Study and Analysis of Water Masses Formation in the Levantine Sea

Geurguess[1,2,3] M.S.K., Chantsev[2] V.U.

[1]Nansen International Environmental and Remote Sensing Center, St. Petersburg, Russia.
[2]Russian State Hydrometeorological University, St. Petersburg, Russia.
[3]National Institute of Oceanography and Fisheries (NIOF), Alexandria, Egypt. theomaged@yahoo.com

Abstract – The objective of this work is to study and analysis the water mass formation in the Levantine Sea. Convection, salinity and evaporation in the Eastern Mediterranean were studied for the coldest year (1964) and the hottest year (1991). The oceanographic data are selected from the World Ocean Atlas and http://ingrid.ldeo.Columbia.edu/ site. Results indicate that for the coldest year (1964), the maximum amount of evaporation is observed in August - September in the vicinity of Crete Island. The error of salinity ranged between (0 ‰- 0.25 ‰) in the west of Cyprus and close to Syria. The depth of convection was detected in the west of Cyprus down to a depth about (320 m). While for the hottest year (1991), the maximum amount of evaporation is in August - September near by Syria. The error of salinity ranged between (0.05 ‰ - 0.3 ‰) near the Egyptian coast and close to Turkey. Location of the depth of convection was detected in the west of Cyprus and the front of Turkey down to a depth (240 m).

Keywords: Levantine Sea; water mass; convection; water temperature; salinity; evaporation; ERS-1.

1. INTRODUCTION

The formation of water masses in the Mediterranean Sea generally slightly differs in general nature from season to season but can be stable due to predominance northwesterly winds throughout the year (Wust, 1959).

During the summer, The Levantine basin is covered by the Levantine Surface Water (LSW). This water mass is formed by intensive heating and evaporation and has the largest salinity and temperature of the entire Mediterranean Sea. Due to general cyclonic circulation of the Levantine Basin the LSW advects to the Rhodes gyre region and due to its large salinity appears to be the source water for the Levantine Intermediate Water (Nielsen, 1912; Hecht et al., 1988; Hecht and Gertman, 2001). Moreover, via the Cretan Arc passages, the LSW advects into eastern shelf of the Aegean Sea and participates in the intermediate and deep waters formation of the Aegean Sea (Theocharis et al., 1999a,b; Zervakis et al., 2000).

The aim of the present work is to study and analyze the freshwater exchange and the instability of surface of the Levantine Sea in the coldest year (1964) and the hottest year (1991).

The area of study, which is the Levantine Sea, lies between longitudes 24^0E and 36^0E and latitudes 30^0N and 40^0N, as shown in Fig. 1.

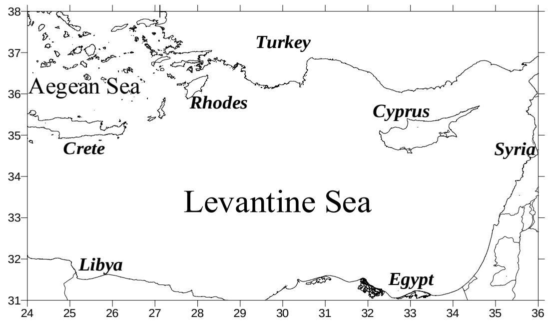

Figure 1. Levantine Sea.

2. MATERIALS AND METHODS

The Data for water temperature and salinity, in the hottest year (1991) and the coldest year (1964), were downloaded from http://ingrid.ldeo.Columbia.edu/NOAA/ NCEP-NCAR. Wind data were collected from ERS-1 satellite. The data for wind speed, water temperature and salinity were downloaded for 50 stations and 13 depths and covered all the study area. The evaporation was calculated using the fallowing equation:

$$E = \frac{0.622}{Pa * \rho} * C * U * (e_0 - e_a) \quad (1)$$

where E= Evaporation rate;
Pa= Atmospheric pressure;
ρ = Air density ;
U = Wind speed;
e_a=water-vapor pressure in air e_a (ta) above a plane surface of pure water at varies air temperatures;
e_0= Saturation water-vapor pressure e_0 (tw) above a plane surface of pure water at varies water temperatures;
C = Dalton's number.

The obtained results for evaporation rate were plotted using the MS Excel software. The MS Excel software has been used to calculate inside intra-annual change of the error of salinity determination (surface of the Levantine Sea), with due account of salinity convection and location of the depth of convection. The obtained results were plotted using the Golden Surfer 7.3 software.

3. RESULTS & DISCUSION

Evaporation analysis:

Ovchinnikov (1976), using long-term climatic data, founded that the evaporation reached its maximum values in September and December and a minimum in May.

In the present work, the maximum amount of evaporation for the coldest year (1964) was observed in August - September in the vicinity of Crete Island ($7.5*10^{-6}$ $kg/m^2.sec$). While, the minimum amount was in February in the same area ($0.5*10^{-6}$ $kg/m^2.sec$). For the hottest year (1991), the maximum amount of evaporation was observed in August - September near by Syria in August ($1.0*10^{-5}$ $kg/m^2.sec$). While, the minimum amount was in April close to Turkey in April ($1.0*10^{-6}$ $kg/m^2.sec$).

Salinity analysis:

Said (1985) suggested that in a cold winter the formation of Levantine intermediate water mass occurs nearly everywhere in the Levantine Sea excepting the southern and extreme eastern parts while in mild winter the formation occurs only at the centers of the cyclonic gyre of the Levantine Sea and north of Crete.

For the coldest year (1964), the annual change of error of salinity, as we see in Fig.2 and the convection, as we see in Fig. 3 on the surface of Levantine Sea, showed that in January, the error of salinity ranged between (0 ‰-0.25‰) in the west of Cyprus and close to Syria respectively, the maximum range was detected next to Syria and Turkey, the location of depth of convection was detected in the west of Cyprus down to a depth about (320m). The convection was detected also in the west of Cyprus in February, These depth was (220m), the maximum change of an error of salinity was (0.1‰) in the west of Cyprus. Allocation of depth of convection increased in March in the same area (320m), and the change of an error of salinity was (0.1‰) in the west of Cyprus. In April, the error of salinity ranged between (0.05‰ - 0.2‰) in the east of Rhodes, the convection not founded. From May to December change of an error of salinity on the surface of Levantine Sea did not exceed 0.25‰, and the convection not founded.

While for the hottest year (1991), the annual change of error of salinity, as we see in Fig. 4 and the convection, as we see in Fig. 5 on the surface of Levantine Sea, showed that in January, the error of salinity ranged between (0.05‰ - 0.25‰) in the area adjacent to the Egyptian coast and in front of Syria respectively.

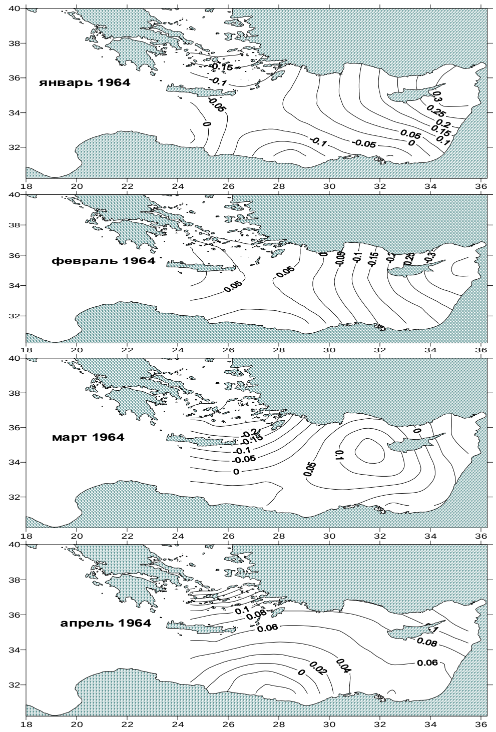

Figure 2. Error of Salinity for the coldest year (1964) {Jan., Feb., Mar. and Apr.}.

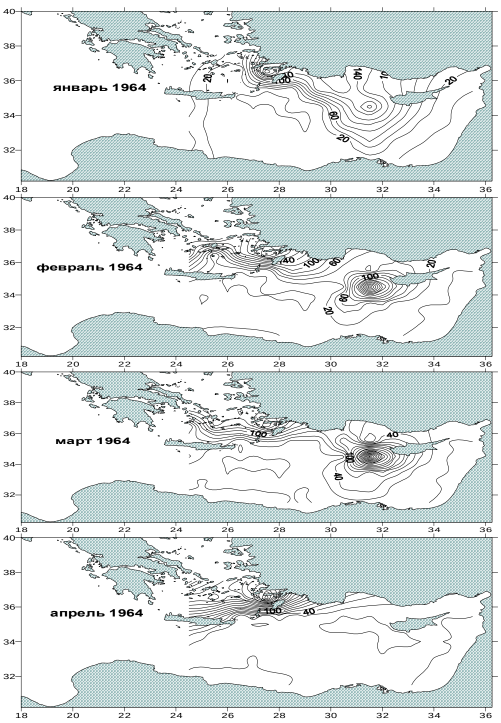

Figure 3. Distribution of convection for the coldest year (1964) {Jan, Feb, Mar and Apr.}.

Location of depth of convection was detected in the west of Cyprus down to a depth (180m). In February, the convection was detected also in the west of Cyprus, The depth was (180m), the maximum change of error of salinity was (0.3‰) in the front of Turkey. Allocation of depth of convection increased in March in the same area (240m), and the change of an error of salinity was (0.15‰) in the west of Cyprus. In April, the error of salinity ranged between (0.02‰ - 0.18‰) in the front of Libya and in the front of Turkey respectively, the depth of convection was detected in the west of Cyprus about (180m). From May to November change in error of salinity did not exceed 0.35‰, and the convection not founded. While in December, the error of salinity ranged between (0.25‰ -0.6‰), in the front of Egypt and in the front of Turkey respectively, the depth of convection was detected in the west of Cyprus and the front of Turkey (240m).

Recent changes of water mass characteristics in the Levantine Sea have considerably influenced the Eastern Mediterranean circulation. A combination of salinity increase and temperature variation during 1964-1991 caused massive formation of dense water and strong outflow towards the deep and bottom parts of the Eastern Mediterranean.

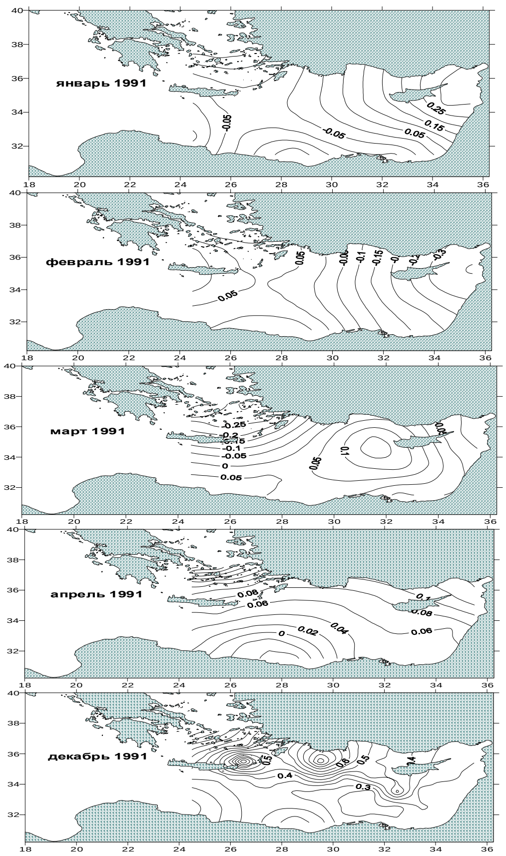

Figure 4. Error of Salinity for the hottest year (1991) {Jan., Feb., Mar., Apr. and Dec.}.

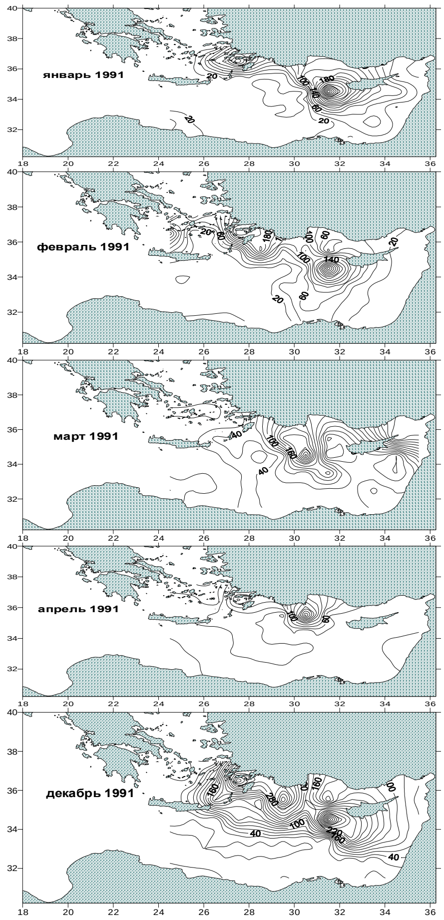

Figure 5. Distribution of convection for the hottest year (1991) {Jan, Feb, Mar, Apr. and Dec.}.

4. CONCLUSION

The circulation of the intermediate water, convection, salinity, evaporation and relative error of wind speed in the Eastern Mediterranean were studied in coldest year 1964 and the hottest year 1991. The oceanographic data are selected from World Ocean Atlas and http://ingrid.ldeo.Columbia.edu/ site. Water temperature and salinity data have been taken from 50 hydographic stations for the last 53 years (1949-2002). Wind data were collected from ERS-1 satellite. The maximum amount of evaporation for the coldest year (1964) was observed in August in the front of Crete Island and minimum amount was detected in February in the same area. While, for the hottest year (1991), the maximum amount of evaporation was observed in August in front of Syria.

The annual change of an error of account of salinity on a surface of the Levantine Sea with the count of a salinity of convection for the coldest year (1964) showed that, the error of salinity ranged between 0‰ in the west of Cyprus and 0.25‰ in the front of Syria, the maximum range was detected in the front of Syria and Turkey and convection depth about 320m in the west of Cyprus. While for the hottest year (1991) showed that, the error of salinity ranged between 0.05‰, in front of Egypt coast, and 0.3‰, in front of Turkey. Allocation of convection depth (240m) was detected in the west of Cyprus.

While for December the salinity error ranged between (0.25‰ -0.6‰), in the front of Egypt and in the front of Turkey respectively, the convection depth was detected in west of Cyprus and front of Turkey (240m).

5. ACKNOWLEDGEMENTS

The authors would like to thank the staff members of the Nansen International Environmental and Remote Sensing Center (NIERSC), St. Petersburg, Russia for support, kind supervision, continuous interest and help.

6. REFERENCES

6.1 References from Journals

A. Hecht, N. Pinardi and A. Robinson, " Currents, water masses, eddies and jets in the Mediterranean Levantine Basin," J. Phys. Oceanogr. vol 18, p.p. 1320-1353, 1988.

A. Hecht and I. Gertman, "Physical Features of the Eastern Mediterranean resulting from the integration of POEM data with Russian Mediterranean cruises," Deep Sea Research. vol. 148(8), p.p. 1847-1876, 2001.

I.N. Neilsen, "Hydrology of the Mediterranean and adjacent waters," Rep. Danisch Oceanogr. Exped. Medit. 1908-1910. vol. I, p.p. 77-191, 1912.

I.M. Ovchinnikov, A. Plakhin, L.V. Moskalenko, K.V. Neglyad, A.S. Osadchiy, A.F. Fedoseyev, and K.V. Voytova, "Hydrology of the Mediterranean Sea." Gidrometeoizdat, Leningrad. p.p. 375, 1976.

M.A. Said, "The sources of formation of the intermediate water masses in the Mediterranean Sea," Acta Adriat. vol. 26 (2), p.p. 191-201, 1985.

A. Theocharis, K. Nittis, K. Kontoyiannis, E Papageorgiou and E. Balopoulos, "Climatic changes in the Aegean Sea influence the Eastern Mediterranean thermohaline circulation (1986-1997)," Geophysical Research Letters. vol. 26(11), p.p. 1617-1620, 1999a.

A. Theocharis, E. Balopoulos, S. Kioroglou, H. Kontoyiannis and A. Iona, "Synthesis of the circulation and hydrographic of the South Aegean Sea and the straits of the Cretan Arc (March 1994-February 1999)," Progress in Oceanography. vol. 44 (4), p.p. 469-509, 1999b.

G. Wust "On the vertical circulation of the Mediterranean Sea," Journal of Geophysical Research. vol. 66 (10), p.p. 3261-3271, 1961.

V. Zervakis, D. Georgopoulos, and P.G. Drakopoulos, "The role of the North Aegean in triggering the recent Eastern Mediterranean climatic changes," J. Geophys. Res. vol. 105, p.p. 26103-26116, 2000.