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Mediterranean and subtropical Atlantic (Gulf of Cadiz) SST gradient from the Messinian Salinity Crisis to the onset of permanent glaciation in the Northern hemisphere

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Mediterranean Outflow Water (MOW) is symptomatic of changes in the hydrological budget of the Mediterranean, which impacts the Atlantic-Mediterranean connection. When the Mediterranean Sea is connected to the global ocean the very salty and dense MOW flows beneath the incoming Atlantic waters and into the deep North Atlantic through the Gulf of Cadiz. The intensity of MOW formation is in part governed by the temperature and salinity differences between the Mediterranean Sea and Atlantic Ocean. MOW is a notable source of salt to global-scale ocean circulation via deep-water formation and has the potential to influence global climate on long timescales. In this work we seek to compare surface water conditions in the Gulf of Cadiz to those in the Mediterranean Sea basin. We present an alkenone-based, sea surface temperature (SST) record from the recent IODP Expedition 339 to the Gulf of Cadiz reconstructing conditions between ~2.5 Ma and ~6 Ma. IODP Expedition 339 in 2012 was the first time the Gulf of Cadiz has been systematically drilled for scientific study. We combine these new measurements with alkenone SST determinations from Pliocene sequences outcropping in the Mediterranean. We show a comparison of the evolution of Pliocene SST gradients between the inflowing Atlantic waters and waters in the central Mediterranean. In the modern regime the sites presented in this work have comparable SST. Our data indicate that during the Pliocene, the surface waters of the Gulf of Cadiz and the Mediterranean Sea were as much as 7°C warmer than the modern average of ~19°C. Warmer conditions are to be expected during the Pliocene time period; however, the warming in this location is greater than previously suspected. The reconstructed temperatures show a ~1°C cooling for the Atlantic side of the Strait of Gibraltar from ~6 Ma to ~2.5 Ma which is the onset and intensification of permanent glaciation in the Northern hemisphere. Between ~2.5 and ~3.5 Ma the Mediterranean and Atlantic surface waters show comparable temperatures analogous to the modern gradient between the sites. Surprisingly, between ~3.5 Ma and ~6 Ma the Gulf of Cadiz remained warm and stable while the Mediterranean cooled rapidly resulting in a large ~3°C gradient. This shift corresponds to a time period when the Mediterranean Sea is largely devoid of sapropels suggesting a shift in hydrology. The absence of sapropels implies low freshwater input into the basin and the new SST data shows the added importance of temperature in inducing circulation changes in the Mediterranean. Altering the salinity and temperature gradient between the Mediterranean and the can change the characteristics of MOW altering its strength and path into regions of deep-water formation in the North Atlantic. Additionally, shift in the SST gradients may indicate strong cooling over Southern Europe, Middle East and Africa that is not reflected in the subtropical Atlantic.