ABRUPT CHANGE IN THE DEEP BALEARIC SEA IN 2005; A YEAR LATER

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Abstract
The properties of the Western Mediterranean Deep Water in a wide area located at the western boundary of the Mediterranean Sea revealed intense changes when sampled in summer 2005 after the extremely severe winter 2004-05. The progressive warming trend observed since 1996 in deep waters north of the Balearic Channels reverted dramatically, and in the deepest levels nearby the Balearic Islands a complex and unprecedented thermohaline structure appeared. In the following year, the temperature of deep water north of the Balearic Channels experienced the highest annual cycle observed, ending by June 2006 with a weak interannual recovery. The new structure in deeper waters persisted with some evolution, indicating that the change was not a short-term transient anomaly.
Keywords : Western Mediterranean, Deep Waters, Balear Sea.

Western Mediterranean Deep Water (WMDW) has been immersed in a process of warming and salt-increase since, at least, the beginning of the 20th century. The net heat and salt gain values presented by different authors are similar:
Béthoux et al. [1]; 1959-1997; 0.13 °C and 0.04 (PSS scale)
Rixen et al., [2]; 1950-2000; 600 dbar-bottom; 0.09°C and 0.035
A similar tendency was observed in the 10-year time-series of θS properties at hydrographic stations in the Balearic Sea performed by the Spanish Institute of Oceanography (IEO). Until 2005, the waters deeper than 600 dbar in station 33 (Figure 1c, 1360 m depth) suffered a progressive warming and salt-increase trend of 0.011$\pm$0.004 °C yr^{-1} and 0.003 $\pm$ 0.001 yr^{-1} (salinity).

However, measurements in June 2005 revealed dramatic changes in the deep waters at the area, as described in [3]. The warming trend observed north of the Balearic Channels was disrupted with a drop in potential temperature of 0.14 °C, higher than the accumulated increase observed since 1996, and higher than the reported net accumulated warming of the whole WMDW during the last half century. At the same time, the deepest waters that bound the Balearic Islands showed intense transformations presenting a striking structure below 1400 dbar (see Figure 1abd). The changes were related to the most intense heat loss in the area of formation of WMDW (MEDOC area) since at least the last 50 years [3]. The formation of the new structure was explained in terms of intense deep convection of salty surface waters combined with strong cascading at the shelf-slope [4]. The extension of the changes affected the whole Western Mediterranean basin [5] and may be influenced by the Eastern Mediterranean Transient [3, 5].

The sampling of the Balearic Channels during the following year revealed a variability not observed before at these levels in the area during the previous 10 years. There was an annual cycle of nearly 0.10°C for water temperature below 600 dbar, reaching a maximum in spring but ending in June 2006 with a value hardly 0.02°C higher than that found in June 2005 (not shown). This finding indicates firstly that the change was not a short-term transient anomaly, and secondly the existence of heterogeneity in the spatial structure at these depths, causing the local alternation of waters with different properties as a response of the local advective regime.

After summer 2005, the deep structure with a clear fingerprint in the θS diagram (Figure 1d) remained year round, but experienced some evolution. The node of maximum salt and temperature increased slightly its values, whereas the signature at the interface with newly formed waters and also the bottom water seem to be less conspicuous (partially eroded) when observed in summer 2006. The combination between diffusive mixing and advection causing the observed evolution of the θS diagram supposes a future challenge for the models when trying to interpret this exceptional event.

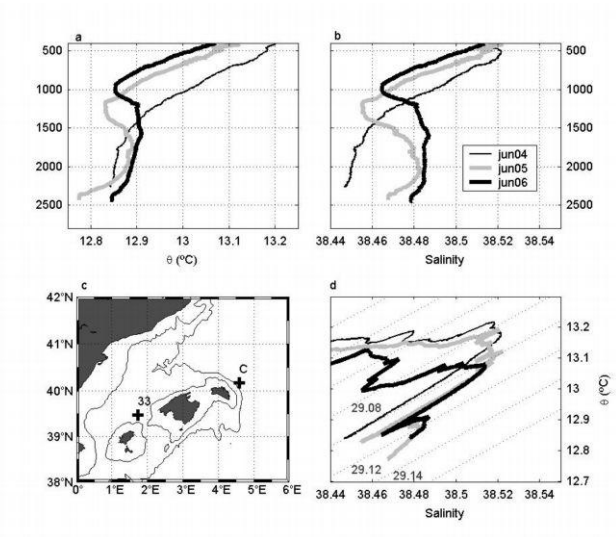

Fig. 1. Western Mediterranean at the Balearic Islands area and stations referred in the text (c). Potential temperature (a) and salinity profiles (b) at a station C for summers 2004-2006 and θS diagram from the same profiles (d).

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