On the influence of coastal mesoscale dynamics on the jellyfish trajectories and distributions

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JELLYWATCH project

Modelling of jellyfish transport and stranding in the NWmed

Main characteristics of *Pelagia Noctiluca*

- **Sparse information** on the Jellyfish repartition and the associated forcing (Temperature ? Currents ? Wind ? Food ? Predators ?)
- Numerous all along the year, in the NW-MED (*Morand et al, 1992*)
- At the surface during the nigth| migration at depth during the day (**Dial vertical motion (DVM): down to 400 m**, *Gorsky personnal communication*)

Main issues

- What are the impacts of mesoscale and coastal dynamics on the jellyfish trajectories/distribution ?
- In which way coastal-altimetry could be a powerfull tool ?

Outline

- Strategy and data used
- Reconstruction of sub-surface currents
- Validations / comparisons
- Jellyfish trajectories: preliminary results

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Strategy and data used

- **Strategy :** Using altimery to simulate the advection of Jellyfish at the surface and at depth
- **Motivation :** altimetry provides almost synoptic currents that should allow a long-term monitoring of Jellyfish transport

Limitation in coastal zone

- Sub-sampling of coastal dynamics
- Significant error

→ **Develop / use alti. products dedicated to coastal zone***

** Dussurget et al, 2011 (see previous talk), Escudier et al 2011 (see poster) …*

NO subsurface information

Dial vertical motion of jellyfish !!!!

Rely SSH to sub-surface geostrophic currents**

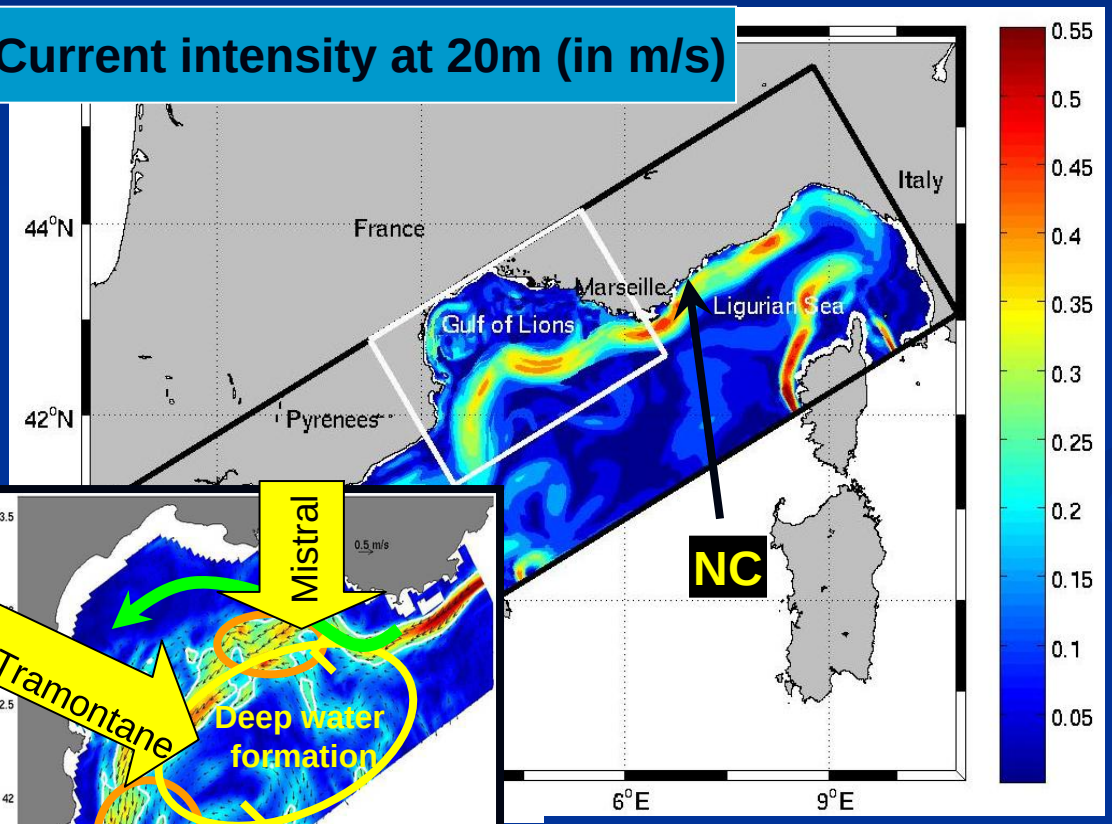
→ **Use of statistics from a realistic regional model**

Pascual et al 2003 *(Vertical **EOF** de mesure in situ + SSH altimétrique)*

Strategy and data used

- The symphonie model (POC-SIROCO, Toulouse) and study area characteristics

Current intensity at 20m (in m/s)



Model: SYMPHONIE

(GoL config., *Hu et al., 2009*)

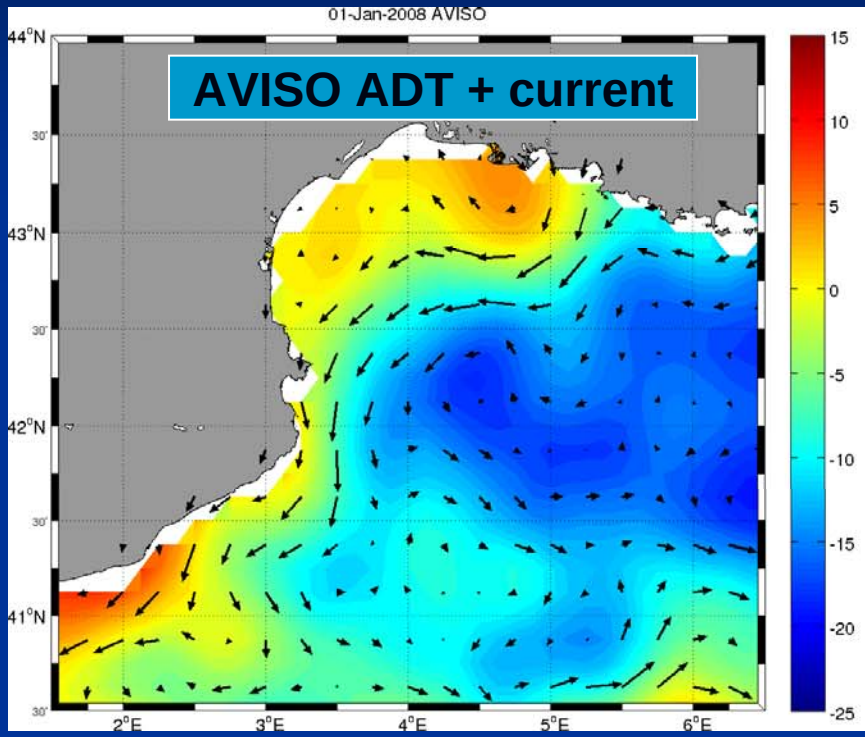
- Boussinesq model
- One way Nesting: 3km -> 1km
- Period 2001-2010

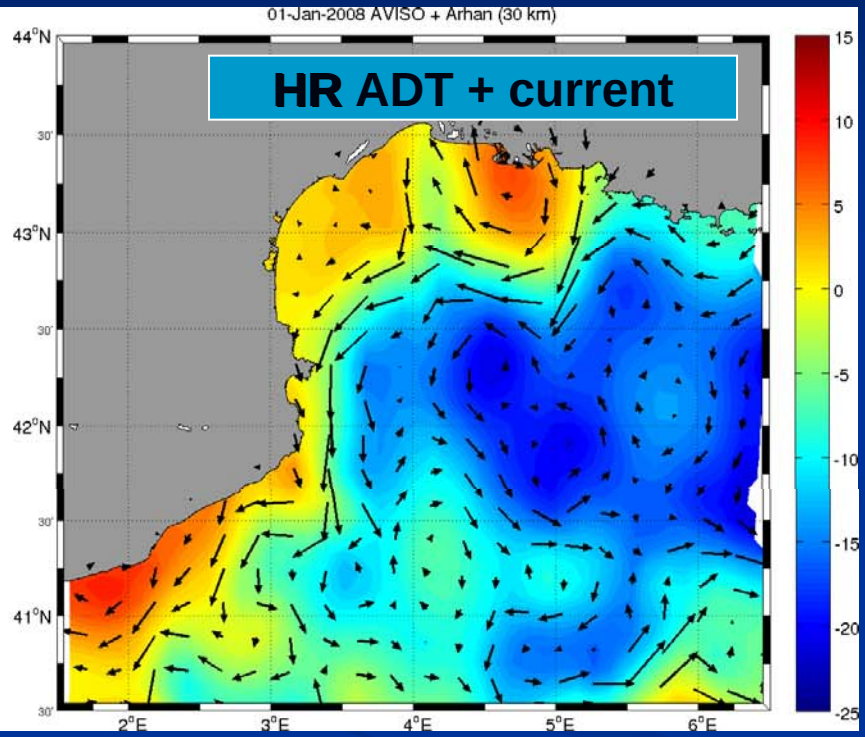
Study area :NWMed

- **Northern Current (NC): seasonnal** variability (*Gostan*, 1967)
- **Intense mesoscale variability:** eddies, meanders (*Millot*, 1991)
- **NC intrusion over the GoL continental shelf** (*Gati et al.*, 2006)
- **Winter deep water formation characterized by a high interannual variability** (*Mertens and schott*, 1998; *Hermman*, 2008)

Strategy and data used

- Altimetric products used





- 2 kinds of (M)SLA : From regional AVISO and Higher Resolution (HR) product (correlation scales: 5 days/30km) from IMEDEA (Escudier et al.,2011)
- 2 kinds of MDT: From Rio et al., (2007) and Dobricic et al., (2005)
- Validations with *in-situ* measurements from the LATEX08 experiment *

** influence of submesoscale coupled physics – biogeochemistry on cross-shelf exchange:s http://www.com.univ-mrs.fr/LOB/LATEX*

Strategy and data used

- Methodology

Step 1 Build daily Dynamic Height (DH) from T,S of SYMPHONIE model (period 2001-2010)

Step 2 Compute a database of daily vertical EOF from the model DH

Step 3 Create an EOF climatology from 10 years of simulation

Step 4 **If 1st mode highly dominant, reconstruct DH at a given depth by projecting altimetric ADT with the EOF climatology of the model**

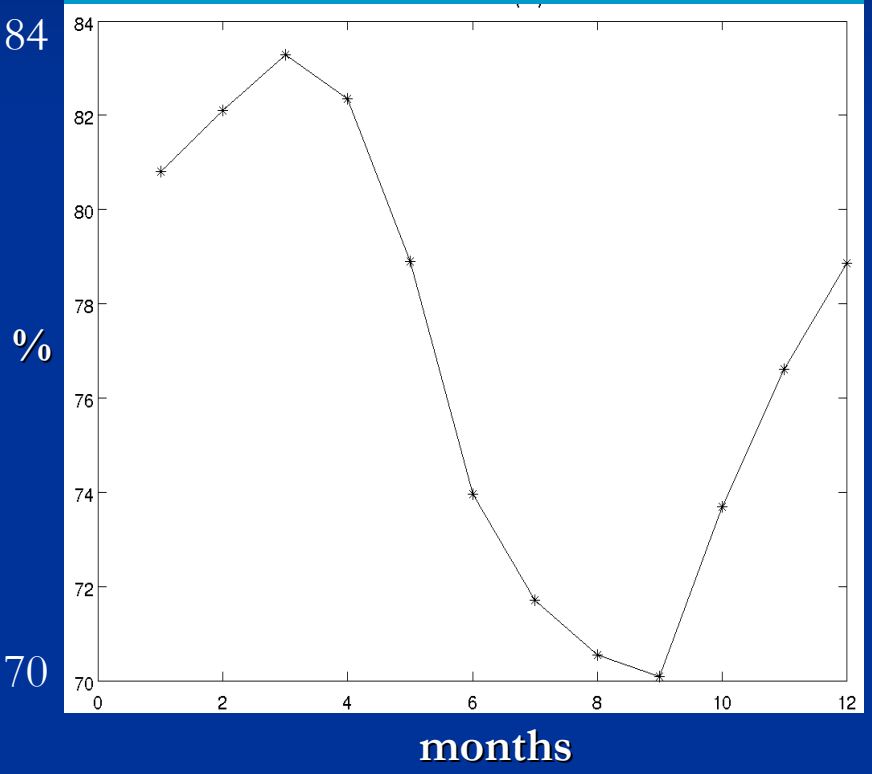
Advection with geostrophic currents by considering Jellyfish as passive particules with dial vertical migations

Is the 1st EOFmode highly dominant ?
Is the climatology representative of daily EOF ?

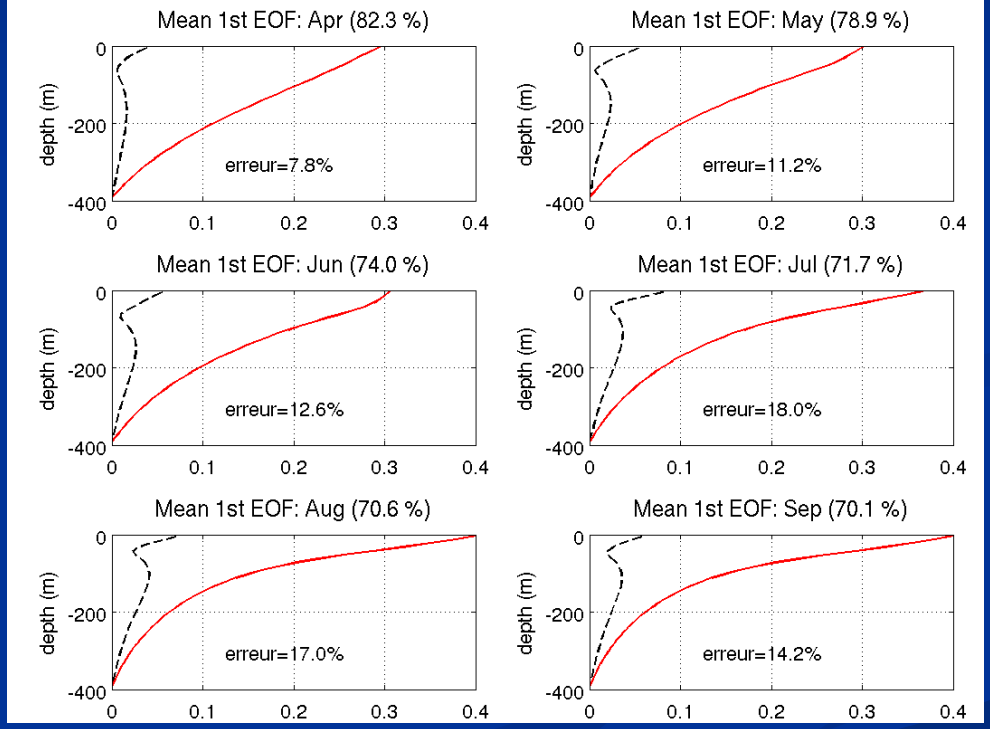
Reconstruction of sub-surface currents

- Create an EOF climatology from 10 years of simulation

Weigths of mode 1 / month



Climatology vertical EOF (mode 1)



1st mode :
70 % < weigths <84 %

Representativity of the climatology
8% < error < 14 %

Reconstruction of sub-surface currents

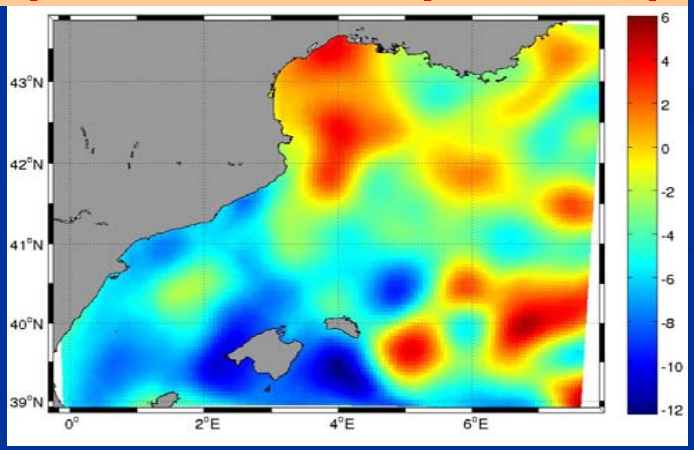
- Create an climatology of EOF from 10 years of simulation:
  - If the first mode is highly dominant (as noted in *Pascual et al.*, 2003) :

DH (t,250m) = **DH (t,0m)** **EOF1(t,250m)/EOF1(t,0m)**

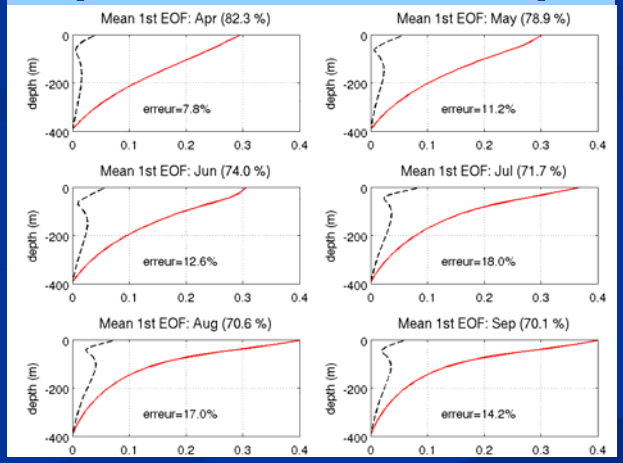
DH rebuilt at 250 m

Geostrophic current at 250m

Altimetric ADT (AVISO and HR products)



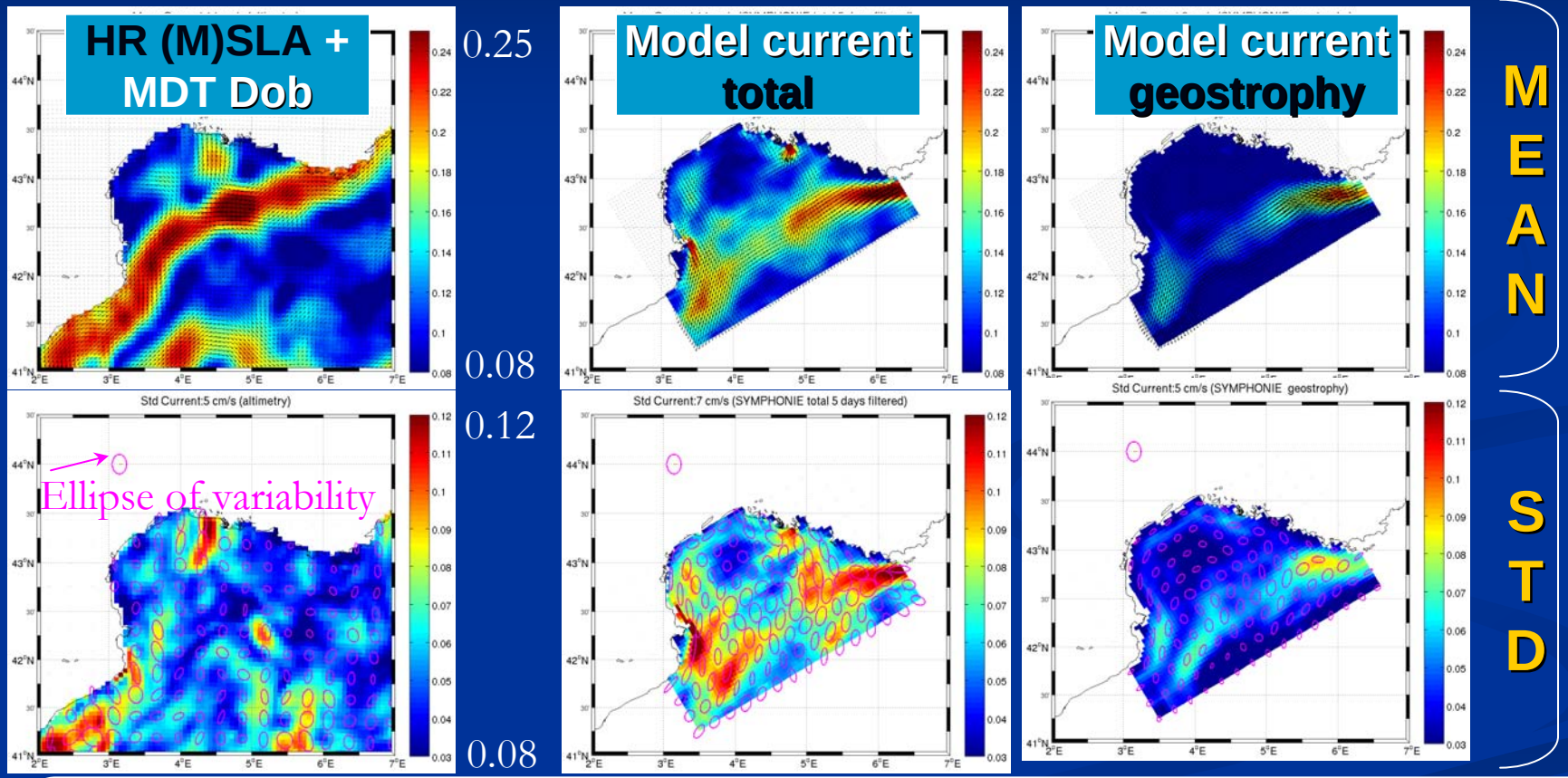
EOF Climatology (from SYMPHONIE)



Are model and altimetric currents sufficiently consitents ?

Validations / comparisons

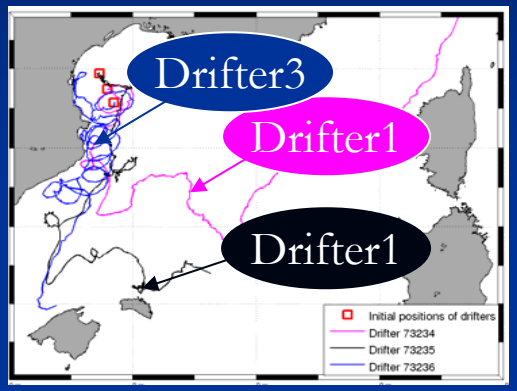
- Altimetry vs SYMPHONIE model currents (April – october 2008)
  - At the surface (m/s):

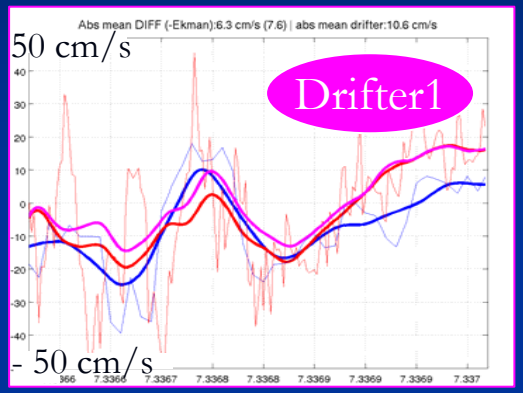


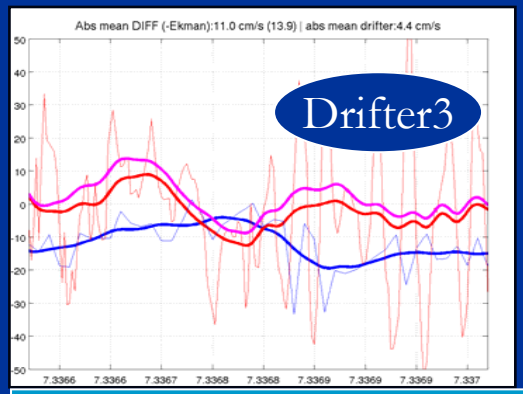
- Good agreement between model and altimetry (NC intensity/position …)
- Model: Amplitude/Variability of total current >> model geostrophic current (➔ importance of ageostrophic and wind effects)

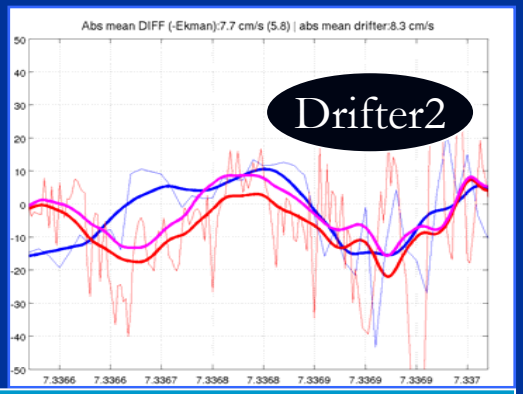
Validations / comparisons

- Altimetry vs LATEX08 drifters comparisons (U & V components)









Comparaison of meridional currents (V)
Altimetry (HR + Dob) , Drifter , Drifter-Ekman

What about the trajectories ?

Method

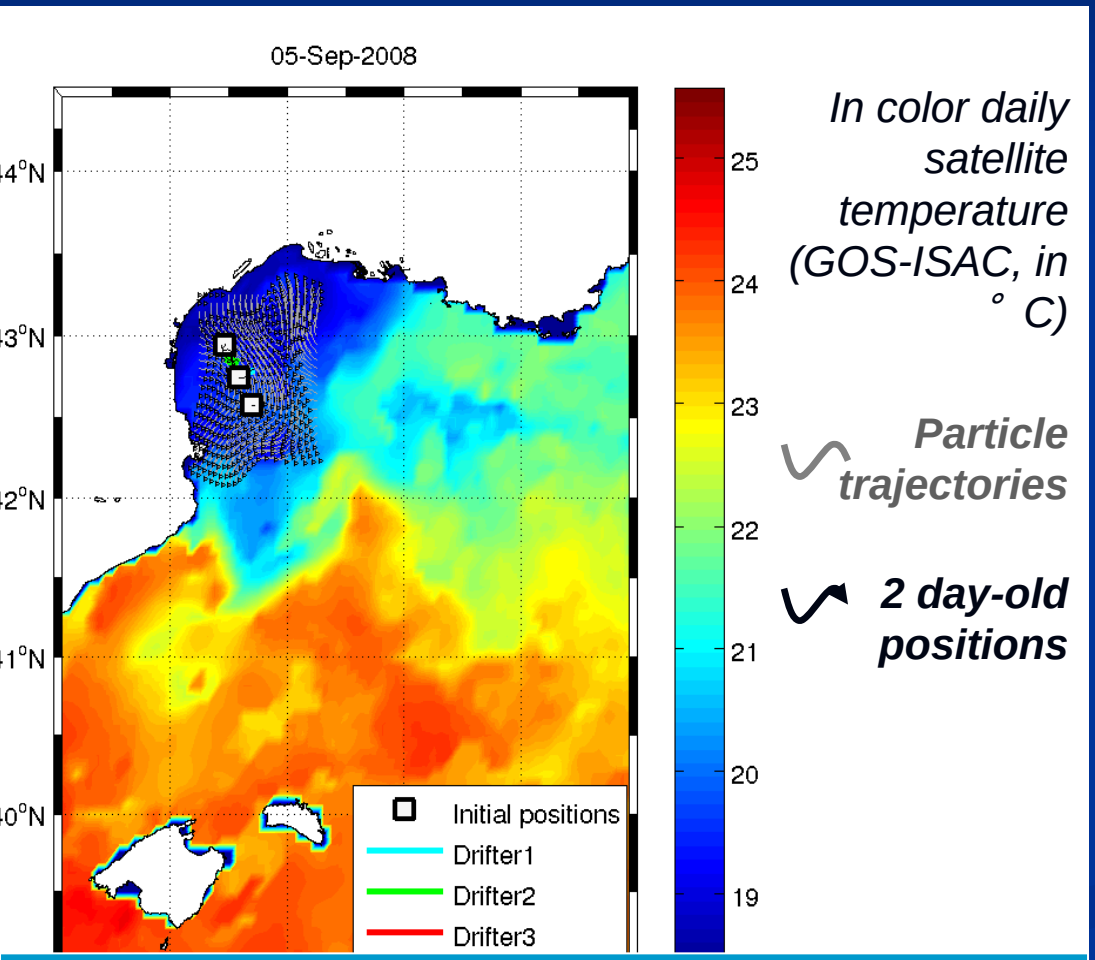
- **Altimetry:** current space/time interpolation at 3 drifter locations
- **Drifters:** current calculated by finite differences (5 days filtered)
  + Ekman current removed

Comparisons (with HR Dob)

- **Drifter 1 and 2:** Good agreement for both (U,V) (absolute mean difference < mean absolute, correlations > 0.5)
- **Drifter 3:** Strong Disagreement (lag between the coastal strucures)
- **Statistics sligtly better with AVISO than with the HR product**

Validations / comparisons

- Altimetry vs LATEX08 drifters comparisons (lagrangian)



Particles advection from altimetry (HR (M)SLA + MDT Dob) and drifters trajectories

Method

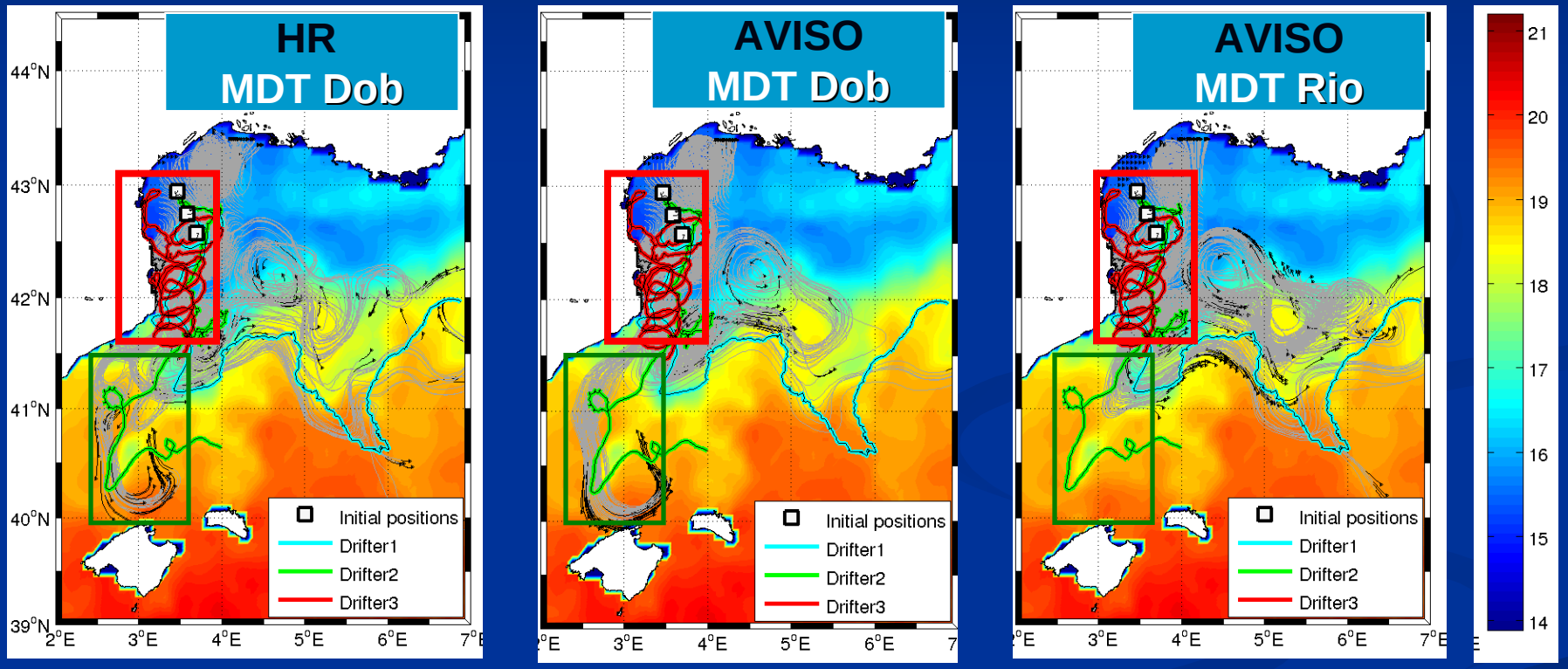
- Virtual particles launched around the LATEX drifters initial positions.
- Particles advected 47 days using RK4 scheme from *d'Ovidio et al.*, 2008 and surface altimetric currents

Results (with HR-Dobricic)

- The particles follow the main temperature fronts
- Very **good agreement** between the **drifters 1 and 2** and the advected particles
- **No particle follows** the drifter 3 which is advected by a coastal eddy (cf. *Hu et al., 2009*)

Validations / comparisons

- Altimetry vs LATEX08 drifters comparisons (lagrangian)
  - Sensitivity to altimetric product used

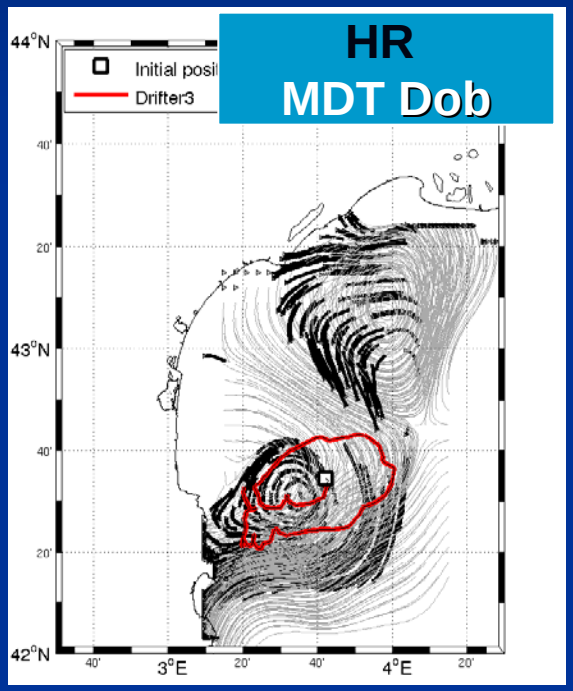


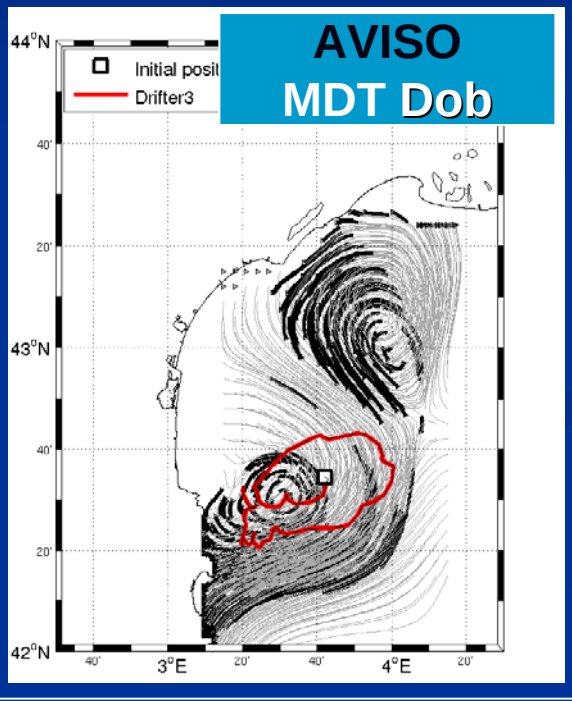
- When the same MDT is used, AVISO and HR (M)SLA show close results
- MDT Dobricic allows a better agreement with drifter 2 ➔ **strong sentivity to MDT**
- No product allows advection by the coastal eddy (observed with drifters 1 & 2)➔

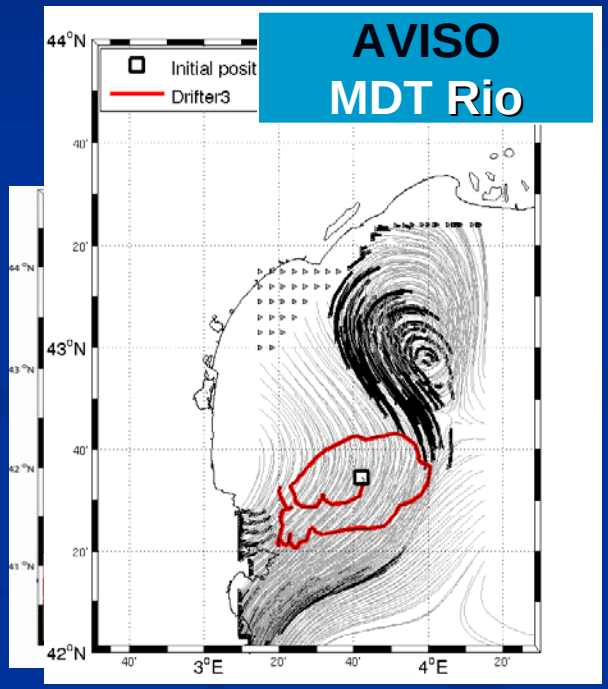
Why ?

Validations / comparisons

- Altimetry vs LATEX08 drifters comparisons (lagrangian)
  - Particles advection with a 10 day delay







• Both AVISO and HR products with MDT Dobricic capture the coastal Eddy (2 coastal tracks intercept the structure) ➔ Importance of track availabilty

• Eddy not reproduced with the MDT Rio: **no grid point in the Northwest part of the GoL (coastal mask non well adapted)**

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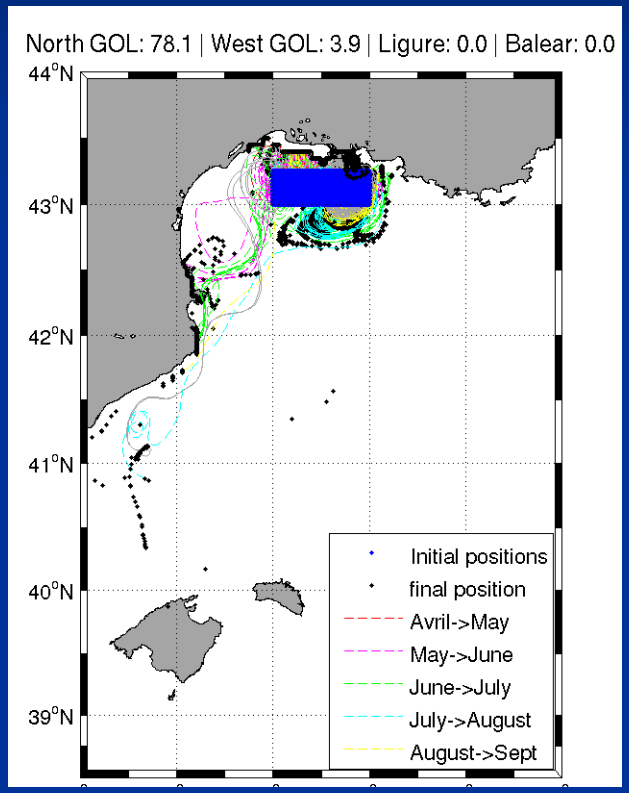
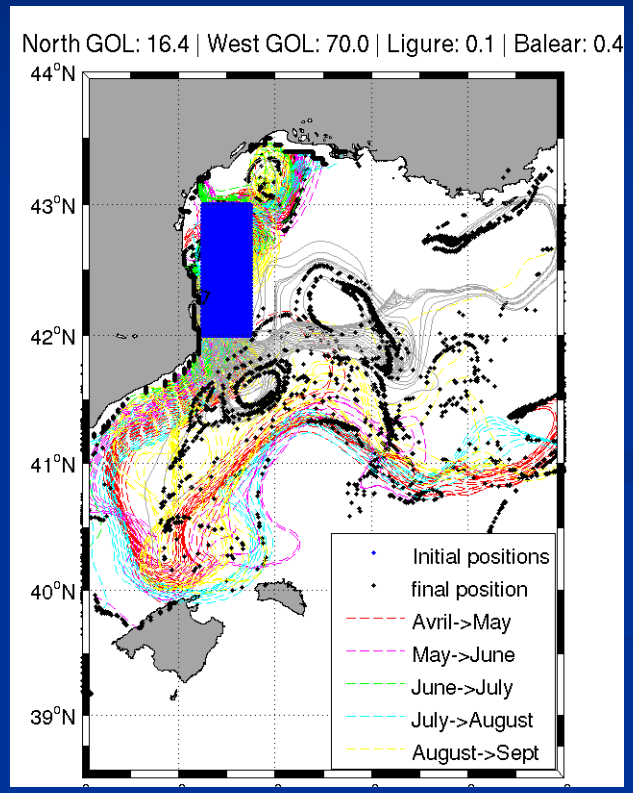
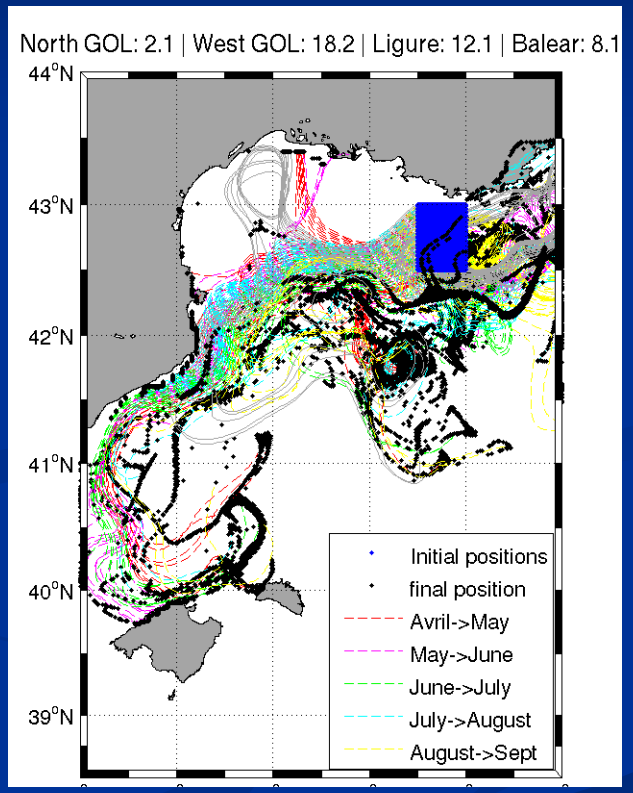
- Conclusions and perspectives

Jellyfish trajectories (preliminary results)

- Simple 40 day forward advection with altimetric surface currents
  - Virtual Jellyfish launched each month from 3 different locations



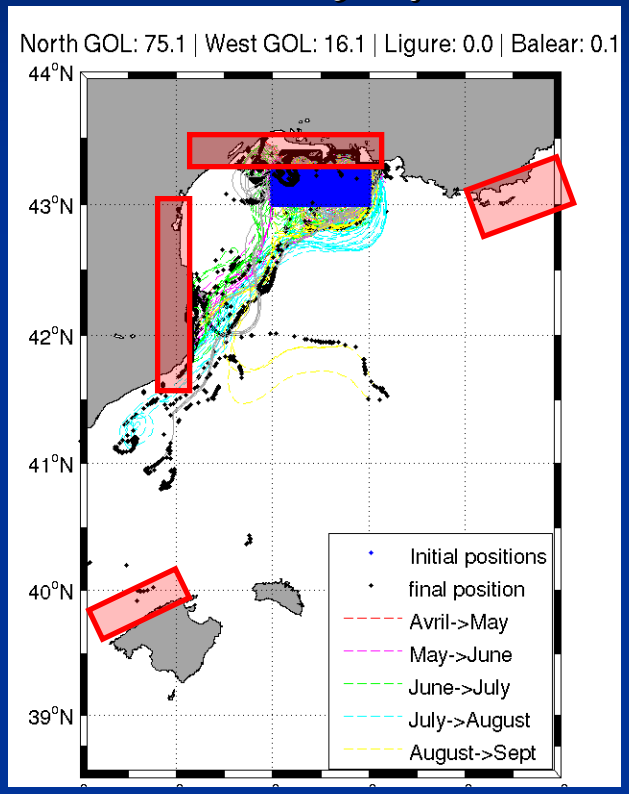


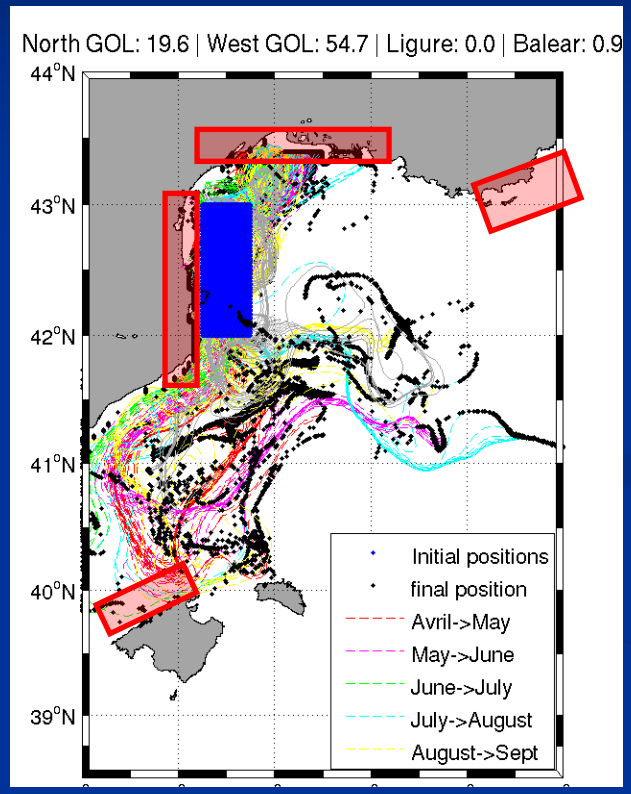


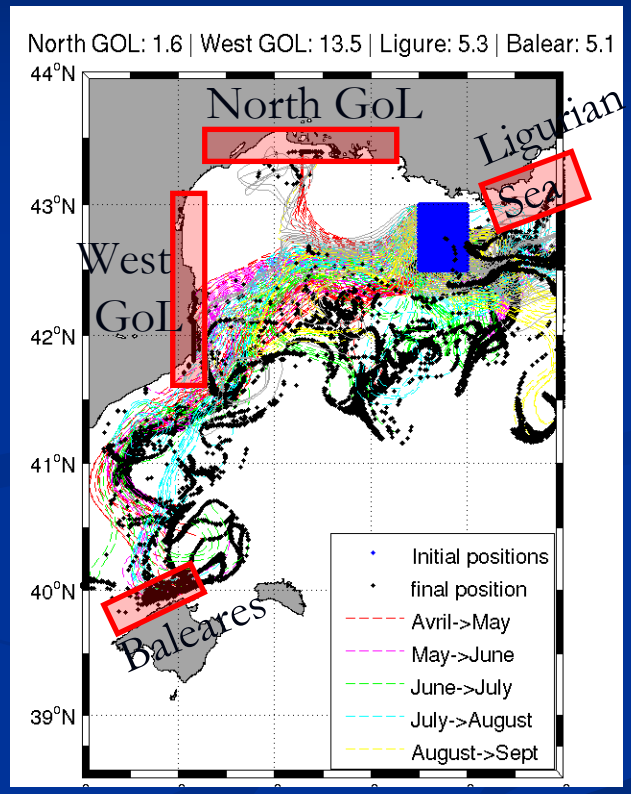
- **North GOL:** Most of the particles remain on the GOL
- **West/East GOL:** Advection southern by the NC in direction of the Balearic Sea.

Jellyfish trajectories (preliminary results)

- 40 day forward advection by taking into account the DVM
  - Virtual Jellyfish launched each month from 3 different locations





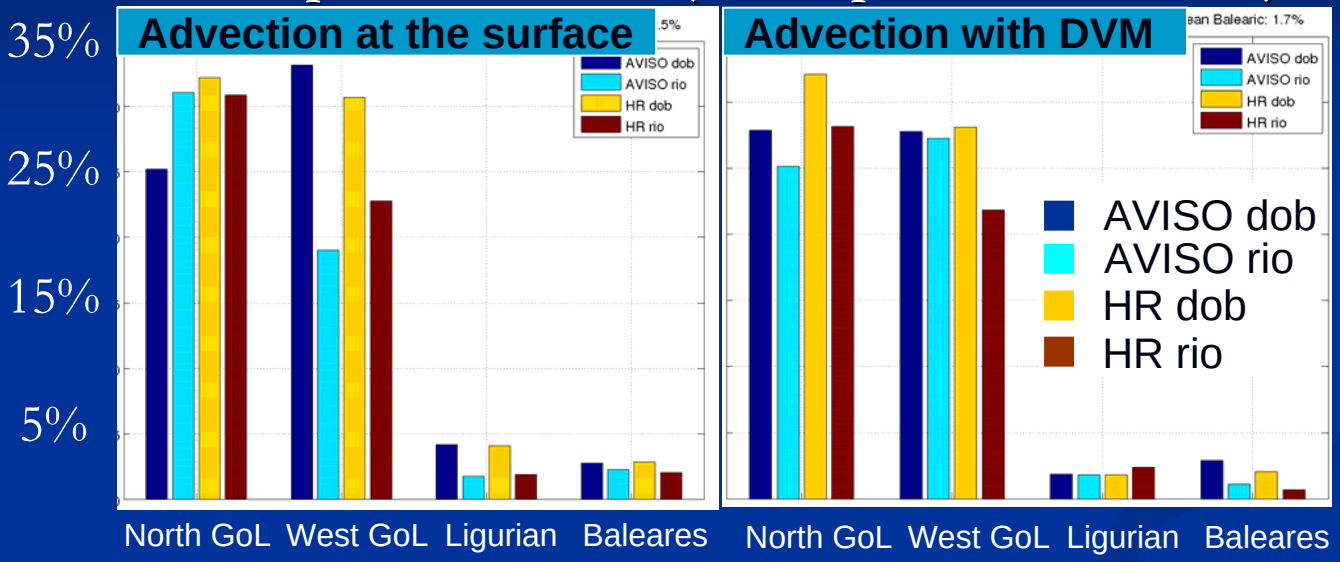


- **North GoL:** Much more particles advected to the south (3 times more)
- **West/East GoL:** Differences, but patterns also depending on the NC dynamics

Impact of DVM ? Impact of the altimetric product used ?

Jellyfish trajectories (preliminary results)

- **Statistics: differences due to DVM and altimetric products used**
  - % of particles shored (/ total particles launched) over 4 areas



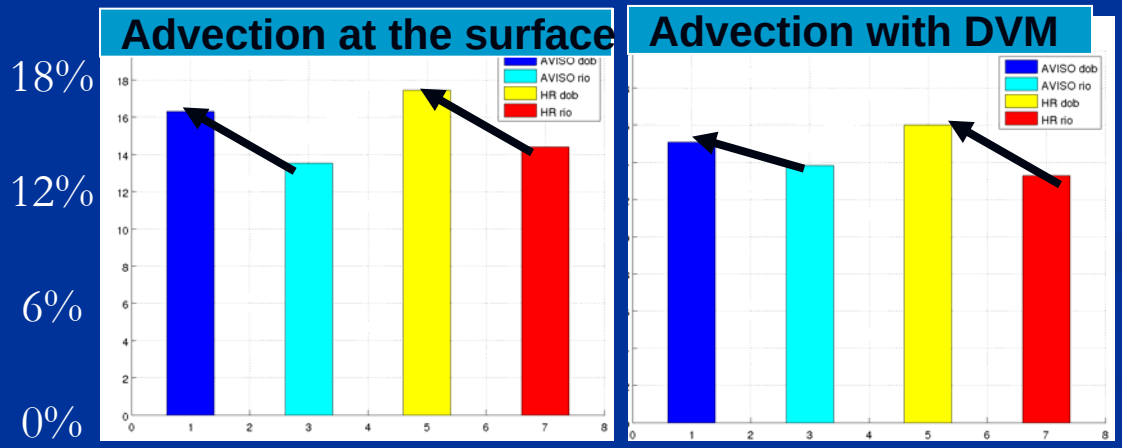
Spatial repartition

- Much more particles over the GoL (~ 50%…)
- Significant differences (e.g. West GoL > 10%)

Influence of the DVM

- Also significant (e.g. AVISO RIO)

  - % of particles shored: averaged over the 4 areas depending on the product



• Influence of the MDT

• More particles shored with MDT Dobricic than with Rio

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Conclusions and perspectives

- **Conclusions**
  - Lagrangian approach is a powerfull tool to evaluate coastal altimetry
  - Comparisons with drifters show:
    - **The importance of the MDT grid resolution**
    - **The importance of the multi-mission**
  - Our simple approach to simulate jellyfish trajectories shows:
    - The influence of the NC (results in agreement with Qiu et al., 2008)
    - The importance of the DVM

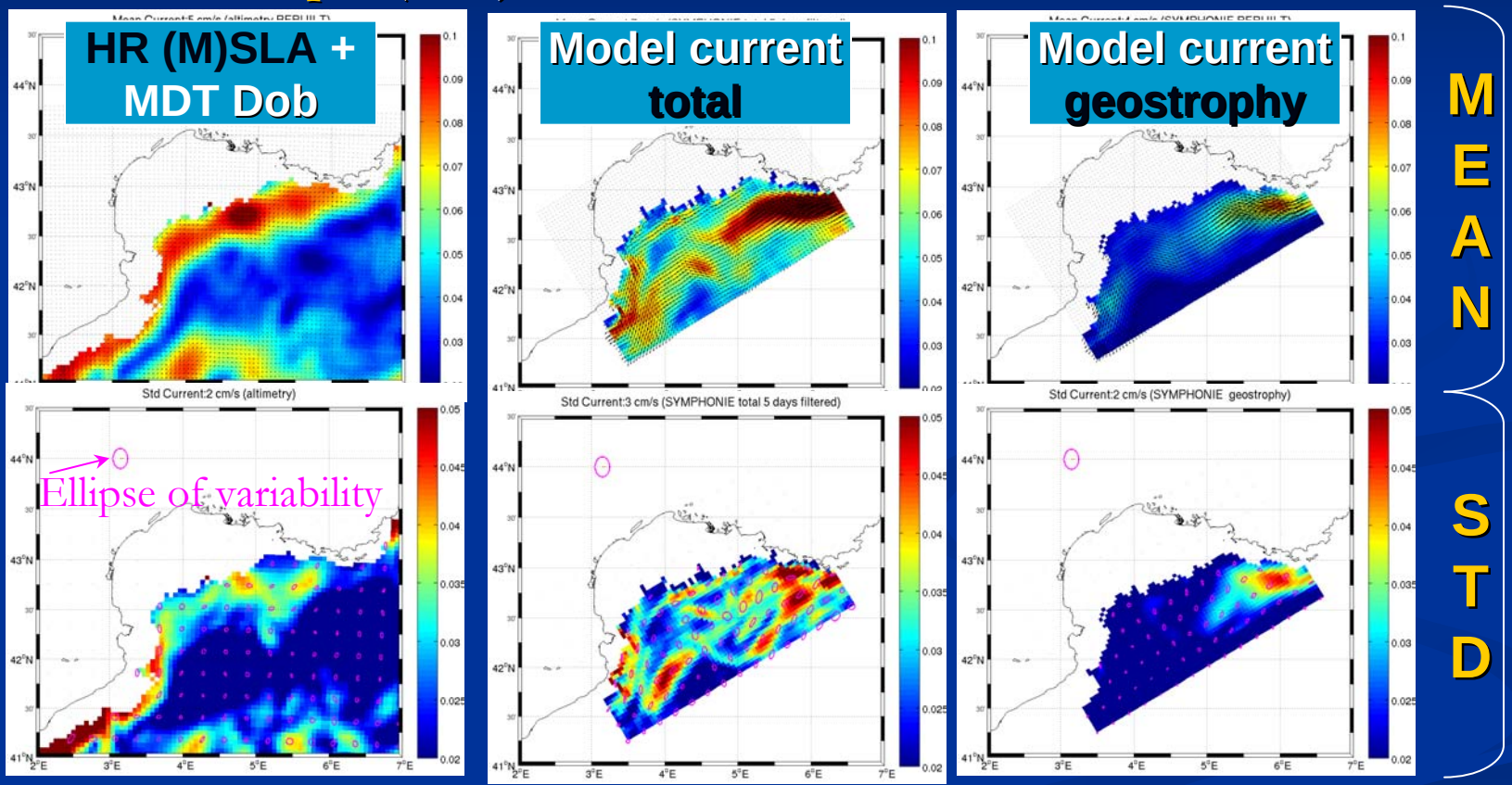
- **Perspectives (on-going work)**
  - The landfall of Jellyfish needs to be validated with independent data (obervations of life guard: number of bite per season etc…)
  - The effect of the wind has to be considered
  - Complexity in the Jellyfish behavior by coupling coastal altimetric current with an ecological model (LAGOO, Qiu et al., 2008)
  - Study the interanual variability of jellyfish distribution and better understand its potential relation with climatological indexes

Thank you for your attention

And specifically at CNES for giving me a travel grant

Validations / comparisons

- Altimetry vs SYMPHONIE model currents (April – October 2008)
  - At 150 m depth (m/s):



- Same conclusions at 150 m depth (but with 3 times less amplitude/variability)
- Other altimetric products (not shown !) show equivalent results (less variability in AVISO)