate signal or proxy noise?



- Spatial variability > work-up procedure error due to heterogeneity of proxy source (lipid) in sediments.
- Intra-tube variability ≈ inter-tube variability; no differences in lipid heterogeneity in sediments within radius <10cm and <1m.
- The mean spatial variability in $U^{K'}_{37}$-T, i.e. 0.3°C, agrees well with the $U^{K'}_{37}$ reproducibility of Laepple and Huybers (2013; see poster P-088).
- Downcore variability ≈ spatial variability in TEX_{86}^{L}-T despite similar long-term trend as in $U^{K'}_{37}$–T → wiggles are climate signal or noise?

5. Implications & conclusions

- **Spatial heterogeneity in proxy signal**: TEX_{86}^{L} > TEX_{86}^{H} > $U^{K'}_{37}$. This suggests that compared to alkenones, GDGTs are more "patchy" in sediments.
- **Signal-to-noise ratio in proxy**: $U^{K'}_{37}$ > TEX_{86}^{L} > TEX_{86}^{H}
- **Estimate of Holocene climate variability**: $U^{K'}_{37}$ suggests **0.4°C**.
- **Substantial noise in TEX_{86}^{L}-T and TEX_{86}^{H}-T records** at our study site inhibits a robust interpretation of Holocene climate signals.
- Downcore long-term trends in organic proxies can also be due to a common factor that affects lipids (e.g. oxic degradation), hence independent inorganic proxies (**Mg/Ca foraminifera, faunal census counts**) are useful for further constraining climate signal (**ongoing work**)

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