Project: **970**

Project title: **TARANTO**

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In the past year, we continued working on the second paper and deepened the analysis of the model results. Our paper addresses the question of the potential limitations of the reconstruction of sea surface temperatures (SSTs) in the Mediterranean Sea based on sediment proxy records, a common transfer function method applied in paleo-climate studies. We use a high-resolution regional physical-biogeochemical ocean model which explicitly simulates the temperature signal recorded in organic matters from its origin in the connection with phytoplankton production to its preservation along with the detritus depositing on the sediment. The simulation from 1901 to 2010 provides interannual to sub-decadal data to evaluate the relationship between the spatial/temporal variations of sediment temperature proxy (SedT) and the upper ocean temperatures. We determine the five-year running mean of the yearly (monthly) sediment temperature signal taking into account the temporal variability in the sediment detritus flux (FwSedT). We use two approaches to construct the transfer functions: 1) A spatial (core-top) calibration, based on the regression between the modeled climatological SedT and the simulated sea surface temperature (SST). 2) A temporal calibration, based on the regression between FwSedT and the SST from our simulations for the period 1910–2010. The reconstructions were performed for both the annual mean SST(AnSST) and the winter SST, the latter defined as the March-centered seasonal mean in this study (MarSST).

To provide an independent validation of the reconstruction skill, we applied the transfer functions to simulated sediment records of the pre-industrial (PI) and Last Glacial Maximum (LGM) periods from Six et al. (2024). The reconstruction performance of the SST was quantified using the Nash–Sutcliffe Efficiency (NSE) metric, defined as follows:

$$NSE = 1 - \frac{\frac{\sum (T'_{rec}(t) - SST'(t))^2}{N}}{\frac{\sum (SST'(t))^2}{N}}$$

A high NSE value (close to 1) indicates that the reconstruction accurately captures both the pattern and amplitude of the observed (modeled) fluctuations. In contrast, a low NSE (approaching 0) suggests that the reconstruction error is comparable to the natural variability, meaning the prediction performs no better than simply assuming the climatology. An NSE below 0 implies that the reconstruction error exceeds the natural variability, indicating that the reconstruction of SST variability is worse than using the climatology. It is important to note that the NSE metric in use excludes the influence of systematic bias, effectively ignoring any mean bias present.

Figure 1 summarizes the reconstruction skills for AnSST and MarSST obtained from the two different transfer functions. The spatially based reconstructions show generally good skill in reproducing the pre-industrial SSTs across most parts of the Mediterranean Sea (Fig. 1a–b), whereby an even higher skill is calculated for MarSST than for AnSST. However, lower skills are observed in several localized areas, including the Gulf of Lions, parts of the Spanish and Algerian coasts, the Strait of Sicily, the Gulf of Gabes, the northwestern Ionian Sea, and the southwestern Aegean Sea across the Antikithira Strait. Overall, the spatially based reconstruction performs better for the pre-industrial AnSST than for the LGM. This is not the case for the LGM-MarSST, which shows a higher reconstruction skill for almost the entire Mediterrean Sea.
A similar improvement between AnSST and MarSST is found for the temporally based transfer function for both time periods. However, the temporally based transfer function performs less effectively than the spatially based method. Interestingly, the reconstruction skill for the temporally based AnSST is higher in the many of the above localized areas with poor skills for spatial based method, e.g. in the northwestern Ionian Sea. Overall, the spatially based MarSST reconstruction still exhibit the highest and most consistent skill among all methods tested. Furthermore, we find a generally higher skill if we base the reconstruction on subsurface

temperature than on SST (not shown). This highlights the role of subsurface production in modulating the relationship between sediment-derived and surface temperature signals. We are currently analysing these findings. The newly obtained results will be incorporated into the manuscript, which is planned for submission next year.

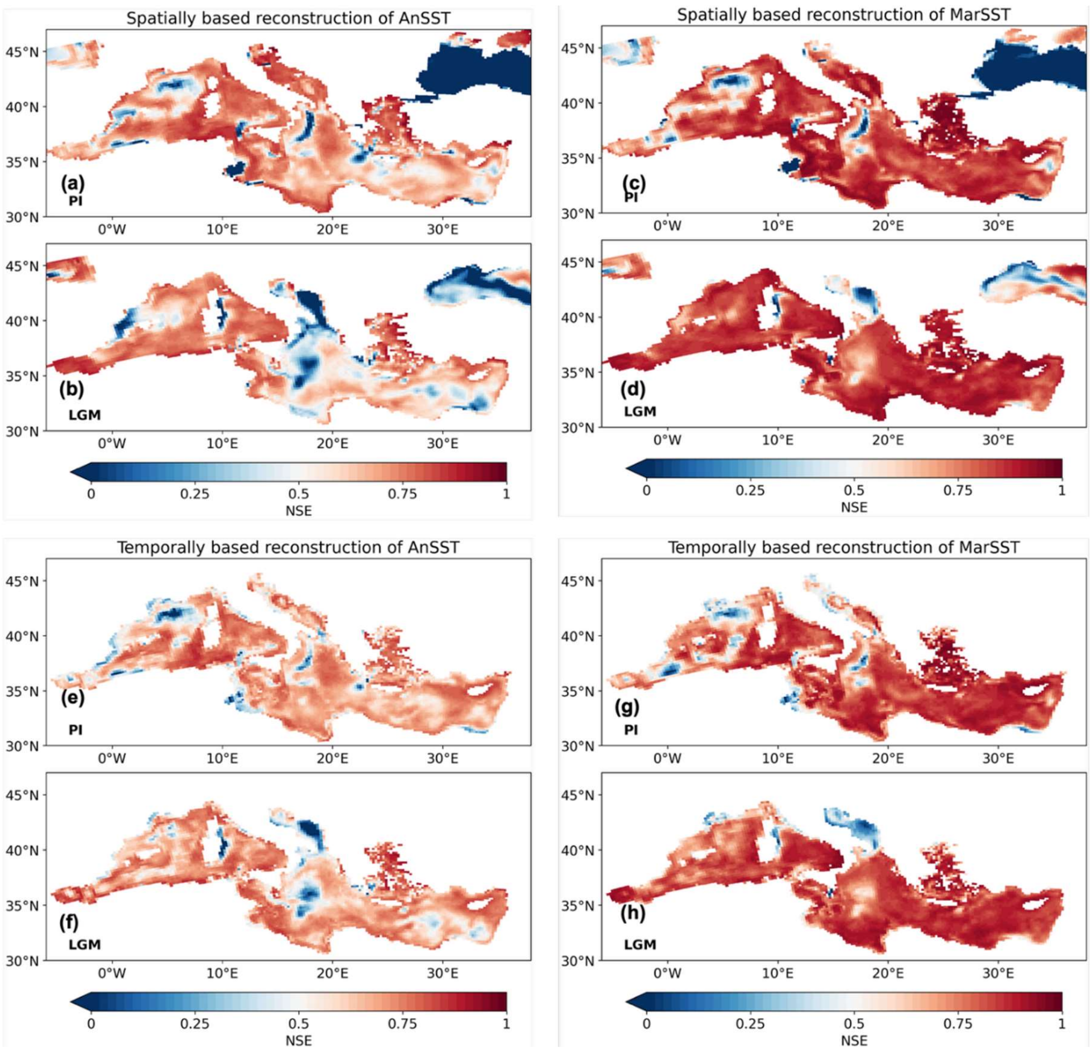

Fig.1 NSE based on the spatial regression for (a,b) the annual mean SST (AnSST) and (c,d) the winter SST (MarSST) for the PI (a,c) and the LGM (b,d). The same as (a)-(d) but for the NSE based on the temporally regression for the PI (e,g) and the LGM (f,h).

References:

Six, K.D., Mikolajewicz, U., Schmiedl, G. (2024) Modelling Mediterranean ocean biogeochemistry of the Last Glacial Maximum. Climate of the Past 20(8), 1785–1816, https://doi.org/10.5194/cp-20-1785-2024