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Mediterranean Water in the NE Atlantic: a study using contemporaneous ARGO, RAFOS, XBT and remote sensing observations

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INTRODUCTION

This work describes some preliminary results of combined analysis of various sources data applied to the study of Mediterranean Water in the North-East Atlantic. We investigate cyclonic and anticyclonic eddies identified by contemporaneous ARGO and RAFOS trajectories in the vicinity of the Horseshoe Seamounts System. We show how the use of ARGO data can improve our knowledge about the dynamics of Mediterranean Water in the North-East Atlantic.

DATA

In situ measurements are based on:

- ARGO float data (Euro-Argo Project, http://www.euro-argo.eu),
- RAFOS trajectories (MEDTOP Project, Center of Oceanography – Faculty of Sciences of the University of Lisbon, http://co.fc.ul.pt),
- XBT profiles (World Ocean Database, National Oceanographic Data Center, http://www.nodc.noaa.gov).

The remote sensing observations include:

- Altimetry (distributed by AVISO, http://www.aviso.oceanobs.com),
- Ocean colour (chlorophyll pigments concentrations) obtained by satellite (Ocean Color Web, http://oceancolor.gsfc.nasa.gov).

Two ARGO floats (green and magenta trajectories in fig. 1) were involved in cyclonic circulation and one (cyan trajectory in fig. 1) in anticyclonic looping.

Two RAFOS floats (red and blue in fig. 1) were involved in anticyclonic circulation.

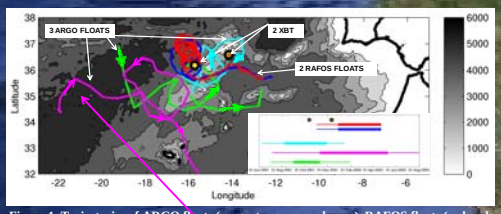

Figure 1. Trajectories of ARGO floats (magenta, green and cyan), RAFOS floats (red and blue) and locations of XBT profiles (yellow and red dots) superimposed on bathymetry. Graph in the inset shows the timeline of data (thicker lines indicate the period when floats were looping).

ARGO AND ALTIMETRY

ANTICYCLONIC CIRCULATION:

Part of the trajectory of the ARGO float that corresponded to an anticyclonic circulation (cyan color) coincides with a positive sea level anomaly (black triangles in fig. 2 a,b) and lasted for about 3.5 month.

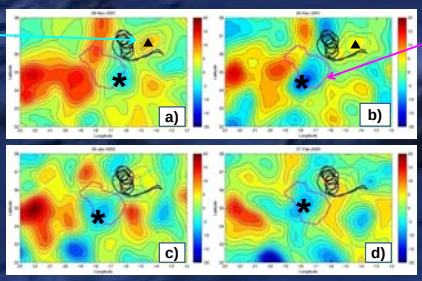

Figure 2. Sea-level anomaly maps (in cm) for: (a) 28/11/2001, (b) 26/12/2001, (c) 30/01/2002 and (d) 27/02/2002. Magenta and cyan lines represent parts of trajectories when ARGO floats were looping (cyclonic and anticyclonically). Note: the cyclonic line is shown only for the ARGO float that was involved for a longer time in this circulation (magenta trajectory from fig.1). RAFOS trajectories for the period of 01 November 2001 – 22 April 2002 are in black (red and blue lines on trajectories indicate RAFOS positions for the period corresponding to the day of the map 1 day). Black asterisk indicate the cyclonic eddy and the black triangle the anticyclonic one.

CYCLONIC CIRCULATION:

From the floats positions in time (inset in fig. 1) and altimetric data (fig. 2) it was concluded that two cyclonically rotating ARGO floats were in the same north-westward propagating cyclone.

One of the ARGO floats (magenta trajectory in fig. 1) made a closed cyclonic loop in about 6.5 month and its trajectory coincided with a cyclonic eddy observed on altimetry maps (marked with an asterisk in fig. 2).

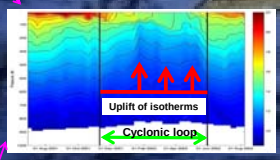

Figure 3. Vertical section of temperature along the ARGO float trajectory (magenta in fig. 1). Vertical black lines indicate the period when the float was involved in cyclonic circulation. Uplift of the isotherms by about 100 – 150 meters is observed.

Vertical section of temperature (fig. 3) collected along the ARGO float trajectory (magenta in fig. 1) shows that the cyclone goes down from the surface to about 700 m depth. This depth was identified by the uplift off the isotherms which was about 100 – 150 meters when the float was inside of the cyclonic circulation.

RAFOS

2 RAFOS floats (red and blue in fig. 1) started looping anticyclonically soon after passing Horseshoe Seamounts System and kept this rotation until the end of their missions (about 4 months). The mean translation speed of the eddy they were following was estimated to be about 2 cm/s in the NNW direction, the mean looping period about 12-14 days and the eddy diameter about 75 km (estimations made from red trajectory in fig. 1). The beginning of the rotation coincided with an increase in temperature from about 10.2 C (value close to the mean climatic temperature for this region and this depth) to about 10.9 C at the drifting level of ~1070 db, (red color in fig. 4). The RAFOS identified by blue was deeper and kept at the ~1200 db level since the beginning of the rotation. Although this float was involved in the same anticyclonic circulation, it made only 2 loops, whereas the red one made 6.5. This indicates that the deeper one (blue) was farther away from the eddy center. On the other hand, relative low temperatures (although higher than climatic values, but lower than 11 C at the level of ~1070 db, and <10.5 C at the level of ~1200 db, see fig. 4) we conclude, that the eddy identified by RAFOS floats was a MEDDY (anticyclonically rotating eddy of the Mediterranean origin) containing the "upper" core waters only. *[Pingree and Le Cann, "A Shallow Meddy (A Smeddy) from the Secondary Mediterranean Salinity Maximum", JGR, Vol. 98, C11, 20169 - 20185,1993].*

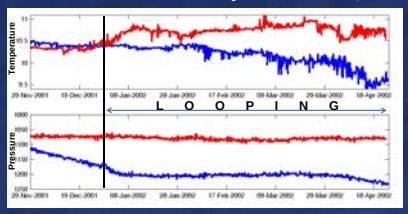

Figure 4. Temperature (upper panel) and depth (lower panel) of two RAFOS floats. Colours correspond to floats trajectories identified in fig. 1. The vertical black line indicates the beginning of the looping.

XBT PROFILES

2 XBT profiles from World Ocean Database were available for the area and time of the episode. One of them was located inside of the anticyclonically rotating ARGO float (red dot in fig. 1). The other one was in the area where the two RAFOS indicated the presence of the anticyclonic eddy (yellow dot in fig. 1). This XBT profile was made about 2 weeks before the RAFOS floats entered into the anticyclonic circulation. This profile shows the presence of Mediterranean Water (blue profile in fig. 5) reaching the maximum temperature of 12.93 C at the level of 790 db (~2.7 C warmer than mean climatic temperature for the region). For the profile taken inside of the anticyclonically rotating ARGO float (red dot in fig. 1), the presence of warm Mediterranean Water was not so obvious (temperature anomaly was about 0.3 C). Unfortunately, the profile was limited to 750 db level and there was no information available for deeper levels.

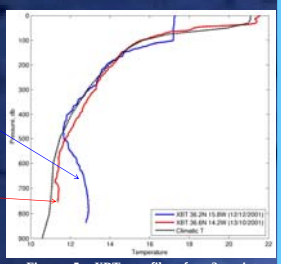

Figure 5. XBT profiles for 2 points identified in fig. 1 and mean climatic temperature profile for October (black dots). The blue one corresponds to 12 December 2001 (yellow dot in fig. 1) and the red one corresponds to 13 October 2001 (red dot in fig. 1). The mean climatic temperature profile corresponds to the area and month of the red XBT profile.

CHLOROPHYLL PIGMENTS

Figure 6 shows chlorophyll pigments concentration obtained by SeaWiFS on 21 April 2002. The cyclonic ARGO float trajectory (magenta) is associated with low chlorophyll contents and the two RAFOS floats trajectories (separated by the distance of about 150 km from each other due to different rotation periods) are coherent with a higher chlorophyll concentrations in the anticyclonically rotating pattern (white arrow).

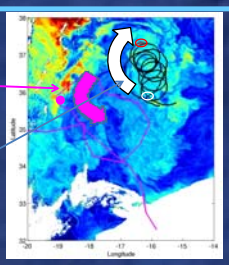

Figure 6. Chlorophyll pigments concentrations map for 21 April 2002 and ARGO (magenta) and RAFOS floats trajectories. Floats positions for the day of the image are marked. Arrows indicate direction of rotation .

GENERAL CONCLUSIONS AND FUTURE WORK

Using ARGO data, the vertical extension of the cyclonic eddy was estimated (from the surface down to 700 – 800 m depth).

With RAFOS trajectories and XBT profiles we conclude that anticyclonically rotating eddy was a MEDDY containing only "upper core" waters and centered at about 750 – 800 db pressure level.

As both eddies were located approximately at the same levels, their relative locations and interaction explain the propagation to NNW direction of the MEDDY (typically, they go to somewhere between west and south).

Future work will include more detailed analysis of this episode involving more ARGO data to explain the evolution of this MEDDY.

ACKNOWLEDGEMENTS

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