Climatic variability in the Northeastern Mediterranean and Black Sea

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The general circulation of the Eastern Mediterranean has been the object of many research efforts. It is known to be dominated by important basin and sub-basin features such as gyres, jets, eddies, meandering currents reflecting its complex geometry, bathymetry and highly variable atmospheric forcing. Its seasonal and higher frequency variability and their regional dependence have been studied in sufficient details in number of studies (see Hopkins, 1978; Malanotte-Rizzoli and Hecht, 1988; Ozsoy et al., 1989). Yet, almost nothing is known about the eventual existence and importance of interannual variability, on time scales of decades or so, of the general circulation of E. Med. The recent interest on climatic oscillations and trends brings this subject to actuality, since the oceans should respond to changes in atmospheric forcing.

In this paper, we examine the low frequency variability, on time scales of decades or so, of coastal sea surface temperatures (SST) in the northeastern Mediterranean and Black Sea, and their eventual relation to atmospheric temperature (AT). Changes in SSTs, especially if they are not totally coherent all over the area, can be considered as an indication of changes in the density field, and therefore circulation.

The long-term variabilities were studied using monthly means of SSTs and ATs from 20 stations covering the Adriatic, Ionian, Aegean and Black Sea. The data were checked qualitatively for spurious spikes and unrealistic values. The common data set was formed for the period 1955 - 1984. The largest variance in both SST and AT time-series is contained in the annual cycle. In order to study longer term variability, the annual variations and other high-frequency signals having periods shorter than two years were eliminated by means of the 24m214 filter (Thompson, 1983).

The resulting time-series do show the existence of quite important variations of SST and AT inside the area during the study period. The main features of these variations are :

a.-Both SST and AT time-series in the Aegean and southern Adriatic Sea show a constant trend of decrease (0.5-1.0 deg.C.) from the early 1960's to the early 1980's. This trend is not however present either in the northern Adriatic or in the Black Sea.

b.-The Black Sea and, to a lesser extend, Aegean Sea AT and SST time series show two distinct periods with respect to the prevalent time scale of variability. The period from 1957 - 1972 is characterized by energetic oscillations at the time scale of about four to five years in which the SST and AT are well correlated. The second part of the records, however displays less energetic and regionally less coherent higher frequency oscillations. This distinction is found not to be evident in the Adriatic Sea.

c.-There exists, in general, a good positive correlation between SST and AT time series. This correlation seems to be best in the northern Adriatic, northern Aegean and Black Sea :

The Adriatic Sea may be divided into two main parts. The entire northern part represents the continental shelf and should display more energetic response to the atmospheric forcing and freshwater inflow. The southern part has a narrow shelf adjacent to the deep central area and is influenced by the interaction with the Ionian Sea and exchange through the Otranto Strait. The Aegean Sea may also be divided into two parts from the point of view of the meteorological and oceanographic conditions. The northern basin has a large continental shelf and its circulation is mainly governed by the inflow from the Dardanelles and cold outbreaks from the northern coast. The southern basin communicates with adjacent basins through the Cretan straits with the rest of the E. Mediterranean and is largely affected by its circulation. Finally, the Black Sea has very limited interaction with the rest of the region due to the fact that the Turkish Straits are narrow and shallow.

It seems therefore that the SST signal can be split in two parts: The local forcing (AT) and the horizontally advected (by currents) heat. This is very clearly seen in the Adriatic where as one moves from north to south (from Pula to Split and Dubrovnic), that is from the shallow and isolated north to the deeper and more open to communication south, the relation between SST and AT becomes weaker as a result of horizontally advected heat.

d.-A common feature of the southern Aegean (Iraklion), Ionian (Katakolon) and southern Adriatic Sea (Dubrovnik) is a strong SST decrease from 1975-1976 to 1980-1981 followed by the sudden increase of more than 1.5 C in a two-year period. This feature was not observed in AT time-series suggesting that it is related to oceanographic processes i.e. probably to the horizontal heat advection. This event, very well correlates with already observed similar decrease of the upper 50 m integrated salinity (~0.7 p.p.t.) in the Western Aegean for the same period followed by a sudden increase to original values in 1982, itself very well correlated with an inverse oscillation of the Aegean sea level (Lascaratos, 1989)

As a concluding remark, we can say that the present initial study has shown the existence of important long term interannual variability in SST's in the Northeastern Mediterranean and Black Sea, themselves an indication of possible changes in the surface density field on those time scales. The continuation of this work should include more atmospheric parameters such as atm. pressure, rainfall and wind and oceanographic parameters shuch as salinity and sea level.

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Large scale inversions in the North Levantine Basin

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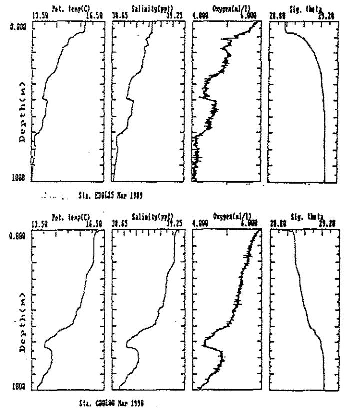
Measurements carried out by R/V Bilim during 1988-1990 in the north east Levantine basin show inversions associated with large scale intrusions of anamolus water masses at depths between 500-900 m. The thickness of the intrusions is between 100 m and 200 m, and they are observed primarily in the fronts between the Rhodes cyclonic gyre and the adjacent anticyclonic eddies. The measurements were taken with a SBE-9 CTD continuous profiling system. The temperature and salinity values of the intrusions differentiate them from the well known Levantine intermediate water (LIW). Both warm and cold intrusions have been observed. The warm water intrusions have relatively higher oxygen than the ambient water; the opposite is true for the cold intrusions. Examples of a warm and a cold intrusion are shown below. At station E30L25 (N34°30 ,E29°25), the intrusion layer is located between 500 m and 700 m; its temperature and salinity are higher by 0.2°C and 0.08 ppt, than the ambient. The intrusion at station G00L30(N36°,E29°30) extends between 600 m and 750 m, and its temperature and salinity are lower by 0.3°C and 0.1 ppt than the ambient. The potential density profile shows that the intrusions are hydrostatically stable.



The temperature, salinity and the oxygen content indicate that the cold intrusions result from lateral sliding of the upwellwing water of the Rhodes gyre towards the periphery of the gyre. The sources of the warm intrusions are the two anticyclonic gyres centered approximately at N34°E30°, and at N36°E30°30 . While the main intrusion layer is stable, Brunt Vaisla frequency plots show that the interface regions are unstable, implying a gradual mixing between the two water masses.