CHARACTERISTICS OF THE SEA SURFACE CIRCULATION IN CANARY WATERS AS OBSERVED THROUGH METOP AND OTHER SOURCES OF REMOTE SENSINGDATA

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ABSTRACT/RESUME

The Canary waters area is highly complex from an oceanographic point of view. It has been partially studied and different aspects of its surface dynamics remain unknown for a large rank of spatial and temporal scales. The main purpose of our future work using MetOp data is to advance in the knowledge of the ocean surface dynamics in this region using observations that verify the needed spatial and temporal resolution requirements. For it the information coming from MetOp and different remote sensors placed on some space platforms, and that obtained with some in-situ measurements devices will be used. As a previous analysis, we have realized a study combining Advanced Very High Resolution Radiometer (AVHRR) and radar altimeter data and some of the results are shown. Of special interest will be tried to find out those patterns of surface ocean circulation showing a recurrent behaviour in this zone.

1. INTRODUCTION

The physical oceanography of the waters placed south of the Canary archipelago shows a complex pattern of oceanic mesoscale variability. This intricate pattern consists principally of eddies and mesoscale meanders or filaments, through which the main Canary Current, flows in a south-westward direction [1]. Similar variability patterns have also been observed in other eastern boundary upwelling regions and it is thought that this is a common feature of these places. However the Canary Region has some distinctive topographic features that could be exerting a significant influence on the observed mesoscale characteristics. First, the African continent in this area shows some capes where coastline modifies its orientation strongly. Second one, a changing continental shelf that is narrow and abrupt south of Cape Jubi and it gets wider and smoother south of Cape Bojador (Fig. 1), and finally the presence of the Canarian Archipelago formed by seven Islands distributed zonally next to the African coast at 28º N approximately.

First studies have revealed the important physical and biological role played by these mesoscale features in Canary waters [2][3], and they have shown the correspondence between the signature of mesoscale features in satellite data and coincident in situ observations [4]. But the majority of these works have limitations due to the inadequate spatial and temporal cover of their observations, and it results that many aspects of the surface ocean circulation in this area are still unknown.

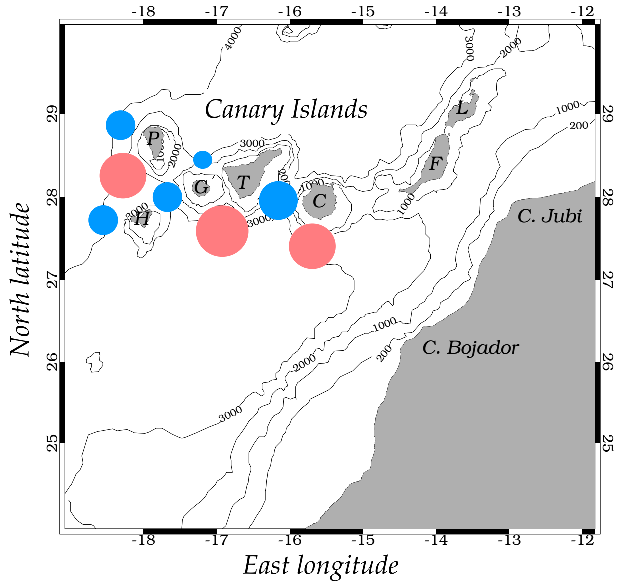

Figure 1. Map of Canary Region. Blue and red circles represent places of generation of cyclonic and anticyclonic island eddies respectively.

However, the advent of improved and continuous series of remote sensing data covering a large interval of spatial and temporal scales provides the capability to monitor a wide range of oceanic processes, including those in which the mesoscale phenomena, as vortex and upwelling filaments are placed (10 to 200 km and several months)[5][6].

In anticipation to the work we will realize with data coming from some sensors onboard MetOp satellite, we present some results about the ocean surface circulation in Canary waters obtained through the combination of past AVHRR and ERS2 and TOPEX/POSEIDON (T/P) altimeter data. Then, we expose our scheduled work using data coming from MetOp satellite.

2. PREVIOUS WORK WITH SATELLITE DATA

AVHRR and altimeter data used for the study of the surface ocean circulation in Canary waters complement

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each other. Then, some results obtained through the combination of these data for the period 1998-2000 are shown. AVHRR data are converted to SST and brightness temperature maps as described in [6], and ERS2 and T/P altimeter data are merged to produce sea level anomaly (SLA) maps as shown in [7].

Island eddies were labeled in these maps to distinguish each other. It was done taking in account their cyclonic or anticyclonic character (indicated with letter C or A), and the place where they were generated (Gran Canaria (C), Tenerife (T), La Palma (P), Gomera (G), Hierro (H) and the African upwelling area (A)). A number was added at the end to differentiate eddies shed at different times from the same location.

2.1. Generation of Canary Island eddies.

Places where newly generated eddies were identified in AVHRR scenes during 1998 are depicted in Fig. 1, and the number of each type grouped by semester is showed in Tab. 1.

Table 1. Number of eddies, classified by type and period of generation during 1998.

	First semester	Second semester	Total
Cyclone	7	18	25
Anticyclone	4	6	10
Total	11	24	35

The number of identified eddies using this procedure is probably lower than real one, due to inherent problems of AVHRR data (clouds and occasional weak surface thermal patterns), but in spite of these limitations, it is possible to extract interesting consequences of the analysis from Tab. 1. First, it is observed that eddies are produced all year around, but the number of generated eddies is higher the second semester, probably related with the reported seasonal character of winds and currents in the area of interest [8]. Second, comparing the number of new cyclonic and anticyclonic eddies in Tab. 1, it results that cyclonic eddies are more abundant in AVHRR images (25 out of 35) than anticyclonic ones (10 out of 35)

The time that eddies need to grow and separate from the islands can be estimated using AVHRR images. On average this time of permanence covers around two weeks for most of analysed eddies in agreement with [2]. An exception was an anticyclonic eddy observed southwest of La Palma island on September 16, 1998, named as AP1 (Fig. 2). Satellite scenes indicate it had a diameter of about 80 km and it was retained in the same position until the end of November (>70 days). After that it shifted quickly to the west, being observed last time on December 26, 1998.

2.2. Evolution of Canary Island detached eddies.

Only a few of the newly generated eddies identified by visual inspection in AVHRR scenes and altimeter maps, were observed as prominent features during an extended time higher than two months (6 in total). The names and periods of observation of these eddies are shown in Tab. 2.

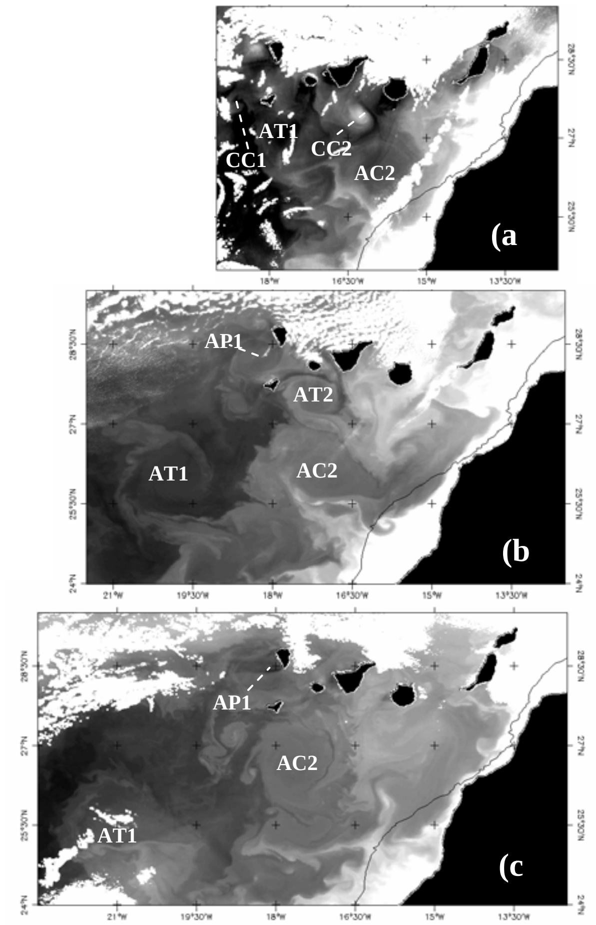

Figure 2. Brightness temperature images of AVHRR for a) August 19, 1998, b) October 24, 1998, c) December 19, 1998.

It is noticeable that most of the long term eddies, were developed the second half of the year (between June and October). It corresponds with the period in which more eddies were generated as discussed in section 2.1, and as it would be expected considering winds and currents as the forcing mechanism of observed island eddies. However, while new generated eddies are preferably cyclonic, over long periods the situation for persistent island eddies is reversed and anticyclonic eddies seem to be more abundant than cyclonic ones.

There is a substantial asymmetry between long life cyclonic and anticyclonic vortices. Cyclonic eddies usually have a smaller size (80-100 km diameter) than anticyclonic ones (100-200 km) as it can be observed in Fig. 2 and Fig. 3. Respect to the time of observation, cyclonic eddies are detected for a shorter period (60-100 days) than anticyclonic ones (100-550 days) as depicted in Tab. 2. The values in brackets in Tab.2 indicate that eddy could be identified in SLA maps but SLA differences between the center and the edge of the feature was below 3 cm,

Table 2.Detected long life eddies.

Name	First observation	Number of days
CC1	8.4.98	105
CC2	3.7.98	61
AC1	20.3.98	228
AC2	26.6.98	474 (572)
AT1	26.7.98	311 (528)
AP1	16.9.98	112

Once eddies get detached from the islands they usually move going to the southwest. In Fig. 4 are shown the tracks corresponding to the long-term eddies AC2 and AT1. These paths are derived from AVHRR (black line) and altimeter (grey line) data, and they agree quite well. Crosses in these figures indicate the position of the eddies each month, and a dotted line is used for the final part of the trajectories, indicating SLA differences between the center and the edge of the feature below 3 cm.

The movement of cyclonic eddies is influenced not only through the advection produced by the Canary Current, but also through the interaction with other bigger anticyclonic vortices. In case of interaction of two vortices of different strength and rotating in different senses, the weaker vortex (the cyclonic one in this case, see Fig. 2 and 3a) is driven around the stronger vortex in a curved path (image not shown).

Likewise, movement of anticyclonic eddies is influenced by other factors besides the Canary Current. Then, next to the generation area the path of these vortices is determined by the presence of other anticyclonic eddies and the nearness of the African coast. This produces the arresting or slowing down of eddies, as observed with eddy AC2 (Fig. 4). Far from the formation region, eddies move to the west under the combined influence of the Canary Current and the beta effect covering around 100 km during a month (Fig. 4).

The higher size and time span of anticyclonic eddies contributes to the collision and possible merging of these mesoscale features in Canary waters. Eddies AC2 and AT1 interact with other anticyclonic eddies south of the Canary Islands before they move to the west. AC2 merged completely with AT2 (Fig. 2b and c and Fig. 3c and d), and AT1 did in a partial way with AC1 and AA1 (Fig. 3a-c). After these collisions eddies appears reinforced.

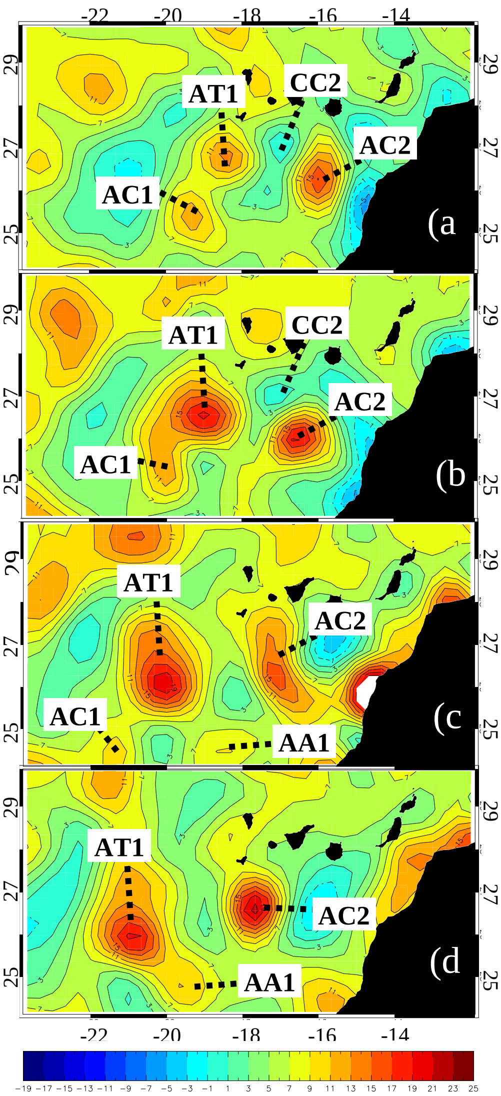

Figure 3. Sea Level Anomaly maps from altimeter for a) September 2, 1998, b) September 23, 1998, c) October 28, 1998, d) November 18, 1998.

3. PLANNED WORK WITH METOP DATA

We have planned to continue with the joint utilization of remote sensing data containing relevant oceanographic information about the mesoscale features of the Canary Region, through the incorporation of MetOp data coming from AVHRR and ASCAT remote sensors. Then it will be possible to derive for them what are the main aspects related with the generation, the drifting, the size and shape evolution, the lifetime and the period and rotation velocity of vortices. Furthermore, the interactions between these mesoscale features and also with those associated to the African upwelling coastal transition zone will be considered.

The analysis of ASCAT data will be relevant, taking in account that wind stress is the main mechanism producing coastal upwelling and shelf currents in this region, and it could be also involved in the observed mesoscale variability.

Our goal is not only to characterize the cinematic and dynamic properties of mesoscale features, as shown in this work. Then it is expected to extent the use of MetOp data to the study of the smaller characteristics (1-10 km and some days) and the larger spatial and temporal scales. In this way, the information related with the seasonal cycles and the large rank variations (seasonal and interannual) of the geophysical parameters derived from AVHRR and ASCAT for the Canary waters will be analysed. This task will be possible if several years of MetOp data are available.

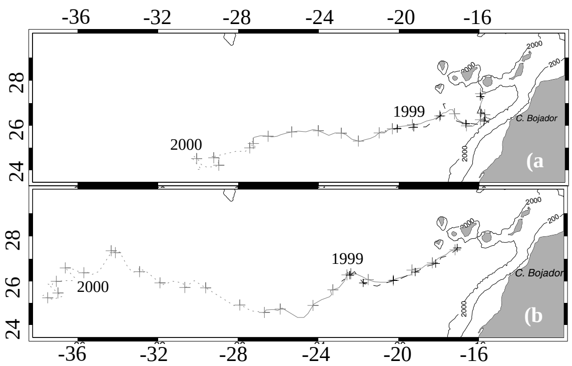

Figure 4. Trajectories of anticyclonic eddies a) AC2, and b) AT1.

MetOp data will be combined with in-situ measurements obtained with WOCE Surface Velocity Program (SVP) satellite tracked drifters, retrieving information about ocean surface circulation and in-situ SST. Twenty of these drifters will be deployed in Canary Waters in selected places. For this purpose the information given by MetOp data will be crucial and they will help to select properly the time and position where buoys will be released, and to monitor its further evolution. These buoys carry out a thermometer and then the SST measurements derived from AVHRR data can be compared with in-situ SST values. Finally, in-situ data will be interpreted jointly with remote sensing measurements.

In conclusion, it is expected to obtain a deeper knowledge of the oceanography of Canary waters using MetOp data in combination with other sources of remote sensing and in-situ data.

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