# Subtropical warming in the Late Cretaceous inferred from clumped isotope paleothermometry

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The Late Cretaceous (ca. 73 to 66 Ma) represents an important analogue for global climate with elevated atmospheric $pCO_2$ (~400 to 800 ppm) [1], and anomalously low sea surface temperatures (SSTs) [2] [3]. However, the absolute magnitude of SSTs reconstructed from some climate proxies remains uncertain [3]. Carbonate clumped isotope paleothermometry has recently been used to reconstruct SSTs during the Cretaceous, and may ultimately help resolve some of these uncertainties [4]. We aim to expand the record of Late Cretaceous SSTs using a variety of marine invertebrate taxa at differing latitudes.

We present results from bivalve and gastropod fossils corresponding to two localities at approximate paleolatitudes of 10 °N (Kharga, Egypt) and 30 °N (southeast US). At 30 °N, we determined average SSTs from multiple taxa of 13.2 ± 1.8 °C in the Late Campanian, 17.0 ± 0.7 °C in the Middle Maastrichtian, and 25.1 ± 0.4 °C for the Late Maastrichtian. The six taxa from this region all exhibited strong agreement in their measured $\Delta_{47}$ values, and show an apparent ~12 °C shift in SSTs from the Campanian through the Maastrichtian. A single taxa from the site at 10 °N yielded a SST of 30 ± 2.5 °C for the Late Maastrichtian. Comparison of SSTs from the two sites implies a thermal gradient of roughly 5 °C between latitudes 10 °N and 30 °N, as compared to ~6 °C between the same modern latitudes (with a lower range at approximately 22 °C to 28 °C, respectively) [5].

The observed warming trend through the Late Cretaceous has been documented using other proxies, but precise magnitude was previously unconstrained [2] [3]. The SSTs we present are significantly cooler than those given by the $TEX_{86}$ proxy and may present an opportunity for new calibrations [3]. We address each of these results in the context of multi-proxy comparisons, informing general circulation models, and paleoclimate implications.

[1] Royer *et al*. (2012) *Geobiology*. **10**, 298-310. [2] Bowman *et al*. (2013) *Geology*. **41**, 1227-1230. [3] Linnert et al. (2014) *Nature Communications*. **5**, 4194. [4] Dennis *et al*. (2013) *Earth and Planetary Science Letters* **362**, 51-65. [5] NOAA Climate Prediction Center, http://www.cpc.noaa.gov