Leaf wax $\delta^{13}C$ shows climatic precession control of C_4-plant expansion in the late Messinian Mediterreanean

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The expansion of C_4-plants in the Oligo-Miocene occurred at different times in different regions. While the photosynthetic pathway of C_4-plants is better adapted than C_3-plants to the cooler, more arid and lower pCO_2 conditions that characterize this period, expansion was also driven by evolutionary changes. Both of these are thought to influence the location and timing of local C_4-expansion, but disentangling the two is challenging. The timing of C_4 expansion in the circum-Mediterranean region is highly uncertain, with estimates ranging from pre-late Miocene to mid-Pliocene. We analyse leaf wax carbon isotopic compositions in combination with archaeal biomarkers from a late Miocene succession in SW Spain to investigate the timing and drivers of C_4 expansion in the Western Mediterranean.

The Sorbas Basin contains a succession of precessionally-forced marls of early Messinian age overlain by gypsum – marl alternations that span the onset of the Messinian Salinity Crisis (MSC) at the beginning of the late Messinian. Changes in the distribution of archaeal biomarkers confirm that in between the gypsum beds were deposited under relatively low (~normal marine) salinity conditions, indicating highly flucuating salinity. The isotopic composition of leaf waxes from these sediments indicate that before gypsum precipitation C_3-plants dominated the Sorbas catchment . In contrast, the gypsum-marl succession is characterized by large cyclic changes in n-alkane carbon isotopic compositions (~8‰), indicating dramatic shifts in the proportion of C_3-C_4-plants, with C_4 dominating during episodes of higher salinity and gypsum precipitation. The in-phase changes between catchment vegetation and basin salinity suggest that both are controlled by insolation-driven climate changes. Intriguingly, however, the vegetation response only occurs after the onset of the MSC, suggesting that this an environmental terrestrial response to the onset of evaportie precipitation.