

TEMPERATURE, HEAT CONTENT AND SEA LEVEL CHANGES IN THE WESTERN MEDITERRANEAN: LONG-TERM TRENDS AND NATURAL OSCILLATIONS

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Abstract

We analyze temperature, salinity and sea level time series in Málaga Bay, extending from October 1992 to October 2005, and series of temperature and sea level at L'Estartit, extending from 1974 to 2005. In both areas a warming trend is detected, but it is also observed a reversal during the initial years of the twenty first century. This reversal is just a fraction of the total accumulated temperature and heat content change in the case of L'Estartit time series not being able to obscure the general trend. Nevertheless it is different in the shorter Málaga time series. These results prevent from extracting conclusions from short time series as natural oscillations superimposed on long term changes can alter the results

Keywords : Global Change, Western Mediterranean.

Previous Works reported an intensification of warming trends in the Mediterranean Sea for the second half of the XX century, and an even more intense increase of these trends during the last decade of the XX century. Vargas-Yáñez et al [1, 2] reported an increase of an order of magnitude ($0.02^{\circ}\text{C}/\text{yr}$) for warming rates in continental shelf waters of the Málaga Bay (Alboran Sea) and this was coincident with a similar acceleration detected in the North western Mediterranean shelf waters [3], in Tyrrhenian deep waters [4] or in the main thermocline of the nearby subtropical North Atlantic [5]. These data suggested that the rate at which the sea was absorbing heat was continuously accelerating.

The analysis of updated time series extending to the end of 2005 has shown that these trends have been interrupted for the last part of the 90s decade and initial part of the XXI century, being also coincident with a recently interruption of warming at intermediate and deep waters in the Catalano-Balearic Sea due to severe winters during the first years of the twenty first century [6].

Temperature and heat content trends in Málaga bay have decreased considerably when considering the 1992-2005 period ($0.007^{\circ}\text{C}/\text{yr}$, 0.28 Wm^{-2}), if compared with those trends reported for the 1992-2001 period ($0.02^{\circ}\text{C}/\text{yr}$, 1.2 Wm^{-2}). It is important to note that temperature trends during 1992-2005 are only marginally significant and the heat content trend is not significant. In the case of L'Estartit, there is a 0.24 Wm^{-2} trend, being it significant, for the 1974-2005 period. Nevertheless we would get a heat loss of -0.4 Wm^{-2} if only the 1997-2005 was considered.

These changes have a clear influence on the thermosteric sea level. Although this is the result of the thermal expansion of the whole water column and it can not be calculated using only the upper 200 m (in Málaga Bay case) or 80 m (L'Estartit case) it is interesting to note that the heat content decrease in the initial part of the XXI century is coincident with an interruption of the sea level rise trend in both Málaga Bay and L'Estartit. Nevertheless, this reversal is just a fraction of the accumulated change and there is a $3\text{ mm}/\text{yr}$ trend when the 1974-2005 period is analyzed in the L'Estartit station. In the case of the Málaga tide gauge, where a longer time series is available (from 1943), we get a $0.9\text{ mm}/\text{yr}$ long term trend. This could suggest that as longer time series are analyzed, pentadal and decadal oscillations, as those evidenced in this work, are removed in the trend estimation, and real long term changes arise. On the other hand, it has to be taken into account that changes in the Mediterranean seem to be stronger than in the Atlantic, probably due to a higher thermal inertia of the latter. This is confirmed by a West-Est and up to bottom (Atlantic to Mediterranean) gradient observed in the trends estimated in the Málaga Bay grid of stations.

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