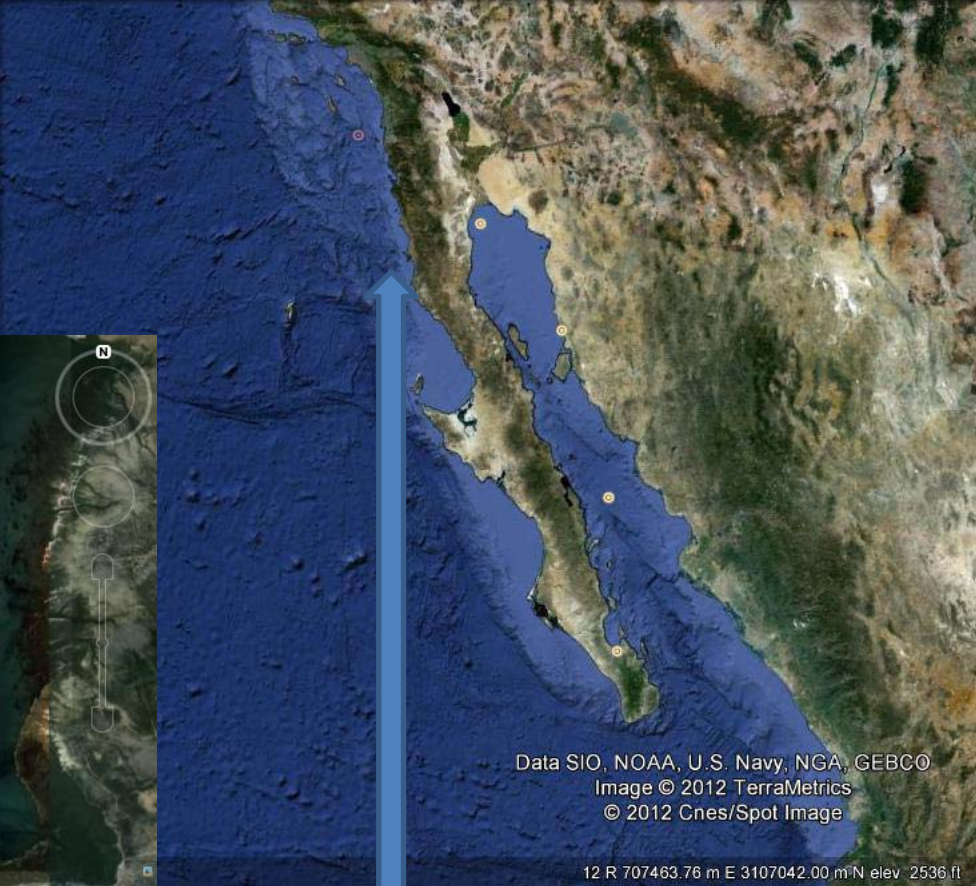


Simulating the Hydrodynamics of San Quintin bay, Bcfa, Mexico

I. Ramirez(1), R. Blanco(2), R.
Vazquez(3), G. Ramirez(1)

1-DOF-CICESE, 2-IIO-UABC, 3-SDT-CICESE

San Quintin Bay is sited on the West Coast of the Baja California Peninsula



Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2012 TerraMetrics
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12 R 707463.76 m E 3107042.00 m N elev 2536 ft

Estuary, Lake and Coastal Ocean Model: ELCOM, CWR-UWA

- ELCOM has been used to simulate the hydrodynamic of different environments and different scales. Our aim was to apply the model as a tool to understand the complex hydrodynamics of the coastal zone looking for a better way to develop sustainable development in the region.

ELCOM, The Model

$$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} + w \frac{\partial u}{\partial z} = -g \left(\frac{\partial \eta}{\partial x} + \frac{1}{\rho_0} \frac{\partial}{\partial x} \int_z^\eta \rho' dz \right) + \mu \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right) + \frac{\partial}{\partial z} \left(v \frac{\partial u}{\partial z} \right) + fv$$

$$\frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + w \frac{\partial v}{\partial z} = -g \left(\frac{\partial \eta}{\partial y} + \frac{1}{\rho_0} \frac{\partial}{\partial y} \int_z^\eta \rho' dz \right) + \mu \left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} \right) + \frac{\partial}{\partial z} \left(v \frac{\partial v}{\partial z} \right) - fu$$

Momentum equations

$$\frac{\partial p}{\partial z} = -\rho g \quad \text{Hydrostatic equation}$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0 \Rightarrow \frac{\partial \eta}{\partial t} + \frac{\partial}{\partial x} \int_{-h}^\eta u dz + \frac{\partial}{\partial y} \int_{-h}^\eta v dz$$

Continuity equation → the free surface

$$\frac{\partial C}{\partial t} + u \frac{\partial C}{\partial x} + v \frac{\partial C}{\partial y} + w \frac{\partial C}{\partial z} = \frac{\partial}{\partial x} \left(K_x \frac{\partial C}{\partial x} \right) + \frac{\partial}{\partial y} \left(K_y \frac{\partial C}{\partial y} \right) + \frac{\partial}{\partial z} \left(K_z \frac{\partial C}{\partial z} \right)$$

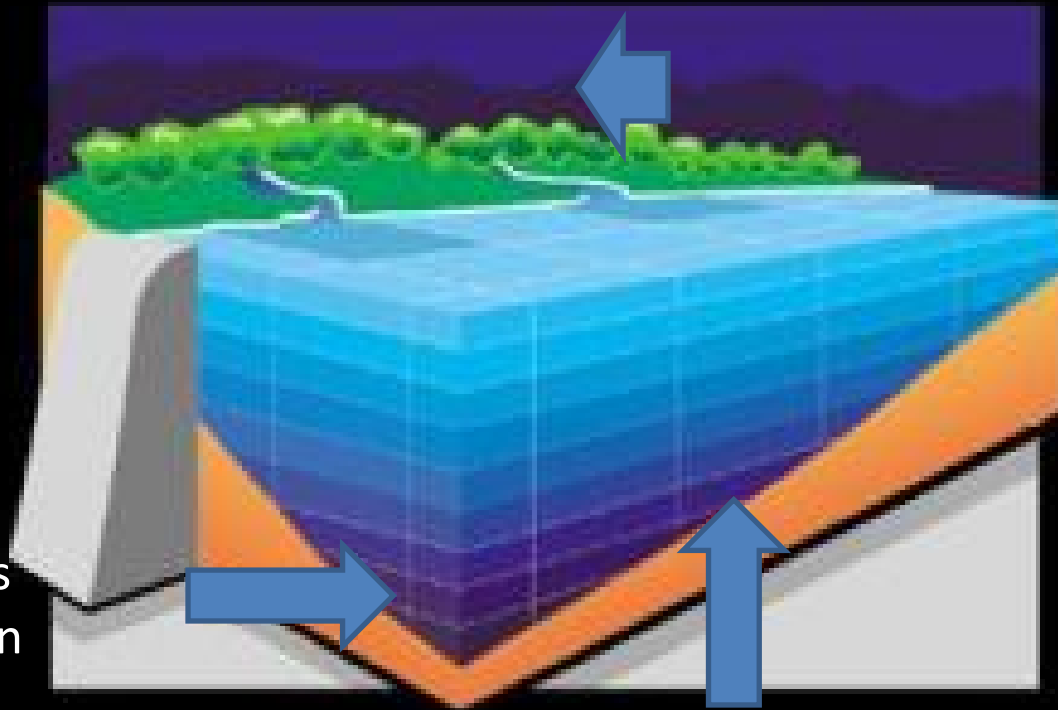
Transport equation

$$\rho = \rho(S, T, p) \quad \text{State equation}$$

- u, v e w components of velocity, t =time, η = surface elavation,
- f = Coriolis, μ e ν turbulent viscoscity coeficient, C= scalar concentration
, ρ = density, K_x, K_y e K_z =turbulent difusivity

ELCOM

Time series of Inflows and flow concentration



Orthogonal layers and stratification

OB time series of temperature, tide, salinity and flow concentration

CAEDYM-DYRESM



The measurements

Initial Condition

Bathymetry

vertical distribution of
salinity and temperature

Open Boundaries conditions

tide

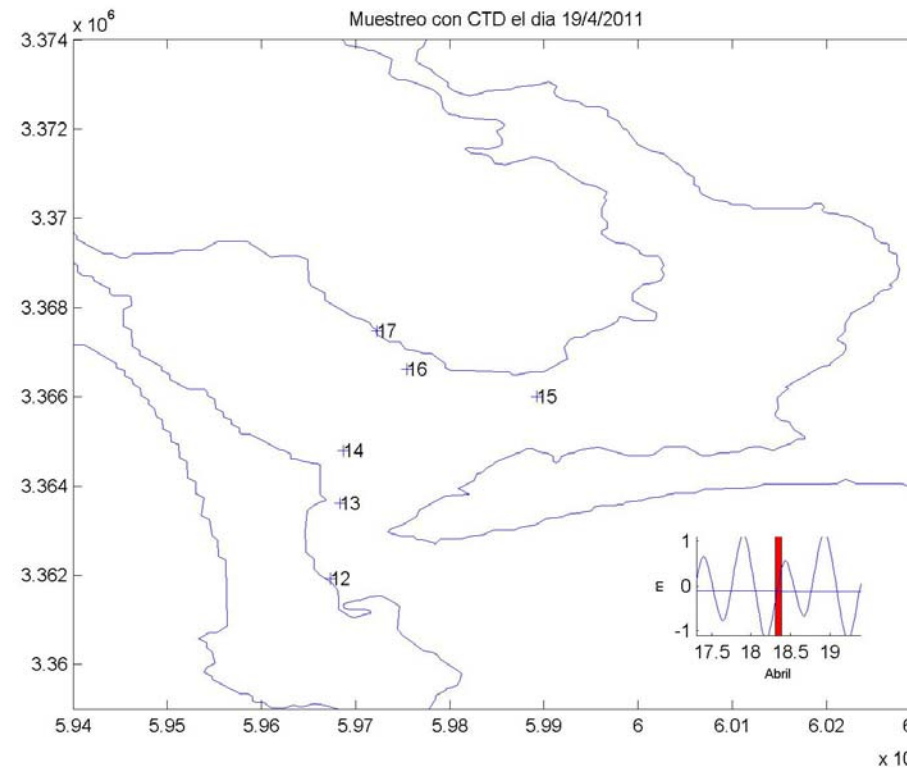
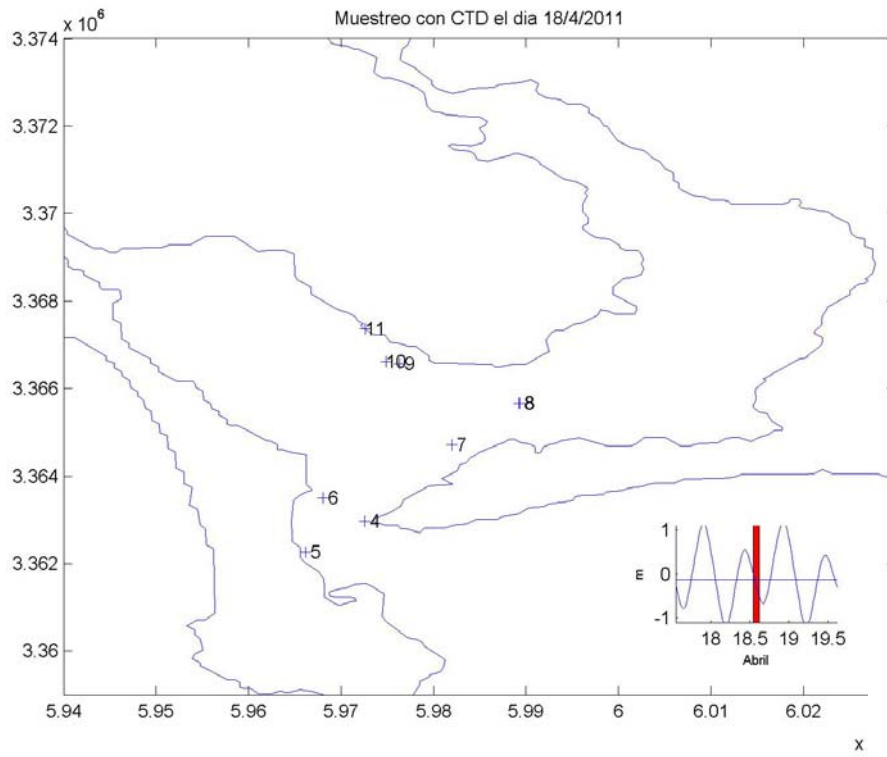
wind

salinity and temperature
at OB



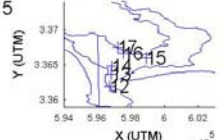
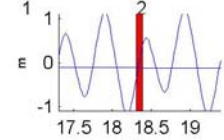
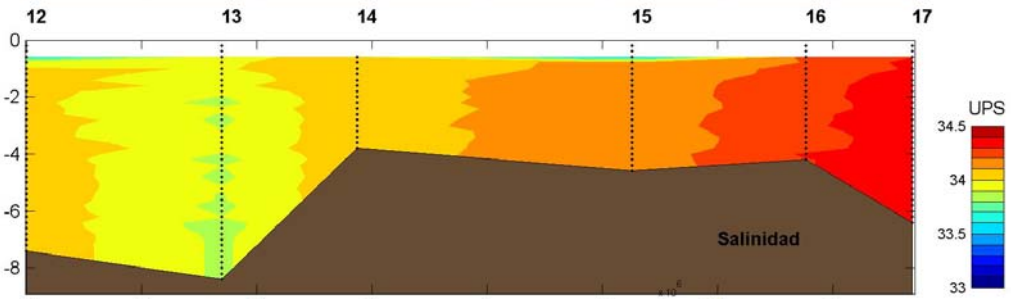
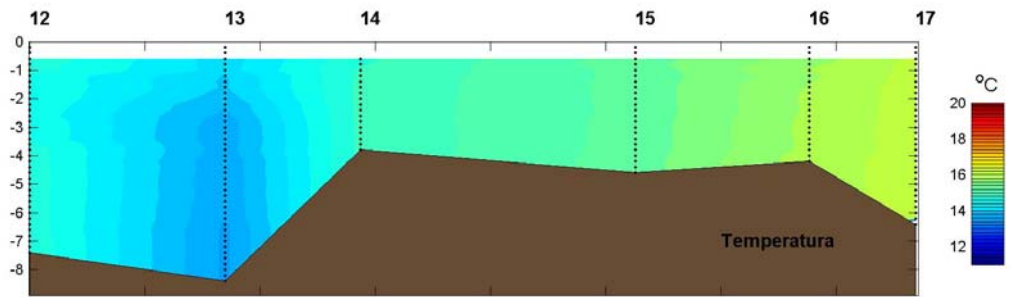
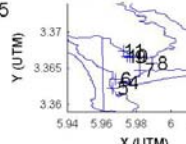
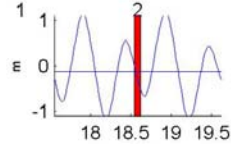
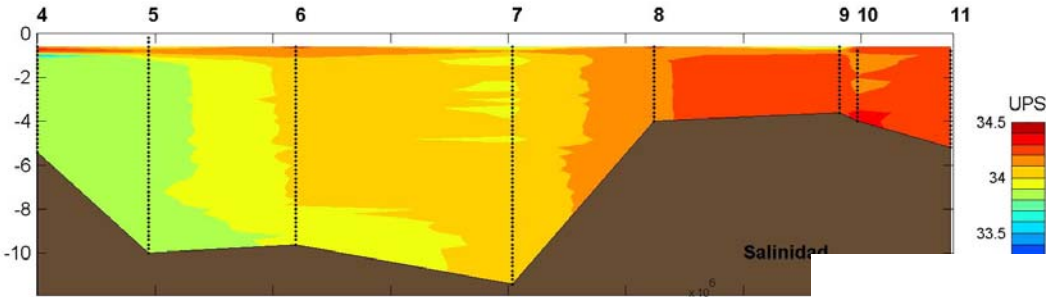
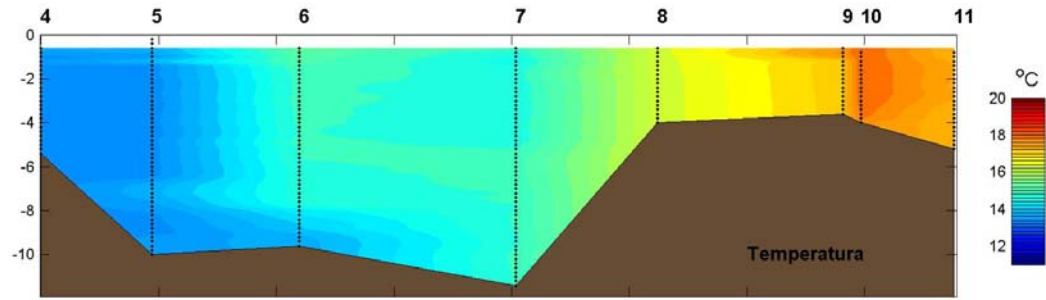


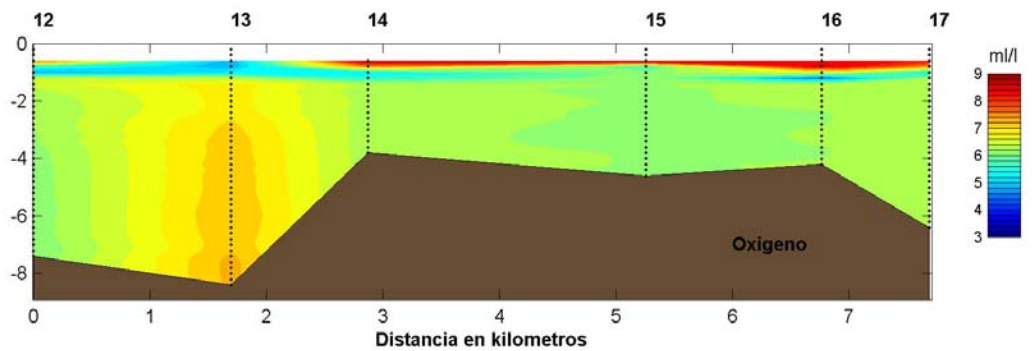
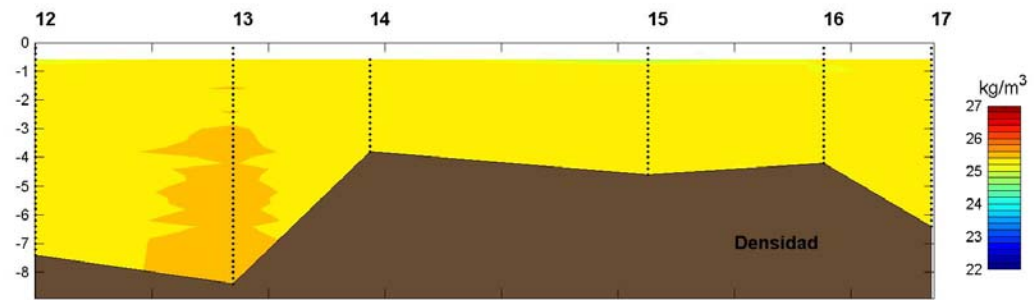
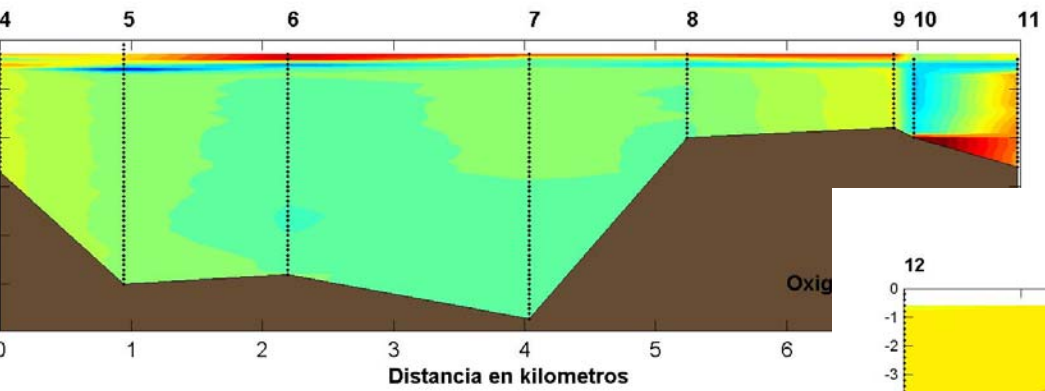
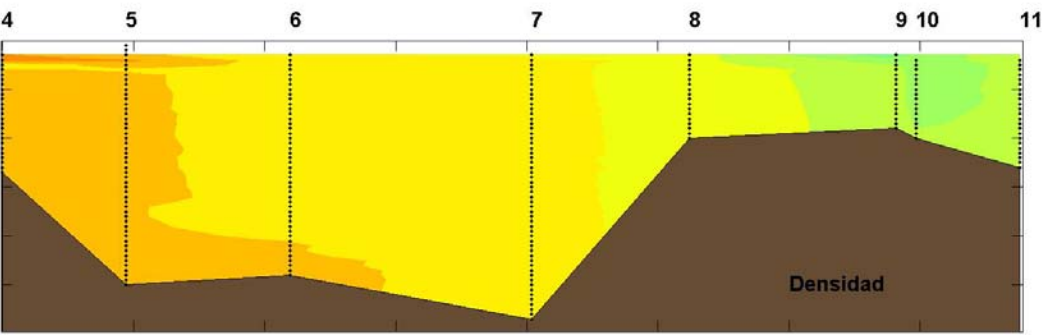
CTD profiles

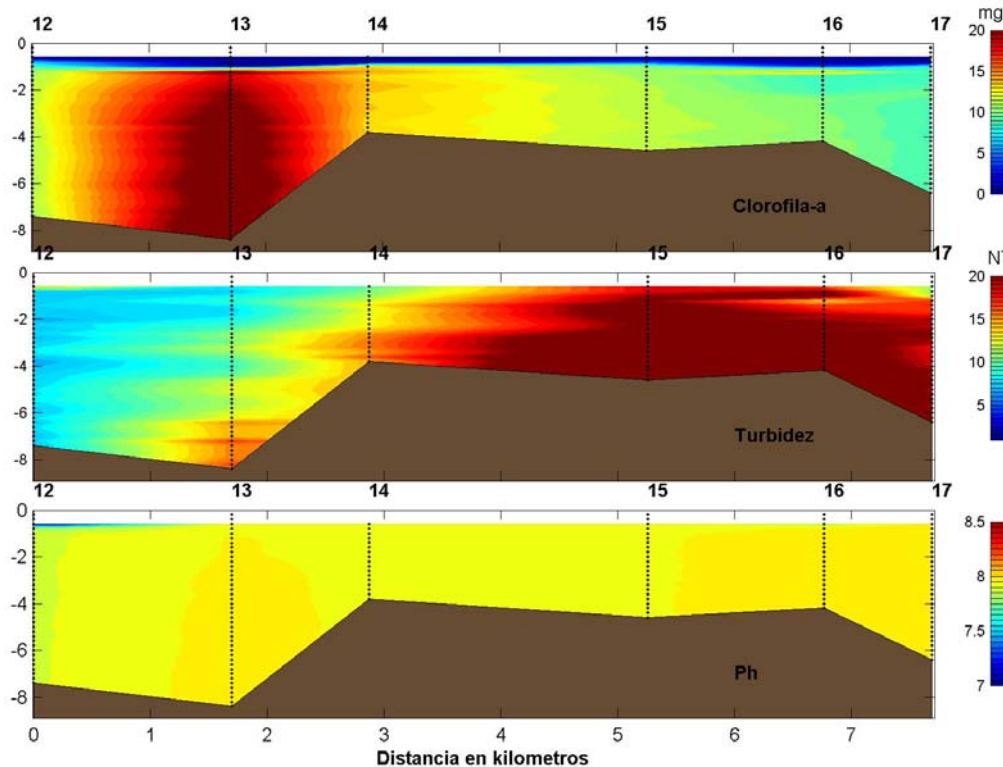
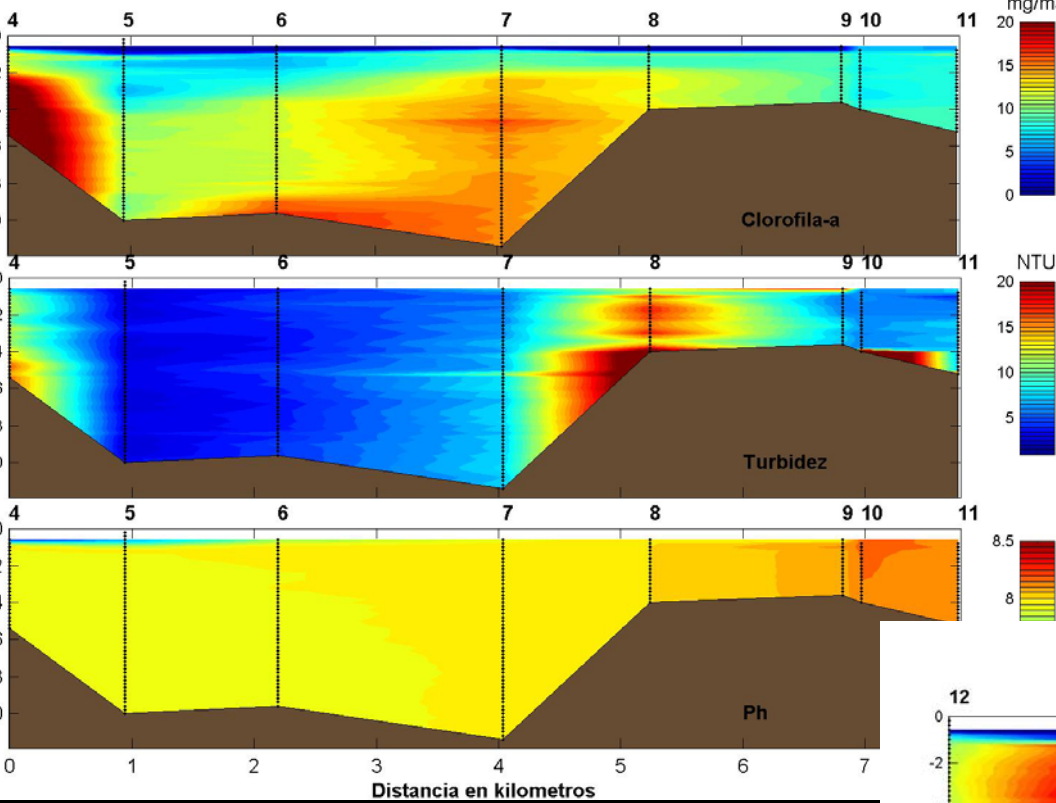


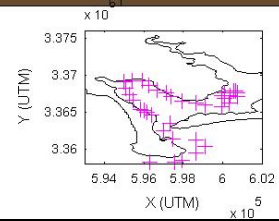
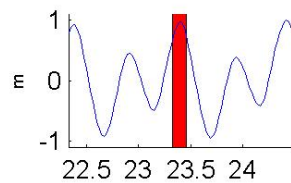
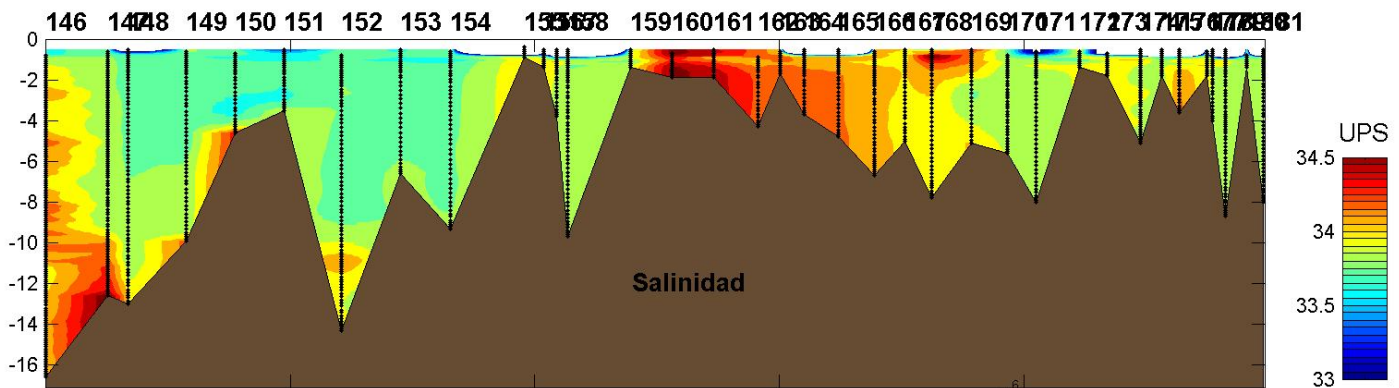
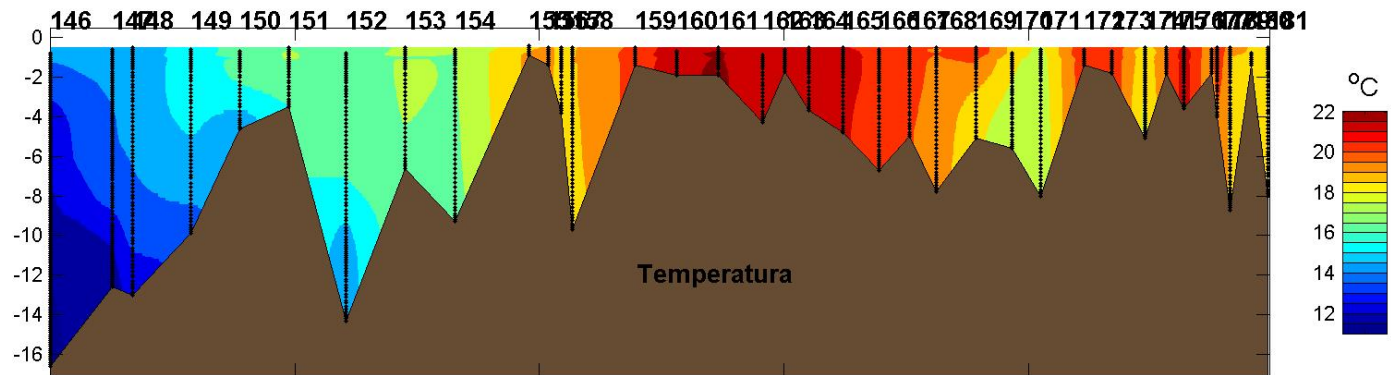


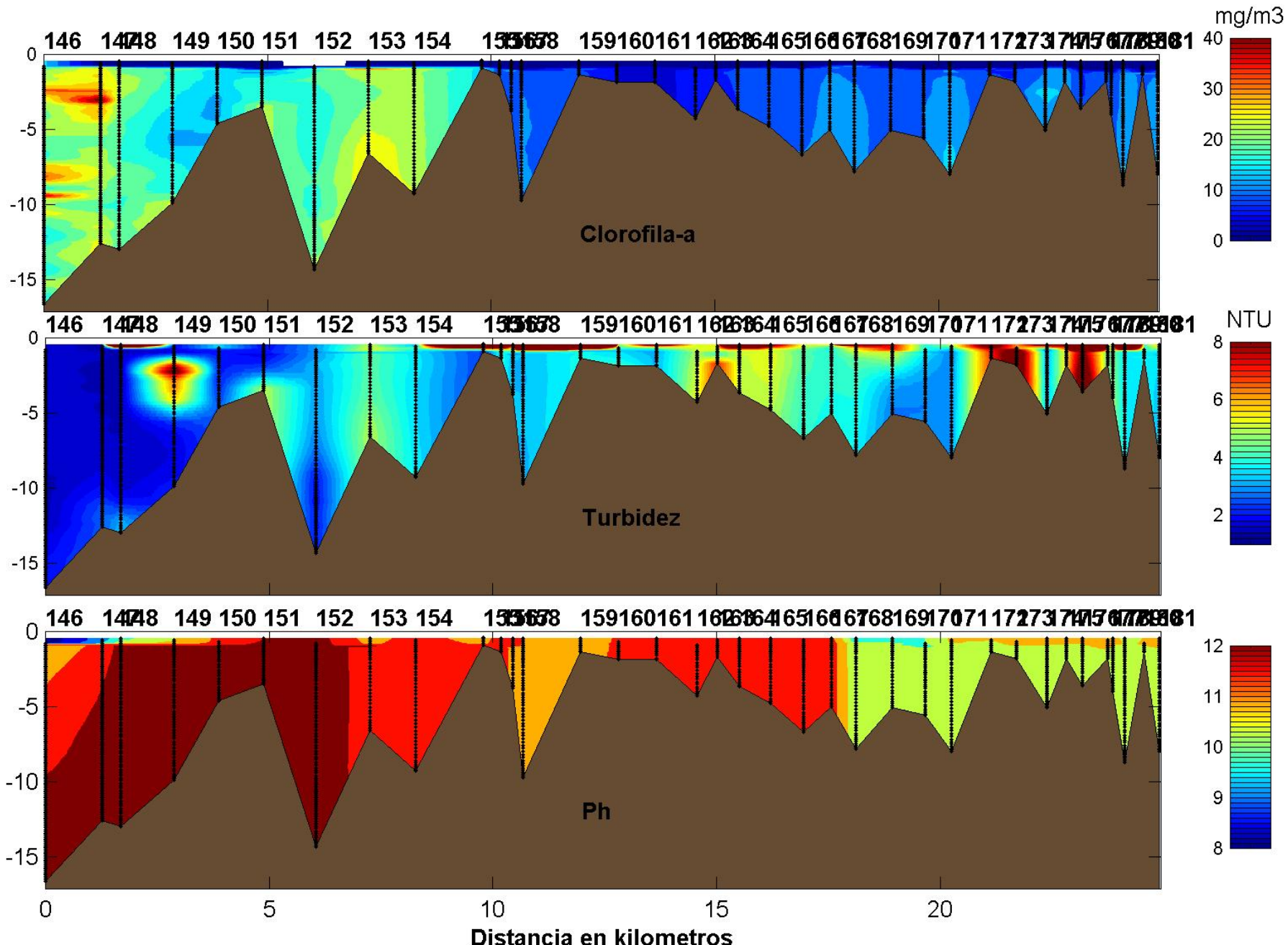
Ebb tide Vs Flooding tide

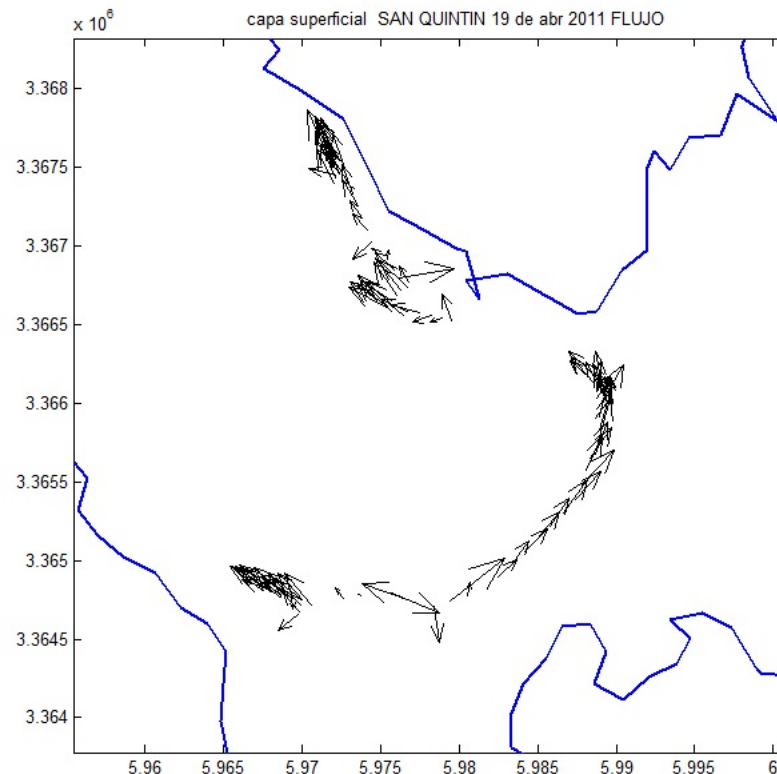
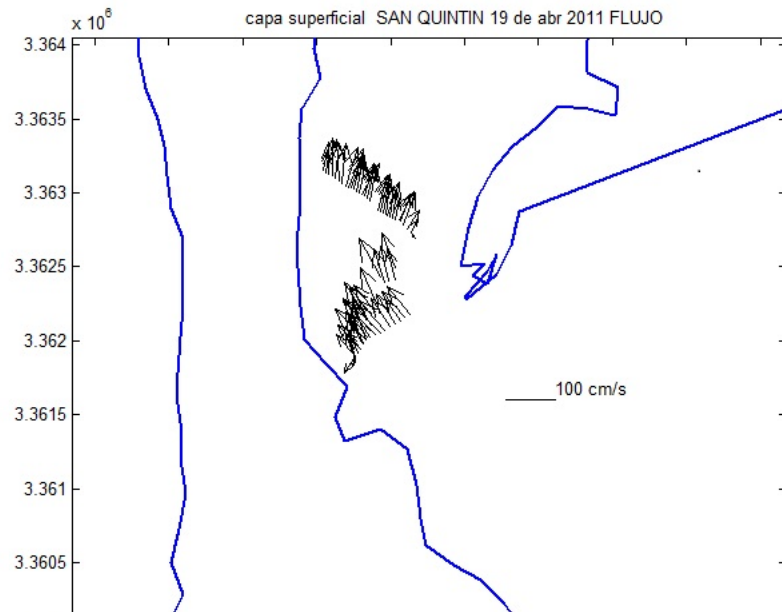










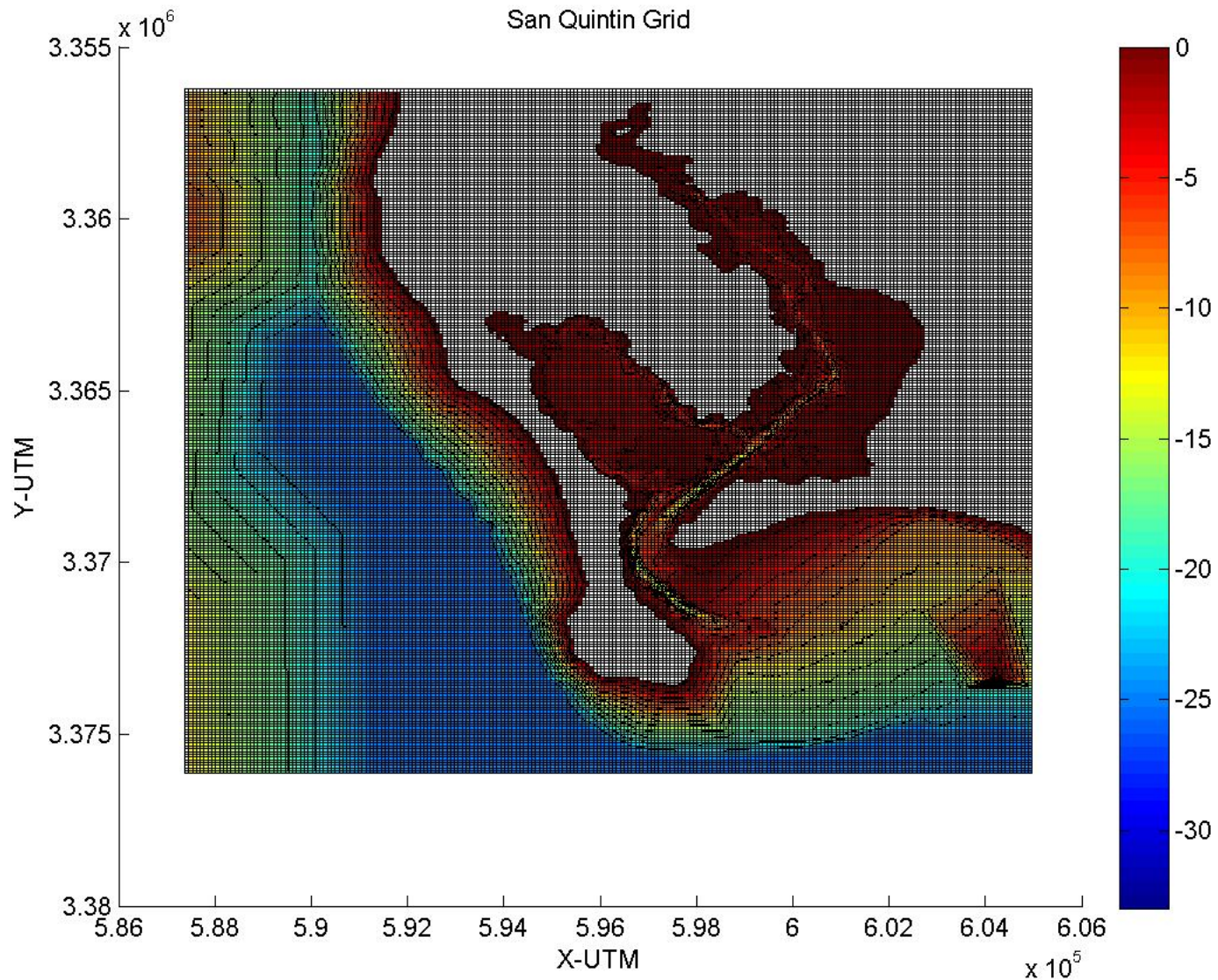


The Model Implementation

The Data:

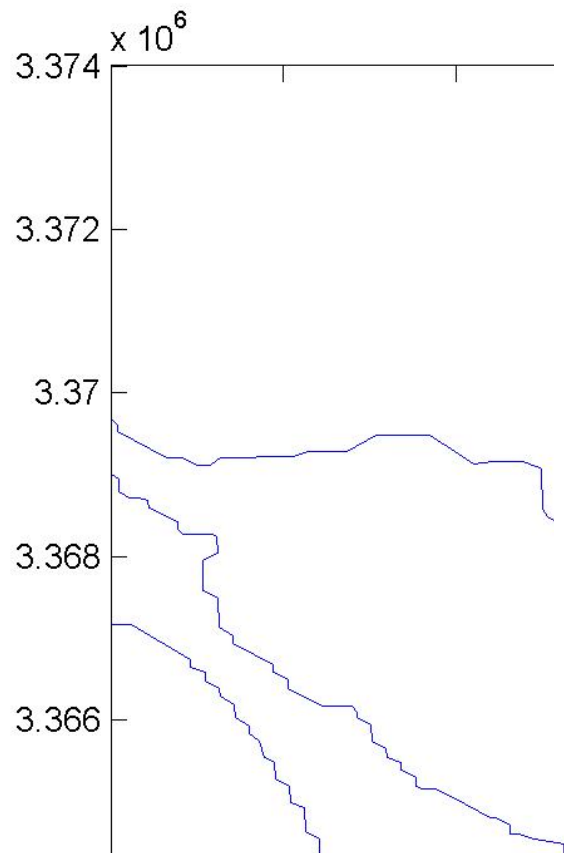
- bathymetry
- initial conditions (T,S)
- open boundary conditions:
 - * open boundary in the ocean: η, T, S
 - * free surface: $\vec{\tau}_w = C_D \rho_a |\vec{w}| w$
 - * bottom: $\vec{\tau}_b = C_b \rho_w |\vec{u}| u$
 - *
- configuration parameters

Bathymetry: $dx=dy=80\text{m}$, $dz=1\text{m}$

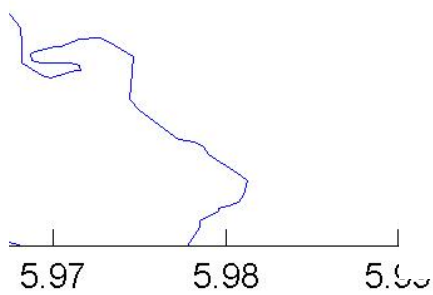
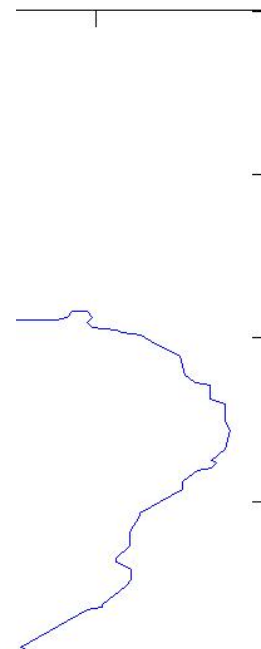
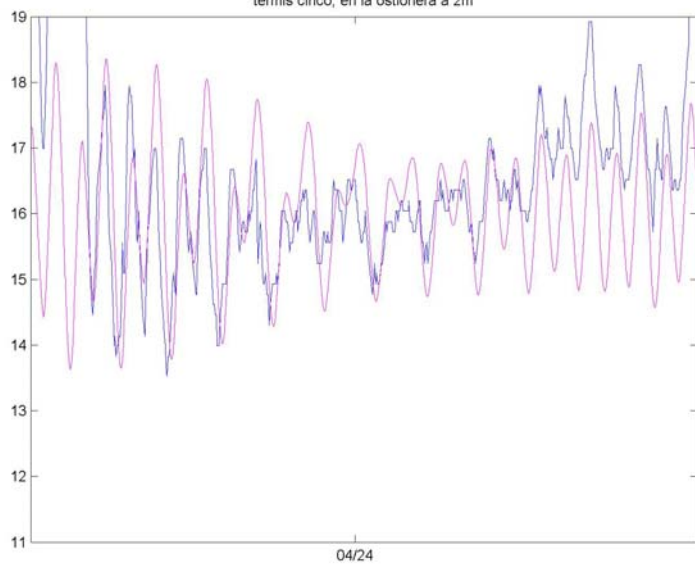
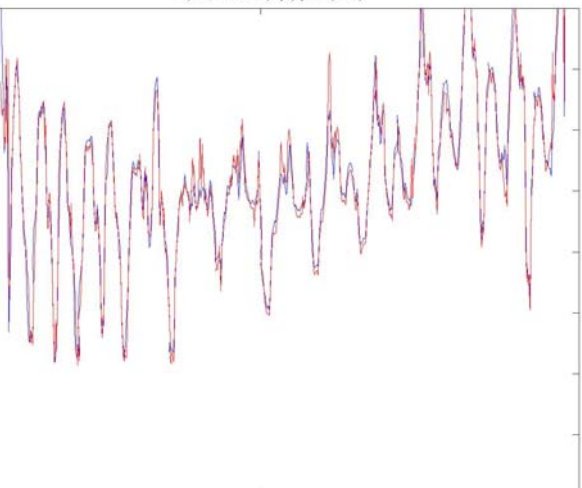


Application to San Quintin Bay

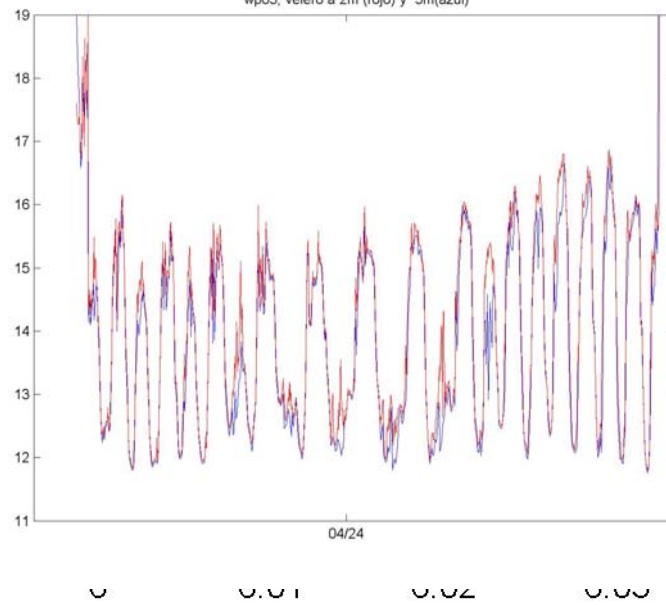
- 3 different mesh sizes were used ($dx=dy=200$, 100 and 80 metres)
- Two different layering schemes were used:
 - 1- dz increasing with depths
 - 2- dz constant = 1m



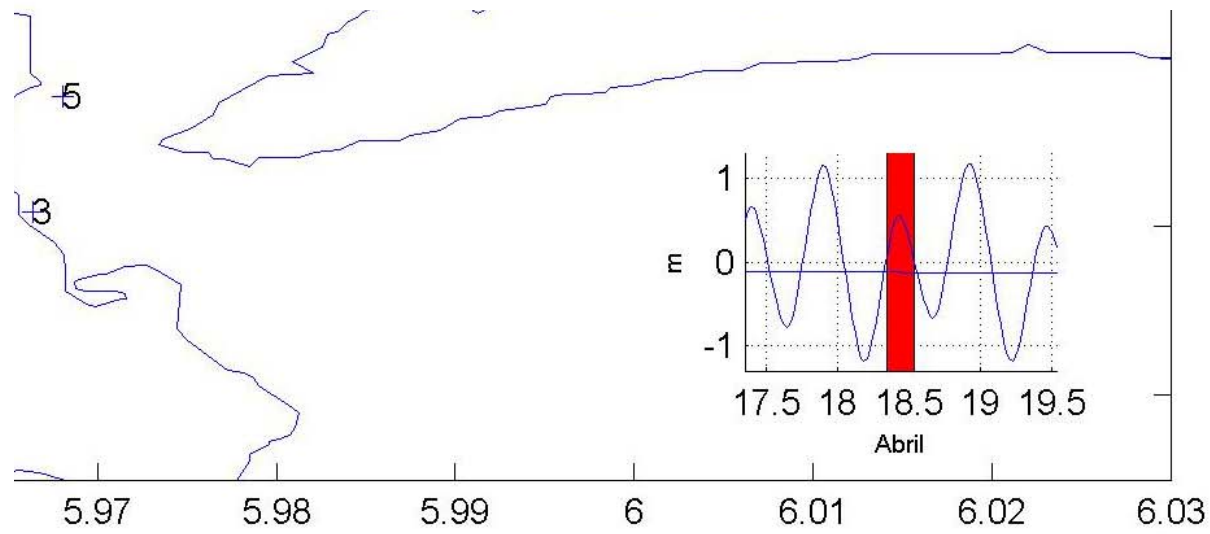
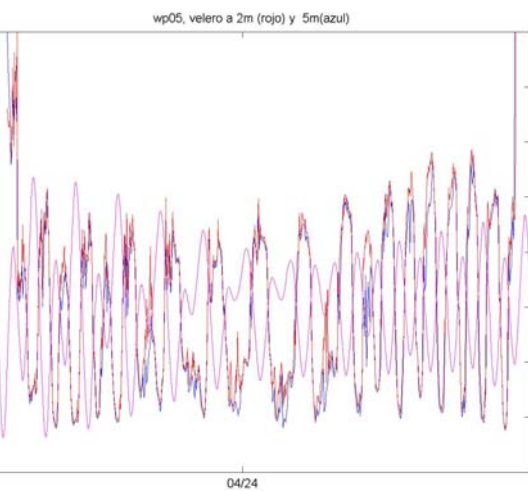
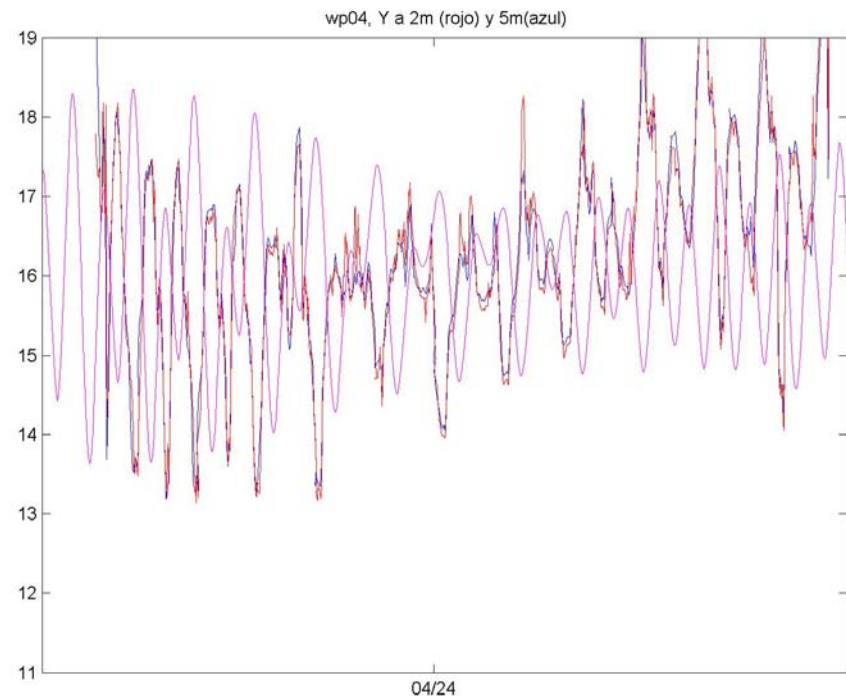
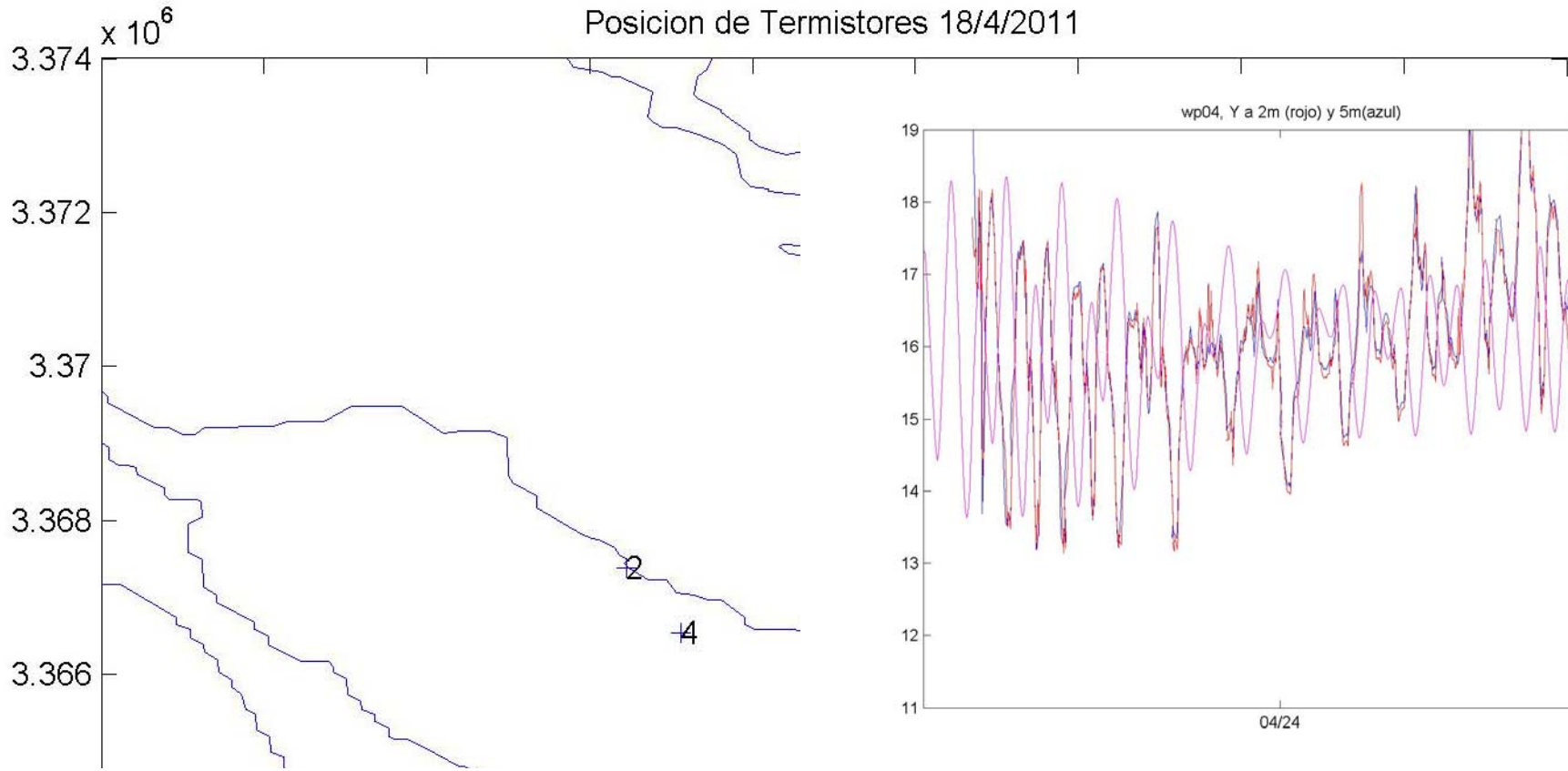
wp04, Y a 2m (rojo) y 5m(azul)



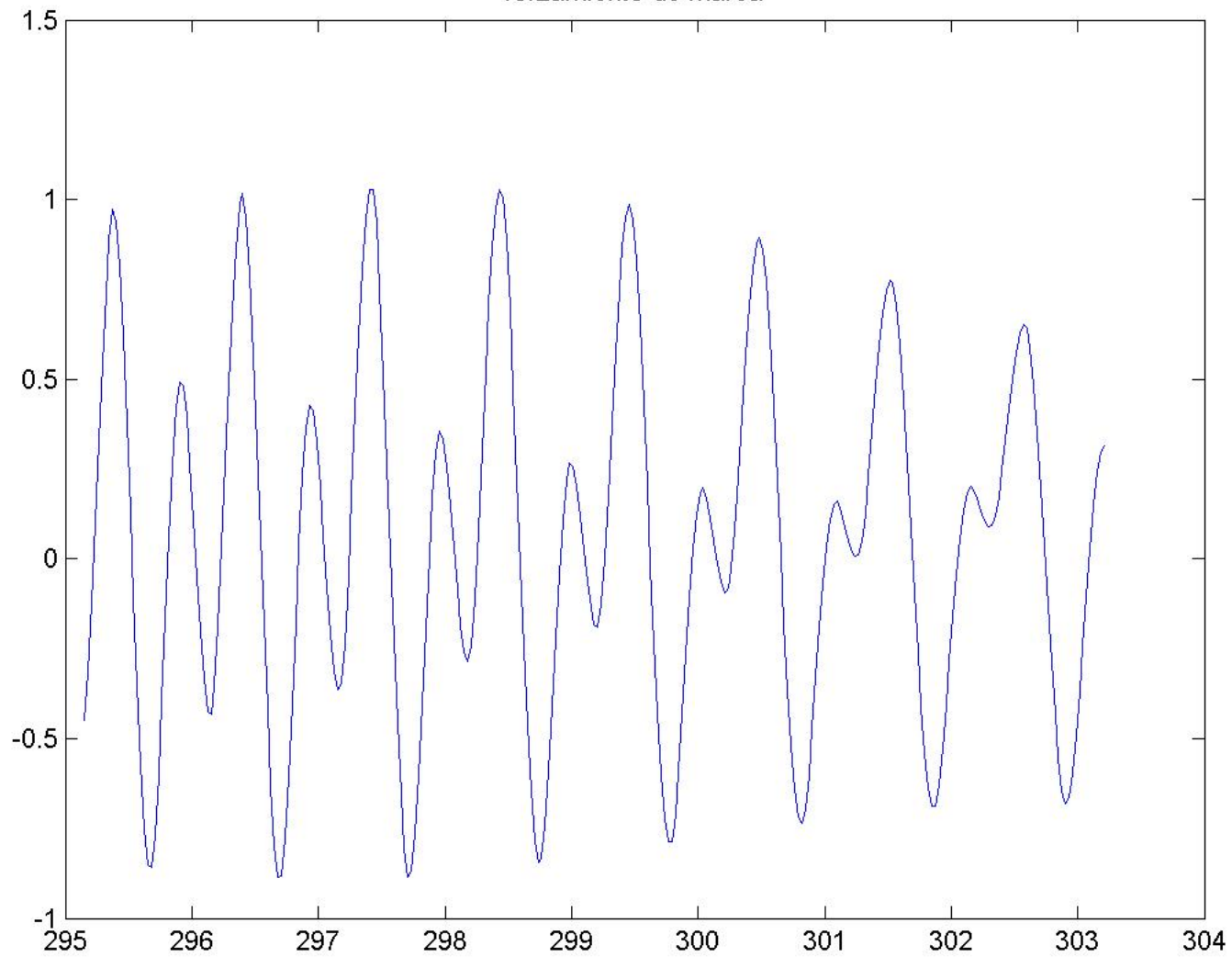
wp05, velero a 2m (rojo) y 5m(azul)



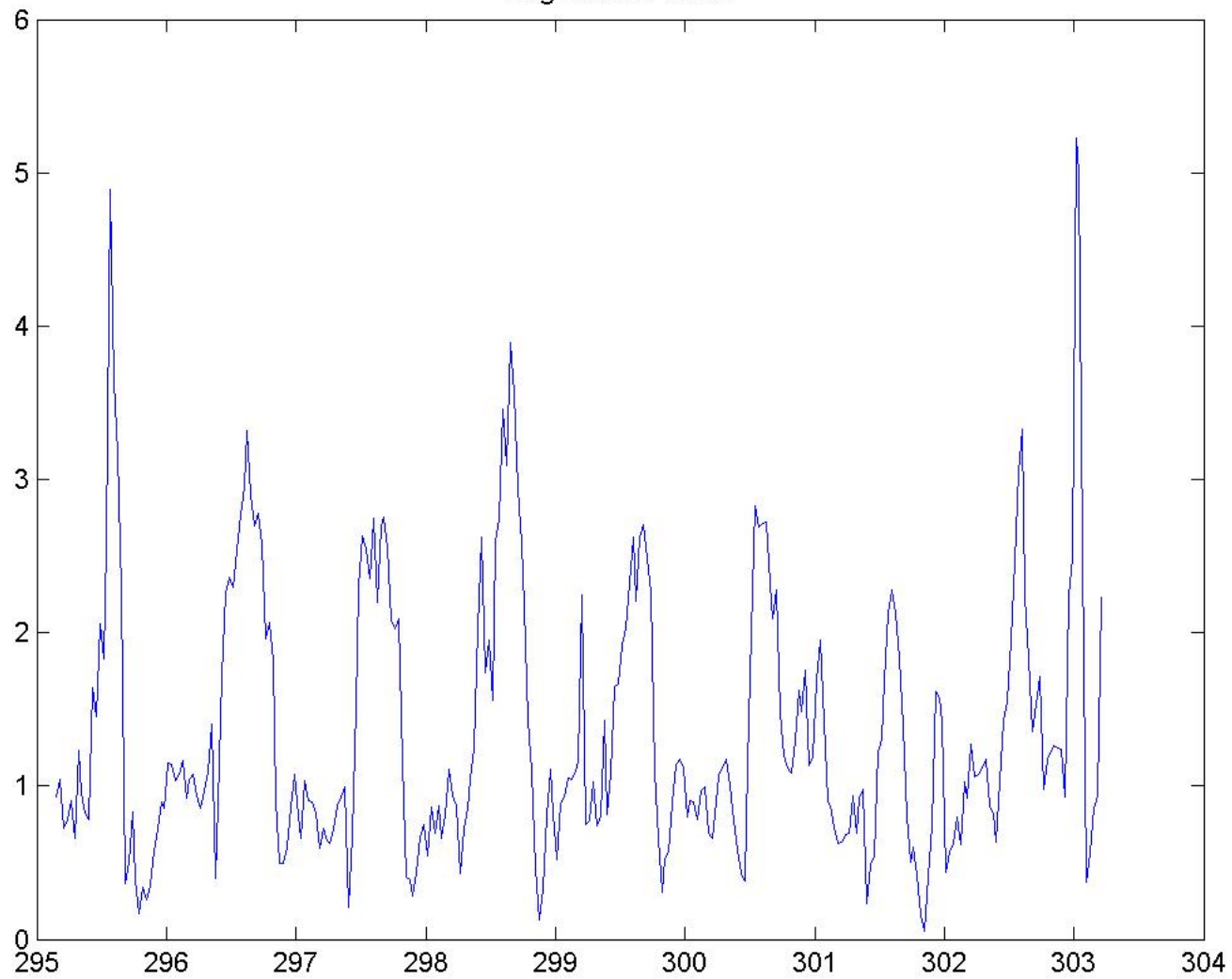
Posicion de Termistores 18/4/2011

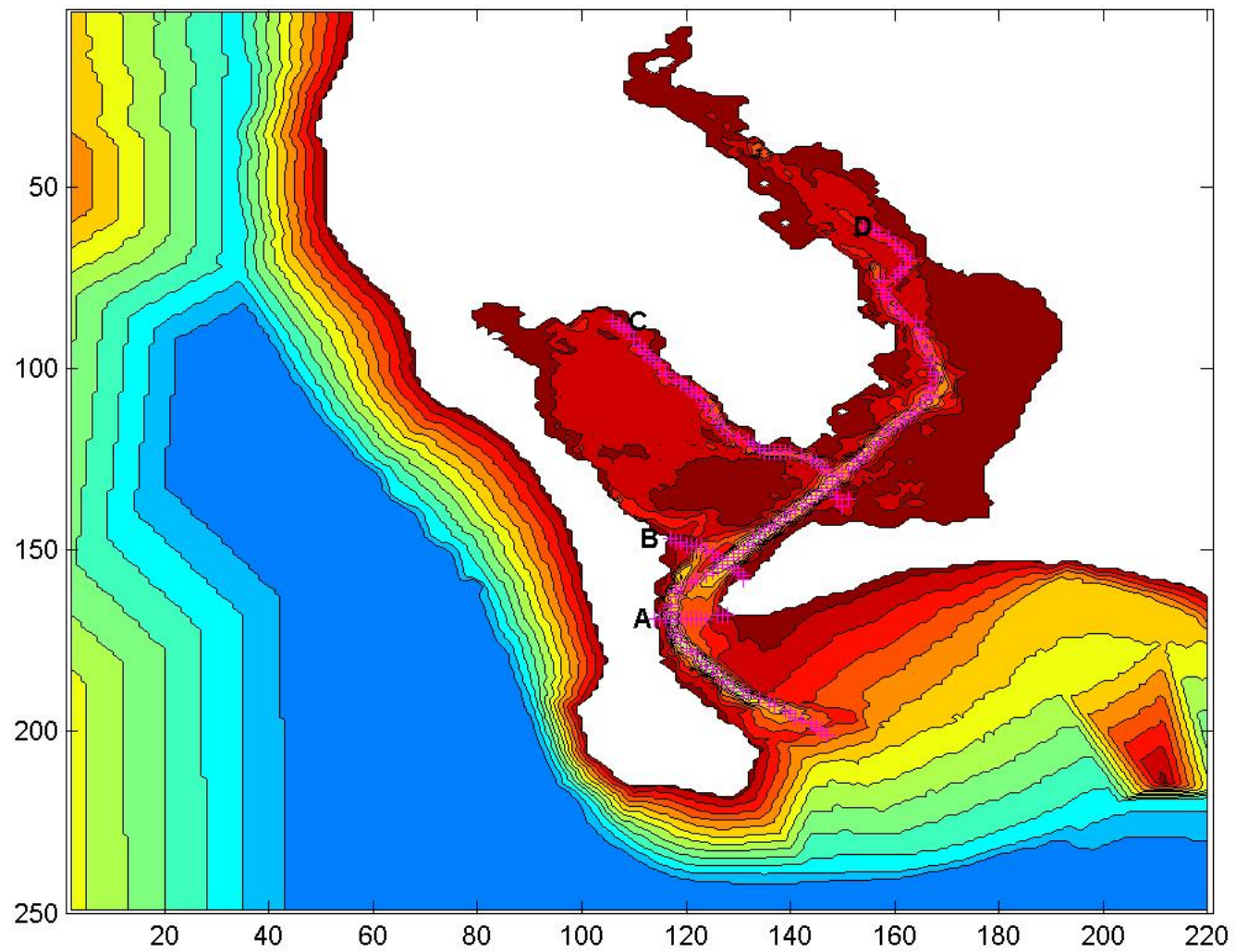


forzamiento de marea

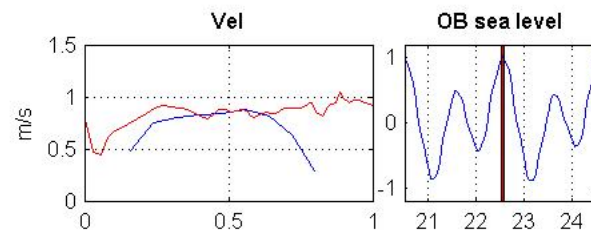
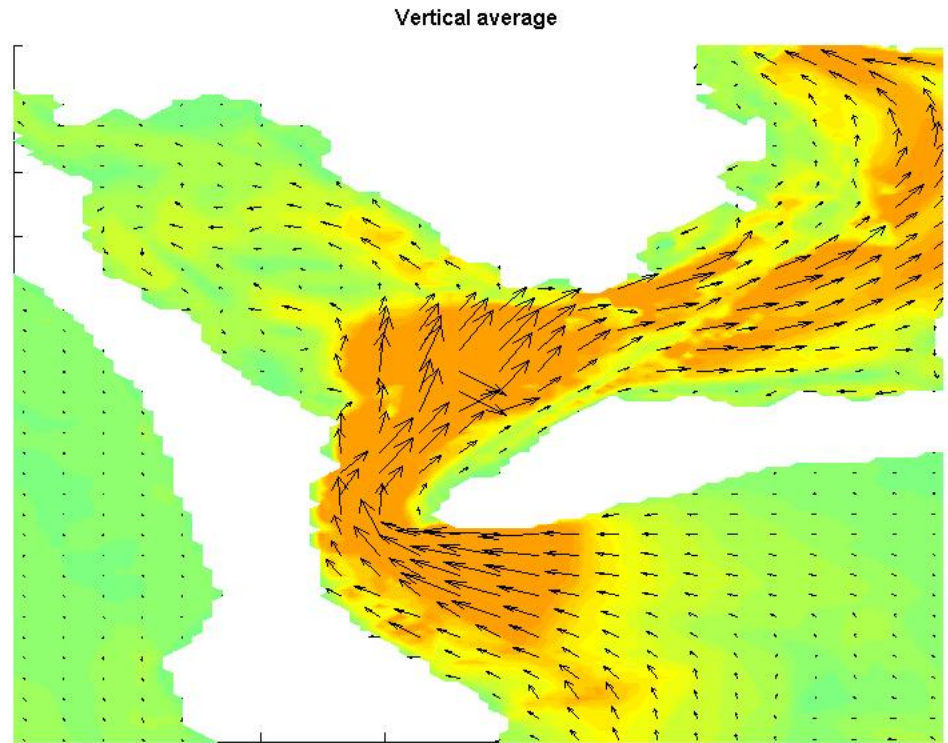
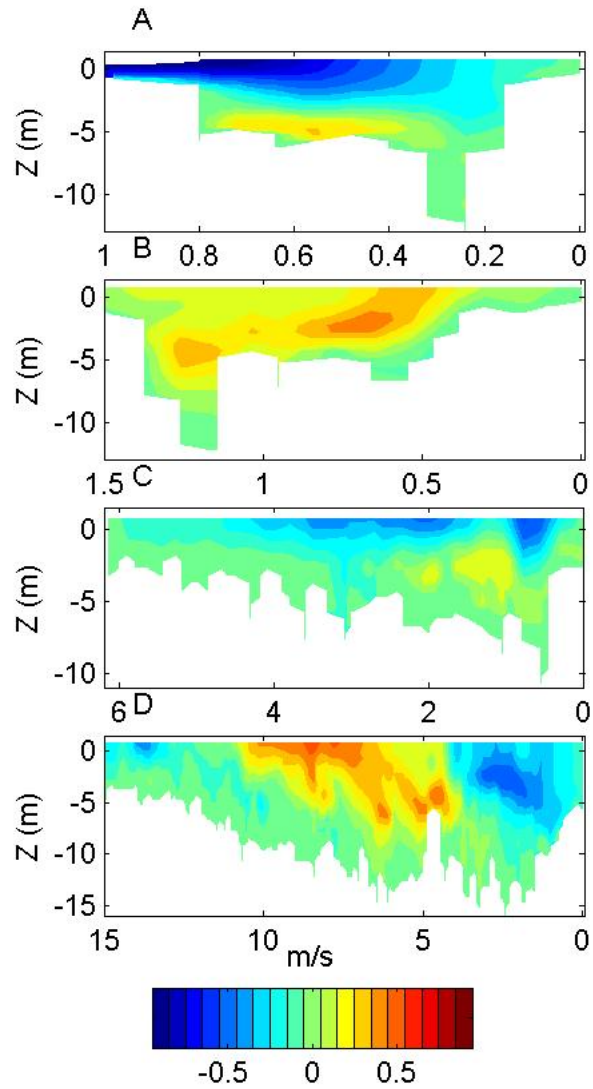


magnitud del viento

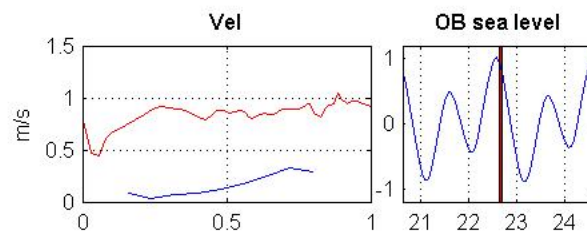
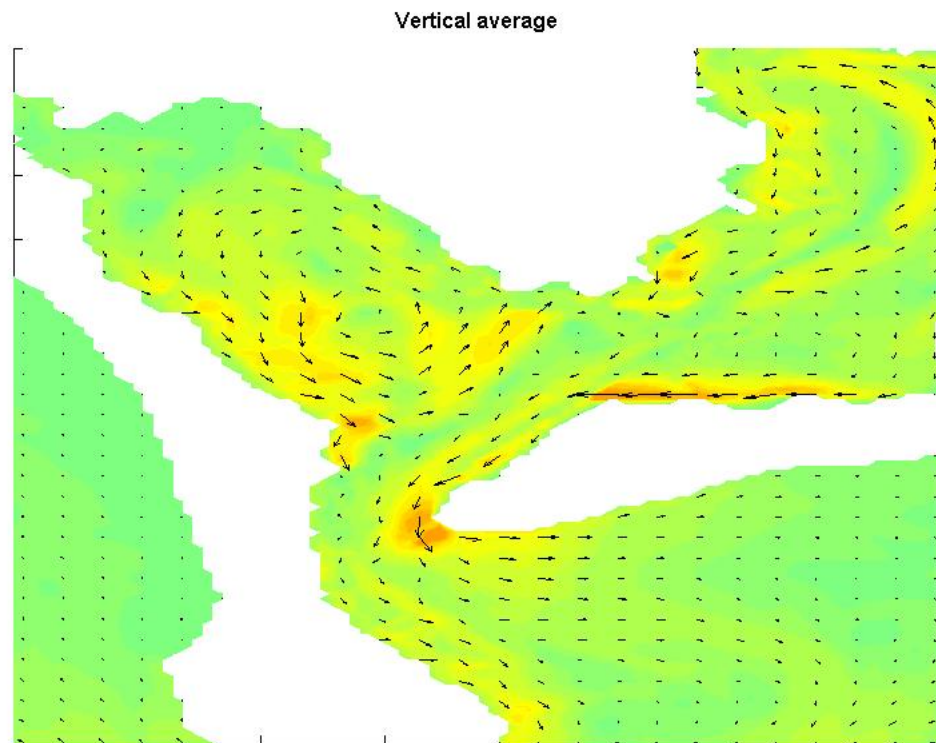
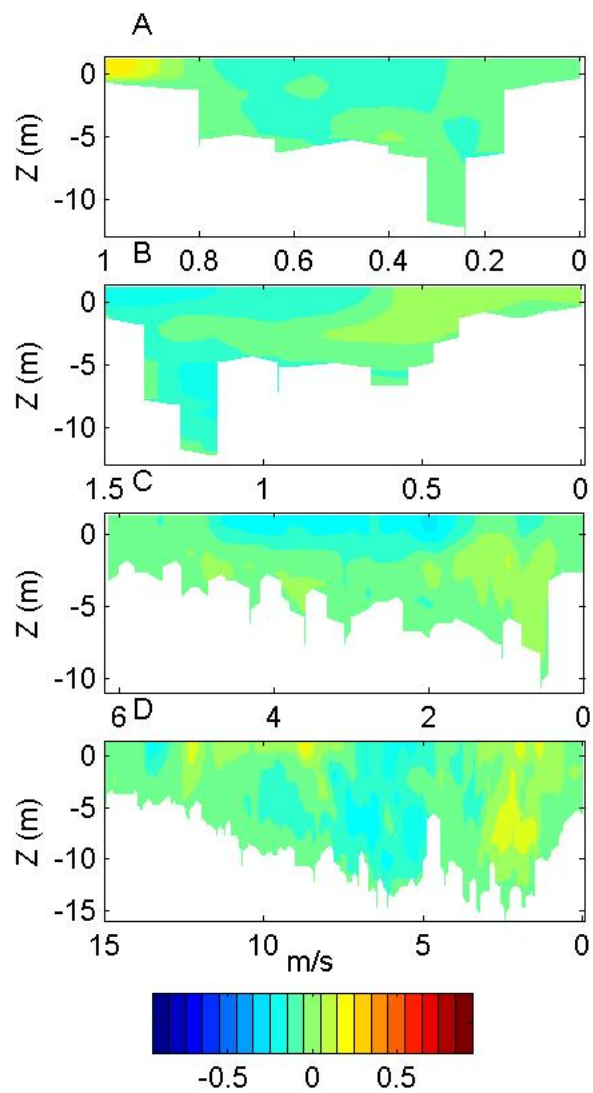




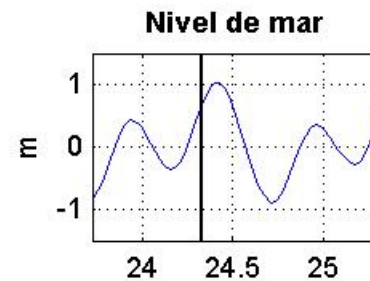
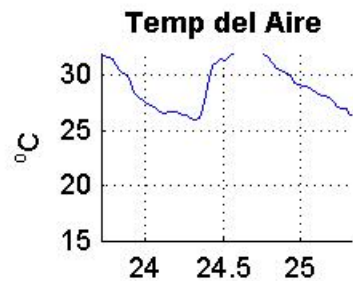
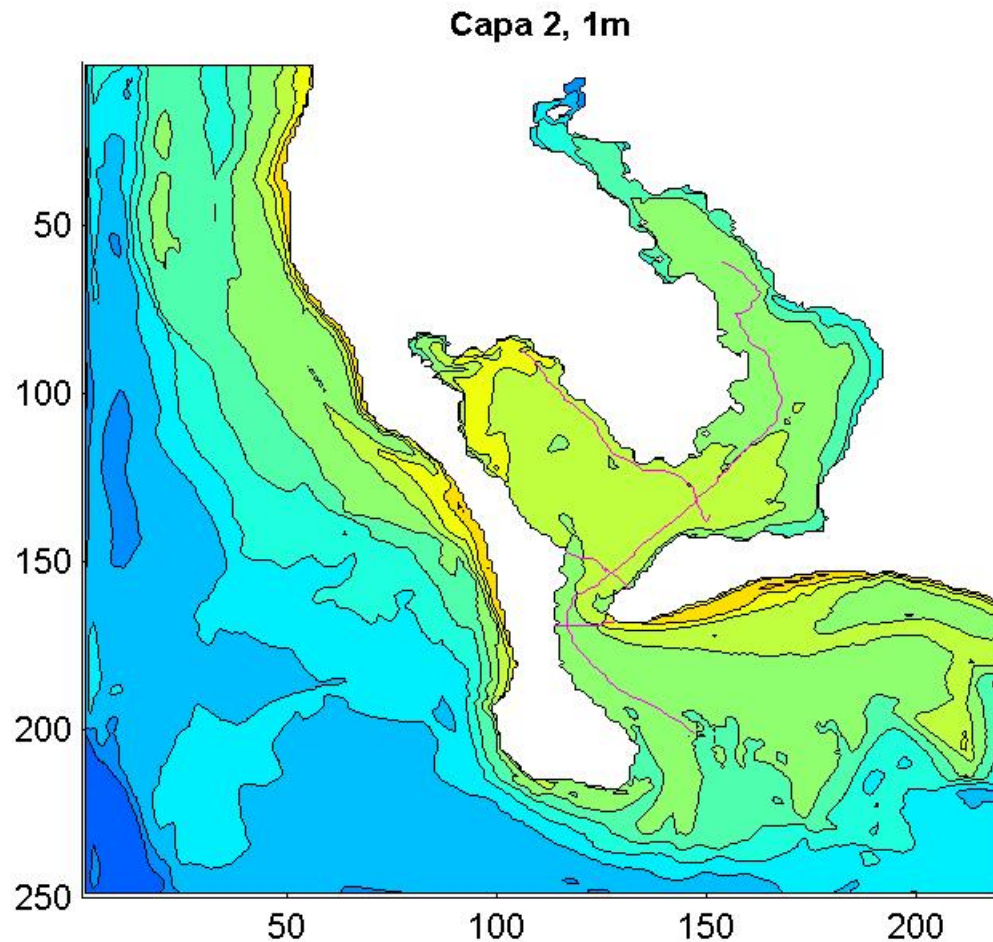
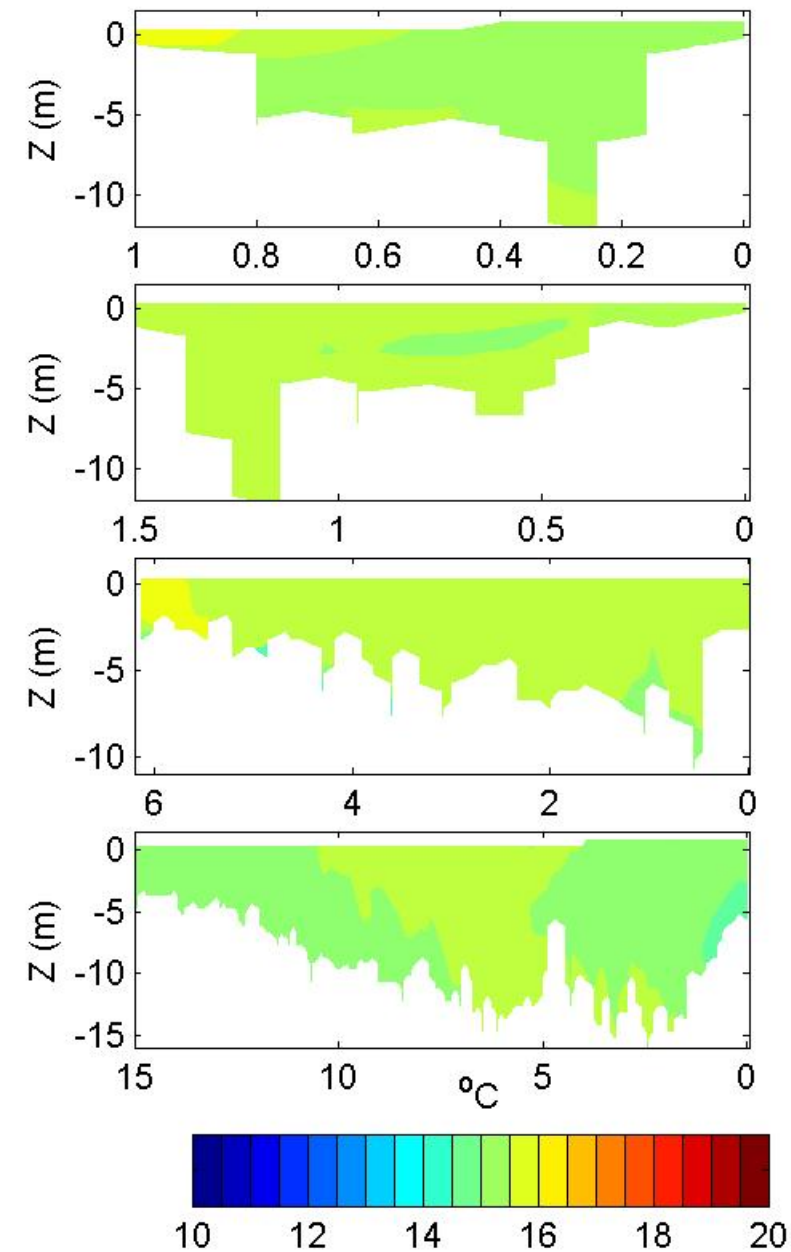
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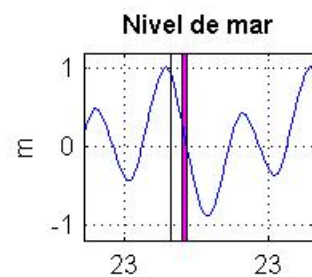
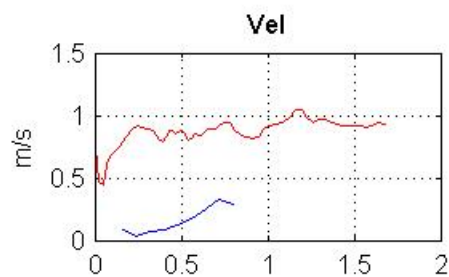
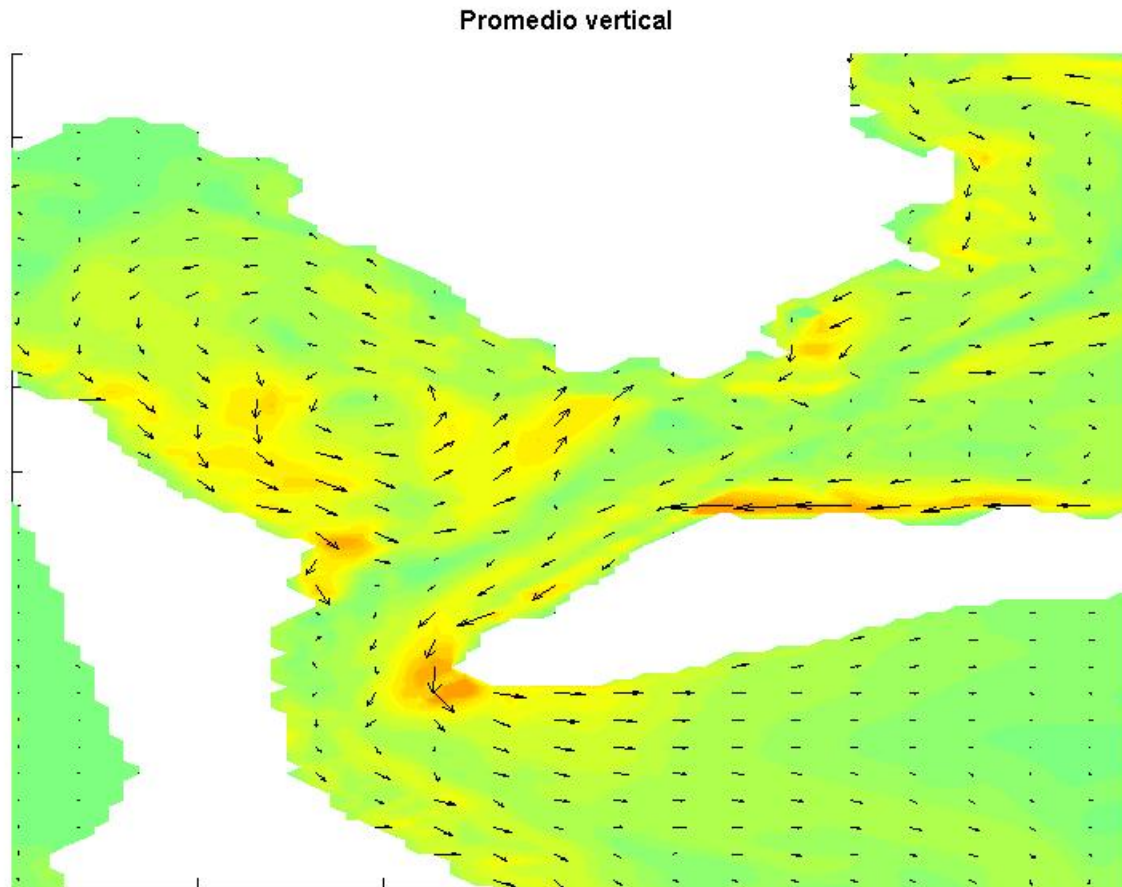
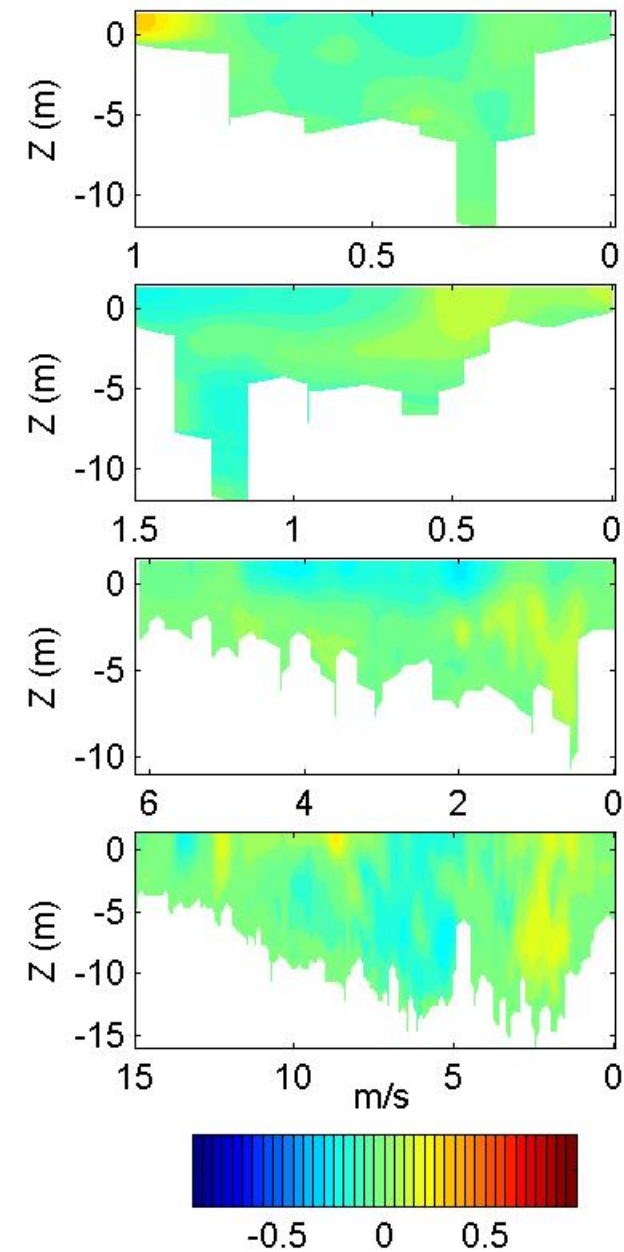
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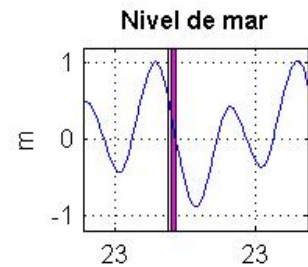
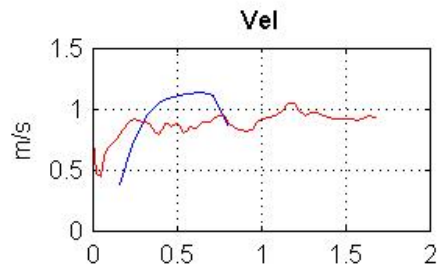
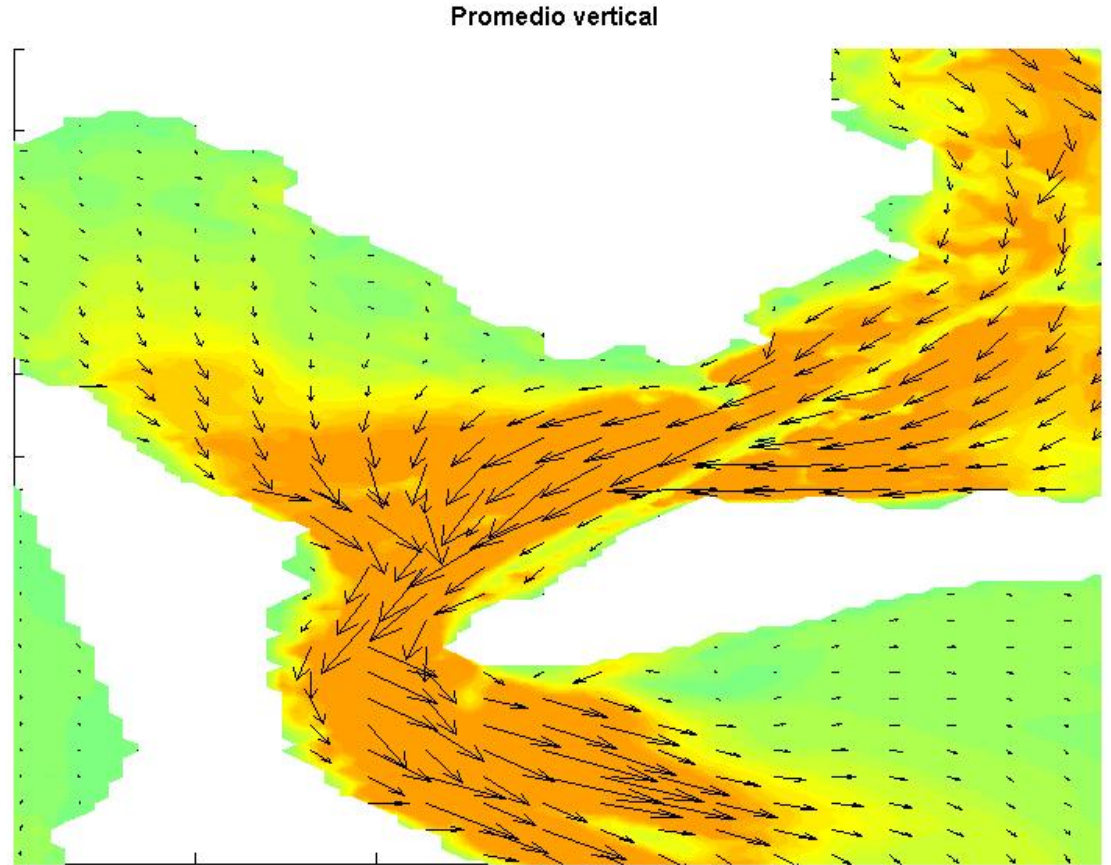
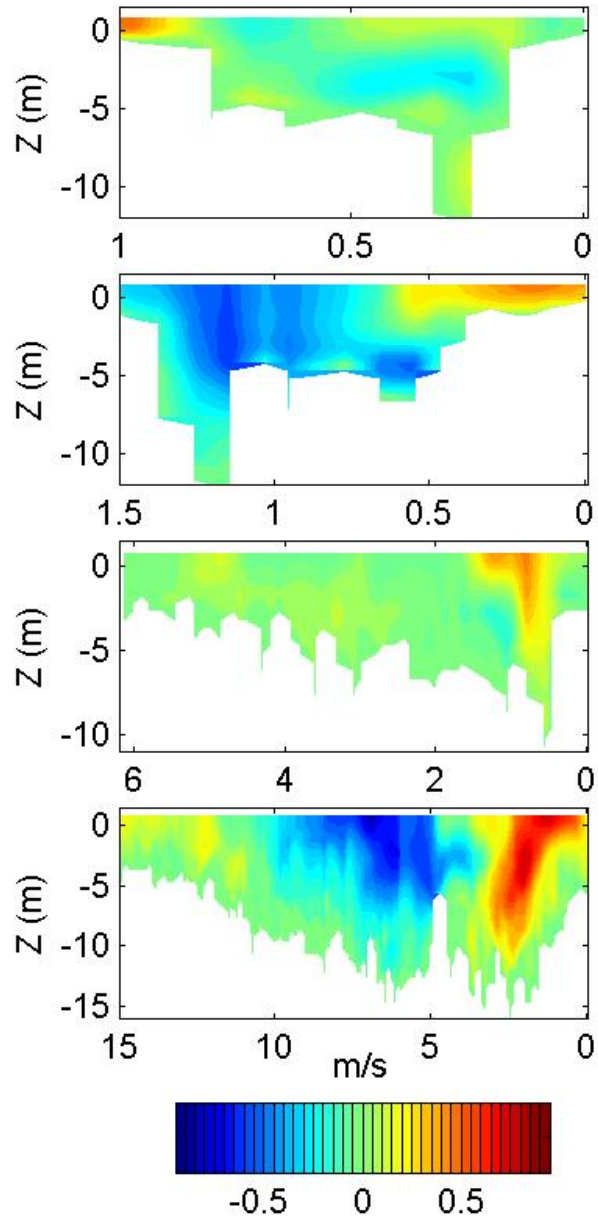
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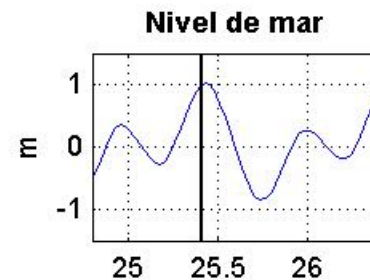
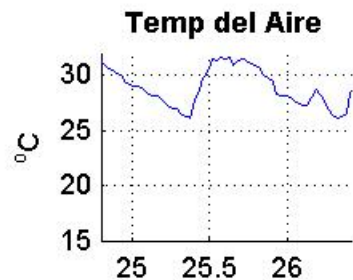
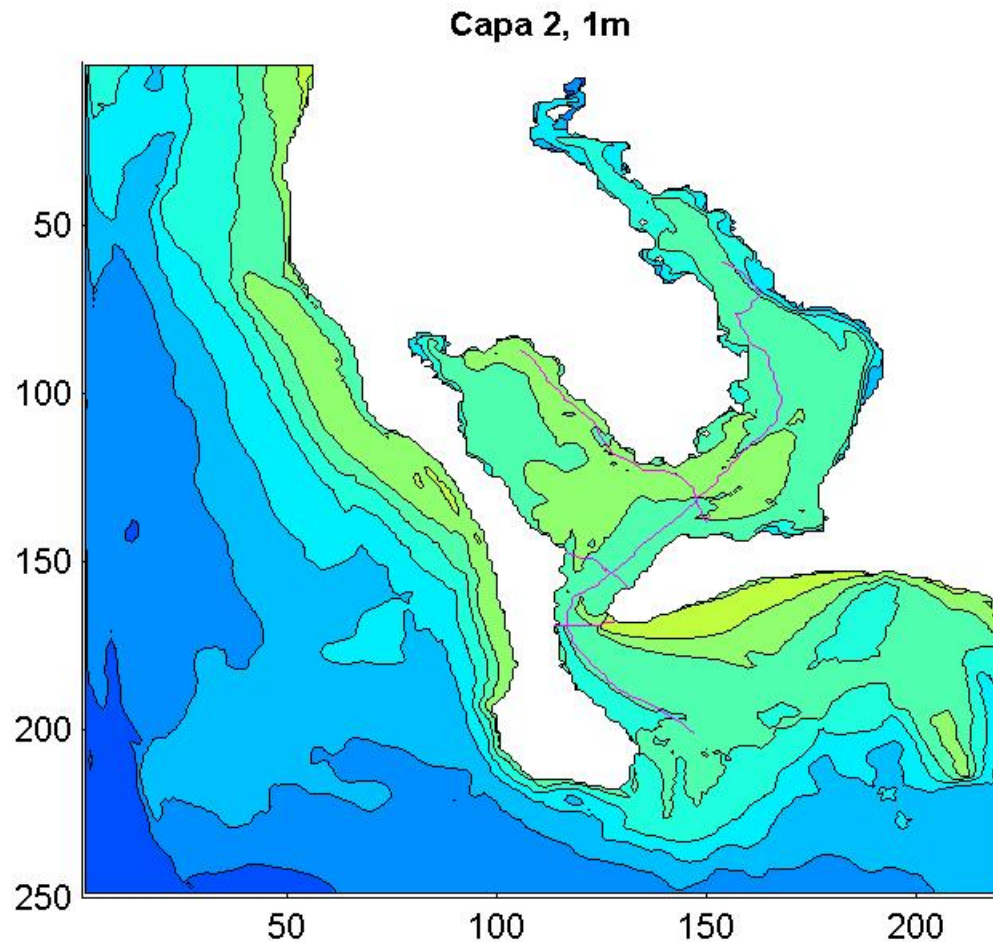
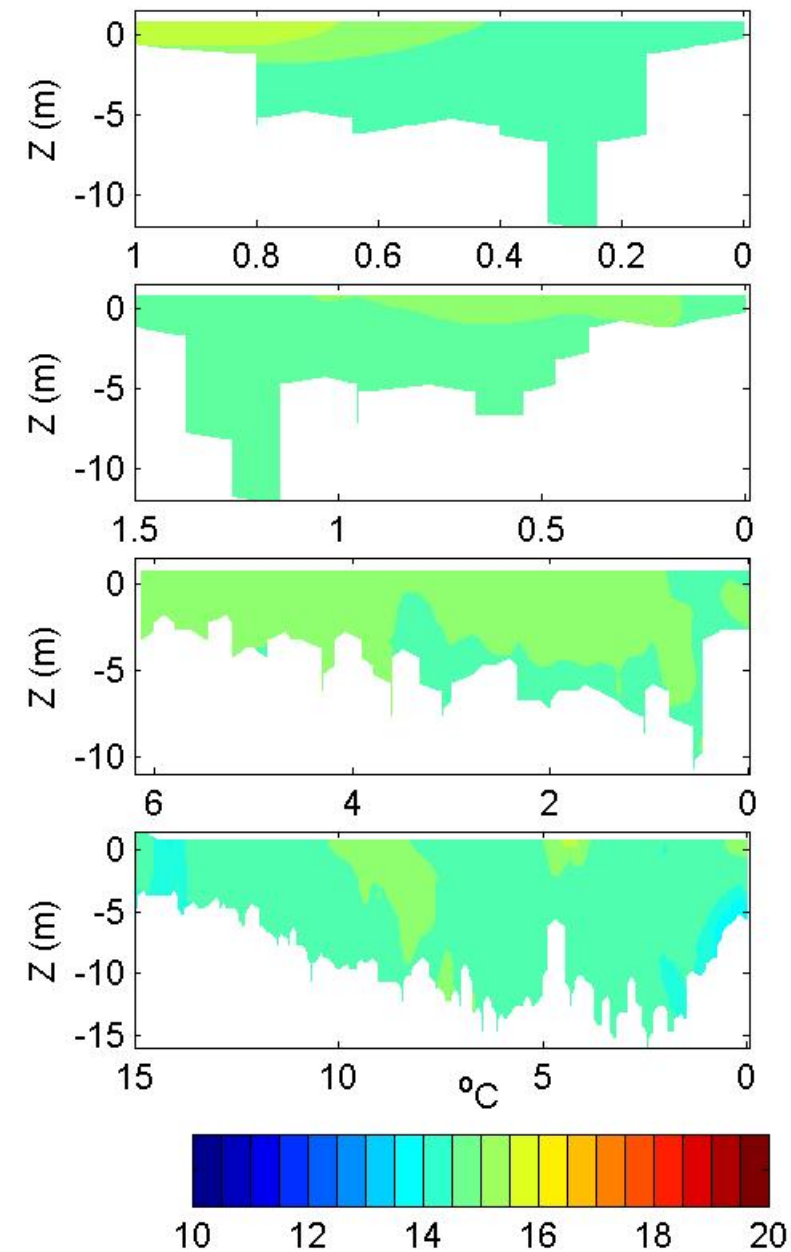
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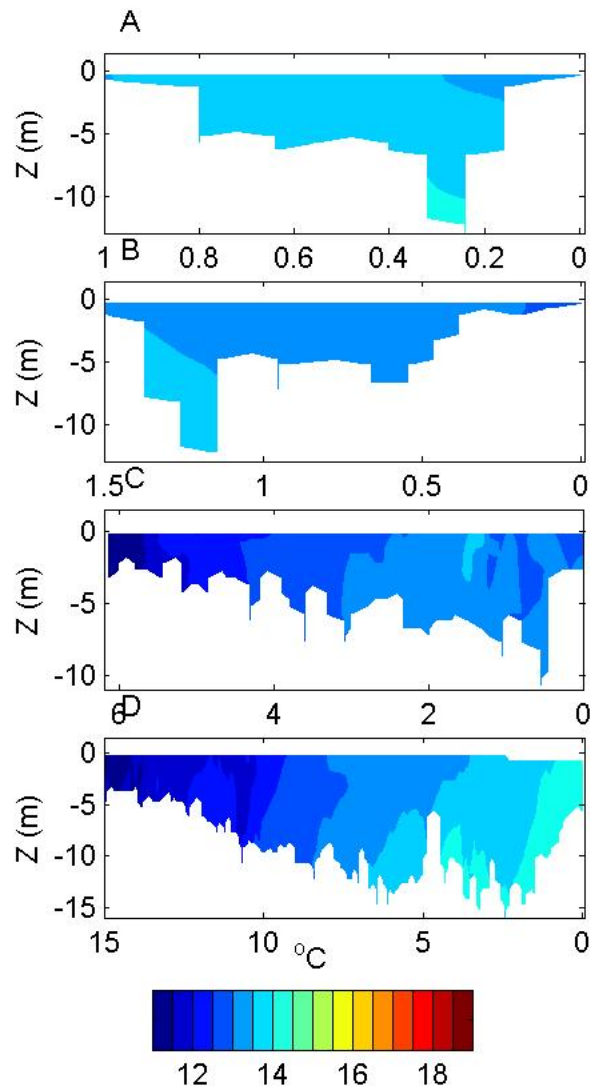
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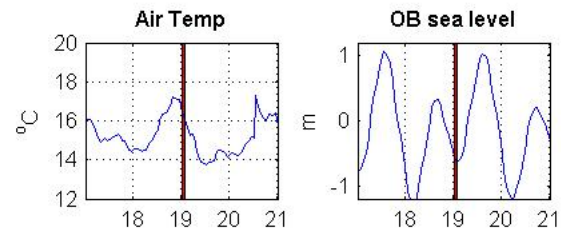
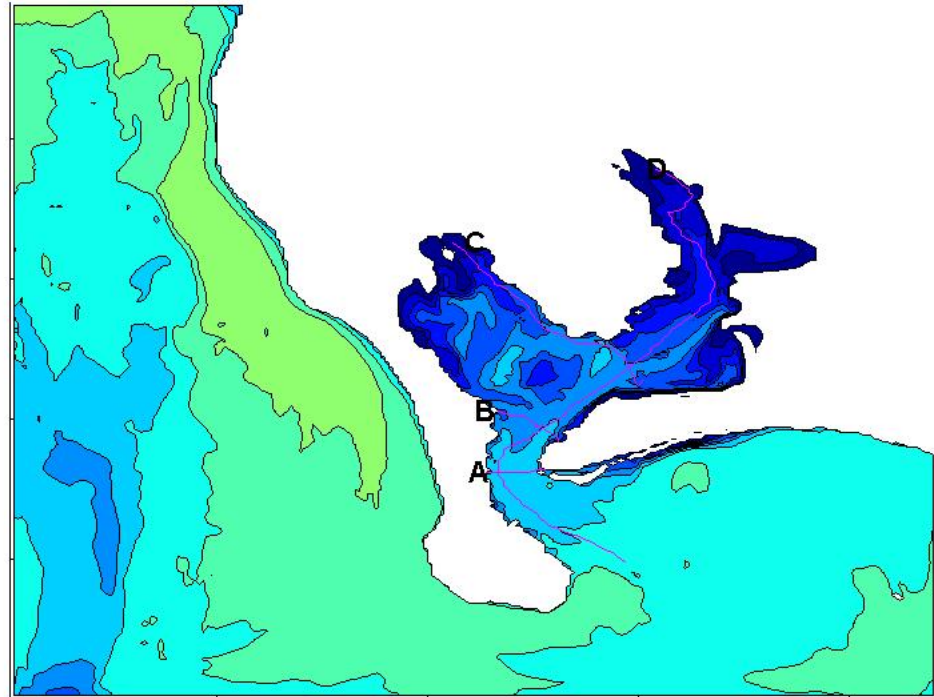
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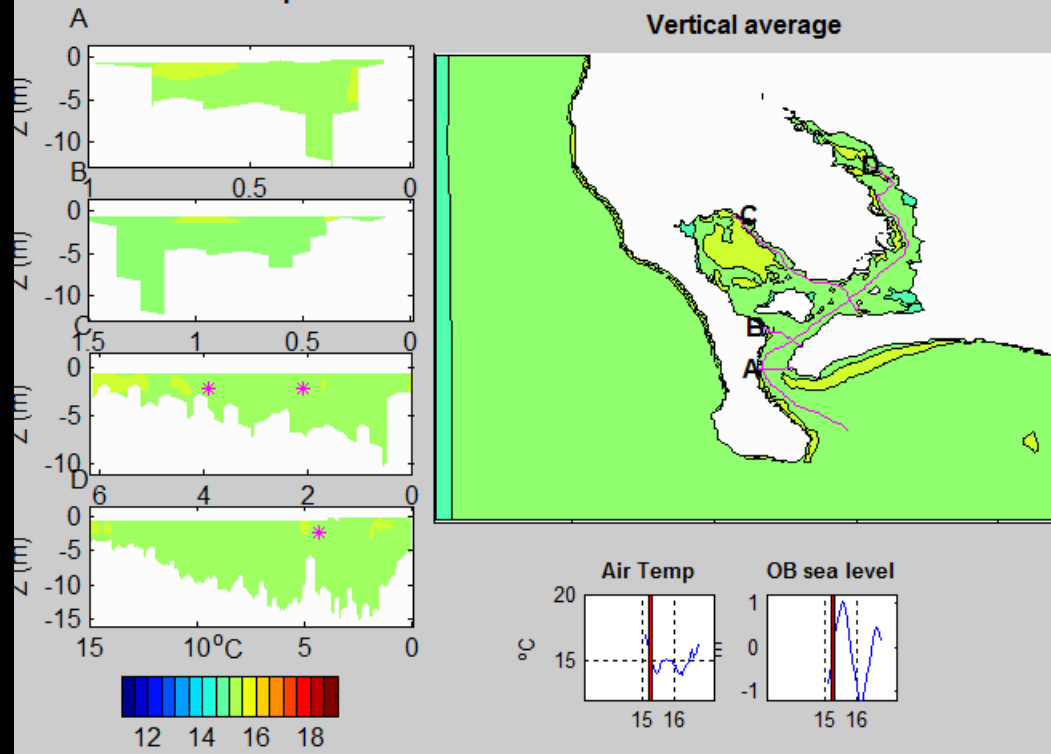
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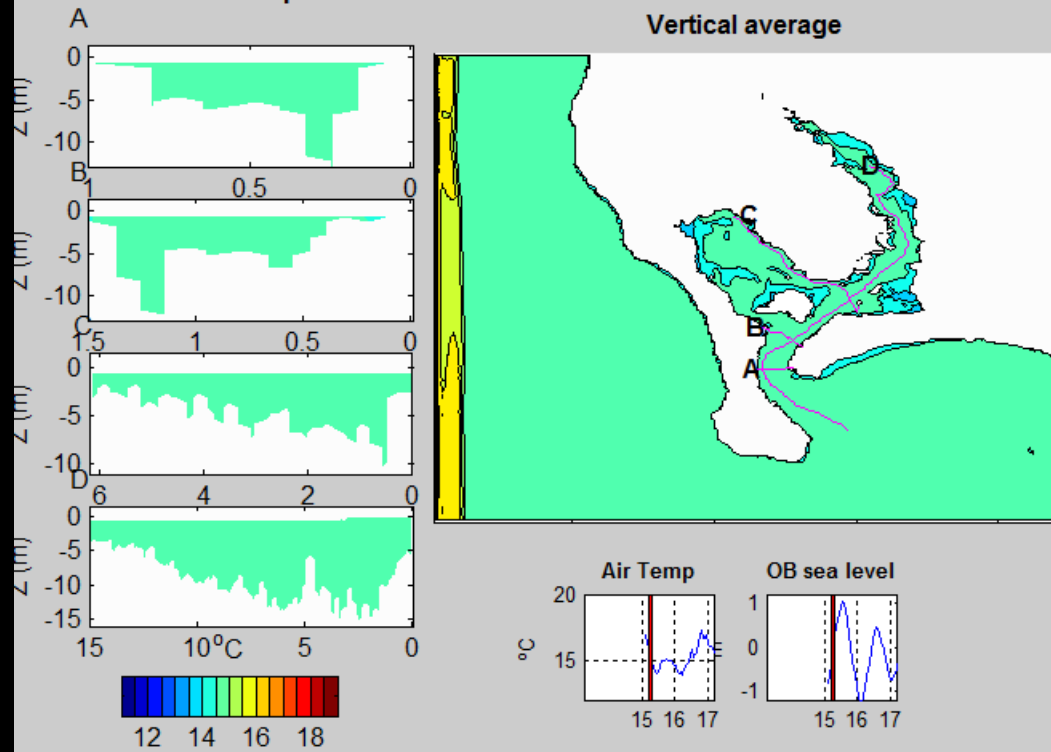
Vertical average



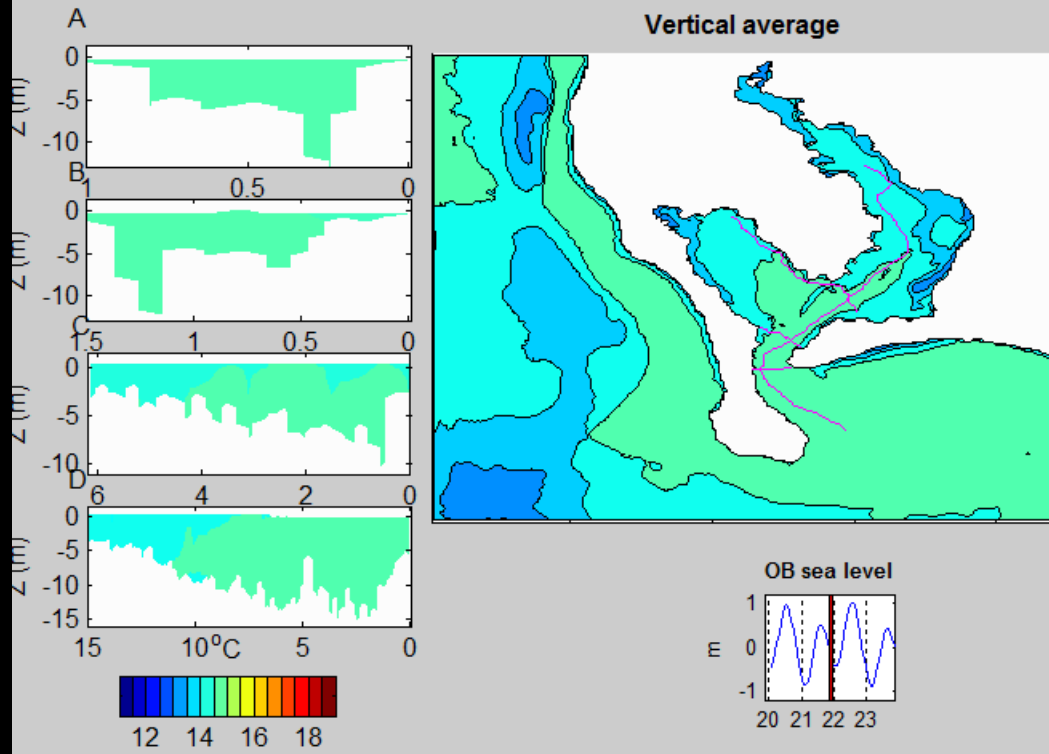
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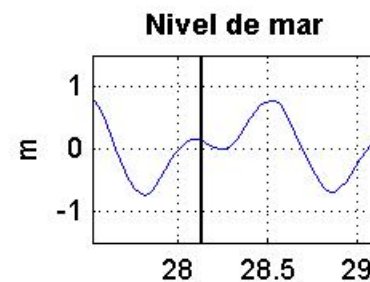
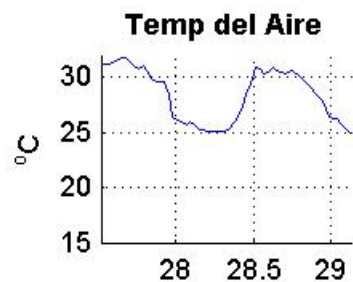
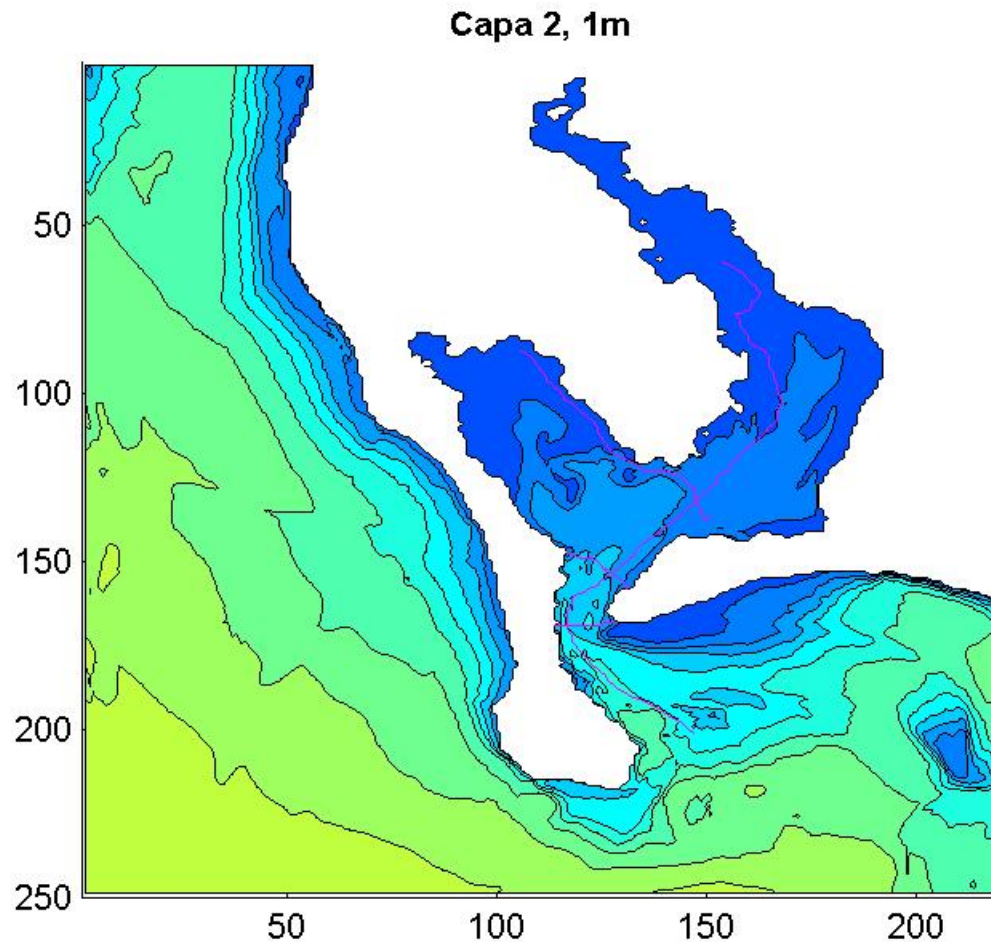
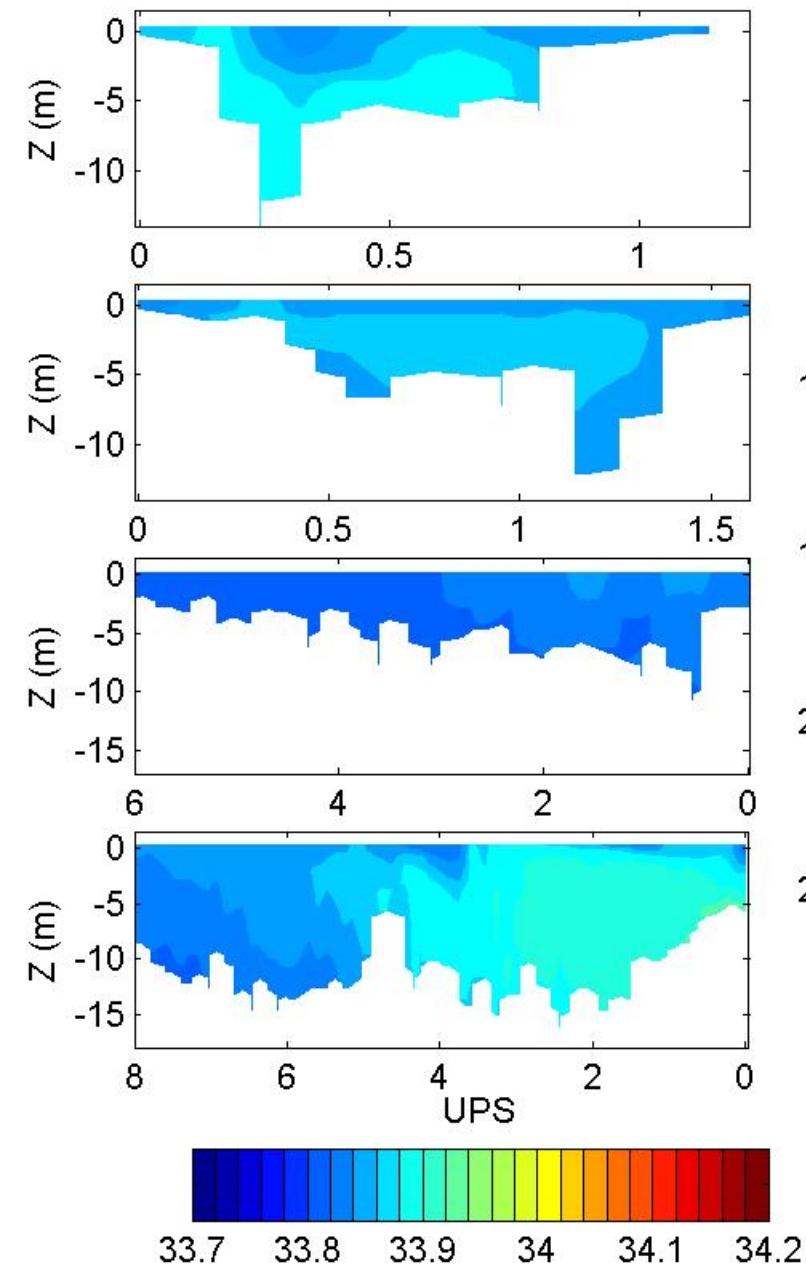
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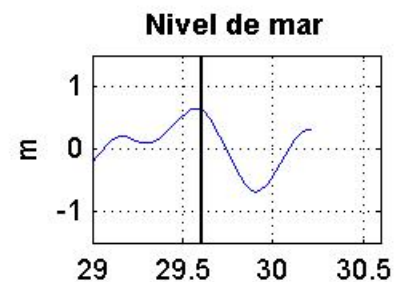
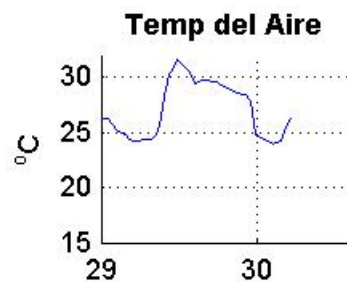
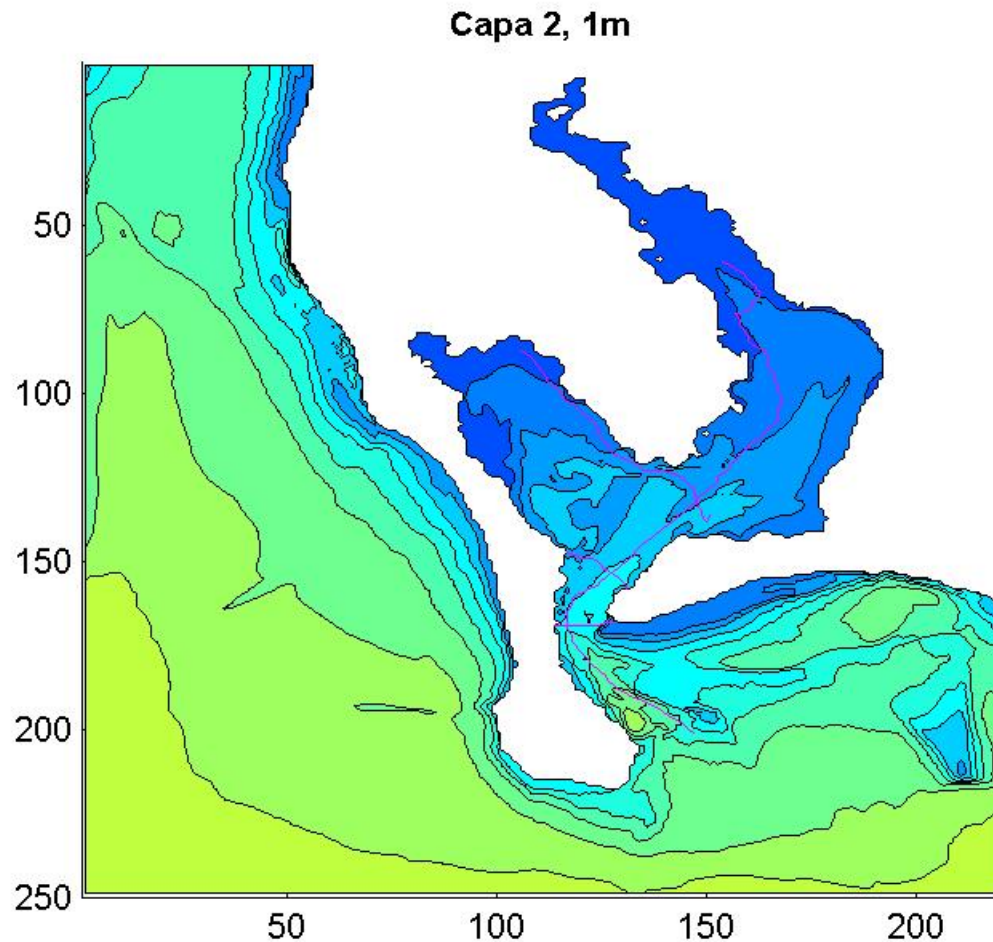
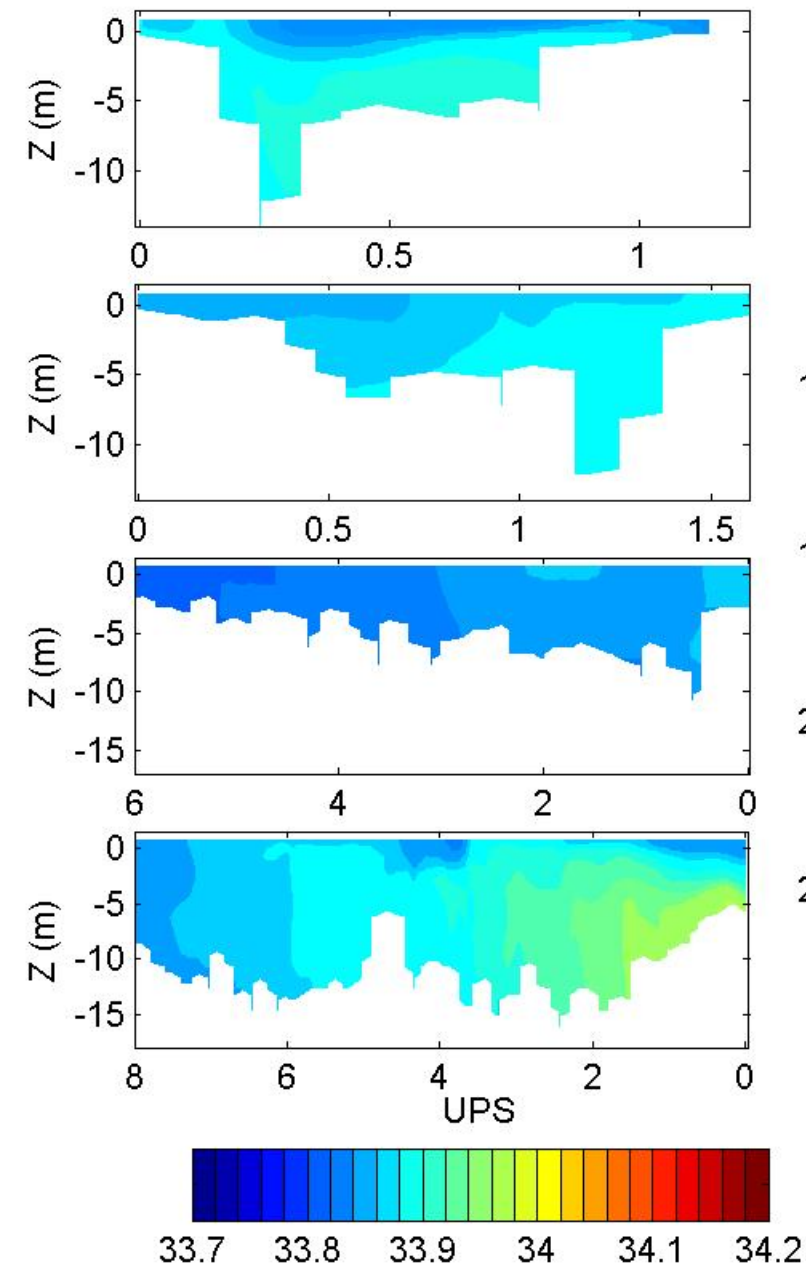
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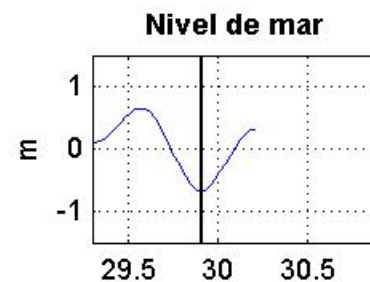
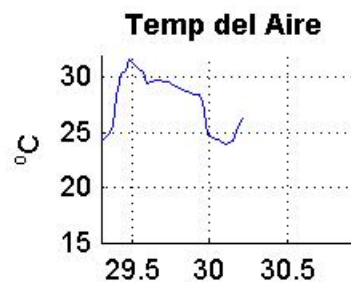
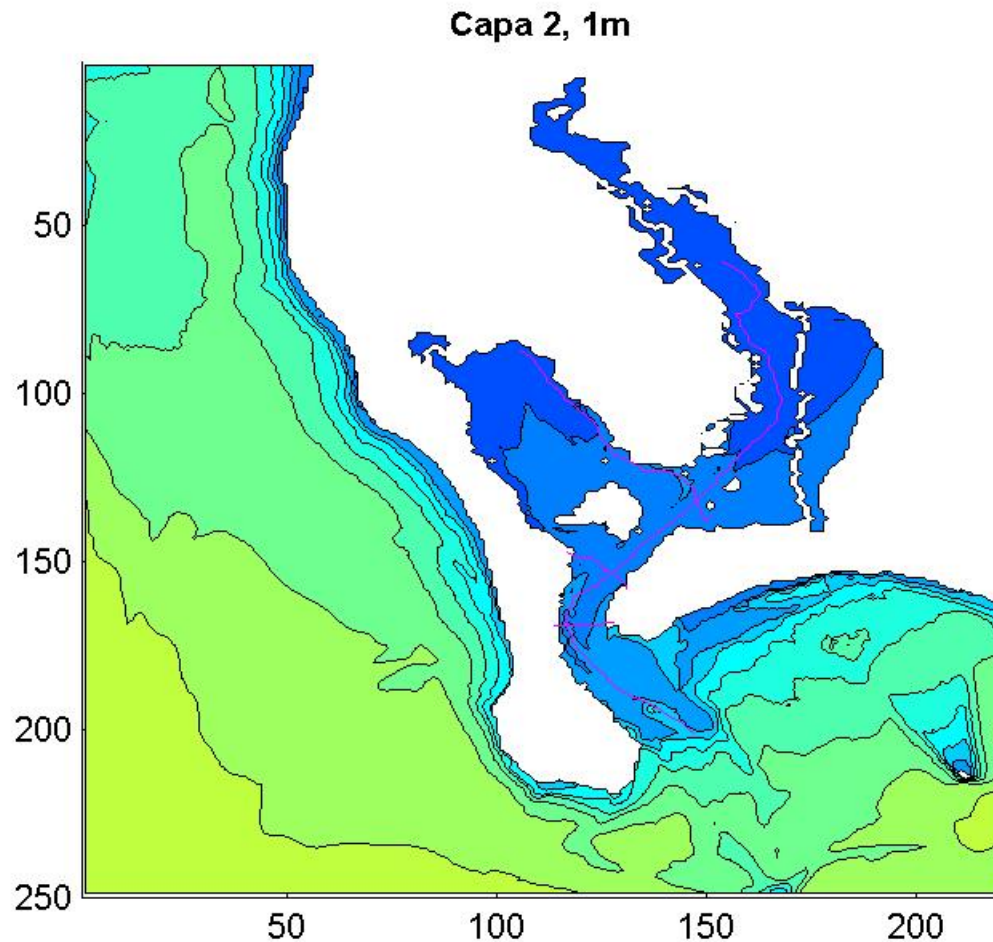
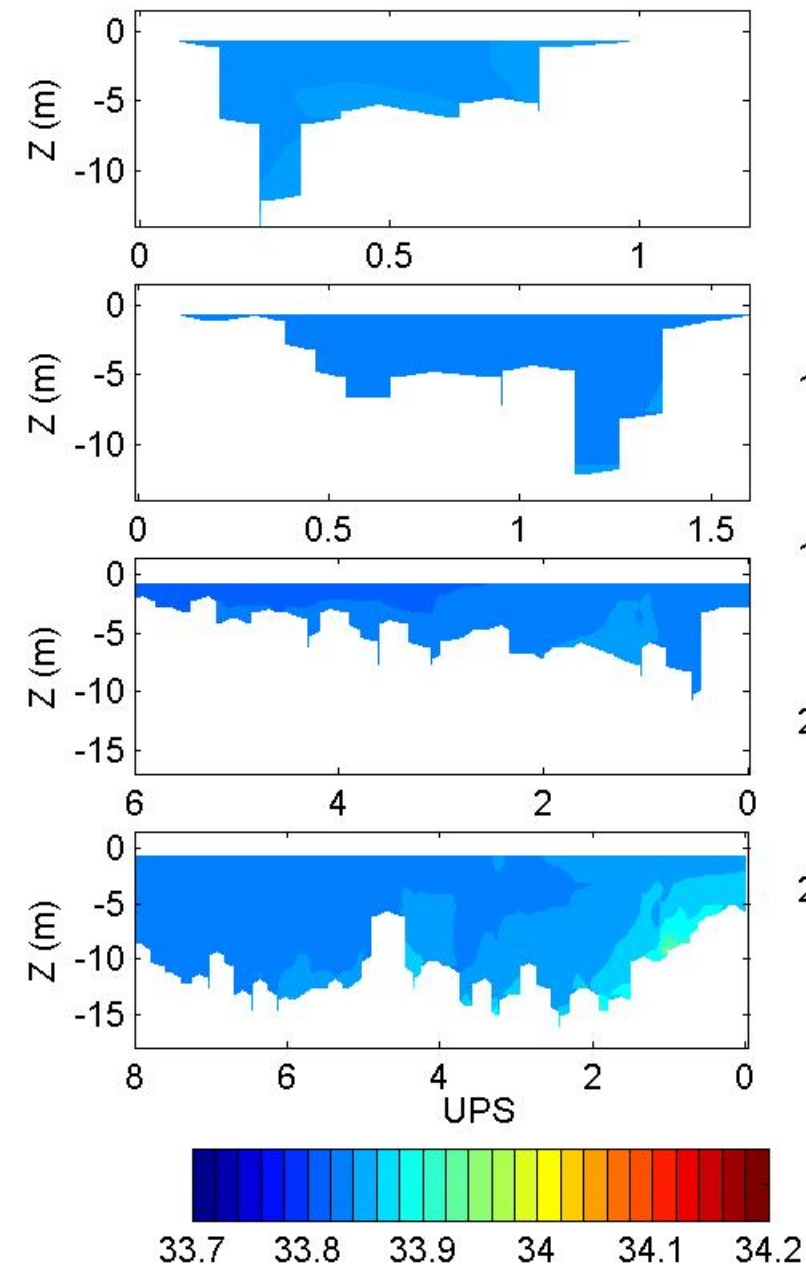
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29-Oct-2010 14:19:59

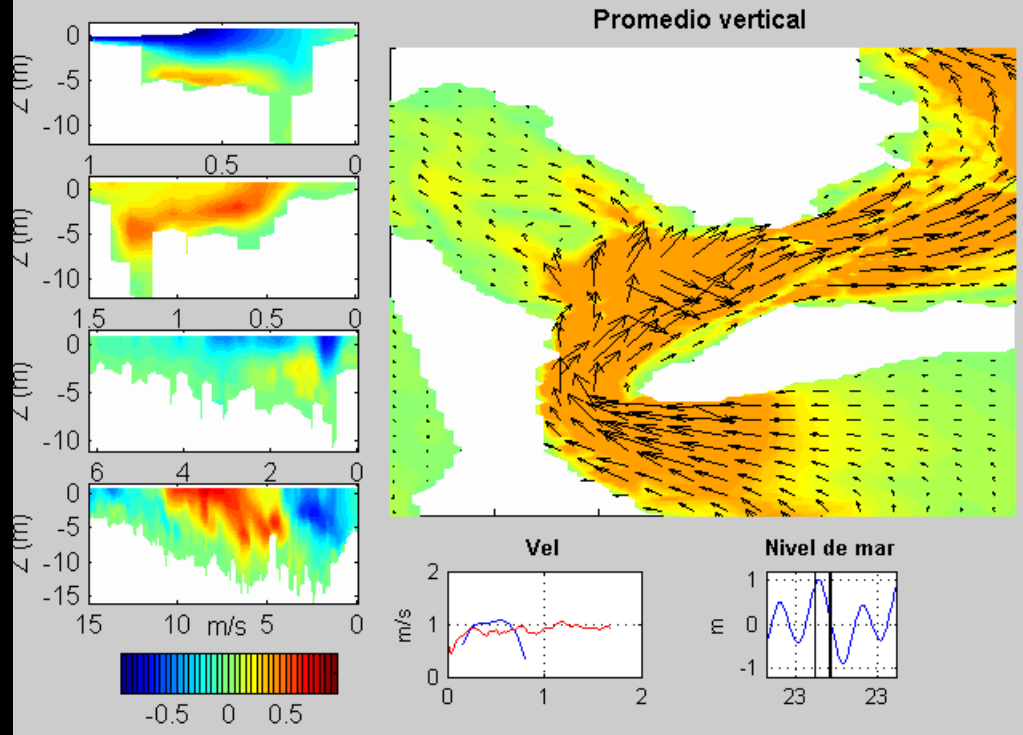


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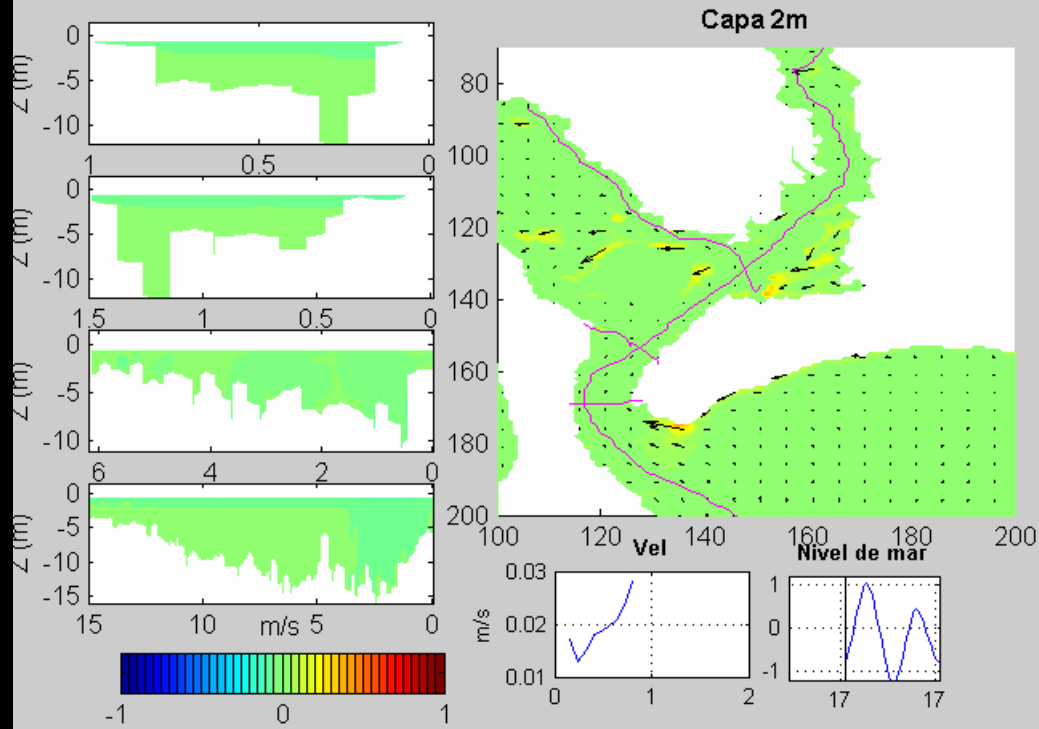


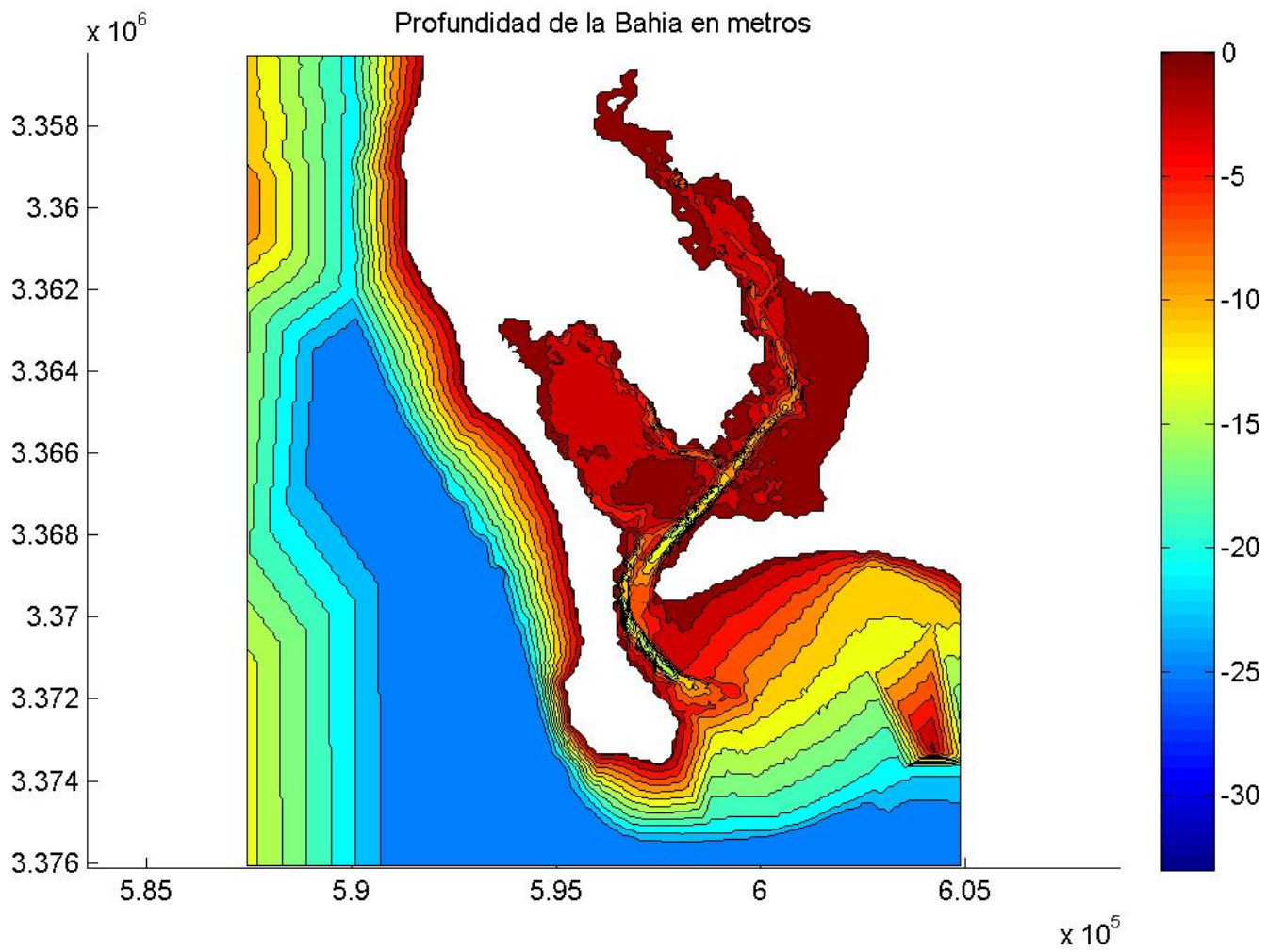
Thanks

23-Oct-2010 08:19:59



17-Apr-2011 16:09:57





- **Oceanographic Measurements**

- temperature, salinity, ph, oxygen, chlorophyll-a, turbidity

- currents

- bathymetry

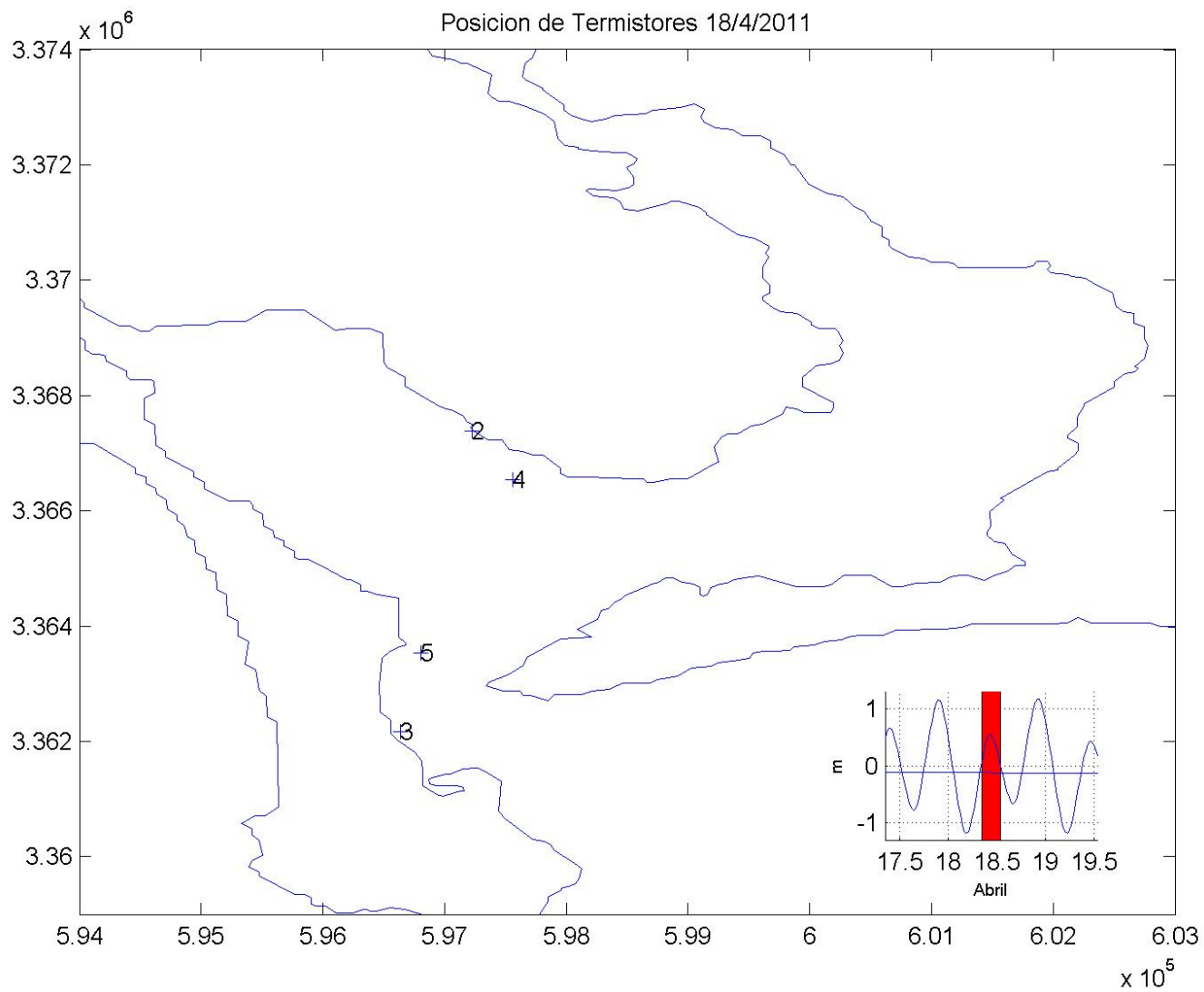
- sea level elevation

- **Meteorological measurements:**

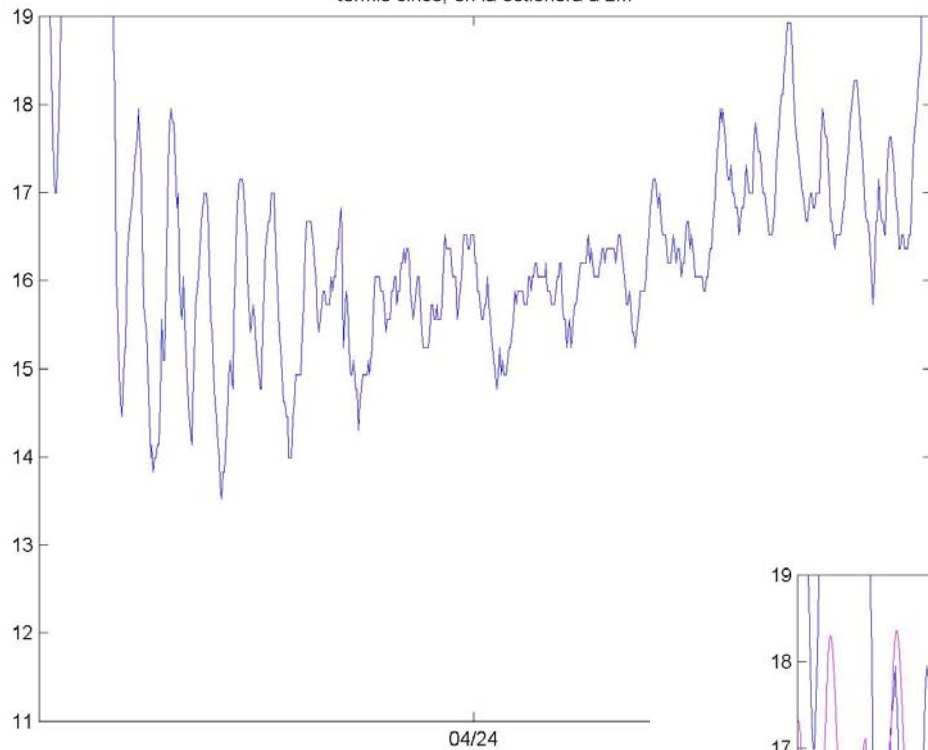
- wind, temperature, relative humidity, solar radiation

Oceanographic Campaign

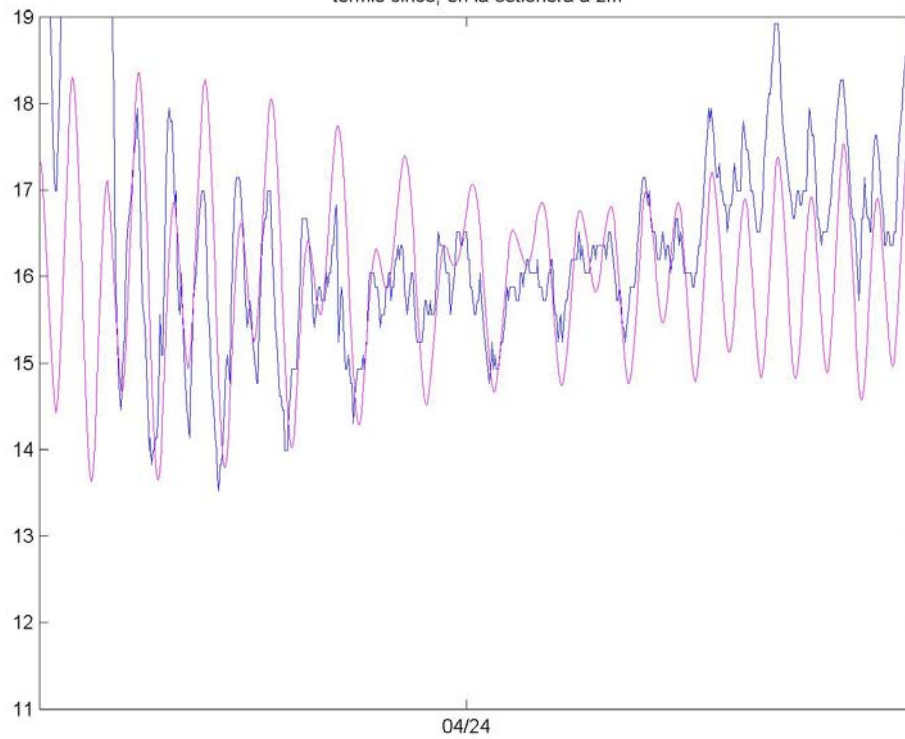
- o CICESE and UABC on October 2010
- o Instruments: CTD, ADCP, GPS with sounder meteorological station
- o Measured variables: depth, T, S, meteorologic data, magnitud and direction of velocity currents



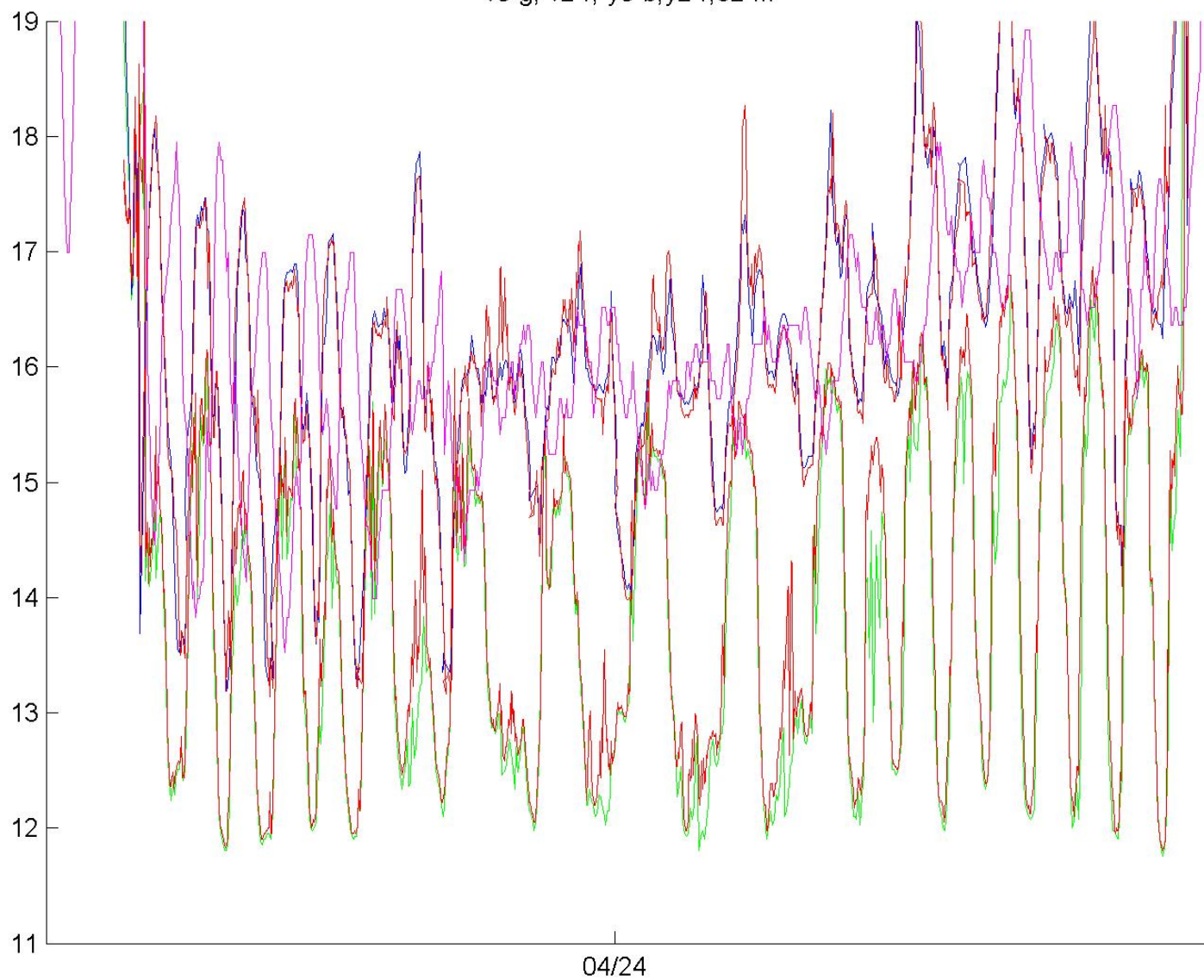
termis cinco, en la ostionera a 2m



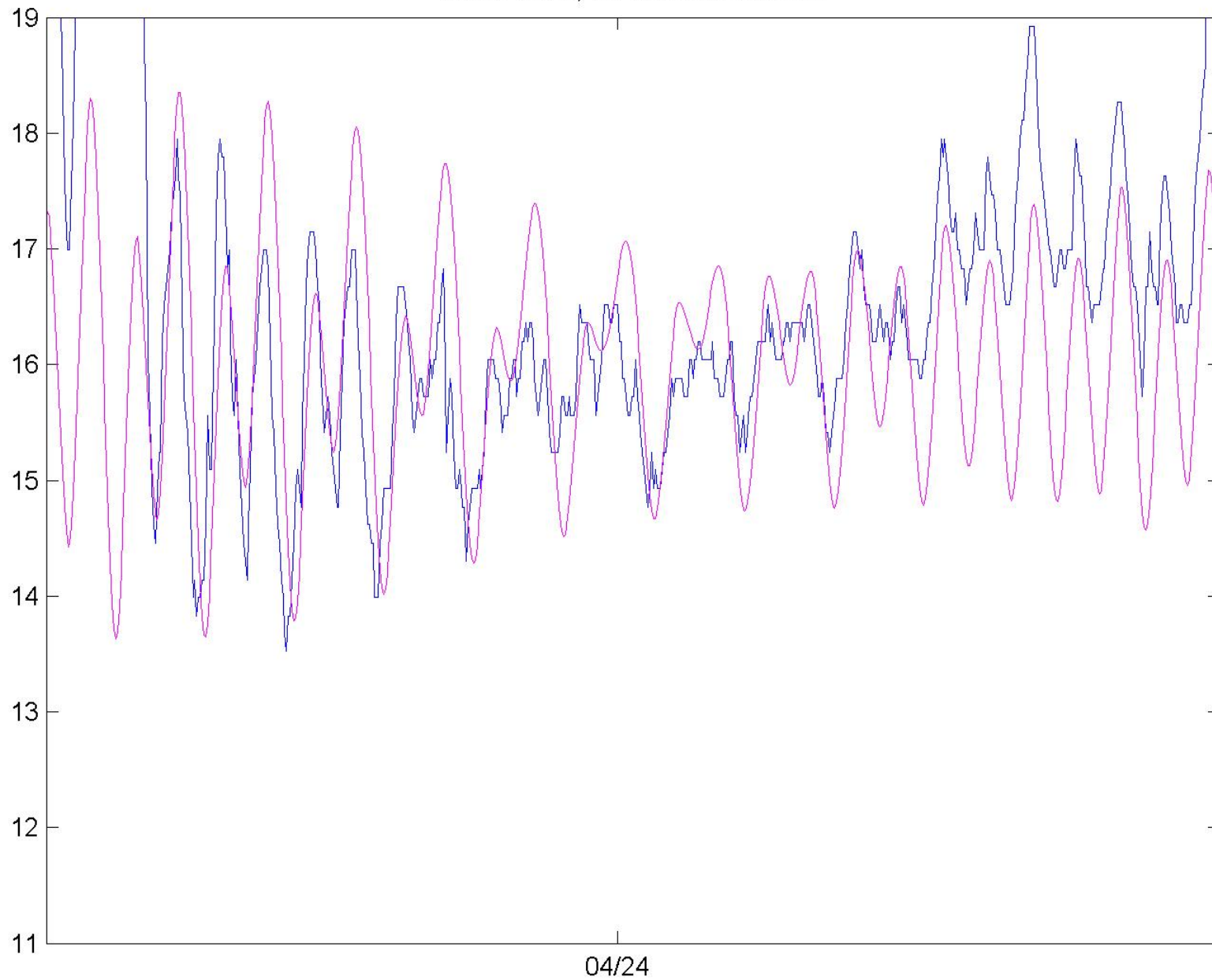
termis cinco, en la ostionera a 2m



v5-g, v2-r, y5-b, y2-r, o2-m



termis cinco, en la ostonera a 2m



Parameters for the simulation

- o Time Step: 30 s
- o Duration of the simulation: 81 hours
- o Temperature of the ocean: 18.5 °C
- o Salinity of the ocean: 33.5 USP
- o Variables to simulate: u , v , η , T , S ,