# Influence of high resolution atmospheric forcing on the circulation of the Gulf of Lions (Mediterranean sea)

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# North-Western Mediterranean


- Microtidal
- Liguro-Provençal current (Northern current)
- Shallow gulf
- Complex coastline and bathymetry

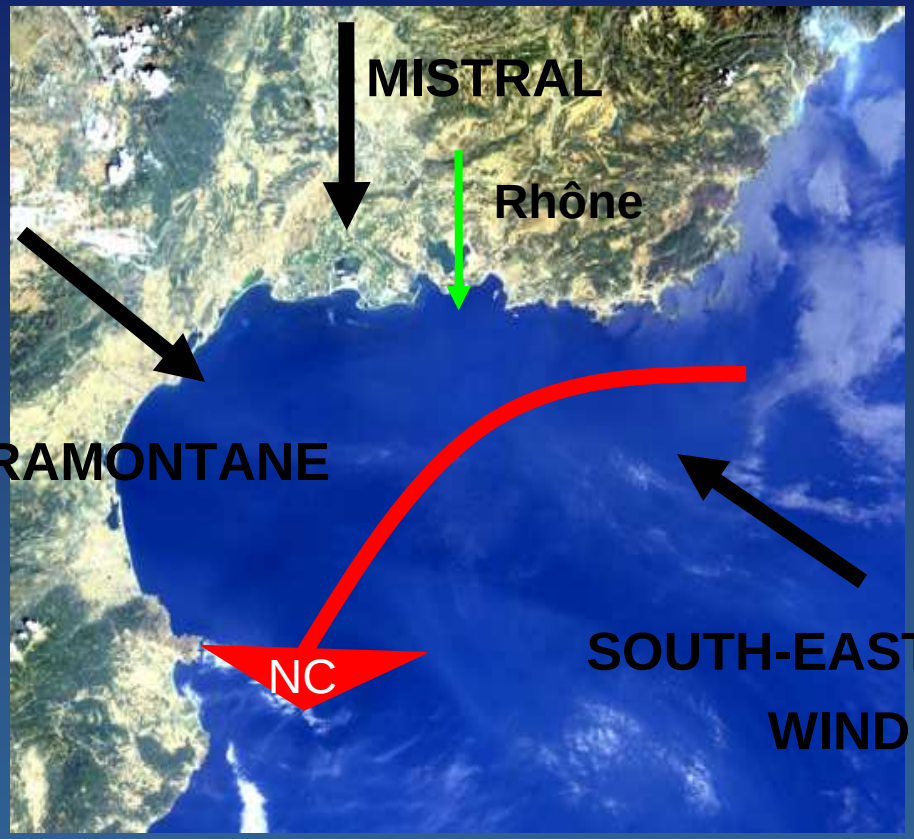
# Influence of wind forcing on the Gulf of Lions (GOL) dynamics

**Predominant wind regime**

- Mistral (northerly wind)
- Tramontane (north-westerly wind)
- South-easterly winds

**Dynamical processes induced by wind stress:**

- Upwellings
- Quasi-inertial waves
- Stratification / mixing
- Dense water formation
- Meso/submesoscale activity

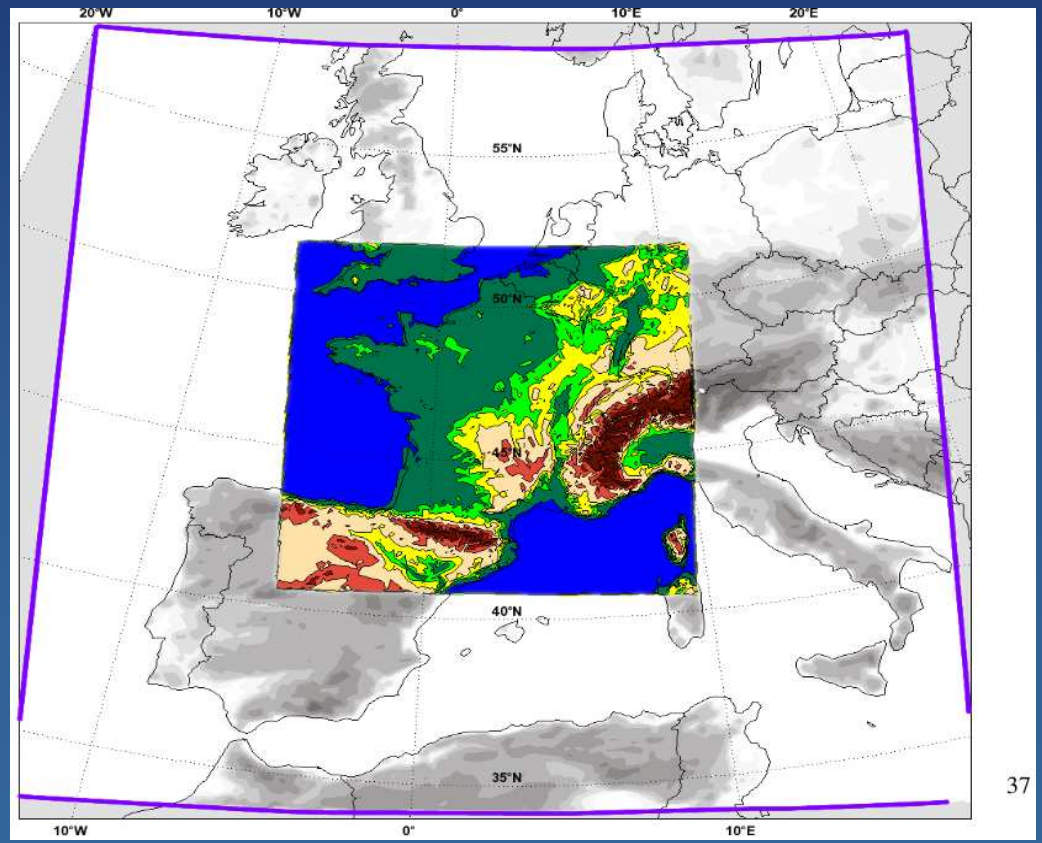



**Main issue: which atmospherical forcing for hydrodynamic modelling? For which target ? What are the benefits of high resolution ?**

# Approach and tools

- Comparison and validation of wind fields from different atmospheric models
  - 3 datasets with different resolution
  - 2 periods: summer 2008 and winter 2008-/09
- Influence of wind forcing and resolution (spatial / temporal /small scale variability) on some ocean physical processes
  - High resolution hydrodynamic configuration
  - “Twin” modelling experiments differing by the atmospheric forcing

# 1. Atmospheric forcing comparison and validation of wind fields: summer 2008, winter 2009

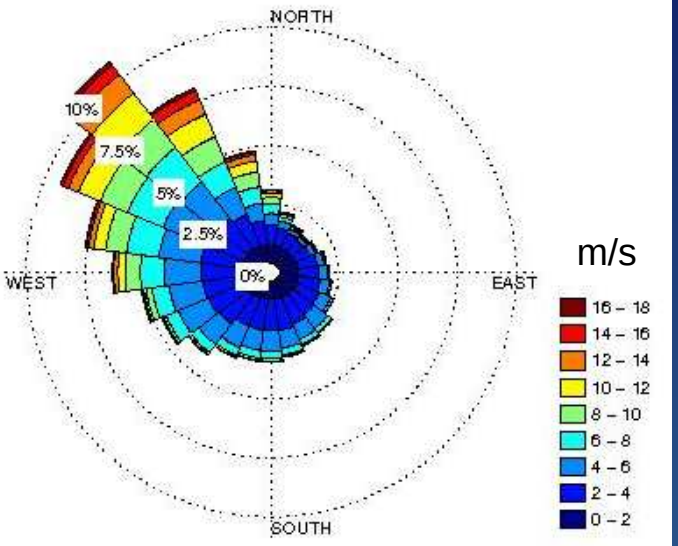


# 3 different datasets:

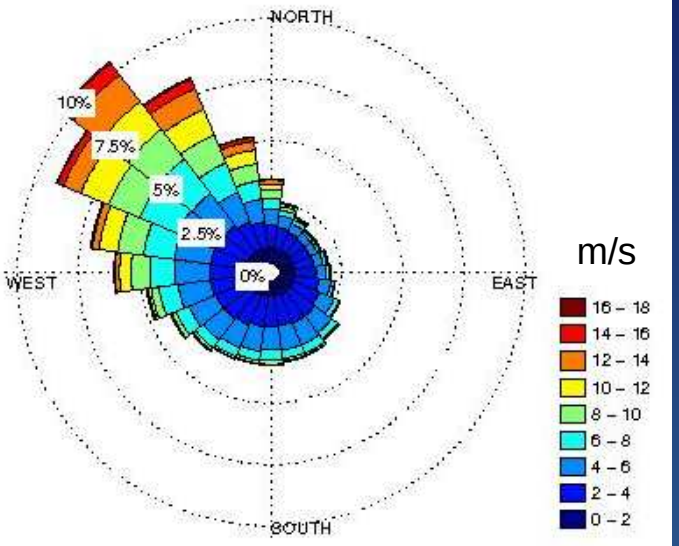
| | ALADIN (Meteo France) | AROME (Meteo France) | MM5 (NCAR) |
|---|---|---|---|
| **Model providing LBC** | ARPEGE France (50km) | ALADIN | NCEP GFS (0.5°) + daily reset |
| **Spatial resolution** | 9.5km | 2.5km | 9km |
| **Temporal resolution** | 3h | 1h | 3h |
| **Non hydrostatic** | no | yes | yes |
| **Data assimilation** | Yes (6h-cycle) | Yes (3h-cycle) | no |

# Wind distribution and intensity

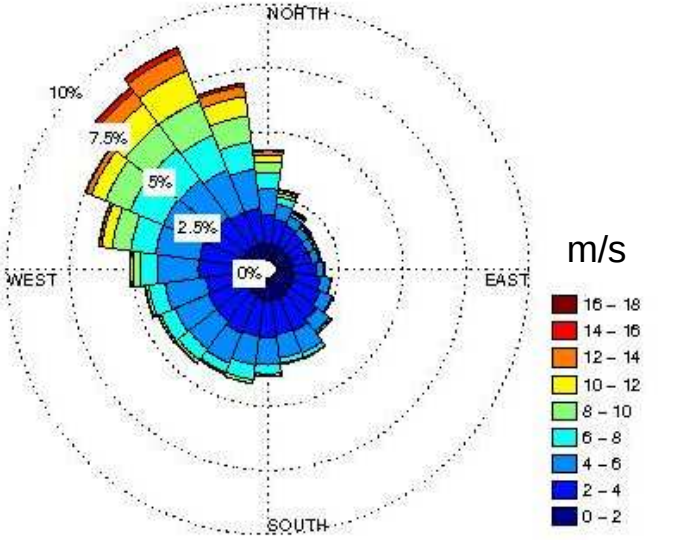
ALADIN (summer 2008)



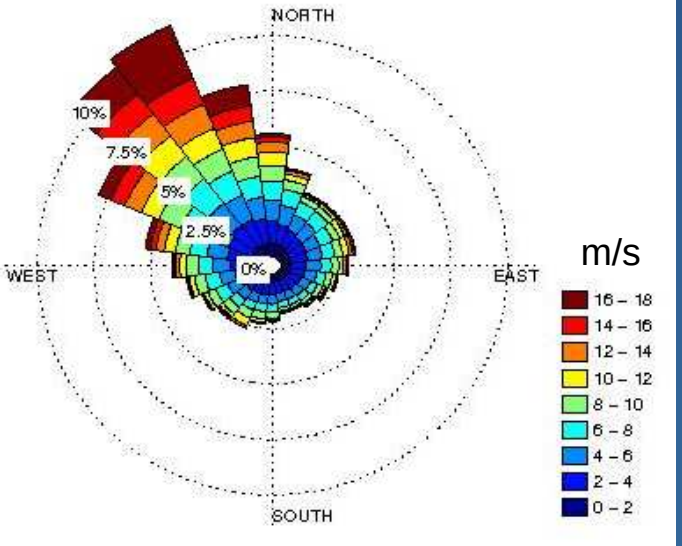

AROME (summer 2008)



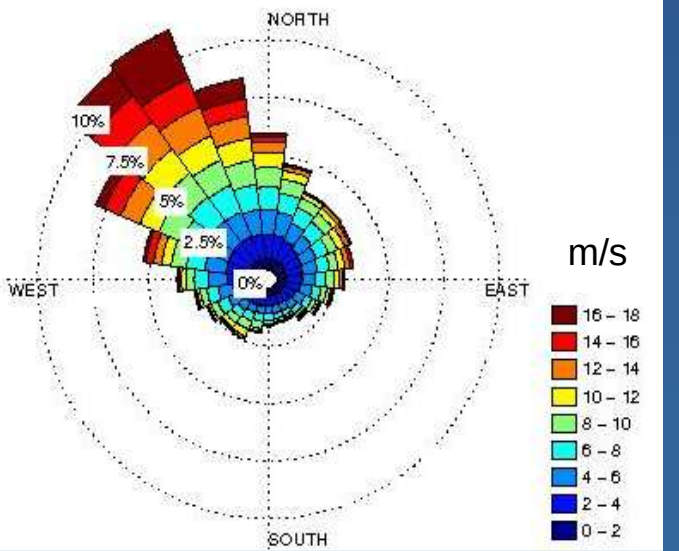

MM5 (summer 2008)



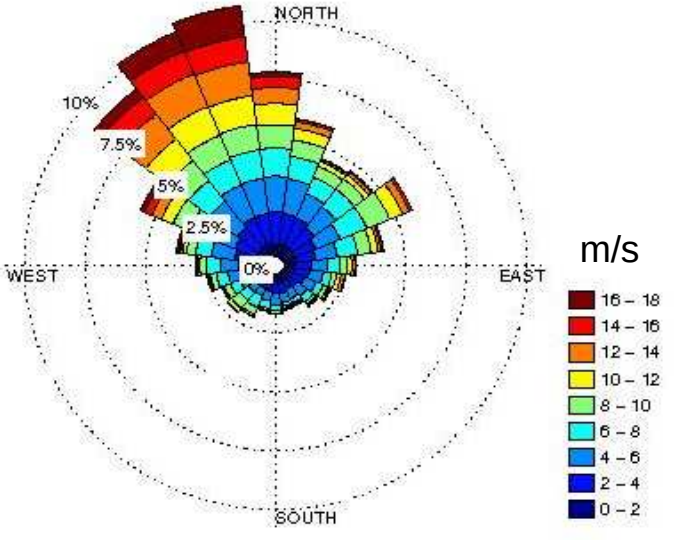

ALADIN (winter 2009)



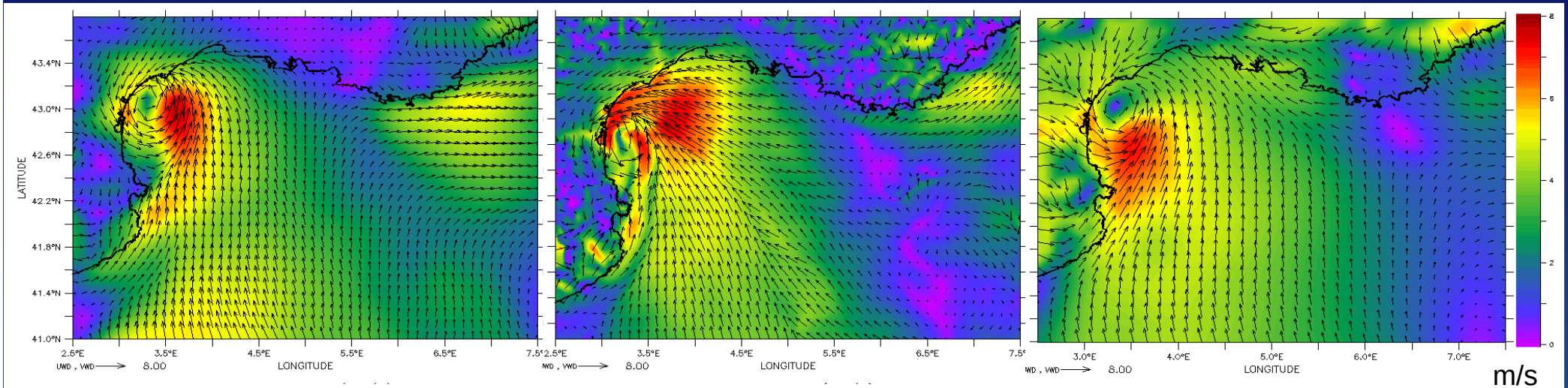

AROME (winter 2009)




MM5 (winter 2009)

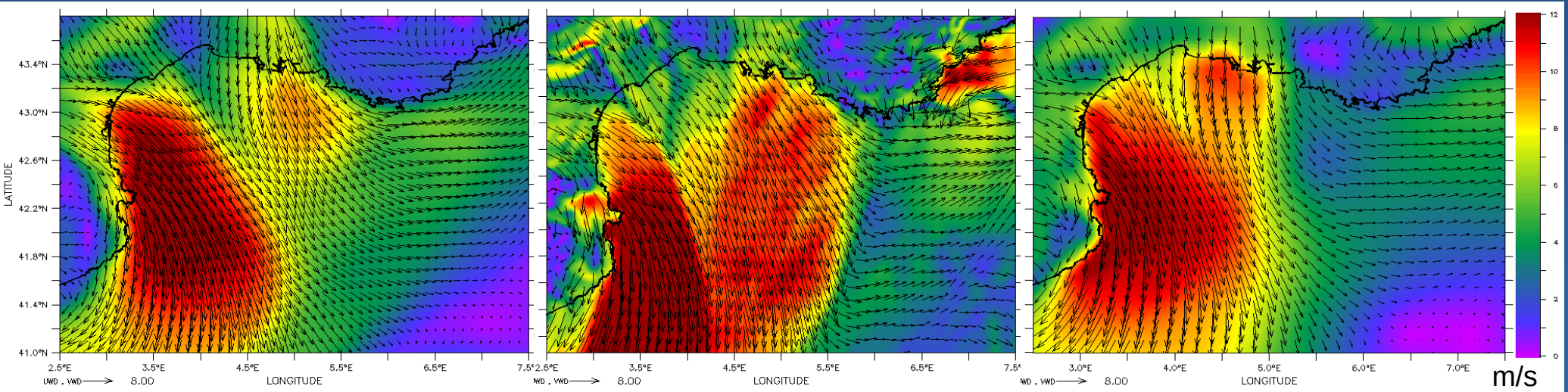


# Wind mesoscale structures




ALADIN AROME MM5

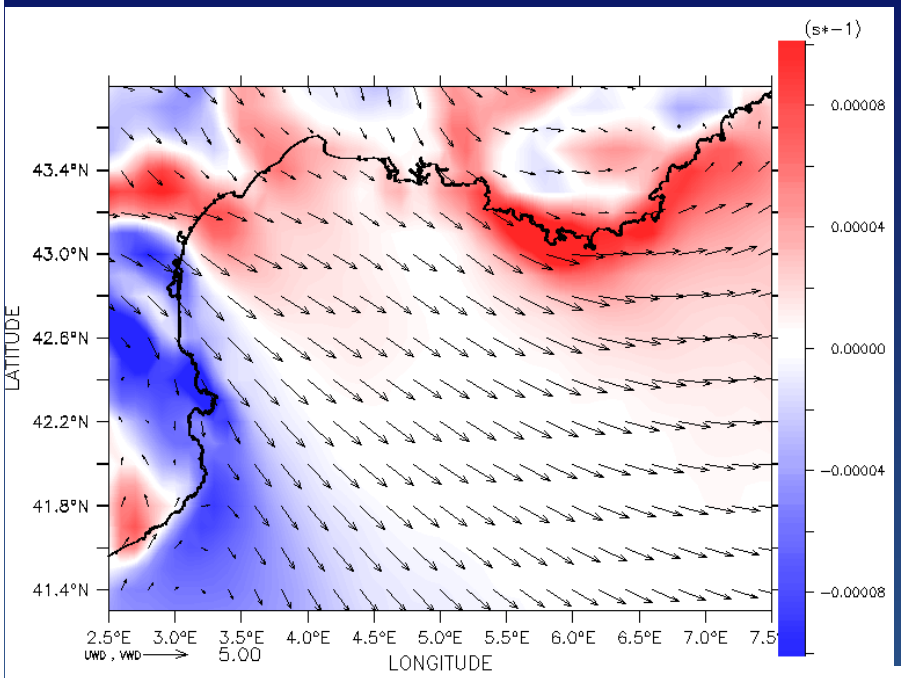
Wind snapshot (1st Aug 2008)



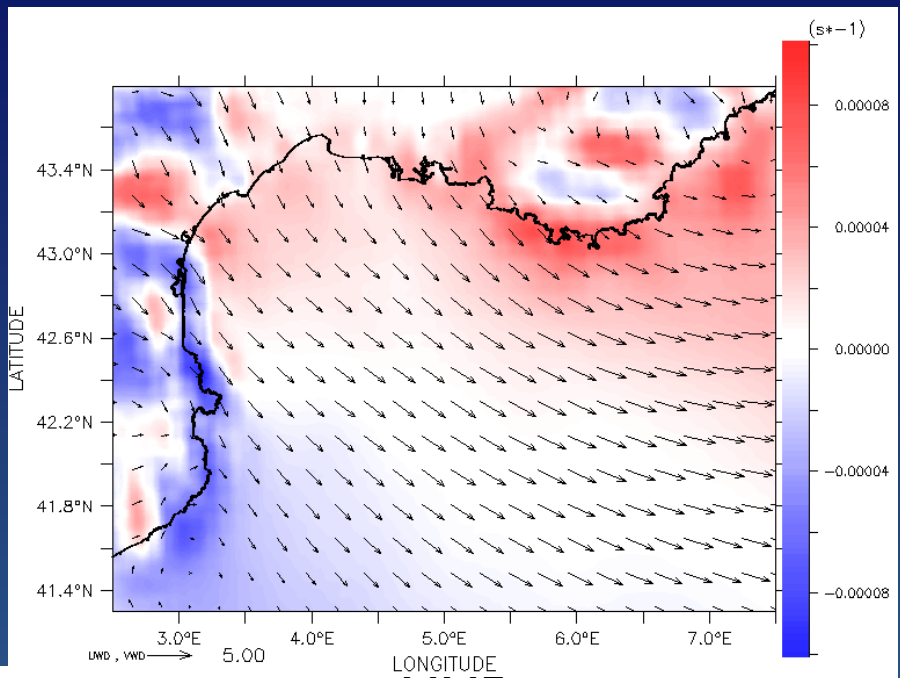

ALADIN AROME MM5

Wind snapshot (2nd Aug 2008)

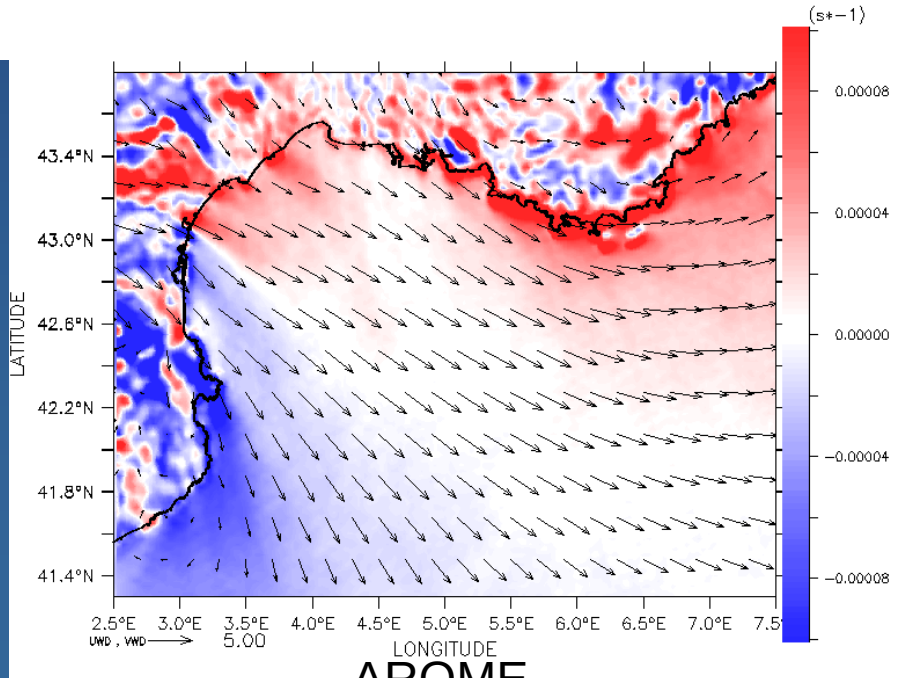
# Mean wind curl (June-August 2008)




ALADIN

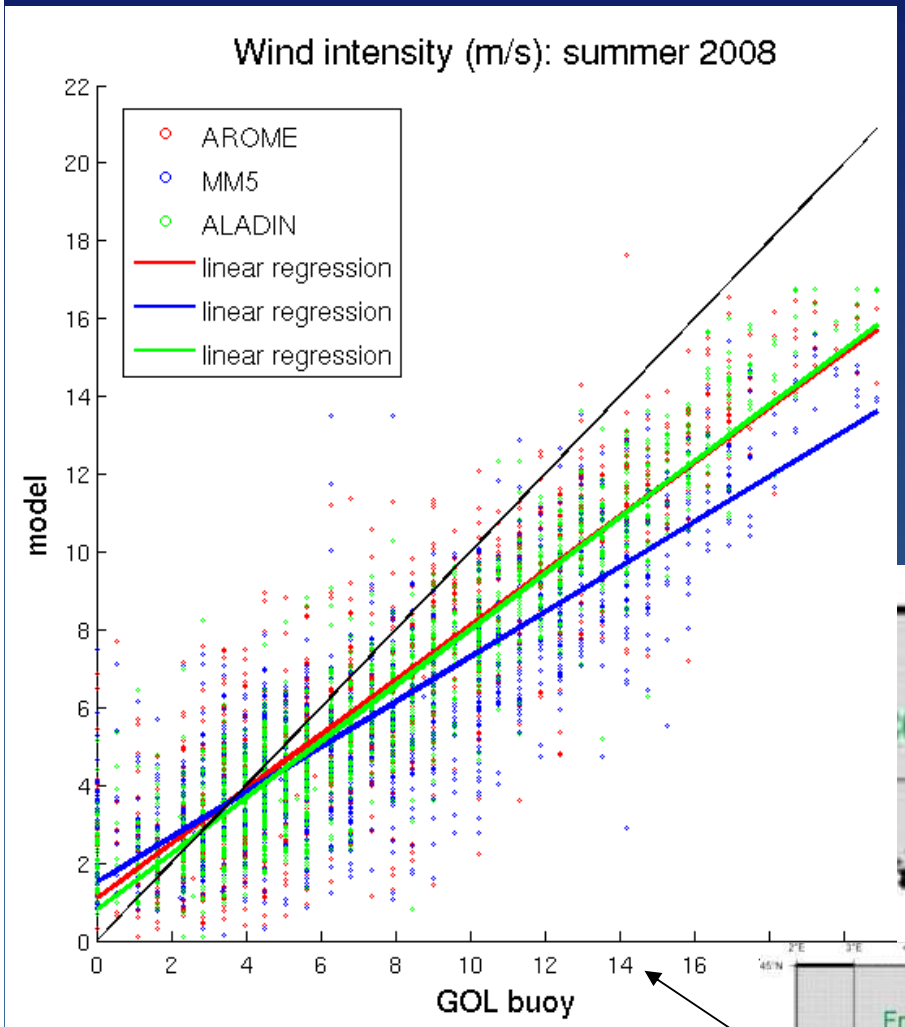


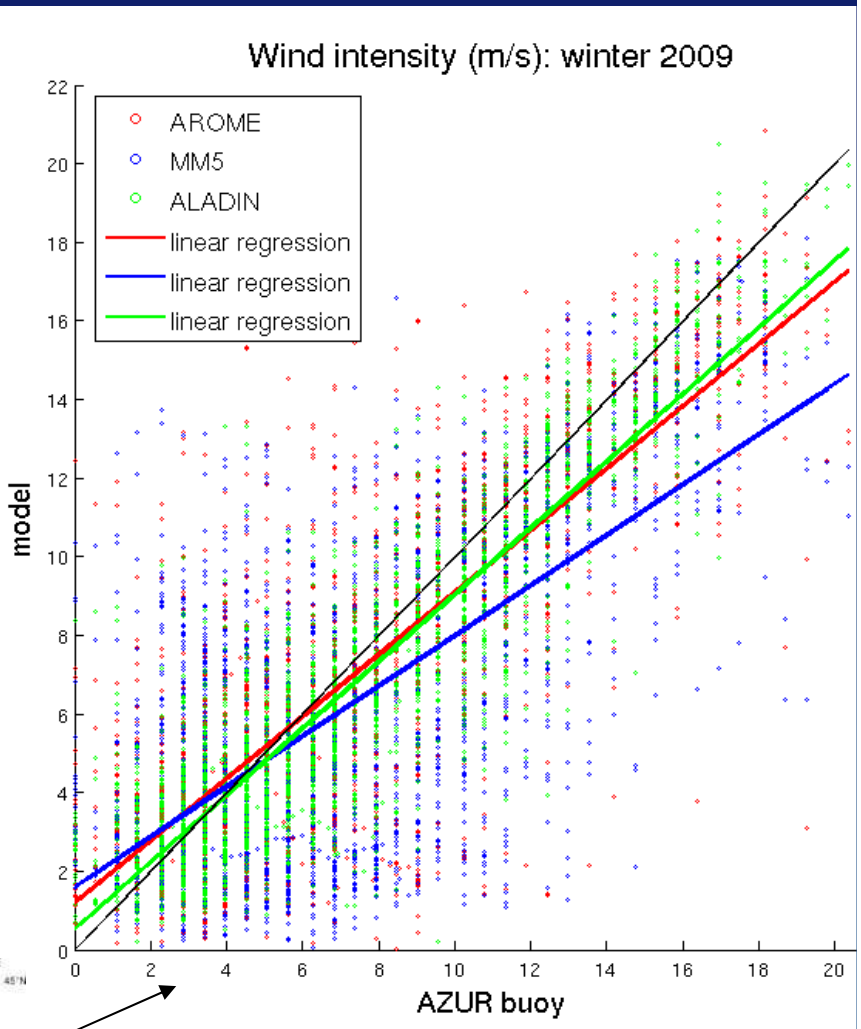

MM5

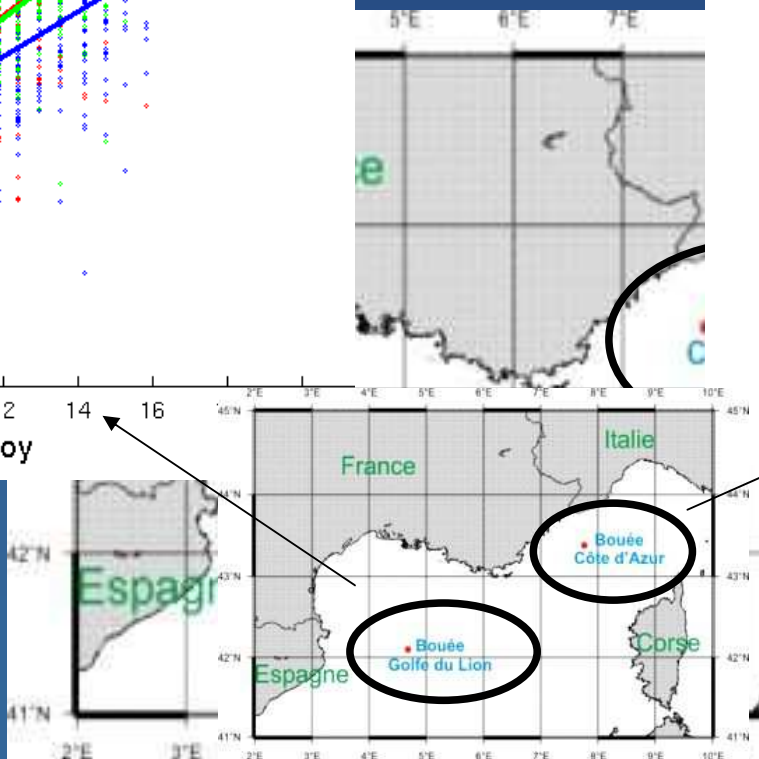



AROME

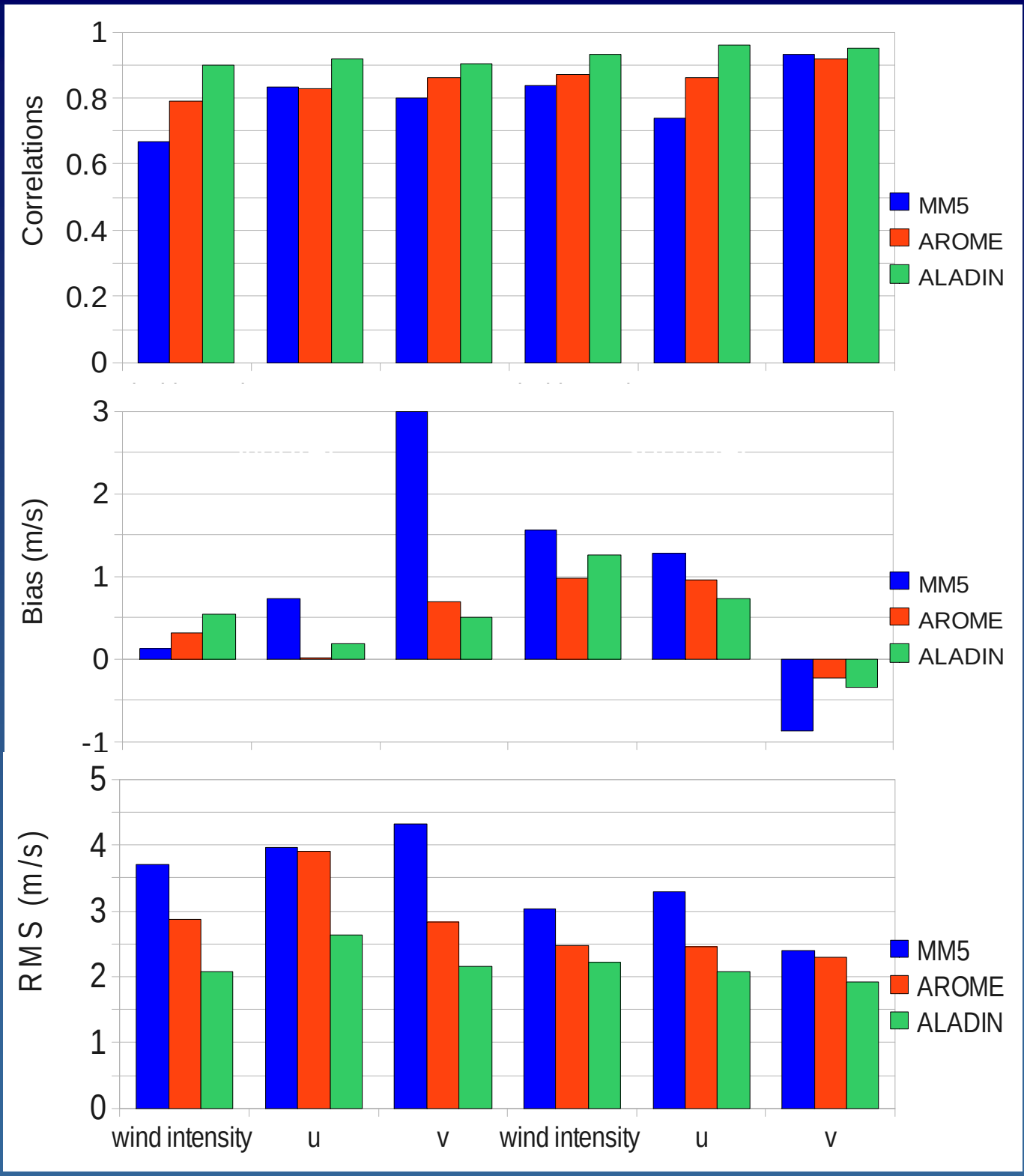
# Wind intensity: comparison to buoy measurements



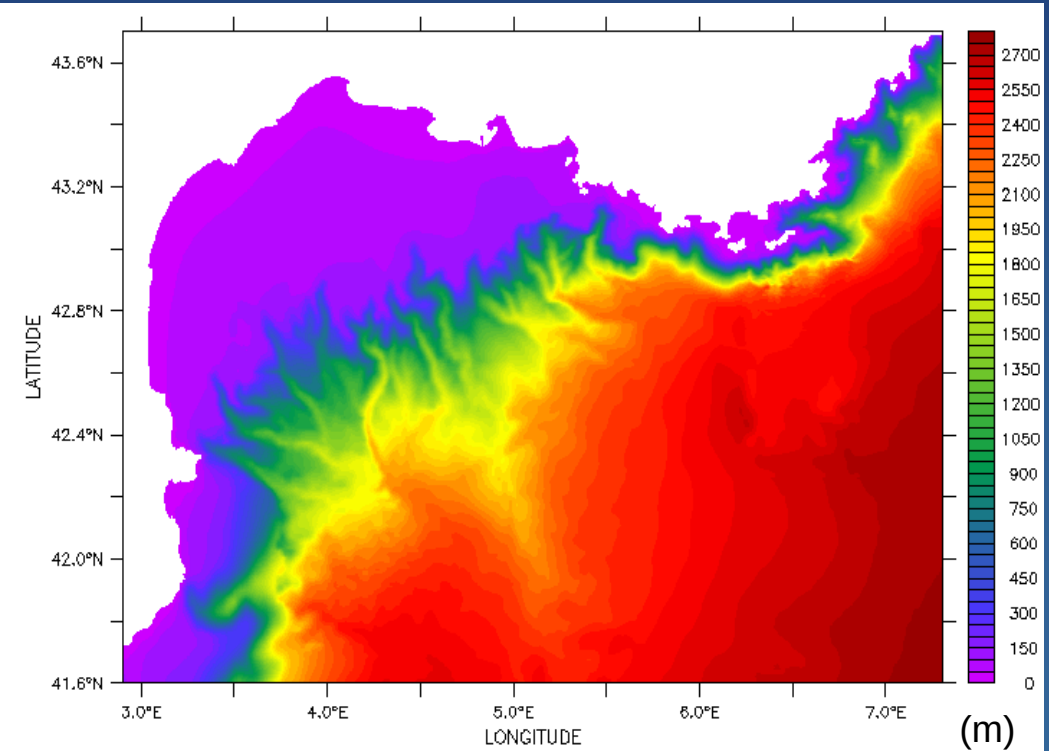



# Statistics on comparison to buoy measurements



# 2. Influence of atmospheric forcing on the GOL hydrodynamics




Bathymetry

# Hydrodynamic modelling

**Hydrodynamic model** : MARS3D (Model for Application at Regional Scale, IFREMER)

PE, finite differences, hydrostatic and Boussinesq approximation

sigma coordinate, free surface (Blumberg and Mellor, 1987)

**Resolution**:

dx~400m, dz=30 sigma levels

**Inputs** :

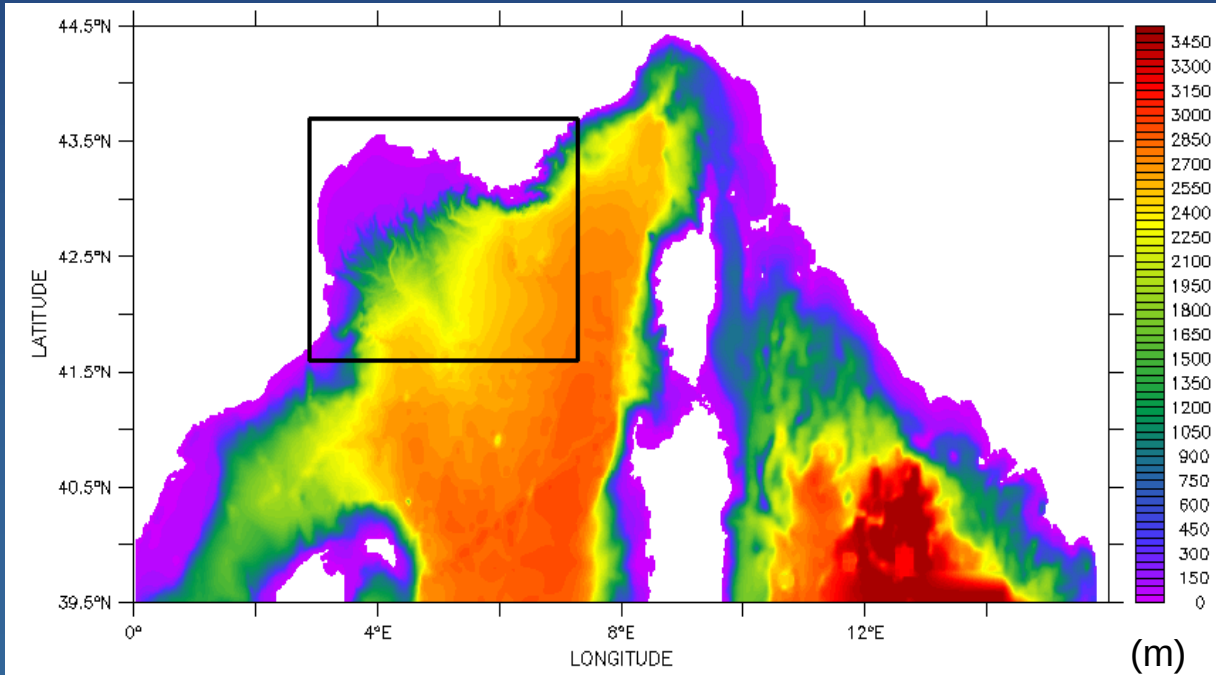
Lateral forcing: MENOR (dx~1200m)

9 rivers: daily outflow

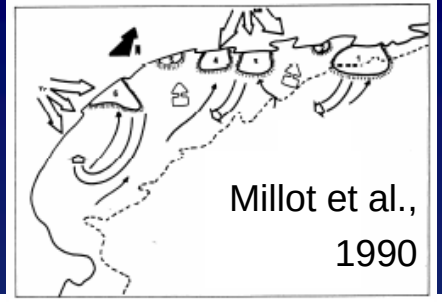
Atmospheric forcing :

AROME or MM5 or ALADIN

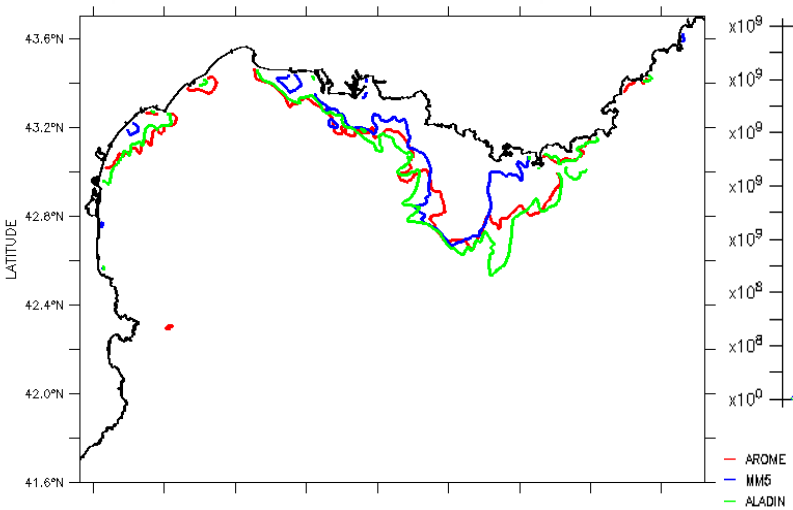
**-> Impact of the atmospheric forcing on different physical processes**



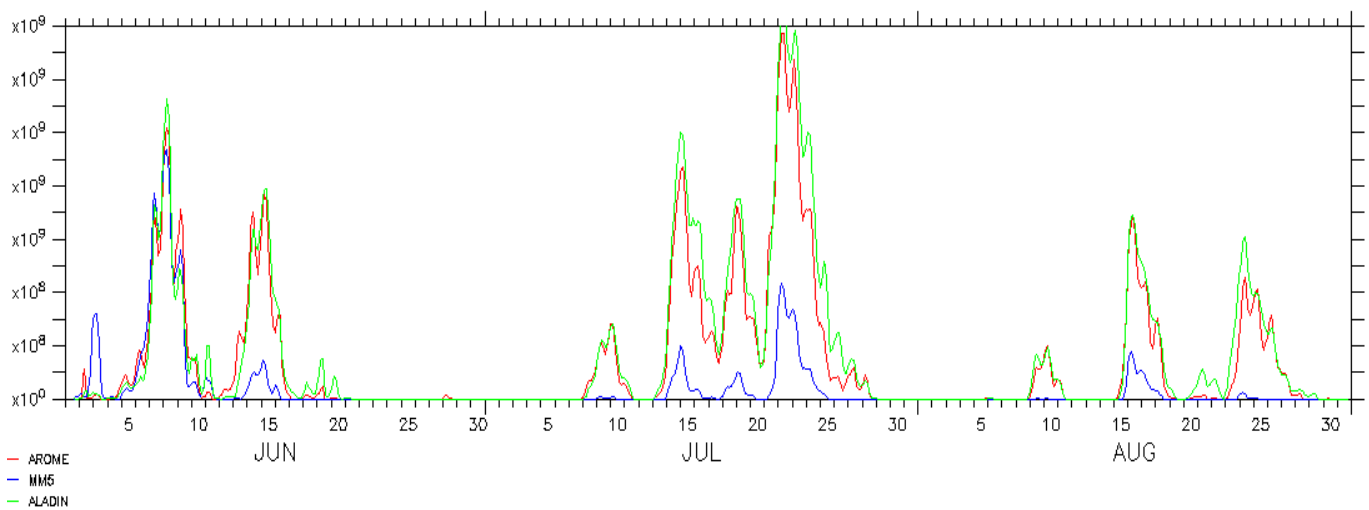

Bathymetry




# Upwellings

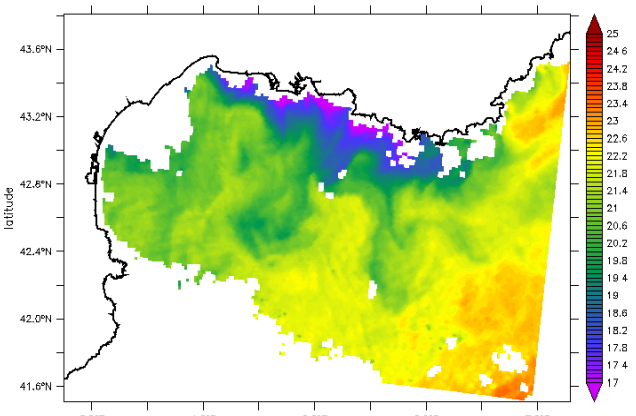



Maximum upwelling extension

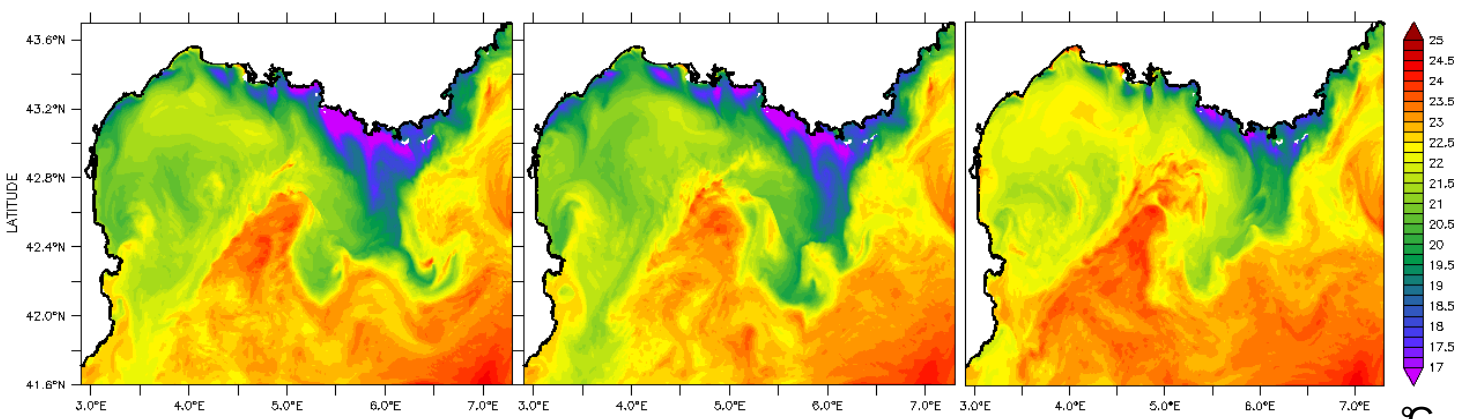



Upwelling events and surface (m²)

## Upwellings defined as SST<17℃




Satellite SST

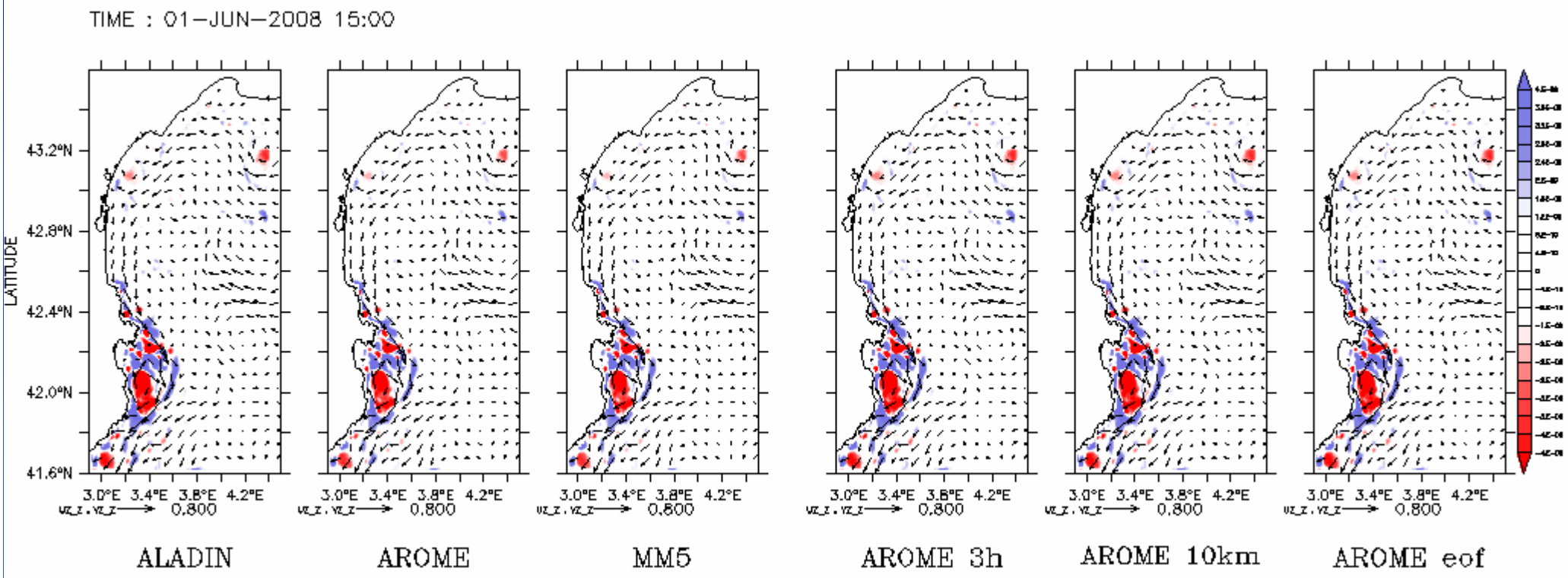



Model SST using ALADIN | Model SST using AROME | Model SST using MM5

## SST 14th of July 2008: satellite (NAR, dx=2km) / models.

# Mesoscale dynamics

Eddy observed and described in Rubio et al., 2009




20-depth Okubo-Weiss parameter ($s^{-2}$) and current vectors

Gulf surface mean Eddy Kinetic Energy:

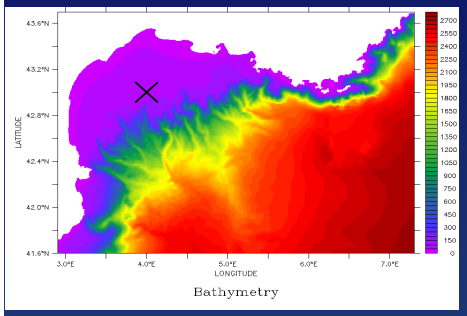
| Summer: | Winter: |
|---|---|
| ALADIN: 0.021 $m^2/s^2$ | 0.019 $m^2/s^2$ |
| AROME : 0.024 $m^2/s^2$ | 0.020 $m^2/s^2$ |
| MM5: 0.018 $m^2/s^2$ | 0.018 $m^2/s^2$ |

Impact of temporal resolution

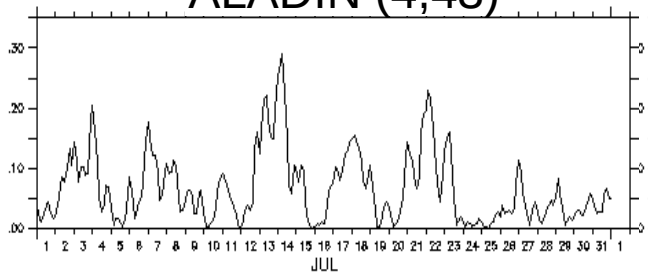
Impact of spatial resolution

Impact of small scale variability: Wind EOF reconstruction (90% of variance)

# Quasi-inertial waves: summer 2008

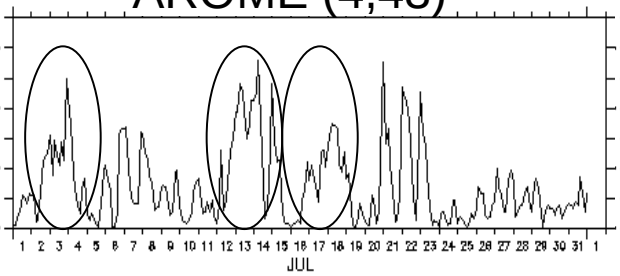



ALADIN (4,43)



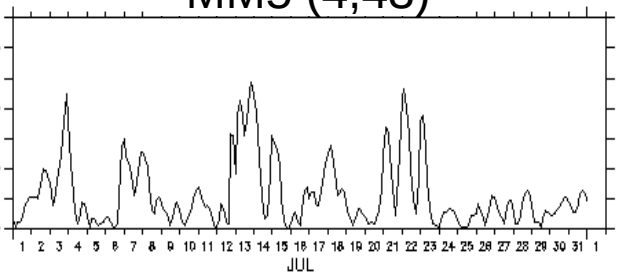

Wind stress (N/m²)

AROME (4,43)

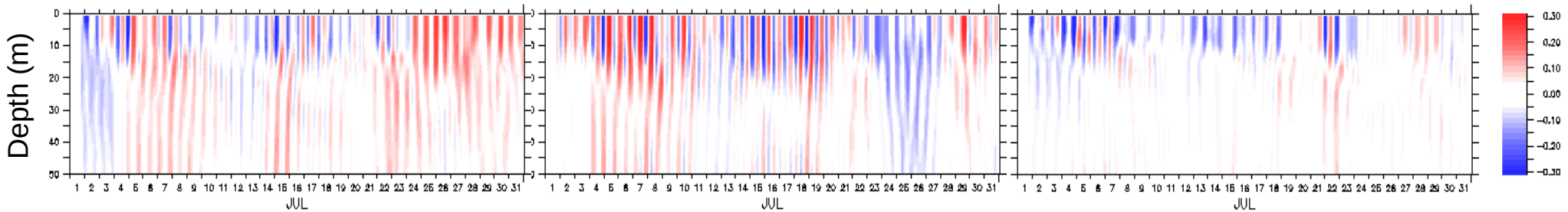



Wind stress (N/m²)

MM5 (4,43)




Wind stress (N/m²)




Zonal velocity (m/s)

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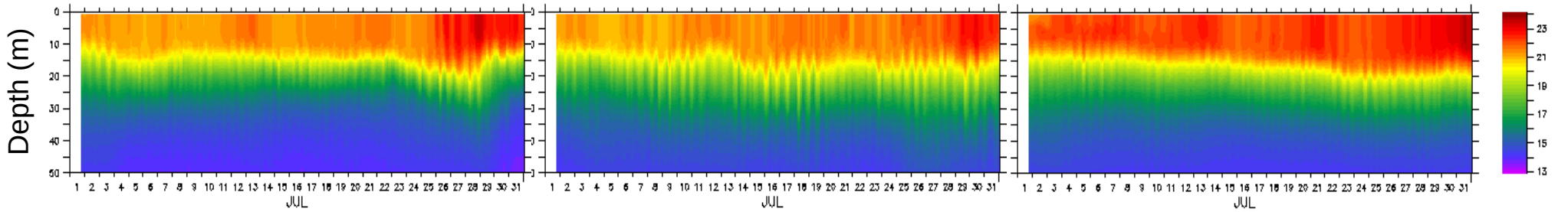
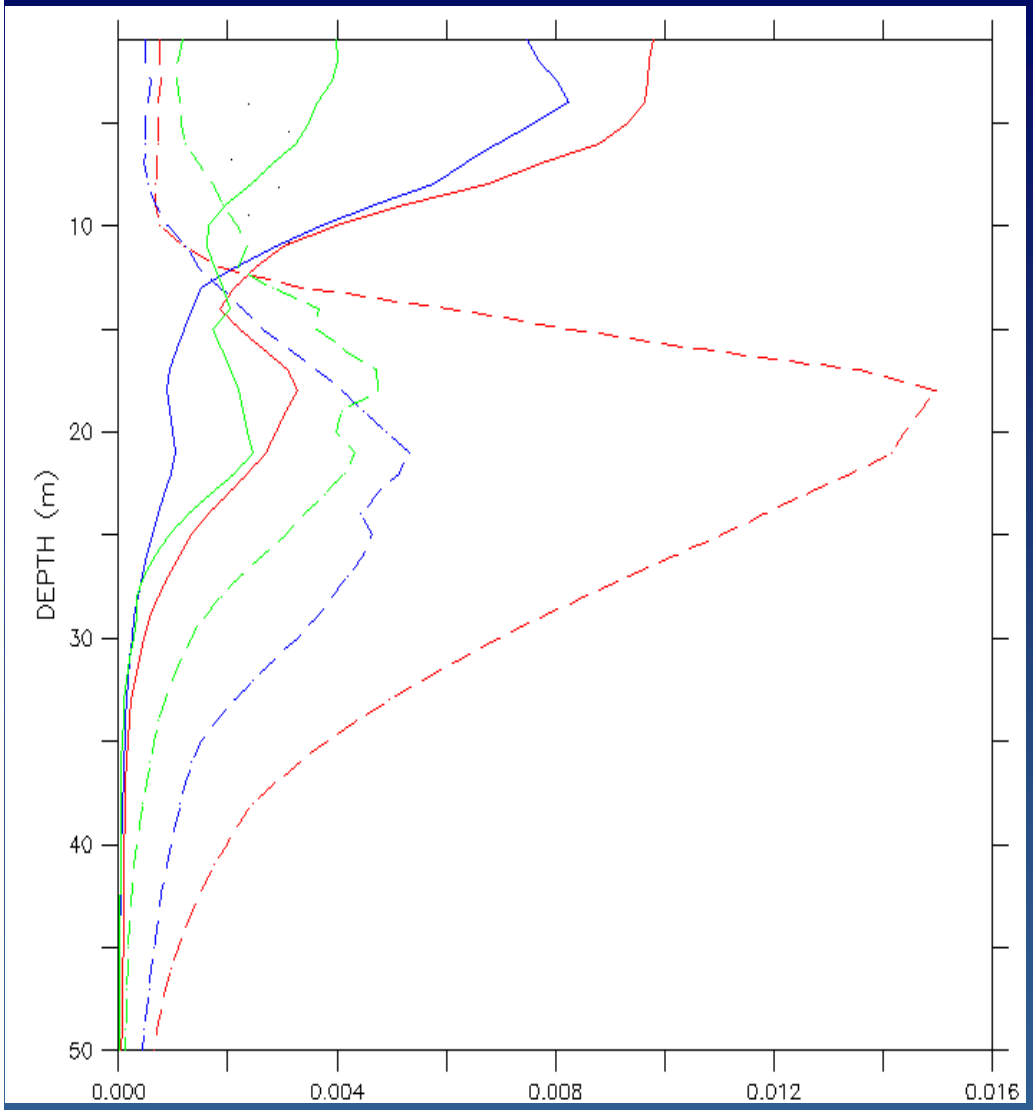
Zonal velocity (m/s)

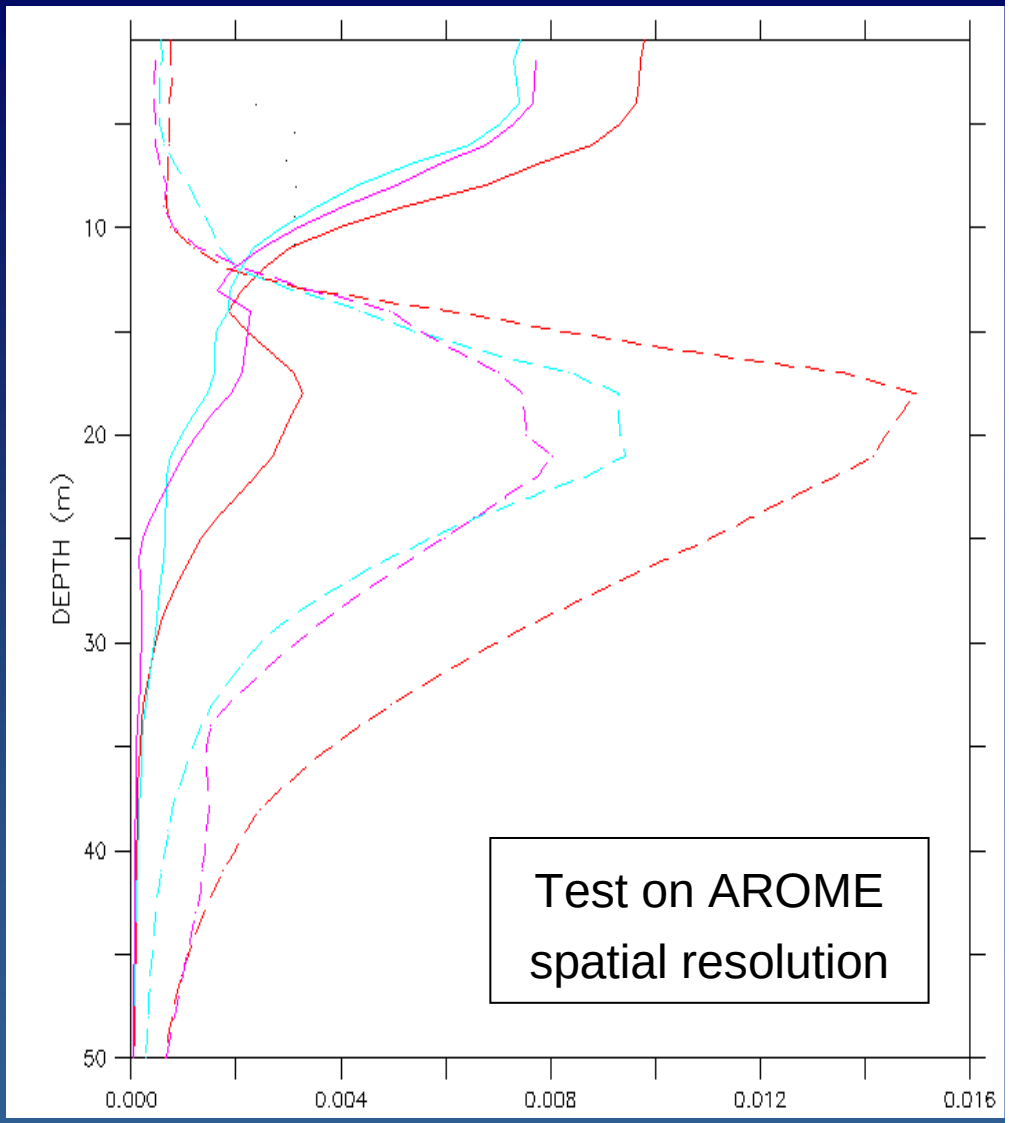



Temperature (℃)

Temperature (℃)

Temperature (℃)

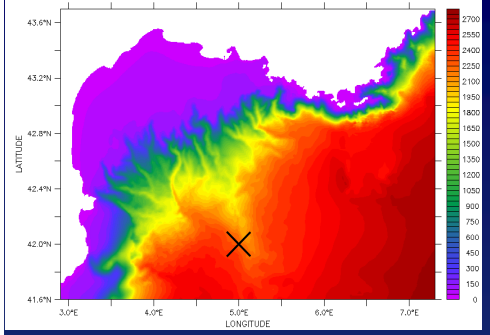



## Power Spectral Density of temperature series (℃)² at (4°E,43°N)

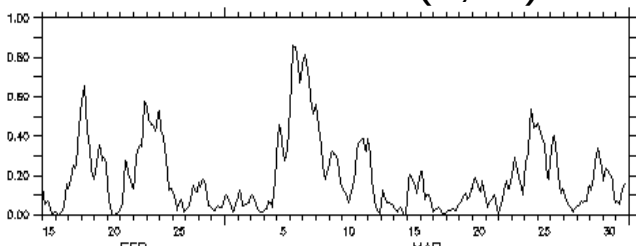
- diurnal period (AROME)
- quasi inertial period (AROME)
- diurnal period (MM5)
- quasi inertial period (MM5)
- diurnal period (ALADIN)
- quasi inertial period (ALADIN)

- diurnal period (AROME)
- quasi inertial period (AROME)
- diurnal period (AROME eof)
- quasi inertial period (AROME eof)
- diurnal period (AROME 10km-average)
- quasi inertial period (AROME 10km-average)

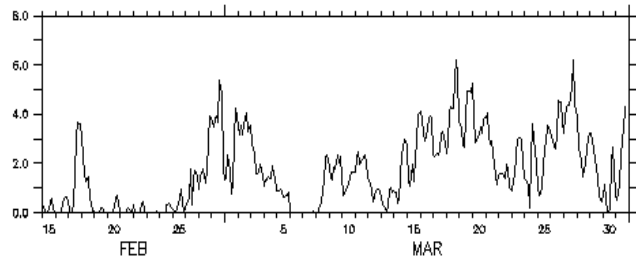



# Winter stratification

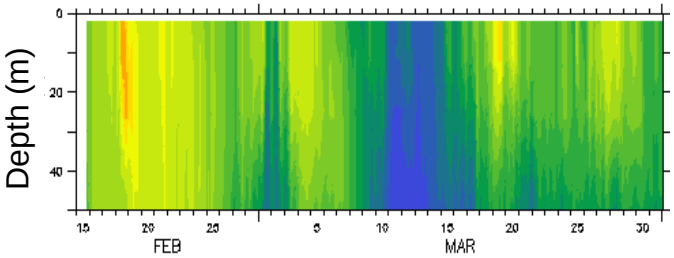
ALADIN (5,42)



Wind stress (N/m²)

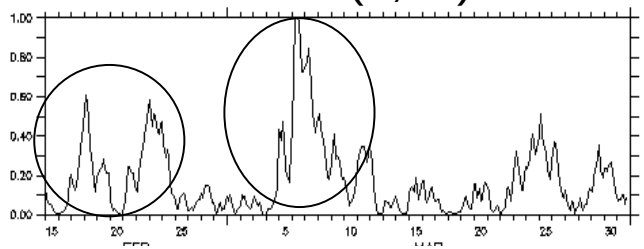



50m Potential energy anomaly (J/m3)

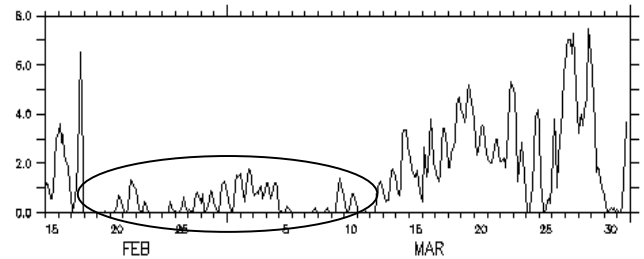



Density

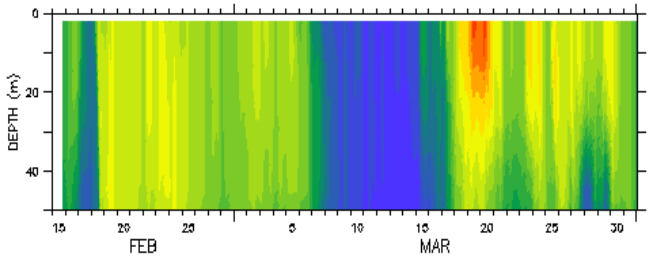
AROME (5,42)



Wind stress (N/m²)

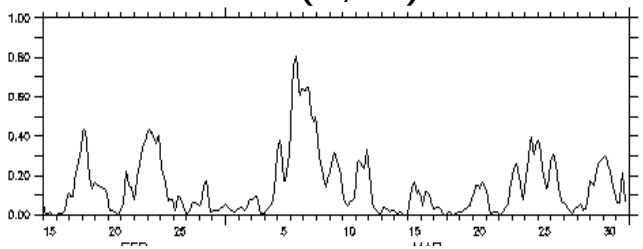



50m Potential energy anomaly (J/m3)

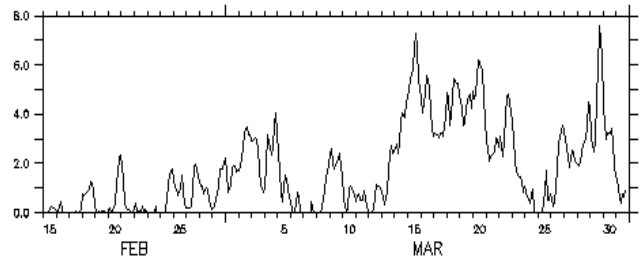



Density

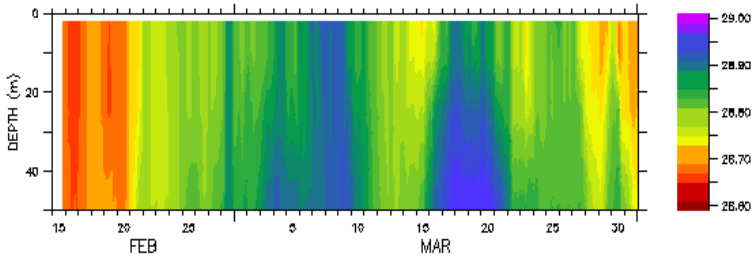
MM5 (5,42)



Wind stress (N/m²)




50m Potential energy anomaly (J/m3)




Density

Potential energy anomaly :

$$\phi = \frac{1}{D}\int_{-H}^{\eta} gz(\overline{\rho} - \rho)\,\mathrm{d}z$$

# Conclusions

- Wind comparison:
  - best correlations between ALADIN and buoys measurements
  - better reproduction of wind extremes with Meteo France dataset
  - Sharp fronts, gradients and curls enhanced in AROME dataset.

- Impact of the high resolution wind on the ocean circulation :
  - summer upwellings
  - mesoscale dynamics
  - internal waves generation
  - winter mixing of the water column

Thank you for your attention.