Detection of mesoscale phenomena in Arzew Bay with ALSAT-1 (high resolution sensor)

Nabil MEGA, Lansari ABDELDJELIL
Centre National des Techniques Spatiales
Division de Télédétection
1, Rue de la Palestine B.P. 13
31200 Arzew - Algérie
Emails : **megan@cnts.dz**, **lansaria@cnts.dz**

1. Abstract :

The study of oceanic circulations has been a field of research under full development for already a few years, and this for certain principal reasons. First, the ocean constitutes one of the essential components of the terrestrial climatic machine: the study of the climate thus passes by the study of the oceans. Also, one currently attends the emergence of a new technique which is the operational oceanography, which consists in making forecasts in time quasi-reality of oceanic circulations in the term of a few weeks, in a way similar to operational meteorology. Operational oceanography becomes very significant then, for very varied fields such as fishing, navigation, military defense, meteorology, etc, and projects of research and development federate around great national and international programs.

The objective of our work is to study the physical answer associated with these hydrodynamic phenomena with mesoscale, for the first time, by the imagery of the Algerian satellite Alsat-1 (a space resolution of 32 meters) and its contribution in the observation and the identification of the water masses and the dynamics of these marine structures. An application was carried out on Bay of Arzew.

Key words: Mesoscale, Bay, Alsat-1, Hydrodynamics.

2. The Bay of Arzew: geographical situation

The Bay of Arzew is located in the Alboran sea (south-western of the Western Mediterranean). Of semicircular form, the Bay is influenced by the general circulation of the water masses, precisely by the entering Atlantic water of the Straits of Gibraltar. Having a rather remarkable bathymetry, the Bay can reach the 500 meters of depth at the exit, towards the broad one.

To pass from the macro circulation (scale of the Mediterranean basin) to the micro circulation (finer scale) and to understand the nature of existing circulation in Bay of Arzew (figure 1), as well as the structures associated with this circulation, one presents, initially a recall of the characteristics of the surface circulation of the water masses in the Alboran sea (figure 2), followed in the second time of an analysis of the treated Alsat-1 images, having the existing structures in Bay of Arzew (figure 3).

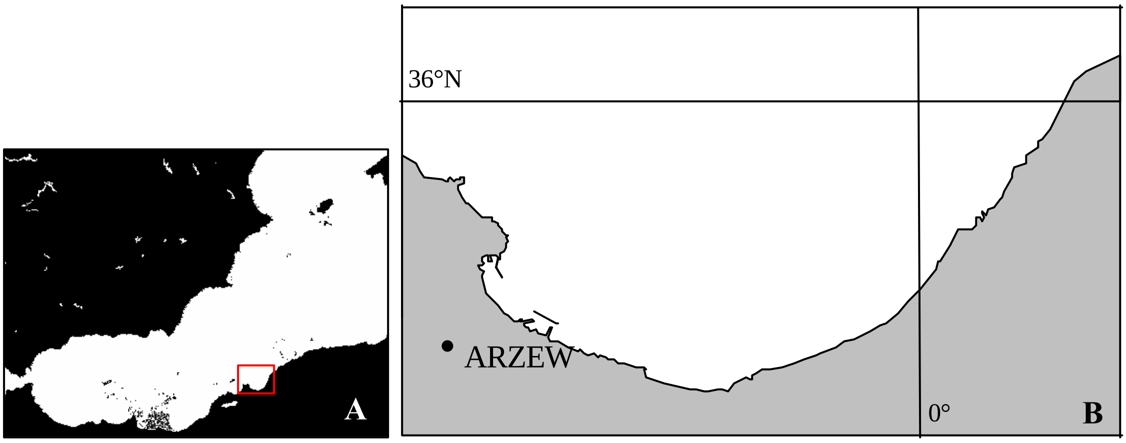

Figure 1. The Bay of Arzew, geographical situation (A: Alboran sea, B: bay of Arzew).

3. The circulation of the water masses in the Alboran sea:

The jet of Almeria-Oran is the structure which interests us more because of his direct influence on circulation of the water masses in Bay of Arzew. A climatological study of the circulation on the sea of Alboran indicates that this jet, (of the Cape de Gata in the south of Spain towards the east between Oran and Arzew), is accentuated in June and July by a difference in temperature of water of the Western eddy and that of surrounding water which can reach 4°C in the Western sea of Alboran (figure 2). In August and September, Atlantic water is still clearly differentiated from Mediterranean water even if the variations in temperature decrease. In October, the gradients appear to be reinforced, in particular along the face Almeria – Oran [1].

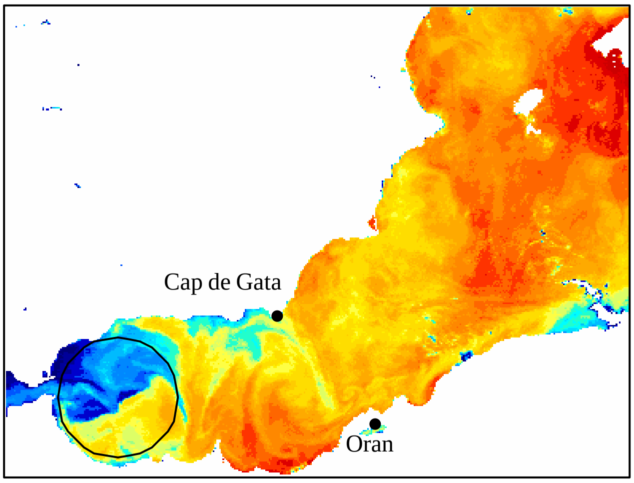

Figure 2. The Western Eddy of the Alboran sea (Image NOAA 14/ A VHRR)

4. The Algerian micro satellite Alsat-1:

Alsat-1 is an Algerian micro satellite of observation of the ground carried out by the National Center of the Space Techniques (CNTS) in the Space Center of Surrey (England) with the participation of a team of 11 researchers and engineers of the CNTS. The launching of this micro satellite was carried out on November 28, 2002 with 6h 07 GMT by the Russian launcher Cosmos-3m of the site of launching of Cosmodrome de Plesetsk in Russia.

4.1. Features of Alsat-1:

Alsat-1 currently provides images in 3 spectral bands (green, red and near infra red) similar to those of sensor ETM+ of Landsat 7 in bands 2, 3 and 4, with a space resolution on the ground of 32 m and a board width of 600 km. The period of repetitivity is 5 days.

Alsat-1 is the first micro satellite of a constellation gathering 5 partners at present (England, Algeria, Nigeria, China and Thailand). This constellation, called DMC (*Disaster Monitoring Constellation*), is dedicated to the major risks and permit to have an image per day, with same geometrical and radiometric characteristics.

- Altitude**:** 686 km, orbital slope 98°;
- Weight**:** 100 kg;
- Repetitivity**:** 5 days.

4.2. Payload (Camera):

The system imager (figure 3) works in Push broom mode and consists of 2 cameras per spectral band (2 bars CCD of 10200 pixels/line) in the form of two benches put coast at coast and allowing one swath on the ground of 600 km (5% of covering). It is possible to use only one with 300 km of width.

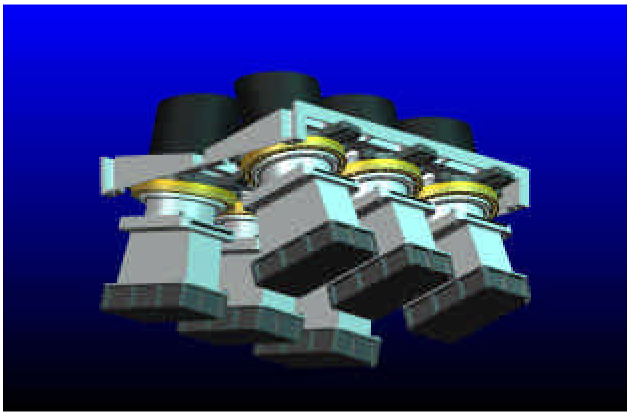

Figure 3. Imager system of ALSAT 1 (source: CNTS)

Table 1 summarizes the design features of Alsat-1

Focal distance	150 mm
Space resolution	32 m
Board width	≈ 600 km
Spectral bands (µm)	0.52 - 0.60 (Vert) 0.63 - 0.69 (Rouge) 0.77 - 0.90 (Near InfraRed)
Fields of View (FOV)	26.62°
Coding	8 bits / pixel
Storage capacity on board	1 Gbyte (~ 450 x 600 km)

Table 1. Design features of Alsat-1

5. Detection and follow-up of the phenomena of mesoscale in Arzew's Bay:

The study and the follow-up of the `locales' marine structures in Bay of Arzew rests on the space-time scale which these structures occupy. At the beginning, an outline on the circulation of the water masses in Bay of Arzew, is presented by the diagram suggested by Caullet (1963). Thereafter, a series of images of the Alsat-1 satellite (images of the channel near infra red) will be processed, to retrieve informations on the existence, the direction of displacement, the lifespan and other physical characteristics of these structures. In this paper, we will use the following notations: Cr, C, U, L, and F which mean respectively: Current, Cyclonic eddy, Upwelling, Langue of water and thermal Front.

5.1. Scheme adopted of Caullet (1963):

The normal way of the current in the north of Arzew's Bay is directed mainly towards the east. The speeds calculated from coast of Mostaganem to 30 – 40 km of the broad and 50 m of depth, reach 20 to 30 cm/s. They are 5 cm/s to 300 m of depth. This current generates in Bay of Arzew, under the effect of the force of Coriolis, against current circulating in the direction of the needles of a watch. Its low speed, is 8 cm/s with Arzew according to measurements' carried out by Caullet J. in 1963 (figure 4) [2]. This speed can increase when the winds blow in the same direction, C ` is with being said the North-East.

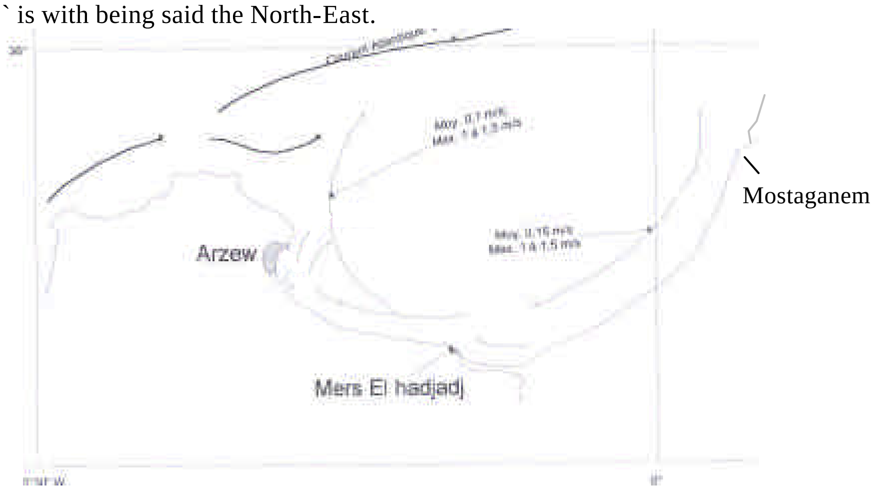

Figure 4. Scheme of Caullet for the circulation of the water masses in bay of Arzew [2].

5.2. Used data:

For our study, we used several images Alsat-1 day to make a good space-time follow-up of marine structures existing in Arzew's Bay. For average the techniques used, a software of image processing WinImage2.0 conceived in France, which functions under the platform Windows 98 and more.

5.3. Analyze of image of March 01, 2003:

This image represents most of the sea of Alboran. Even if it does not include all Bay of Arzew, it gives us an excellent outline on the presence of oceanic structures in our area (figure 5).

Of premium on board, we can note the presence of two eddy: first Anticyclonic A and second Cyclonic C a water L langue very announced by its contrast, skirts the Oranaise coast towards the east. The eddies A and C appear in 0,2°, in an area where starts the instability of the Algerian current, noted CA (between 0° and 1°E). We note an Upwelling between A and C.

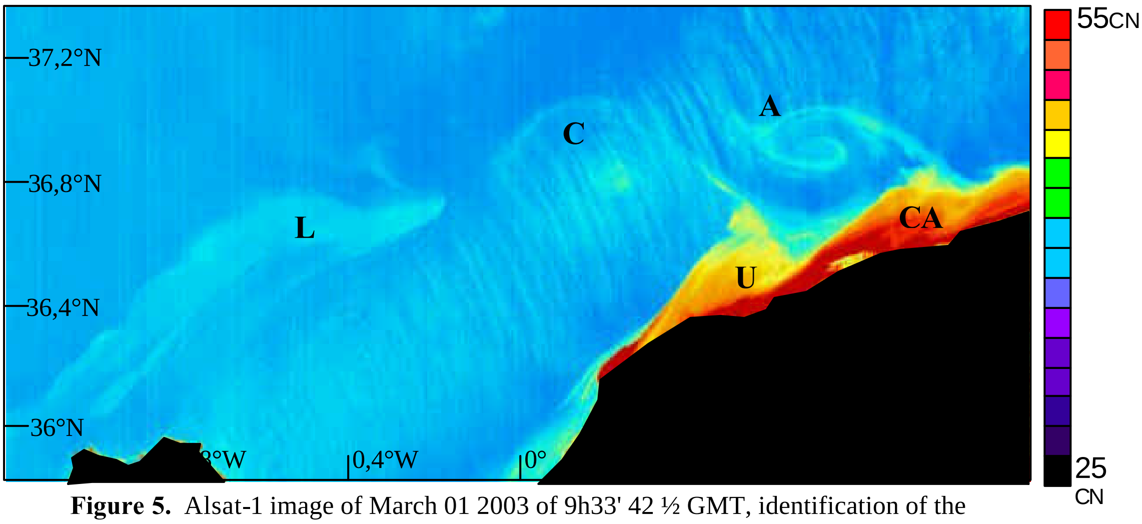

Figure 5. Alsat-1 image of March 01 2003 of 9h33' 42 ½ GMT, identification of the dynamic structures.

5.4. Analyze of image of September 21, 2003

This image (figure 6) informs us about the presence of a coastal current Cr in the North-East of Bay, and of a cyclonic eddy C1 apparent than C2. Moreover, one observes a spot U identified very well by his signature more than surrounding water in the area of the Port of Arzew.

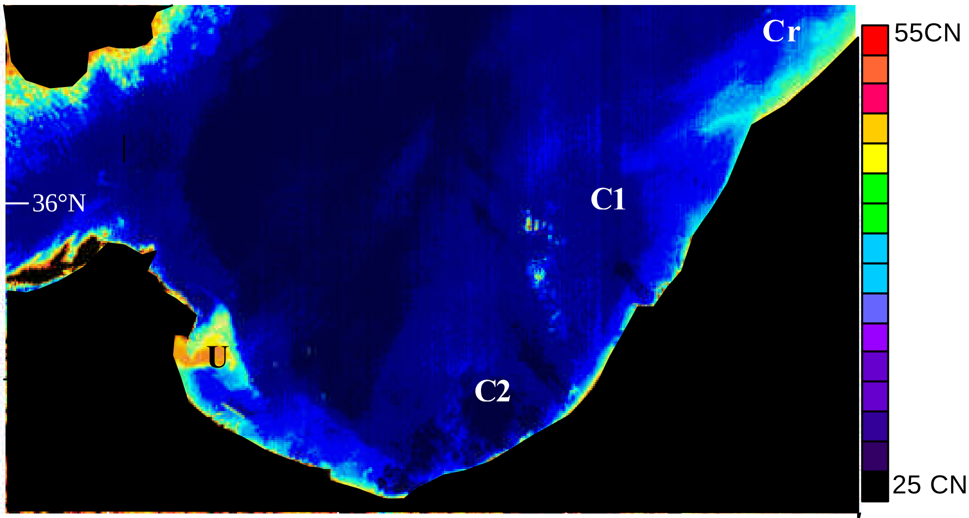

Figure 6. Alsat-1 image of September 21 2003 of 9h46 ' 48 ½GMT, identification of the dynamic structures

5.5. Analyze of image of November 30, 2003:

In this image (figure 7), it is quite apparent that has coastal current Cr, area of Mostaganem (0,1°E) skirts the central Easts coast towards the coasts of Bay. Several cyclonic eddies distinct are. It is seen that C1 is attached to the current Cr around 0°. The C2 eddy, which occupies the southern share of Bay, is quite remarkable by its thermal signature, then vertical butt his extension in this area (between 150 and 200 meters). C3, which appears in the north-western leaves of Bay, occupies a considerable surface with has diameter of 18 km. Lastly, C4 has small not very visible eddy, appears in the area of Bethioua with 0,15°W (bathymetry between 80 and 120 meters).

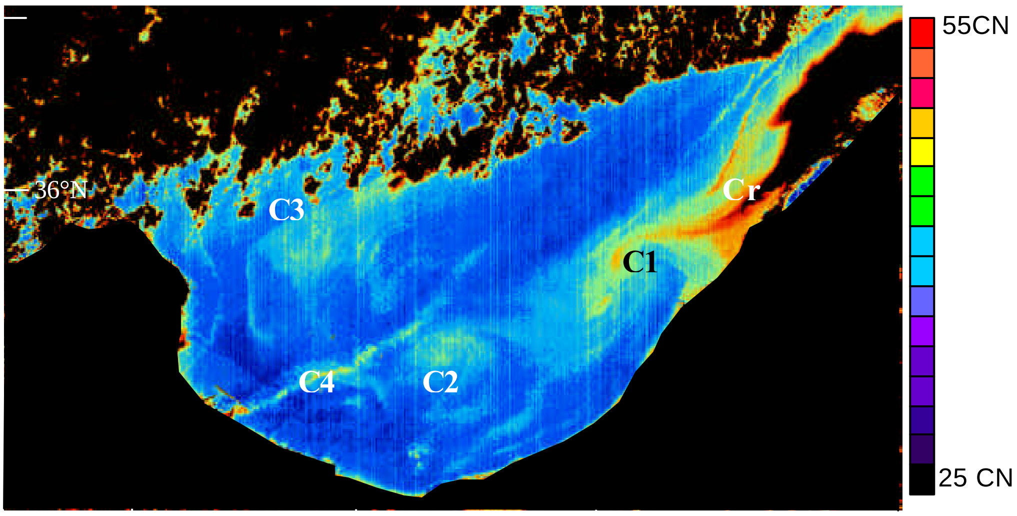

Figure 7. Alsat-1 image of November 30 2003 of 9h40' 03 ½GMT, identification of the dynamic structures

5.6. Analyze of image of December 13, 2003:

The image of December 13, 2003 (figure 8) clearly confirms the existence of against coastal current Cr which always appears in the same place and guard the same direction of movement (according to ten images). A succession of cyclonic eddies is created thereafter: C1, C2, C3 and C4.

We observe also a Langue of water L very contrasted and small a upwelling U induced by the displacement of C4 towards the North-West under the action of the flow of the coastal current Cr. What explains the strong activity of this current in this Bay. A thermal Front F, quite visible, explains the cyclonic movement of the C3 eddy, and its displacement towards the West's coast of the Bay of Arzew.

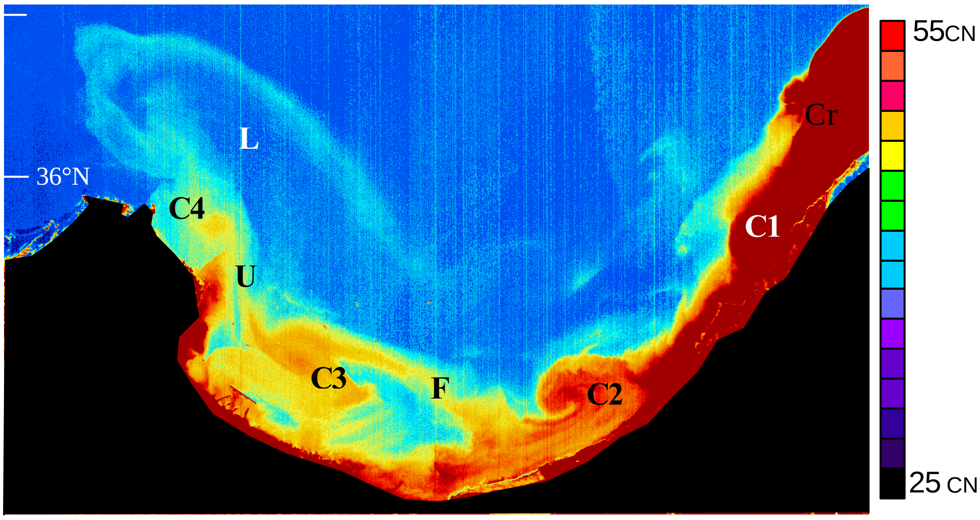

Figure 8. Alsat-1 image of December 13 2003 of 9h39 ' 21 ½ GMT, identification of the dynamic structures

6. Conclusions:

After having treated and having analyzed the Alsat-1 images, over one period relatively sufficient for our study, we can define, compared to this whole of data, a flow chart for Bay of Arzew. This first flow chart (figure 9) is not yet final, the continuous measurements of boat and permanent follow-up with the Alsat-1 images is necessary to supplement it. It is a convincing test of presentation of flow chart of surface with a finer space scale.

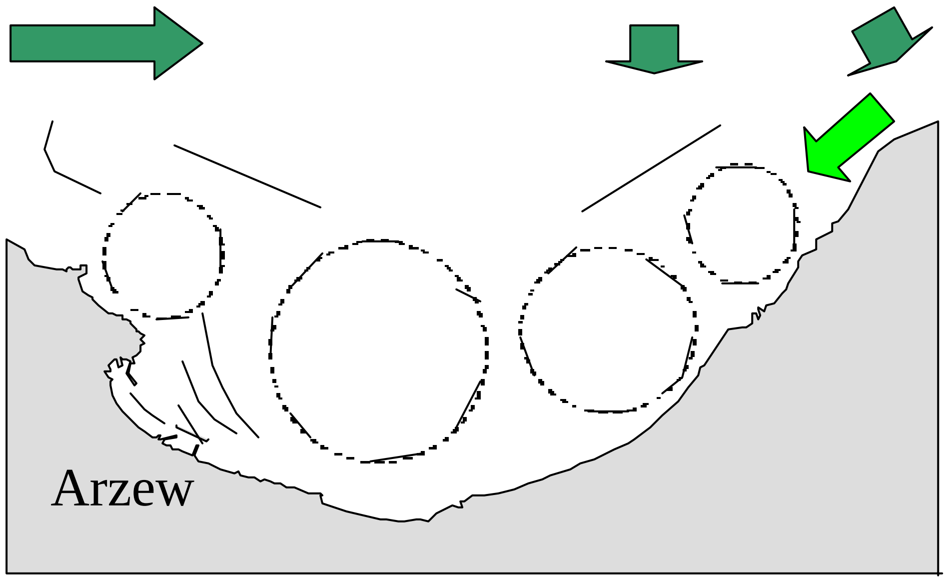

Figure 9. General outline of circulation of the water masses in bay of Arzew.

We also notice that the circulation of the water masses in Bay of Arzew is influenced by the flow of the Atlantic water characterized by the instability of the Algerian current. This instability of the current, which starts to appear as of 0° until 1°E by meanders and successions of cyclonic and anticyclonic eddies, to him is associated coastal upwellings skirting the Algerian coasts, with different space-time scales [3].

In our case of study on Bay of Arzew, we are also interested to highlight the geostrophic components of the Algerian current, because they influence directly the Bay.

If we consider the diagram of figure 9, the coastal current (noted Cr in the Alsat-1 images) which appears in the area 0,2°E, is the person in charge for the creation of the cyclonic eddies skirting the coasts of the Bay (Cr plays the role of the Algerian current, with a movement in opposite direction and a reduced space-time scale).

We can say that the cyclonic eddies of Bay of Arzew have one lifespan of a few days, within sight of the space extension which they occupy and compared to the bathymetry of this Bay.

The tool for remote sensing, as well as the satellite images Alsat-1, allowed us, for a first approach, of speaking about a ` energetic against courant' coastal existing in Bay of Arzew supporting the formation of cyclonic eddies along the coasts of this Bay.

This study of circulation of the water masses, the level of such a significant Bay, will make it possible to put at the profit concerned very significant information’s within the framework of the marine installation, fishing, the control of pollution, merchant marine, environmental marine protection, aquacoles, etc.

References:

[1]. Millot, C. 1985, 1987a. Circulation in The Western Mediterranean – Oceanology acta, 10 (2), 143-149.

[2]. Benzohra M. et Millot C., 1994. Characteristics and circulation of the surface and intermediate water mases off Algeria. Deep-Sea-Research 0967-0637-(95)00043-7.

[3]. Millot, C. 1985. Some features of the Algerian current - Journal of geophysical research, 90, 7169-7176.