CLIMATOLOGICAL TRENDS FROM 32 YEARS OF OBSERVATIONS AT L'ESTARTIT STATION, NEAR THE CATALAN COAST (NW MEDITERRANEAN)

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Abstract

The air and sea temperature trends observed along the last 32 years and the evolution of the sea level during the last 15 years at a coastal station in the Western Mediterranean are presented. The results show a general temperature increase, especially during the spring period which implies an advancement of the summer conditions at sea. The evolution in the minimum annual values of the heat content in winter is related to the reported trends in intermediate and deep waters. Finally the net increasing trend in sea level is related with the thermal expansion due to the increasing heat content of the whole Western Mediterranean.
Keywords : Air-sea Interactions, Temperature, Time Series, Sea Level, Western Mediterranean.

Introduction

L'Estartit is a small town located in the northern Catalan coast, near the Gulf of Lions. Since August 1973 up to now, a station located 2.5 nautical miles offshore (42°N 03' N, 03° 15' 15"E), over a depth of 90 m has been sampled weekly (50-60 times per year) for temperature and salinity, at seven levels: surface, 5, 20, 35, 50, 65 and 80 m. Coastal meteorological data has also been recored during the whole period, and a continuous record of the sea level has been obtained since January 1990. A location map and complete description of all the measurements obtained, as well as the typical climatological annual cycle can be found in [1]. Although salinity remains almost constant around 38, it may decrease due to heavy rain episodes and the proximity of the Ter river mouth. The influence of the Rhone can also affect the surface layer salinity down to 25 m, by the end of spring. Thus, except at surface during those episodes, density is mainly driven by the temperature.

Temperature evolution

The interannual variability of the temperature cycle has been very high with differences in extreme values (annual maxima and minima) as larger as 6°C for air temperature, and 4 and 2°C for maxima and minima of the sea temperature, either at surface or even at 80 m depth. These differences are especially significative as the mean annual temperature oscillations for air, sea surface and 80 m are 12, 10 and 3°C respectively. The interannual variability of air temperature depends mainly on the general atmospheric circulation subjected to large scale cycles such as the NAO. Harmonic analysis carried out by [2] showed that there are typical periods from 3 to 5 years. The variability of sea surface temperature can be explained in general by heat exchanges with the atmosphere. By contrast, the variability at 80 m is more depending on the mixing mechanisms that drive surface heat to these depths, than on the surface temperature. Then, it is more influenced by the intensity of the autumn storms and how early they act.

From monthly averages and besides the interanual variability, all temperatures show increasing trends along the last 32 years. These trends can be considered quite robust given the length of the time series some times longer than the typical cycles [2]. However the trends are neither regular nor the same all along the year cycle. Dividing the annual cycle in seasons: Spring (April-June), Summer (July-September), Autumn (October-December) and Winter (January-March), we obtained the trends in Tab. 1. The table also contains the trend of the mean temperature (0-80 m), calculated from the data of all sampled levels, as a proxy for the heat conent of the water column.

One of the most interesting results is the tendency of the net heat gain represented by minimum of the sea surface temperature trend (0.011°C/year). This figure can be considered as the minimum trend of heating and corresponds to a net increase of 0.35°C during the period 1974-2005. This tendency coincides exactly with that observed by [3] from 1996 to 2004 at 600 m depth near the Balearic Islands.

The next outstanding result is that the most exaggerated trends are found during the spring period. They account for a net increase of sea surface temperature of 1.38°C at the end of the season along these 32 years. This result is especially relevant in the biological context because it contributes to bring forward the cycles of several species. To evaluate the advancement of the summer conditions we used the time when sea surface temperature reached 16°C, and we obtained a rate of 0.4 days/year, which is equivalent to 13 days within the whole period. This trend is still higher (0.56 days/year) if we consider a temperature of 15.5°C at 20 m depth.

Finally, this acceleration recorded on the spring phase has a consequence on the air-sea temperature difference (Table 1). In particular it has been found that since 1990 mean air temperature exceeds systematically that of sea surface during both April and May. This has implications on evaporation rates and hence on the spring precipitations over the coastal region, that have been reduced around 20%, in average, from 1974 to 2005.

Tab. 1. Summary of the relevant tempreature trends. Max. trend of sea surface temperature, for the stratified period, and min. trend for the mixing period are included.

Trends °C/year	Annual	Winter	Spring	Summer	Autumn
T. air	0.060	0.048	0.082	0.063	0.053
T. surface	0.034	0.020 0.011 (min)	0.043 0.060 (max)	0.033 0.049 (max)	0.034 0.025 (min)
T. 80 m	0.022	0.016	0.019	0.015	0.040
T. mean (0-80 m)	0.032	0.019	0.032	0.040	0.040
T. air - T. surf.	0.031	0.024	0.053	0.024	0.021

Sea level evolution

Sea level records are not so long as temperature (16 years) so that the observed trend (an increasing rate of 0.33 cm/year) is not as significant as temperature trends. The interannual variability of the sea level compensated from the effect due to the atmospheric pressure can be estimated in such a way that the result will be only depending on water expansion. This calculations gave a value of 0.28 cm/year, wich is lower than the previous but still important as it represents 4.2 cm in 15 years. If we take into account the increase of the mean temperature of the local water column (0.50°C), in Tab. 1, we obtain that the contribution of the local water column (0-80 m) to this expansion is 0.76 cm in 15 years. The remainder, 3.44 cm has to be attributed to the net heat gain within the whole Mediterranean. Assuming a mean depth of 2000 m the trend in the expansion accounts for a mean increase of 0.1°C in 15 years, which is equivalent to a rate of 0.0067°C/year. This figure is not far from the results that can be obtained by comparing recent data on deep water from those collected 20 years ago, in mid eighties: 0.12°C in 20 years; 0.006°C/year) [3]. Moreover this trend is slightly lower than the estimated rate of 0.01°C/year found at 200 m depth in several stations in the Western Mediterranean recorded in [2]. The series of compensated sea level also show some shifts, breaking the tendency, that are not correlated to any local event but with years of abundant Deep Water formation like 2005 [3].

References

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