Project: **970**

Project title: **TARANTO**

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The aim of our project is to understand the temporal variability of the Mediterranean ocean climate and its influence on marine biogeochemical processes with the regional focus on the area of the Gulf of Taranto, and how this variability is recorded in marine sediments. To achieve this goal, we combined proxy records (CEN, Uni HH) with an advanced physical/biogeochemical model (MPIOM-HAMOCC), which was described in the last report.

We have extended our analysis from the Gulf of Taranto to the Eastern Mediterranean Sea (EMed), and are preparing a publication. The underlying mechanism for decadal variability of the EMed, in particular the variability of the upper layer circulation in the Northern Ionian Gyre (NIG) has been identified. The impact of climate on biogeochemical cycles as well as the related sediment processes have been assessed.

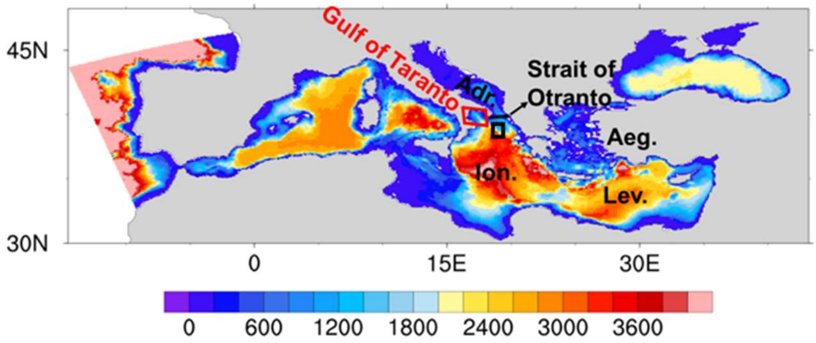

Fig.1 Model domain and the bathymetry (m). Adr: Adriatic Sea, Ion: Ionian Sea. Lev: Levantine Basin. Aeg: Aegean Sea. Red box is the Gulf of Taranto. Black box marks the area over which the zonal current velocity is calculated. The black line shows the Strait of Otranto.

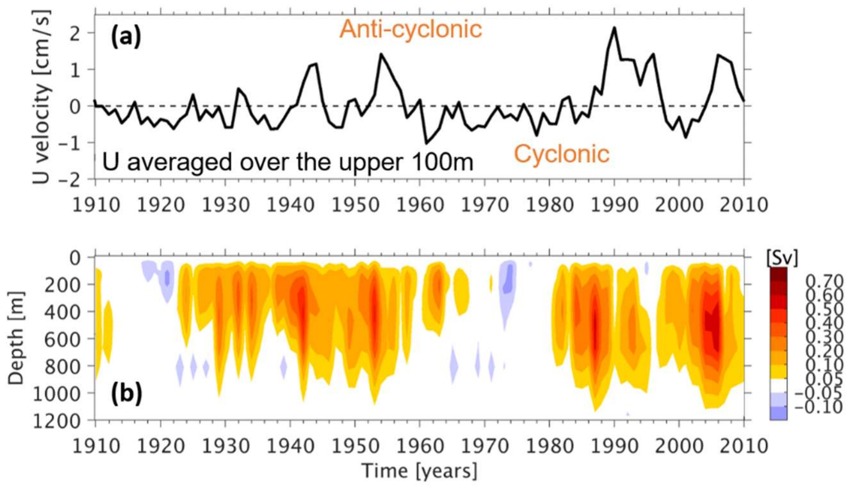

Fig.2 (a) Zonal component of the current velocity averaged over the upper 112m in the area denoted by the rectangle in Fig.1. (b) Time series of the meridional overturning stream function across the Otranto Strait (line in Fig. 1) during 1910-2010. Note the nonlinear spacing of the color bar.

The simulated variability in the EMed since the late 1980s, in particular the decadal reversal of the NIG circulation, is in good agreement with the oceanographic survey, which is described in Gačić et al. (2010). However, in the long run, the NIG circulation variability differs from the known pattern which is derived from the limited observations (since 1985 to present). One prominent feature is a 20-year long lasting cyclonic phase during 1960-1980, with only weak signals of reversal in particular years. The reversals of the NIG circulation is found in good coherence with the strength of the Adriatic Deep Water (AdDW) outflows (Fig.2). Further analysis verifies our hypothesis that cyclonic circulation is the background status in the NIG and that the occurrence of the anticyclonic mode can only be triggered by strong AdDW outflow events, which is also corroborated by the observed circulation reversal following the 2012 extremely cold winter (Gačić et al. 2014). The absence of the NIG circulation reversal during 1960-1980 demonstrates that internal processes alone, as was suggested in the literature based on the observational record, are not sufficient to explain the NIG circulation variability over the entire 20th century. Instead, the NIG circulation pattern can be linked to the large-scale atmospheric circulation pattern, e.g. NAO, as the variation of the freshwater flux of the Adriatic Sea is out of phase with the winter NAO index (Hurrell, 2003). During the negative NAO period, strong freshwater input to the Adriatic Sea hampers the process of AdDW formation and outflow, thus impeding the inversion of the NIG circulation from cyclonic to anticyclonic.

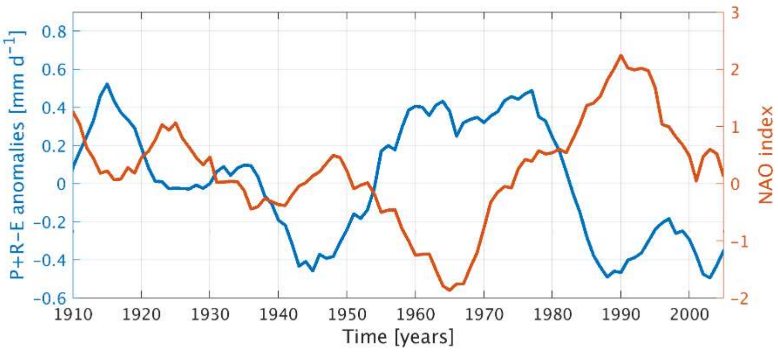

Fig.3 11-year running mean of annual mean fresh water flux (P+R-E) anomalies over the Adriatic Sea (blue line) and the NAO index in winter (orange line).

Within our model framework, we test the quality of the SST reconstruction skill from a synthetic temperature proxy in our sediment record. Therefore, we calculate the temporal correlations between temperatures recorded in sediment flux of detritus and the local annual mean SST and spring SST over the entire Mediterranean Sea. High correlations are found in wide areas of the Eastern Mediterranean Sea (Fig. 4), implying that the surface signal can be reconstructed with some confidence from the sediment records. In the Ionian Sea, the sediment tracer is rather recording spring temperatures than annual means, as the correlation is higher with spring SST (Fig.4b) than with annual mean SST (Fig.4a). This finding is in contrast to the standard assumptions used for temperature reconstructions from alkenones. However, in some regions the reconstruction does not work very well, even in the model framework, which simulates a perfect sampling. The reconstruction quality is generally low near the coasts and e.g. in the Tyrrhenian Sea. In the Adriatic Sea, the pattern of the quality of reconstruction is rather patchy. Local displacement of resuspended matter is the possible cause of such low correlations in these places.

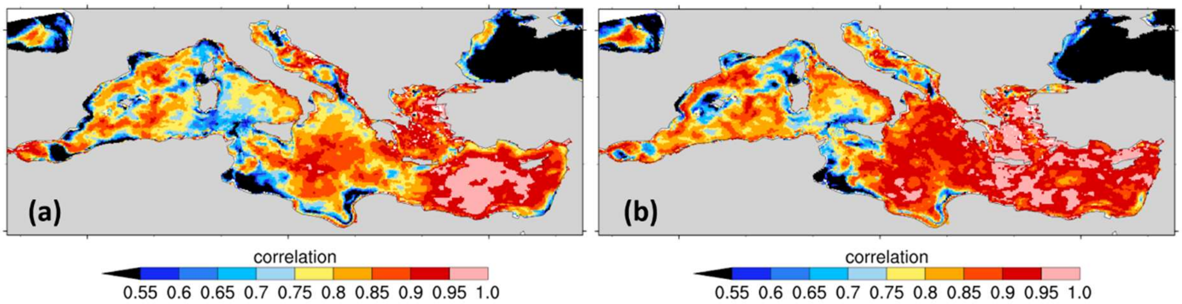

Fig.4 Spatial distribution of the time correlation coefficient between modelled 10-year running mean annual mean temperature tracer recorded in sediment flux of detritus and the modelled local 10-year running mean (a) annual mean SST and (b) spring SST in the Mediterranean Sea. Areas marked with black color has low correlations and are not statistically significant.

In summary, our analysis reveals that the variability of the EMed is influenced by climate variations through large-scale physical processes, e.g. the NIG circulation reversal is modulated by the AdDW outflows under large-scale atmospheric circulations (NAO). The temperature tracer allows for a direct comparison between model simulations with observations, showing a certain agreement between the modelled temperature recorded in sediment flux of detritus with the alkenone-derived SST in the core sites (Figure not shown). High correlations between the synthetic sediment temperature record and the local SST in many areas of the Mediterranean Sea indicate a good quality of the SST reconstruction skill by the sediment record. This synthetic sediment tracer can be further used to derive an improved transfer function for SST reconstruction.

References

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Hurrell, J.W., 2003. CLIMATE VARIABILITY j North Atlantic and Arctic Oscillation. Academic Press, Oxford, <http://www.sciencedirect.com/science/article/pii/B0122270908001093>.