INTERANNUAL VARIABILITY OF THE CIRCULATION IN THE BALEARIC CHANNELS (1996-2000)

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Abstract

Two well differentiated flow regimes have been observed in the Balearic Channels during 1996-2000, linked to the presence (1996 and 1999-2000) or not (1997-98) of large amounts of Winter Intermediate Water (WIW). In some years, large WIW eddies can in fact drastically modify the channel circulation. This points out the connection between the water exchange through the channels and the winter climatology in the northern Mediterranean where mainly WIW are formed (1).

Key-words: Intermediate waters, circulation, hydrography, Balearic Sea.

Introduction

In the framework of the MATER project (UE-Mast III - 1996-99), we monitored the hydrodynamics in the Balearic Channel during 1996-98. Sixteen hydrographic surveys were carried out and five mooring lines were deployed (2). Part of this research has been continued in the frame of the Spanish project CIRBAL during 1999-2001 to further investigate the interannual variability of the channel circulation.

Circulation regimes

During 1996, the predominant winter flow regime was dominated by the southward Northern Current (NC) carrying large amounts of northern waters into the Ibiza Channel. This flow decreased during spring as wind forcing in the north relaxed (3), and a large, deep anticyclonic eddy (AC96) was observed, trapped to the north of the Ibiza Channel, partly deflecting the NC toward the Mallorca Channel. This eddy was composed of a large amount of WIW. In summer, the NC almost vanished, allowing moderate northward inflows of Modified Atlantic Water (MAW) through the Ibiza Channel. The NC was entirely deflected into the Mallorca Channel due to the combined obstruction effect of eddy AC96 and MAW inflows in the Ibiza Channel. Eddy AC96 was eroded during summer and, in fall, the re-intensified NC was detected flowing in the Ibiza Channel again.

A different circulation regime was observed during 1997 and 1998, characterized by low amounts of WIW. This time, the main core of the NC was almost systematically found in the Ibiza Channel. No major persistent eddy was observed to the north of this channel. Only sporadic anticyclonic eddies and meanders, due to the instability of the NC, were found travelling southward with the current. Thus, only during short periods of several days, while one of these eddies crossed the sill of the channel in its narrowest part, obstructing the water exchange, the NC was retroflected behind the eddy toward the Mallorca Channel. The seasonal variation of the NC was observed again, its weakening in summer allowed the northward progression of MAW through the Ibiza Channel. However, the Mallorca Channel represented the preferential pathway for the northward spreading of these waters. MAW inflows were generally moderate, but from January to June 1998, they were strongly enhanced by large anticyclonic eddies lying in the Algerian Basin to the south of the channels (4).

In 1999, a moderate amount of WIW was observed again to the north of the Ibiza Channel. Also, as in 1998, a large anticyclonic Algerian eddy lied to the south of Ibiza driving MAW into the Ibiza Channel. The blocking effect of WIW and MAW inflows for the NC forced its deflection toward the Mallorca Channel. A vigorous Balearic Current, fed by southern (MAW) and northern (NC) waters, thus was flowing over the Balearic slope forming marked meanders, possibly due to an instability of the front between light (southern) and dense (northern) waters.

In 2000, CTD data collected in the Mallorca Channel evidenced the presence of WIW there. It is thus very likely that WIW was also present in the Ibiza Channel. Satellite imagery revealed numerous eddies in the Gulf of Valencia to the north of the Ibiza Channel, and, most probably, they impeded the southward progression of the NC. This interpretation was confirmed by the trajectory followed by a drifting buoy which was deployed (01/06/2000) off Cape Creus and recovered one month later (05/07/2000) in the Mallorca Channel. WIW lenses were observed in the Ibiza Channel during a survey in September and again as late as in November.

Conclusion

The analysis of this multi-year data set evidences that WIW eddies can significantly alter the flow regime in the Balearic Channels. Large amounts of WIW, as those dectected in 1996, 1999 and 2000, which reach the channels in early spring, seem to favour eddy activity at the edge of the NC and the formation of eddies (as eddy AC96) which are too large and deep for drifting through the Ibiza Channel. Thus, they remain trapped to the north of the channel until fall and partially deflect the NC eastward. This blocking effect is enhanced by the northward spreading of southern waters through the channel, a characteristic of the spring-fall period also. The eddy activity seems to be reduced with smaller amounts of WIW (1997 and 1998): eddies are smaller, shallower, and likely less numerous, and can cross the sill. As a consequence, they do not induce any long-term deflection of the NC. The northward inflows of southern waters alone are not energetic enough for forcing the deflection. All these observations are in good agreement with numerical simulations of the Balearic Sea (5). In conclusion, our analysis points out the importance of eddy formation, linked to the unstable character of the NC, for the water exchange through the Balearic Channels, and for the meridional tranport of properties in the western Mediterranean. It also establishes the link between eddy activity and the interannual variability of WIW formation in winter. Historical data show that during the period 1985-2000, quite large amounts of WIW were present in the Balearic Channels almost all years except in 1997 and 1998. This would suggest that the deflection of the NC forced by WIW eddies before reaching the Ibiza Channel is the 'normal' flow regime from spring to fall (following, hence, normal or cold winters) whereas the direct southward path of northern waters through the eddy-free channel during this period is an 'exceptional' flow regime (following, hence, very mild winters).

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