TIME FLOW VARIABILITY IN THE BALEARIC CHANNELS AND ITS RELEVANCE TO THE WESTERN MEDITERRANEAN CIRCULATION

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Abstract

The "CANALES 96" field experiment was carried out during March-July, 1996, to investigate the time variability of the water exchanges through the Balearic channels (Western Mediterranean). Four instrumented moorings were deployed and monthly hydrographic surveys were carried out. The main result is that ocean properties are characterized by energetic mesoscale events due to cold eddies of Winter Intermediate Water (WIW, T<13°C). Eddies aggregation can even lead to the sporadic appearance of a large anticyclonic WIW gyre to the north of the Ibiza channel which drastically modifies the water exchange dynamics through the channels, therefore affecting the northward spreading of Modified Atlantic Waters and the southward flow of Mediterranean Waters. Simulations with a numerical model are also carried out to help understanding *in situ* observations.

Key-words: Balear Sea, Straits and Channels, Hydrography, Monitoring

Introduction

For several years now, the Balearic Sea has been considered as a key transition basin between the northern Gulf of Lions and the southern Algerian basin in the Western Mediterranean. The Balearic Sea communicates with the Algerian basin through the Balearic channels: the Ibiza channel between Ibiza and the Spanish peninsula, and the Mallorca channel between Mallorca and Ibiza. The idea that the Balearic channels concentrate the meridional fluxes between the (thermo)dynamically well contrasted northern and southern Mediterranean leading to an energetic seasonal adjustement between the southward spreading of Mediterranean Water (MW) cooled in the north and the northward spreading of lighter Modified Atlantic Water (MAW) from the south was reinforced by recent satellite [1] and large scale modelling [2] studies. *In situ* high resolution surveys also highlighted that the circulation in this basin is characterized by a high mesoscale activity that substantially distorts the mean circulation pattern of along-slope currents [3]. More recent studies emphasized the role played by the Balearic channels in controlling the meridional mass transport and fluxes of heat, salt and other properties, hence showing its relevance to the general circulation of the Western Mediterranean [4, 5]. Satellite and *in situ* observations in the Balearic channels also suggested complex interactions between surface and subsurface mesoscale eddies and channel topography, with strong effects on the mean seasonal exchange dynamics through the Ibiza channel [6]. All these previous studies were extremely useful for defining the spatial characteristics of the circulation in the Balearic Sea but missed the time evolution of the flow.

The INTERMESO group, composed by oceanographers from the Institut Mediterrani d'Estudis Avancats, Centro Oceanografico de Baleares and Institut de Ciencies del Mar, carried out a unique field experiment during 1996-97 to investigate the annual cycle of the ocean circulation in the Balearic channels. The experiment was mostly oriented towards determining the nature and the time scales of circulation variability. The data presented here were collected during the "CANALES 96" field experiment, March-July, 1996, and relied on two major efforts: 1) The deployment of 4 instrumented mooring lines to continuously monitor currents and water properties and resolve the time variability at subinertial frequencies and 2) Repeated hydrographic surveys every month to sample the water mass structure and help assess flux seasonal variability. All CTD casts reached the bottom and moorings were designed to record the current and water properties for each layer of the water column. Additional data of sea surface temperature from NOAA satellite imagery were obtained and used to interpret *in situ* measurements. Also numerical modelling experiments were carried out to help in the understanding of observed phenomena. Crucial data were thus obtained for the first time, for a broad range of ocean processes in the Balearic Sea which appear to be fully relevant for the general circulation of the Western Mediterranean.

Design of the experiment and instruments used

The typical pattern of the mean circulation in the Balearic Sea is shown in Figure 1 which also highlights the question of the flow interaction in the channels. Triangular shape hydrographic surveys to be repeated every month were designed for each channel (Figure 1). Four days were needed every month to sample both channels (37 stations in total).

Four sub-surface moorings were also deployed to continuously monitor the fluxes and physical properties of ocean waters flowing through the channels at particular locations, over the 900 m isobath (Figure 1). The four moorings included a total of 12 mechanical current meters (vector average) and 2 thermistor strings (10 thermistors each).

During all cruises a SBE-25 CTD probe was used for hydrographic measurements. A critical point in this kind of study dealing with hydrographic climatology is the correct calibration of the sensors which should allow sensible comparison between all cruise data sets. The SBE-25 probe was calibrated in situ during the May cruise, half way between March and July using another SBE-25 probe which had been calibrated a few days prior to the cruise in OSI laboratory (Southampton, UK). Temperature and salinity data were obtained for all cruises on the basis of this particular calibration. Temperature and conductivity sensors of moored instruments were also calibrated using the closest CTD profiles performed in their vicinity at the time of the cruises.

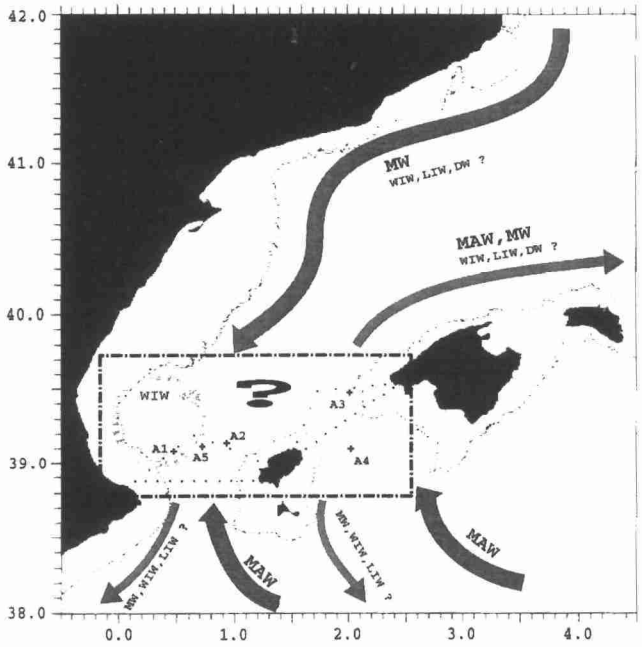

Figure 1: Classical picture of the main inflow patterns into the Balearic Sea (dark grey solid arrows). Surface Mediterranean Water (MW), Winter Intermediate Water (WIW), Levantine Intermediate Water (LIW) and Western Mediterranean Deep Water (DW) are assumed to enter the basin along the continental slope from the northern Gulf of Lions. Modified Atlantic Water (MAW) flows into the Balearic Sea from the southern Algerian basin. Light grey solid arrows sketch likely outflows resulting from water exchange dynamics through the channels where complex high frequency subinertial flow interactions are expected to occur. The WIW eddy recurrent in spring-summer to the north of the Ibiza channel is represented by a dotted arrow. Crosses indicate A1 to A5 mooring locations for long-term monitoring of the water fluxes and dots represent hydrographic stations repeated every month from March to July, 1996.

Overview of hydrographic data analyses

The hydrographic data set obtained from the March (late winter) to July (early summer) surveys, 1996, give snapshots of the circulation occurring in the Balearic Channels during the transition period from winter to summer with information on the structure, dynamics and transport of the water masses. The analyses were based on plotting distributions of temperature, salinity, density, dynamic height and geostrophic velocity. Dynamic height was computed with a reference at 600 m. For shallow profiles located over the slope, the closest offshore station was extrapolated. A general result that can be derived from the analysis of properties distributions is that two signals are superimposed: a mean, smooth seasonal month-to-month variability at climatological scale which modulates an energetic signal due to mesoscale eddies transiting through the channels.

The March survey evidences thermal homogeneity of the water column resulting from winter convective processes. The circulation in the different