



# CAIBEX workshop

## Mesoscale experiments and modelling – Cape Ghir

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Spain

29 November – 1 December 2010



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## Mesoscale experiments and modelling – Cape Ghir

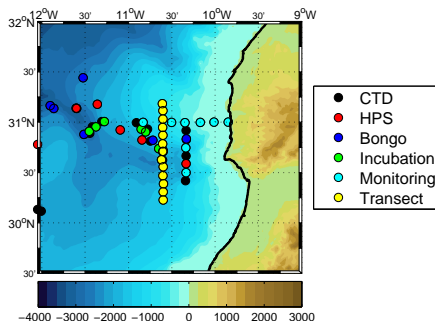
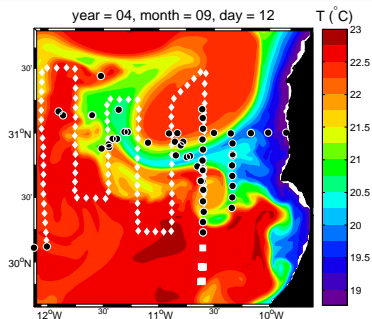
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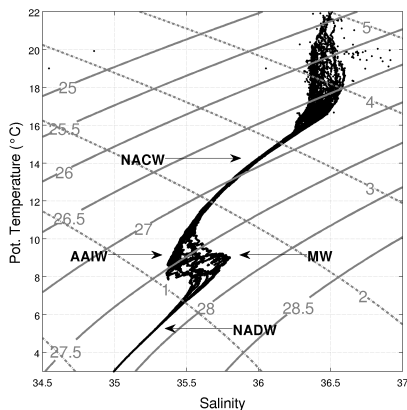
29 November – 1 December 2010

# Data locations



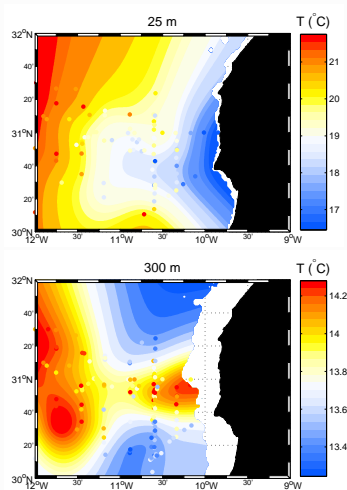
- ▶ Sampling strategy ← model results
- ▶ 9 SeaSoar tracks, 56 CTDs, 6 drifters
- ▶ High spatial resolution

# T-S diagram



- ▶ North Atlantic Central Water:  
 $10^{\circ}\text{C} \geq T \leq 16^{\circ}\text{C}$
- ▶ Antarctic Intermediate Water:  
salinity minimum (700–1000 m)
- ▶ Mediterranean Water:  
 $T > 9^{\circ}\text{C}$  and  $S > 35.5$
- ▶ North Atlantic Deep Water:  
 $T \simeq 3^{\circ}\text{C}$ ,  $S \simeq 35$

# Horizontal mapping



→ overall picture of the filament

**Variables:** T, S, [O<sub>2</sub>], Fluorescence

**Depths:** from 5 to 3000 m

**Near-surface:** upwelling and filament

$$T_{\min} \simeq 16.5^{\circ}\text{C}$$

$$T_{\max} \geq 21.5^{\circ}\text{C}$$

**200-300 m:** warm core close to coast

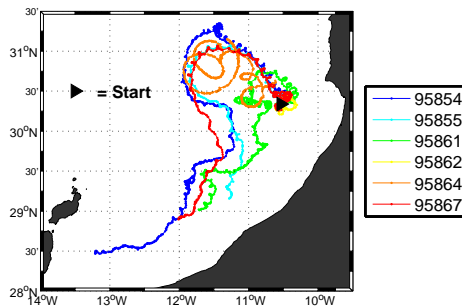
$$T_{\max} \simeq 14.25^{\circ}\text{C}$$

→ subsurface anticyclonic eddy?

# Drifters

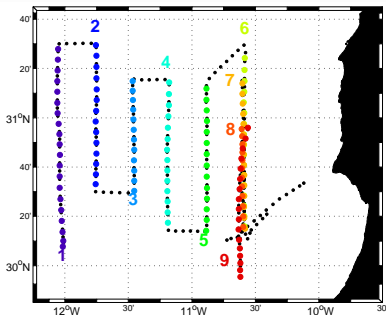
Locations → SeaSoar measurements

Date: September 3, 2009



- ▶ filament core  
→  $5 \times 10$  m-drogue drifters
- ▶ anticyclonic eddy  
→  $1 \times 300$  m-drogue drifter
- ▶ median velocity:  $\mathcal{O}(0.35 \text{ m/s})$
- ▶ 300 m-drogue drifter:  
 $T \simeq 5 - 6 \text{ d}$ ,  $R \simeq 30 - 40 \text{ km}$

# SeaSoar tracks



August 17-20 (tracks no. 1–6): synoptic picture of the filament

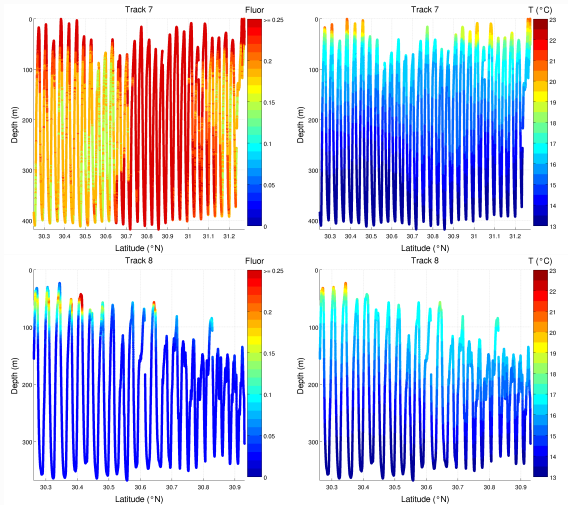
August 22-23 (track no. 7): variation of the filament position

September 2-3 (tracks no. 8 and 9): drifter locations + final picture of the filament

## Issues:

1. Fluorescence calibration (tracks 1–7)
2. Rough sea conditions → no measurements near surface (tracks 7–9)

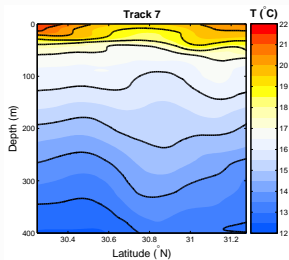
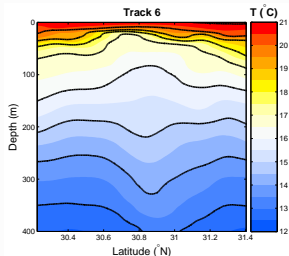
# SeaSoar measurements



Left: fluorescence  
before and after  
calibration

Right: temperature

# SeaSoar interpolated temperature

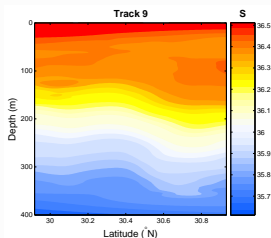
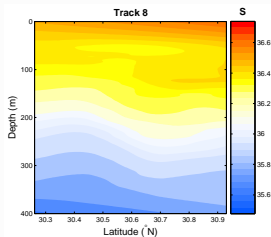


Tracks 1–3: descent of isotherms  
possible surface anticyclonic eddy

Tracks 4–7: filament more visible  
descent of isotherms at 200–400 m

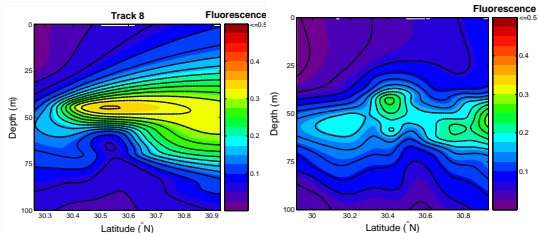
Tracks 8–9: descent of the isotherms  
few near-surface data

# SeaSoar interpolated salinity and fluorescence

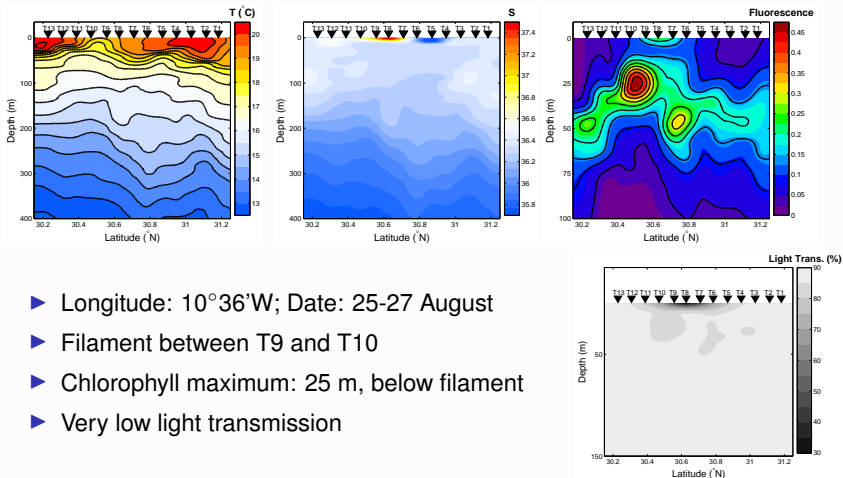


**Fluorescence:** lack of surface data  
maximal concentration: 50 m

**Salinity:** filament signal less evident  
subsurface anticyclonic eddy



# CTD meridional transect



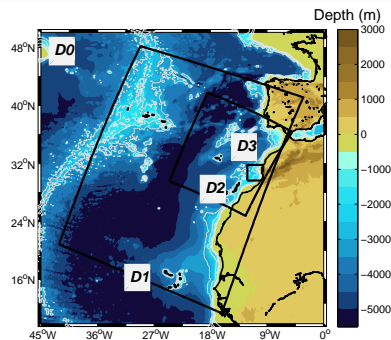
- ▶ Longitude: 10°36'W; Date: 25-27 August
- ▶ Filament between T9 and T10
- ▶ Chlorophyll maximum: 25 m, below filament
- ▶ Very low light transmission

## Summary – checklist

- Data pre-processing
- Preliminary analysis: property diagrams, mean profiles
- Horizontal property maps
- Vertical interpolation + interpretation
- Drifter analysis
  
- Current-meter processing
- Thermosalinograph data?

# Process study

2008 Grid

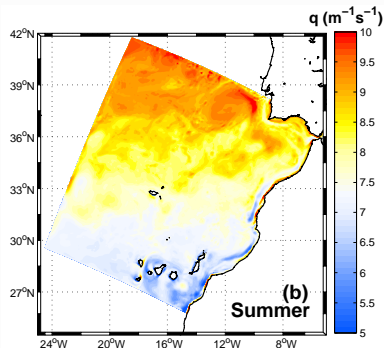
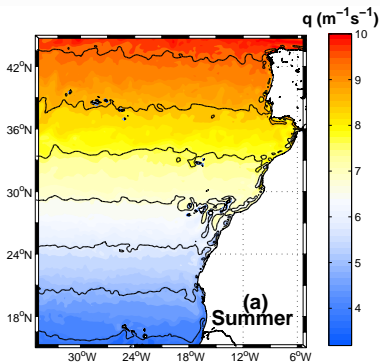


- ▶  $D_i \rightarrow D_{i+1}$ : One-way, off-line nesting
- ▶  $D_0$ : high-resolution climatology [Troupin et al. (2010) JGR]
- ▶  $D_1$ : solution from E. Mason

Domain	Res. (km)	Size
$D_1$	15.0	227 × 330
$D_2$	5.1	258 × 290
$D_3$	1.7	162 × 162

# Process-oriented experiments

- ▶  $\beta$ -effect
- ▶ Wind intensity and wind curl
- ▶ Topographic effects
- ▶ Friction

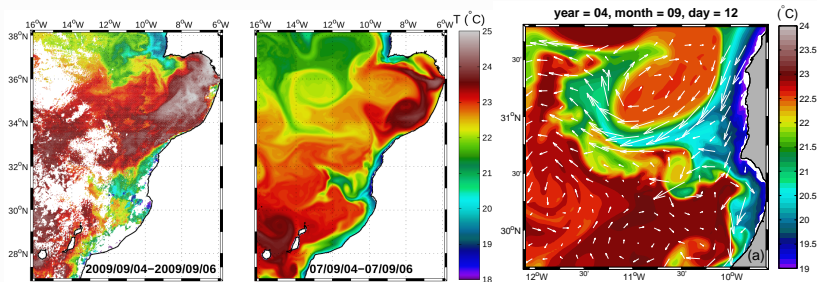


## Mecanism:

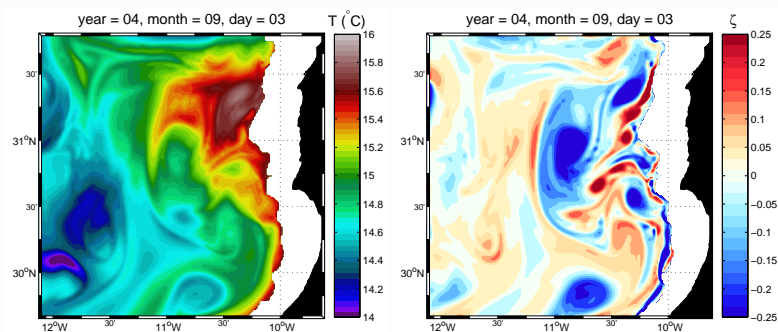
1. Conversation of potential vorticity
2. Injection of relative vorticity by the wind

# Realistic solution

- ▶ Validation against Medspiration satellite images (left)
- ▶ Correct scales and location of the filament (right)
- ▶ Agreement with in situ data



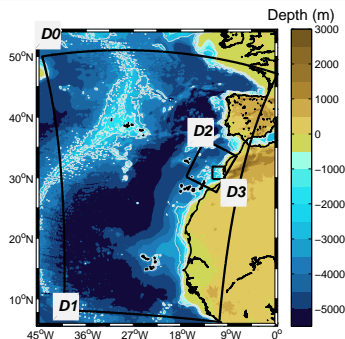
# Sub-surface anticyclonic eddy



- ▶ Model agrees with CAIBEX observations
- ▶ Mechanism: interaction undercurrent + topography
- ▶ Similar in California Upwelling System

# Sub-mesoscale study

2009 Grid

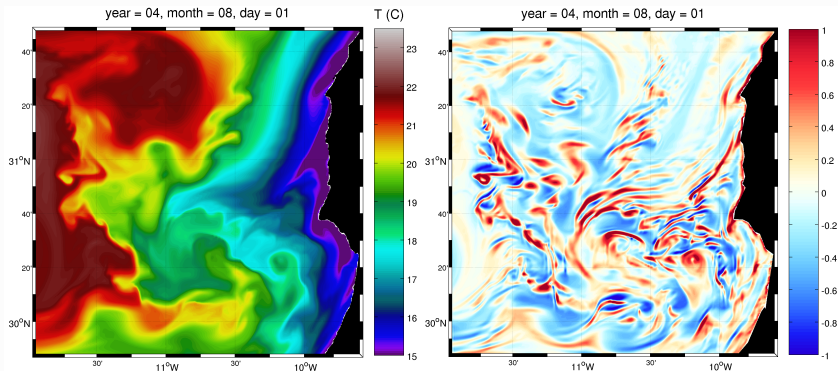


- ▶  $D_i \rightarrow D_{i+1}$ : One-way, off-line nesting [Mason et al. (2010) Ocean Model.]
- ▶  $D_0$ : high-resolution climatology [Troupin et al. (2010) JGR]
- ▶  $D_1$ : solution from E. Mason et al. (subm.)

Domain	Res. (km)	Size
$D_1$	7.5	442 × 646
$D_2$	2.5	242 × 290
$D_3$	<b>0.8</b>	290 × 290

## Sub-mesoscale fields

Temperature and normalized vorticity at 10 m  
800-m horizontal resolution



► Broader filament; Frontal instabilities

► Animation: <http://www.youtube.com/watch?v=-aadsMNjRIo>

# EOF analysis

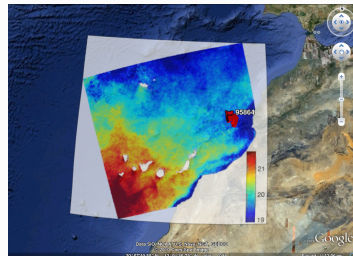
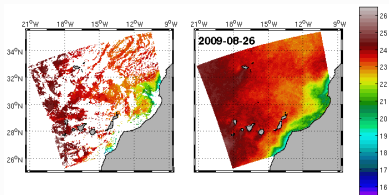
Source: Medspiration project (ESA)

Sensor: AATSR (1 km-resolution)

Period: 2009 ongoing

Method: DINEOF [Alvera-Azcárate et al. (2005, 2009)]

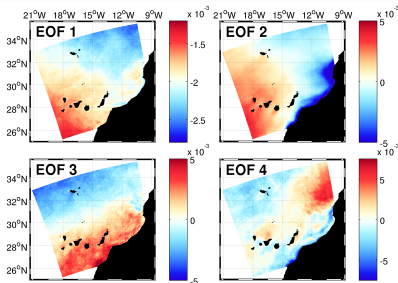
- Objectives:
1. Extract dominant modes
  2. Fill incomplete images



[http://gher-diva.phys.ulg.ac.be/DINEOF/dineof\\_allCAN.html](http://gher-diva.phys.ulg.ac.be/DINEOF/dineof_allCAN.html)

# EOF analysis: dominant mode

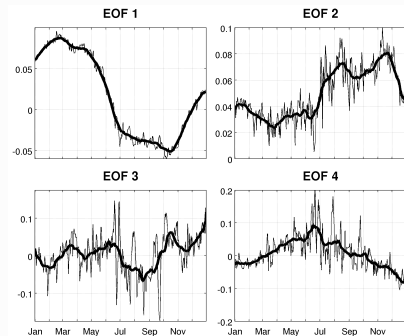
Spatial modes:



EOF no. 1: seasonal cycle

EOF no. 2: related to filament  
related to wind curl?

Temporal modes:



## Summary – checklist

- Realistic model results + validation
- Process-oriented experiments
- Generation mechanism
- Sub-mesoscale modeling effort
- EOF analysis
  
- Inter-annual forcing
- Publication

# Publications

1. Generation of the Cape Ghir coastal upwelling filament: a numerical study [modelling]
2. High-resolution sampling of the Cape Ghir upwelling filament during the CAIBEX cruise [observations]
3. Observation and modeling of a subsurface anticyclonic eddy off Cape Ghir (NW Africa) [modelling + observation]

# Conferences

- ▶ **VLIZ Young Scientists' day**, Oostende (Belgium), November 27, 2009:  
*High-resolution measurements and modelling of the Cape Ghir upwelling filament during the CAIBEX cruise* [oral presentation and poster]
- ▶ **Ocean Science Meeting**, Portland (USA), February 22-26, 2010:
  - ▶ *Poleward front of upwelling filaments generates subsurface anticyclonic eddies (feddy): a CAIBEX project contribution* [poster], P. Sangrà, J. Arístegui, C. Troupin and E. D. Barton.
  - ▶ *The Cape Ghir (NW Africa) upwelling filament: Modeling and observation during the CAIBEX Campaign* [poster], C. Troupin, P. Sangrà, J. Arístegui, J.-M. Beckers and E. D. Barton.
- ▶ **42<sup>nd</sup> International Liège Colloquium on Ocean Dynamics**: Liège (Belgium), April 26-30 2010:  
*High-resolution measurements of an upwelling filament during the CAIBEX campaign* [oral presentation and poster], C. Troupin, J. Arístegui, J.-M. Beckers and P. Sangrà.