TEMPORAL CHANGES IN CHEMICAL PROPERTIES OF A WARM CORE EDDY IN THE LEVANTINE BASIN OF THE EASTERN MEDITERRANEAN SEA

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Recently a persistent quasi-stationary warm-core eddy has been found south of Cyprus in the Levantine basin of the eastern Mediterranean Sea. A series of nine cruises over a three-year period (1989-1992) was carried out to examine its physical and chemical structure (BRENNER *et al.*, 1990; KROM *et al.*, 1992, 1993). The eddy is characterized by an isothermal, isohaline lens of water wedged between the seasonal and permanent thermoclines. In the winter, this thermostad extends from the surface to a depth of nearly 400 m, while in other seasons it lies in the layer from 200-400 m. Similarly, dissolved oxygen and nutrient (nitrate, o-phosphate and silicic acid) concentrations at the eddy core are essentially constant during winter, from the surface to a depth of 550 m, while during summer, the concentrations are constant at the depth interval 150-550 m.

Temporal changes in temperature and salinity values at the eddy core indicated a process of renewal or replacement of the water trapped in the core of the eddy (BRENNER, 1993) and therefore we assumed that between February 1989 and March 1992 three different realizations of the Cyprus eddy were sampled. We examined the chemical characteristics of the core water during this time in order to check if the chemical parameters could be indicative of changes related to the proposed renewal processes. Each time when temperature and salinity increased, an increase in dissolved oxygen concentration followed, consistent with the fact that "new" water formed or flushed the eddy core (Table 1). During the period that the core was isolated from the surroundings, oxygen was utilized and the concentration decreased, increasing after the water renewal. It is therefore possible to see a cycle during the lifetime of a particular eddy. The increase in oxygen concentration indicates penetration of surface (or upper layer), oxygen rich water and not lateral penetration of water at the same depth as the core. Only during November 1989 we detected a deviation from this trend and saw a slight increase in dissolved oxygen.

The changes in nitrate concentration were consistent with those noticed for the dissolved oxygen, but not as "unequivocal". The beginning of the eddy cycle was characterized by a decrease in nitrate concentration, followed by an increase during the time that the core was isolated from the surrounding water. An exception is the nitrate concentration found during September 1989, lower than the values found in May and November 1989.

Assuming that: a) the core water is isolated from the surroundings during the lifetime of the eddy; b) all the addition of nitrate to the core during the eddy's lifetime is due to decomposition of organic matter and c) surface water with negligible amounts of nitrate intrudes the core to form a new eddy, it is possible to compare the changes in dissolved oxygen and nitrate concentrations in the core of the eddy. The difference between the average dissolved oxygen concentration found in the core of Eddy-08 and Eddy-09, was 8.1 µmole/kg (Table 1). Using Redfield's ratio of 138:16 for O_2:NO_3, the respective calculated amount of nitrate depletion is 0.94 µmole/kg. The decrease in nitrate concentration actually measured was 0.86 µmole/kg, a very good fit. The same comparison was performed for Eddy-06 and Eddy-07. The difference in dissolved oxygen concentration measured was 4.8 µmole/kg, corresponding to a calculated value of 0.55 µmole/kg nitrate. The measured decrease in nitrate concentration was 0.47 µmole/kg, again in very good agreement with the calculated value.

Ortho-phophate concentrations were expected to follow nitrate concentration. As a whole it is true except for an unexplained increase during April 1990. However, one must keep in mind that the ortho-phosphate concentrations measured in the core of the eddy are very close to the detection limit of the method (KROM *et al.* 1992, 1993).

Date	Cruise no.	Temp. °C	Sal ppt	O_2	NO_3	PO_4	$Si(OH)_4$
					µmol/kg		
5/88	02	16.44	39.08	222.8 (2.3)	0.55 (0.18)	0.008 (0.009)	1.55 (0.24)
2/89	03	16.43	39.15	220.0 (1.6)	0.57 (0.07)	<0.01	0.99 (0.06)
5/89	04	16.43	39.15	216.0 (0.9)	0.73 (0.10)	0.013 (0.004)	0.92 (0.06)
9/89	05	16.43	39.15	------	0.47 (0.34)	0.014 (0.009)	0.89 (0.27)
11/89	06	16.43	39.15	219.0 (1.6)	1.23 (0.35)	0.034 (0.015)	1.11 (0.36)
*4/90	07	16.68	39.27	223.8 (0.6)	0.76 (0.22)	0.051 (0.021)	1.36 (0.48)
10/90	08	16.68	39.27	214.3 (1.8)	1.02 (0.41)	0.021 (0.029)	1.29 (0.34)
*3/92	09	16.61	39.38	222.4 (1.2)	0.16 (0.05)	0.006 (0.006)	1.58 (0.06)

Table 1: Physical and Chemical characteristics of the eddy core (in parenthesis, standard deviation, * renewal of the eddy)

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SOIL DERIVED DUST PARTICULATES OVER THE EASTERN MEDITERRANEAN

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Beginning from 1991 a continuous aerosol sampling program is being carried out at a coastal location of the eastern Mediterranean (34°15'18"E, 36°33'54"N). Totally, 339 aerosol samples were collected by utilizing a hi-vol pump during August 1991-December 1992 on daily basis. Soil derived dust load (mineral particulates) concentrations in the atmosphere were estimated from the measured Al concentrations which is 8% of the average crustal material. The arithmetic average value of 1255 ng Al m^{-3} of air for the eastern Mediterranean aerosol yields an average dust loading of 15.5±25 µg m^{-3} of air over the region. The geometric mean of the dust concentration for the study period is 8.4 µm^{-3}. The wide concentration range (0.25-287 µg m^{-3}) during the sampling period is the explanation of the high standard deviation of the average concentration. Temporal variation of the dust load concentration is highly variable on a time scale of one day (Fig.1). The daily precipitation amounts obtained from the nearest meteorological office are also plotted on the same figure. Our data indicate a seasonal pattern for the dust concentrations over the eastern Mediterranean atmosphere: during wet period (December-February), the arithmetic mean concentration is 4.5 µg m^{-3} whereas for the dry summer time (June-September) it is 15.7 µg m^{-3}. As can be seen from the figure sporadic dust load concentration peaks were observed in spring and fall time. This time periods have well defined meteorological processes on synoptic scale which result in long-range transport (LRT) of soil derived dust from the surrounding deserts (DAYAN, 1986; DAYAN *et al.*, 1991). Our data suggest that precipitation and LRT of soil derived dust are the major factors causing the intense time variation. Indeed, it appears from the figure that precipitation events are systematically followed by abrupt decreases of the dust concentration. For example during October 1991 an event which has the maximum dust loading throughout the sampling period was sampled (279 µg m^{-3}). After this enormously high dust loading a local rain event caused two orders of magnitude decrease in the dust concentration (5.3 µg m^{-3}). October 1991 event is one of the episodes observed associated with LRT of dust from the desertic areas. Air parcel back-trajectory calculations are evaluated as a basic tool to detect potential remote source areas for the dust particles over the sea. The trajectory model of European Center for Medium-Range Forecasts (ECMWF) is applied to three dimensional analyzed wind fields available at the archive of the center. Calculations are performed as three days backward, starting at the mid time of the day (12 00 UT) and arriving to the receptor coordinates at 900, 850, 700, 500 hPa standard pressure levels. Examples of the trajectories originated from Saharan desert (Fig.2.a) and Arabian Peninsula (Fig.2.b) are given in Fig.2. Total (wet+dry) annual flux of the dust deposition is estimated and extrapolated to the eastern Mediterranean (320 000 km²). The conclusion of this study served as a basis for the simulation of desert dust transport to the Mediterranean by utilizing NMC/Eta model.

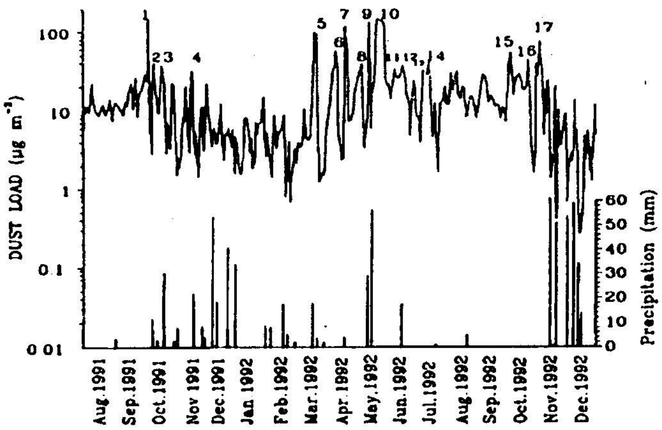
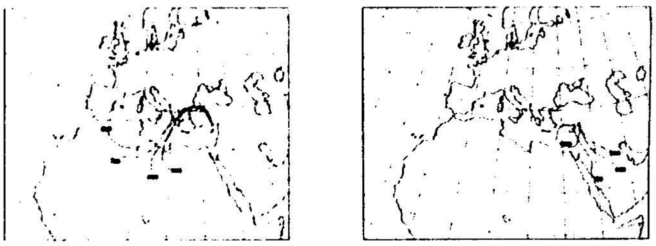


Figure 1. Temporal variation of the dust loading and local precipitation events.



(a) (b)

Figure 2. Air mass back-trajectories for the situations on (a) 6 Oct. 1992, (b) 5 Nov.1992.

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