

FIGURE 1: The sea surface temperature and wind images show different stages of development of the filament. The coldest and widest filaments occurred between July 20 and 24, 2009. The time-averaged image corresponding to the period of the cruise (first image) shows the coastal upwelling, the mean position of the filament and a region of higher SST along the coast, starting at 31°N.

## 1 Upwelling filaments

- Upwelling filaments = narrow, elongated structures of cold water extending offshore in the ocean upper layers (Figure 1).
- They deserve a particular attention because of their role in the offshore exportation of nutrients.
- Their mechanism(s) of generation are not perfectly understood.
- The filament we have studied lies off Cape Ghir (30°38'N, Morocco).

## 2 CAIBEX–Cape Ghir

Canaries–Iberian marine ecosystem Exchanges cruise off Cape Ghir:

- Aboard R/V *Sarmiento de Gamboa*
- From August 16 to September 5, 2009.
- Data: CTD, SeaSoar, drifting buoys and ADCP velocities.

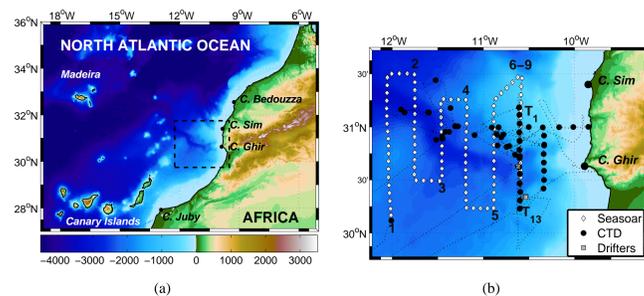


FIGURE 2: Numbers from 1 to 9 indicate the SeaSoar meridional transects. Transects 6–9 are repeated at different times of the cruise in order to examine the variability of the filament on a time scale of a few days.  $T_1$  and  $T_{13}$  indicate the positions of the northernmost and southernmost stations of the CTD transect, respectively.

The development of the filament appeared to be **correlated to the intensity of the wind**: the period of strong winds were followed by an large offshore extension of the filament.

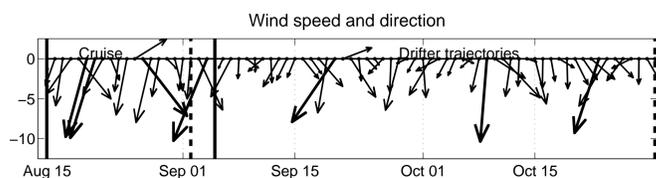


FIGURE 3: Wind vectors obtained by averaging the QuikSCAT measurements over the domain 30°N–31°45'N, 11°30'W–9°W. Winds stronger than  $10 \text{ m s}^{-1}$  are indicated by bold arrows. During most of the cruise, wind had a stronger meridional component and was generally upwelling-favourable.

## 3 Structure of the filament

### 3.1 Horizontal maps

At 4.5 m: cool water along the coast → **upwelling**, offshore extension of upwelled → **filament**, warmer area south to 30°40'N → **wind shelter**.

At 25 m: the filament appears as an elongated structure with a mean latitude corresponding to that of Cape Ghir. The **persistence of the filament** throughout the three week observation period is reflected in the strong signal in the mean.

At 300 m: structure of relatively warm water, centred at 31°N and close to the coast.

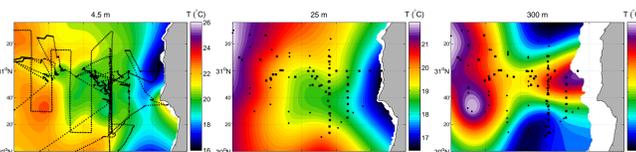


FIGURE 4: Horizontal maps of temperature obtained by spatial interpolation of all the measurements made during the cruise: the thermosalinometer data at 4.5 m (black dots), the CTD (squares) and SeaSoar data (dots) at 25 and 300 m.

### 3.2 Vertical sections

**Temperature:** filament between stations  $T_9$  and  $T_{10}$ .

**Salinity:** signal of the filament not identified.

**Chlorophyll-a:** highest values at 25 m.

**T & S:** doming of the isotherms and isohalines below 200 m between  $T_4$  and  $T_7$  → **vertical velocity?**

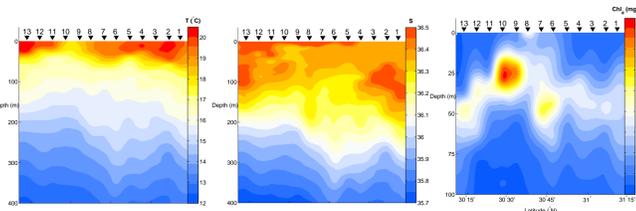


FIGURE 5: Vertical sections of temperature, salinity and chlorophyll-a ( $Chl_a$ ) obtained by interpolation of the meridional CTD transect.

**Transects 5, 6 and 7:** downbowing of the isotherms between 200 and 400 m.

**Transect 9:** filament position slightly south of 30°30'N ( $SST \approx 19^\circ C$ ).

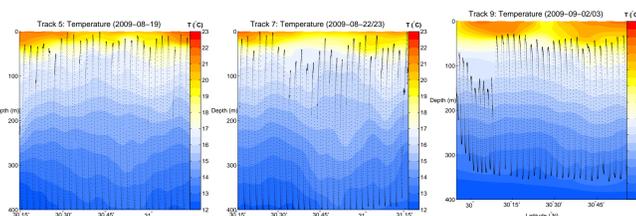


FIGURE 6: Vertical sections of temperature obtained by interpolation of the data SeaSoar and thermosalinometer data during the SeaSoar transects. The black dots represent the trajectory of the SeaSoar vehicle.

### 3.3 ADCP velocities

**Surface layer (0–25 m):** max. velocity =  $0.55 \text{ m s}^{-1}$  at 30°40'N.

South of 30°30'N: flow directed toward the coast ( $v \leq 0.35 \text{ m s}^{-1}$ ).

**250–350 m:** north-eastward velocities in the southern part of the transect. Negative shear between  $T_3$  and  $T_6$  → **anticyclonic eddy?**

**SeaSoar transects, 0–25 m:** highest velocities in transects 1 and 4.

Current mainly westward.

Steep changes of velocity direction → **mesoscale eddies?**

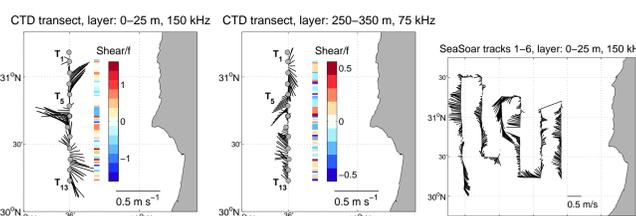


FIGURE 7: ADCP velocities measured along the CTD transect in the 0–25 m layer (top), in the 250–350 m layer (middle) and along the SeaSoar transects 1–6 in the 0–25 m layer. The color scales indicate the current shear normalized by the Coriolis frequency  $f$ .

### 3.4 Drifters

**First 10–15 days:** weak displacements (calm winds).

**After 15 days:** north-westward motion for drifters 95854, 95855 and 95867 → **entrainment by the filament**.

**Between 31°N and 31°30'N:** cyclonic trajectory then south-westward motion. Median velocity  $\approx 0.35 \text{ m s}^{-1}$ .

**300 m-drogue drifter (95864):** **cyclonic loops:** period  $T \approx 5\text{--}6$  days; radius  $R \approx 25\text{--}30$  km; median velocity  $v \approx 0.15 \text{ m s}^{-1}$ .

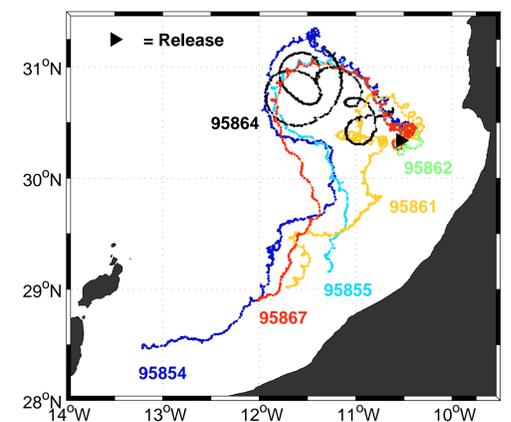


FIGURE 8: The drifter trajectories from September 3 to October 31, 2009, show an overall north-westward displacement, followed by a cyclonic loop and a southward motion. Drifter no. 95864 (black line) was drogued at 300 m.

## 4 Conclusions & future work

The main features occurring off Cape Ghir in summer:

1. the coastal upwelling, with a width of 50 km and minimal surface temperature of  $16^\circ C$ ;
2. the filament, with an extension on the order of 100 km, a depth of 50 m and surface temperature up to  $4^\circ C$  lower than the open-ocean water at the same latitude;
3. the warm subsurface anticyclonic eddy, located north of the filament, at depth between 200 and 400 m;
4. the wind-sheltered area south of Cape Ghir, where the coastline undergoes a change of concavity.

**Future work:**

- Confirm the existence of the **subsurface anticyclonic eddy** and its interaction with the filament
- Compare with observations of other cruises in the same area at different time of the year.

## 5 Acknowledgements

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