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Bivalve isotope records of seasonality from warm climate intervals during the Neogene, US Atlantic Coastal Plain

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The Mid Miocene Climate Optimum (MMCO: 15-17 Ma) and the Middle Pliocene Warm Interval (MPWI: 2.5-3.2 Ma) provides insight into a globally warmer world. During these warm climate episodes, relative to today, continental and oceanic configurations and atmospheric CO_2 levels were similar; sea and continental ice were reduced; and the continental interior was arid. Here we present isotopic records of marine bivalve shells (*Chesapecten* and *Mercenaria* spp.) to reconstruct seasonal variation across a latitudinal (∼27° to 37°N) gradient along the US Atlantic Coastal Plain during the MMCO and the MPWI.

We analyzed variations in annual shell growth, $^{87}Sr/^{86}Sr$, O, and C isotope ratios of *Chesapecten* and *Mercenaria* shells from MMCO deposits in Florida (Oak Grove and Chipola Fm) and Delaware (Kirkwood Fm) and MPWI deposits in Florida (Tamiami Fm) and Virginia (Yorktown Fm). During the Miocene and Pliocene *Chesapecten* were restricted to subtidal marine environments, and *Chesapecten* and *Mercenaria* shells were collected from the same horizons. Faunal assemblage data indicate that these formations represent the warmest intervals in this region during the Neogene. We used Sr isotope geochronology to confirm that both warm intervals were targeted. We estimated seasonal temperature variability from the O isotope time series assuming interglacial O isotope seawater values of -0.05 and -0.35 per mil for the MMCO (Florida and Delaware) and 0.96 and -0.5 per mil for the MPWI (Florida and Virginia) and accounted for latitudinal effects. Growth temperatures recorded in *Chesapecten* shells

during the MMCO from Florida ranged from 19.7-31.4˚C, and those from Delaware ranged from 13.3-26.1˚C. Growth temperatures from *Mercenaria* shells during the MMCO from Delaware ranged from 18.0- 34.4˚C. We propose that the equable, tropical conditions during the MMCO were the consequence of reorganization of atmospheric and oceanographic circulation. Models demonstrate that small changes in the position and intensity of the subtropical jet stream at low latitudes restrict the polar front jet stream to high latitudes. Repositioning and change in the intensity of the subtropical and the polar front jet streams would produce divergent jet streams and a double zonal wind pattern intensifying and warming the Gulf Stream. The enhanced meridional heat transport as a result of complementary atmospheric-oceanic processes would generate equable climate at low and mid latitudes consistent with the data presented here.

Like the MMCO temperature estimates, temperature recorded in MPWI shells from Florida lacked seasonal variability, as expected from low latitudes, with temperatures ranging from 15.6- 21.3˚C. *Chesapecten* and *Mercenaria* shells from the MPWI of Virginia recorded seasonal growth temperatures from 2.7-20.1˚C and 6.4-19.8˚C, respectively. These data are similar to modern temperatures at this latitude. These findings have important implications for paleoceanographic and atmospheric circulation during the MMCO and MPWI. Future work will include comparisons to bivalve isotopic records from cold climate intervals and modeling MMCO and MPWI climate along a latitudinal gradient.