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Freshwater forcing of eastern Mediterranean circulation and sapropel formation during Marine Isotopic Stage 11

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The hydrological balance and the resulting circulation regime of the Mediterranean are on orbital time scales tightly linked with the intensity and distribution of monsoonal precipitation over North Africa. In pace with the precession cycle, intensified monsoon rain is channelled by the Nile and from the North African borderland into the eastern Mediterranean, where it causes salinity stratification and disrupts the overturning circulation. The timing and intensity of these freshwater episodes, often connected with the deposition of sapropels, are correlated with orbital parameters, but this relationship is not straightforward and it remains to be established how exactly the magnitude of the freshwater signal in the eastern Mediterranean is related to orbital forcing. In this context, marine isotopic stage 11 (MIS 11), centred on 400,000 years ago, provides an excellent opportunity to study the behaviour of the freshwater signal under extremely low-amplitude insolation forcing. In this project, we generated new high-resolution isotopic and paleoenvironmental records across MIS 11 from ODP Site 964, ODP Site 969 and piston core GeoTü-SL96. The stable isotopic data generated in this project allowed us to unambiguously identify the position of Termination V and the MIS 10 glacial inception in all records. The resulting age model indicates that the position of the MIS11 sapropel (or sapropel equivalent) correspond to the second insolation peak of MIS11, as predicted by the African Monsoon Index model by Rossignol-Strick. The MIS 11 sapropel is associated with a short and distinct negative oxygen isotopic excursion, which is indicative of the presence of a significant freshwater discharge into the eastern Mediterranean at MIS 11, presumably from North Africa by enhanced monsoonal precipitation. This is interesting given the lower insolation forcing during MIS 11 compared to the Holocene. Remarkably, at ODP Site 964, the sapropel of MIS 11 is associated with a positive excursion of up to -1.8 ‰ in stable oxygen isotopes. Both the magnitude and the absolute values of the MIS 11 isotopic excursion at this site have no analog in the Holocene or in MIS5. A much more intense freshwater input during MIS 11 might be the reason for this large peak, but since the Ionian Sea is far from the Nile source region, it remains unclear where this large freshwater flux would have come from. Analysis of benthic foraminifera abundances in the three cores shows that the anoxia associated with the MIS11 sapropel was much less developed than during the Holocene, which is counter-intuitive to the apparently stronger freshwater forcing. In terms of Ba concentrations and Ti/Al and K/Al ratios, MIS 11 and MIS 1 are highly comparable for this core. This indicates a similar source of particulates and presumably also freshwater for the two time intervals: the southern monsoonal and fluvial systems (mainly Nile river discharge and perhaps Saharan river courses at that time).