THE EASTERN MEDITERRANEAN TRANSIENT. CAN WE EXPECT REPETITION OF THIS FENOMENA?

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Since the first oceanographic Mediterranean cruise in 1910 until 1987 the Eastern Mediterranean Deep Water temperature and salinity were stable within the accuracy of oceanographic equipment. The deep water formed in the Adriatic Sea and the Aegean Sea dense water contributed basically to the Levantine Intermediate Water. During 1987-1989 development of a multilobe anticyclonic circulation in the southwestern Levantine basin (Malanotte-Rizzoli et al., 1999) impeded penetration of less saline Atlantic Water (AW) into the Levantine basin and prevented the outflow of high salinity Levantine Intermediate Water (LIW) into the Ionian Sea. Thus a long-term increase in the salinity of the Levantine basin was initiated. Advection of abnormally saline Levantine Surface Water (LSW) in the Aegean Sea during 1989-1990 (Gertman et al., 2006), followed by extremely cold winters 1992-1993 (Lascaratos et al., 1999), forced water formation with potential (relative 2000 db) density anomaly of about 37.83 kg/m^3. This Cretan dense water cascaded through the Cretan Arc and established the Eastern Mediterranean Transient (EMT) (Roether et al., 2007). The excess over the pre EMT bottom water density was just 0.03 kg/m^3. However it was enough to generate a wave like spreading of newly formed water. In 1995, three years after the apogee of dense water outflow from the Cretan Basin, the Levantine Deep Water bellow 2000 m had a stable inversion layer both in salinity and potential temperature. According to a long term series of Israeli observations on station h5 located near the continental slope of the south-eastern Mediterranean shelf (33.0°N, 34.5°E) the first evidence of such inversion was found in 1996. A coarse estimation of propagation velocity of dense water from Cretan Passage to the south-eastern continental slope brings value of about 280 km per year. Before the EMT influence, the h5 station's water in depth of 1400 m had salinity 38.68±0.02 with a negative vertical gradient of about 0.005 per 100 meters. Potential temperature was 13.37±0.02°C with a decrease rate of 0.015°C per 100 meters. During the period 1996 – 2002, salinity and potential temperature in the bottom layer increased monotonically reaching values 38.77, 13.59°C and changing the vertical gradients signs. Relatively regular observations in the framework of Israel's national project "Haifa Section" from 2002 to 2009 show fluctuations in salinity and potential temperature with ranges of 0.02 and 0.02°C respectively.

Observations from R/V "Meteor" during 2001 (Roether et al., 2007) revealed quite homogeneous water for regions east of 25°E and deeper than 2000 m (38.82±0.02, 13.71±0.02°C). However on the most western stations an intrusion of new water was already observed. This water was slightly less saline (38.78) and colder (13.56°C) than the water which originated from Cretan Basin. In the field of potential density relative 2000 db it is possible to see that the new deep water is denser by about 0.005 kg/m^3 than the relict water from the previous wave of renewal.

Further eastward propagation of the new water, which Roether et al. (2007) defined as having Adriatic origin, was observed in winter 2008 during the R/V Shikmona cruise. The western boundary of the Cretan origin water was shifted to about 27.5°E. The boundary is clearly observed in the salinity field as well as in fields of potential temperature and dissolved oxygen. The Cretan origin deep water was disconnected from their origin in the Aegean Sea and became, due to mixing, less salty and colder (38.79, 13.63°C) than they were during 2001. The Adriatic origin water did not change their parameters compared to observation from 2001. Apparently this water mass had a permanent feeding from the Otranto strait. Differences in potential density between the Adriatic and Cretan water masses remained the same as in 2001 (about 0.005 kg/m^3). The eastward propagation rate of Adriatic origin water was seven times slower than the propagation of the Cretan origin water. This seems to be connected to the smaller difference in potential density.

As a necessary but not sufficient predictor of the EMT activation can be salinity of the LSW, which is the warmest and saltiest water mass of the Mediterranean (27-28°C, 39.2-39.4 for summer and 17-18°C, 39.0-39.2 for winter). The LSW, while propagating cyclonically from the Southeastern Mediterranean to the North Levantine, and entering the Aegean Sea, is losing its buoyancy and become a potential water source of the LIW. The climatological data analysis showed a significant salinity increase (about 0.8) of the LSW during summer periods from 1979 to 1990, before development of the EMT. One of the possible reasons for this increase of the salinity can be decrease of the regional runoff (diminishing of the Nile discharge). Additional cause for the salinity increase may be changes of the general circulation in the area. The latter changes leaded to the restriction of the AW penetration in the Southeastern Mediterranean. During the last 10 years the salinity of the LSW increased by

about 0.6. A massive advection of the LSW into the Aegean due to an appropriate circulation can lead to reactivation of the EMT situation.

References.

Gertman, I., Pinardi, N., Popov, Y., Hecht, A., 2006. Aegean Sea water masses during the early stages of the Eastern Mediterranean Climatic Transient (1988–1990). *Journal of Physical Oceanography* 36 (9), 1841–1859.

Lascaratos, A., Roether, W., Nittis, K., Klein, B., 1999. Recent changes in deep water formation and spreading in the Mediterranean Sea: a review. *Progress in Oceanography*, Vol. 44, 5–36.

Malanotte-Rizzoli, P., B. B. Manca, M. Ribera d'Alcala, A. Theocharis, S. Brenner, G. Budillon, and E. Ozsoy, 1999. The eastern Mediterranean in the 80s and in the 90s: The big transition in the intermediate and deep circulations. *Dynamic of Atmospheres and Oceans*, 29, 365–395.

Roether, W., Klein, B., Manca, B. B., Theocharis, A., Kioroglou, S., 2007. Transient Eastern Mediterranean deep waters in response to the massive dense-water output of the Aegean Sea in the 1990s. *Progress in Oceanography*, Vol. 74, 540-571.