Drift forecast with Mercator-Océan velocity fields in the Western Mediterranean Sea and the Angola offshore zone

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Scientific context

- *Predicting the fate of sea pollutions and drifting objects = crucial need during disasters (ie : Rio-Paris AF447, Gulf of Mexico, etc.)*

- Météo-France : 1 Oil spill/drift model : MOTHY (Daniel, 1996)

  - Evaluates the top layer's currents from wind and pressure.
  - Long range currents and eddies ? → background velocity fields coming from operational systems (Mercator-Océan).

Q : - Can we improve operational currents (Mercator) for drift applications ?
→ Recent developments for high regional modeling

- What are the typical forecast error ranges obtained with operational currents ?

→ 2 bench-marked scenarios (Med + Angola) reproducing real drifters' trajectories

Outline

0/Scientific context

1/ Data and models

- Zones and case studies
- Oceanic simulations
- Protocol of drift simulations

2/ The Angola scenario

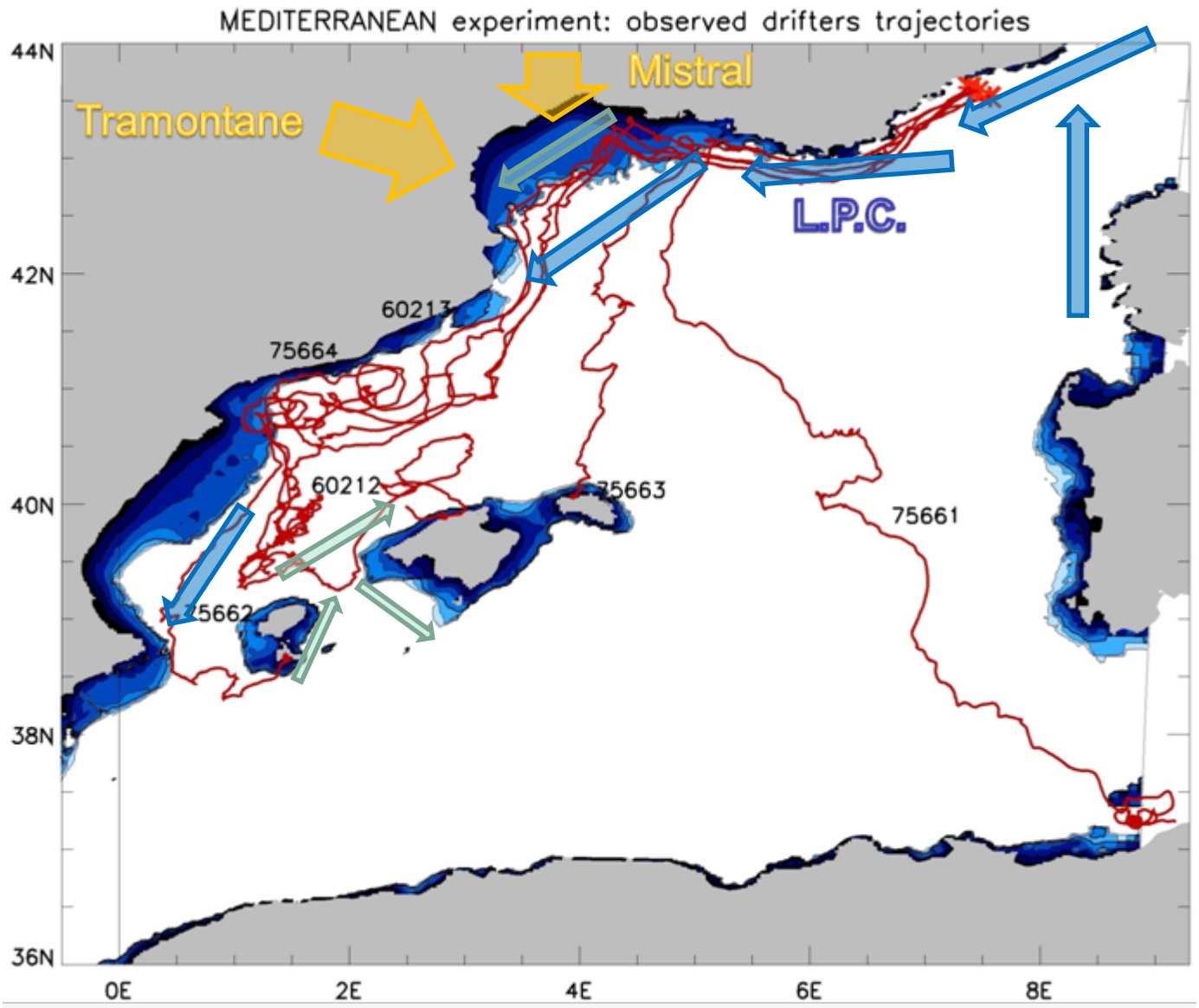
- Description of trajectories (1/12° and 1/36°)
- Statistic results
- Congo River plume effect

3/ The Mediterranean scenario

- Description of trajectories (1/12° and 1/36°)
- Statistic results
- Offline inclusion of wind related effects (Stokes drift and windage)

4/ Conclusions and perspectives

Case study in the Western Mediterranean sea



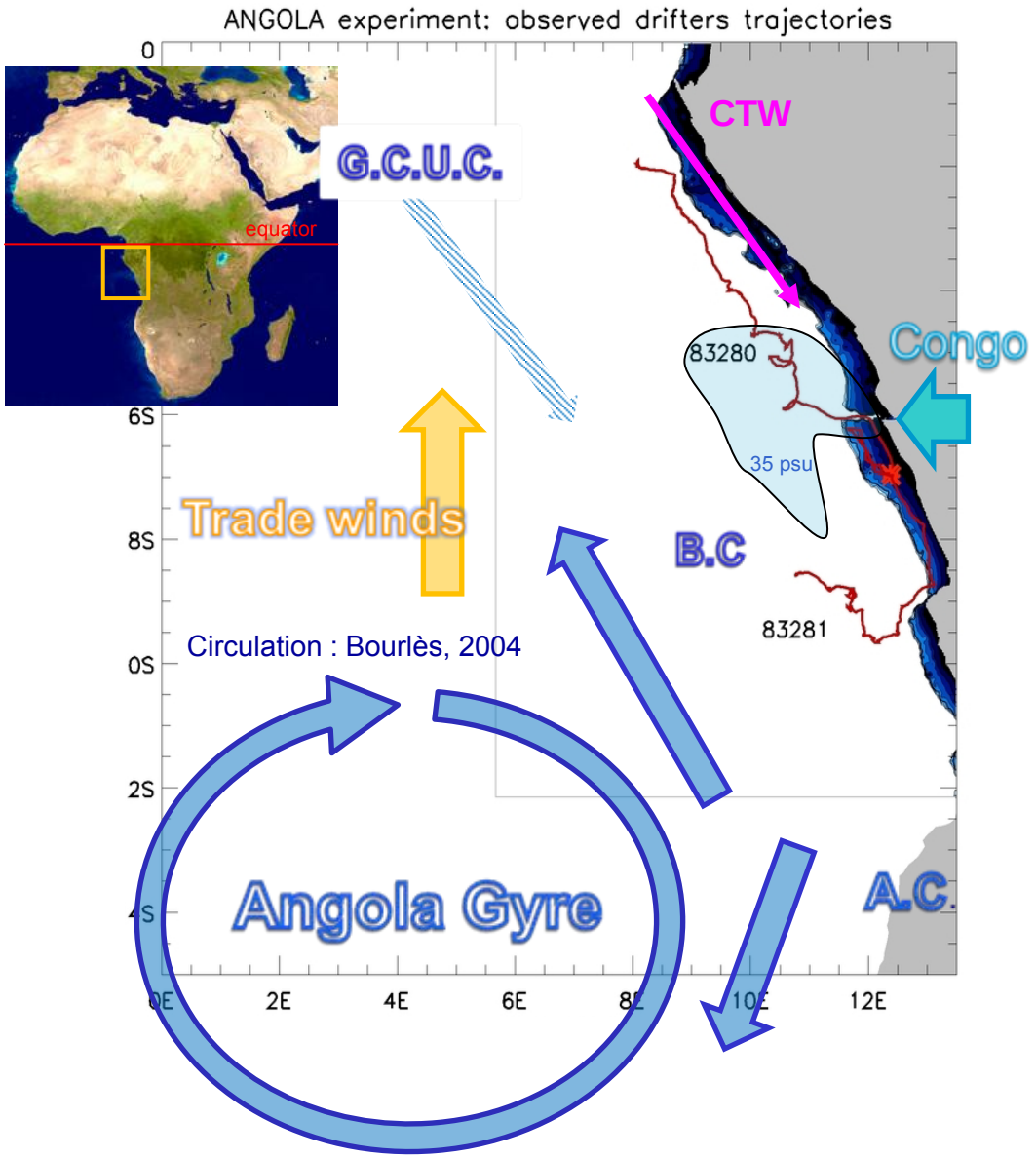
- 6 satellite tracked surface drifters (PTR model)
- Winter 2007 (Oct. 10th → Dec. 6th)
- Two months of trajectories :
  - •4/6 on the shelf
  - •2/6 offshore

• Slope current : LPC
• Strong winter winds
•Meso-scale in the Balearic sea

Case study off the coasts of Angola

- 2 surface drifters (PTR model)
- Released a day apart from (7°S,12.5E)
- March 1rst and 2nd 2008
- 1 month of data

• Congo's river plume
• Coastal trapped waves (Guiavarch' et al, 2009)
• Trade winds : weak at this season

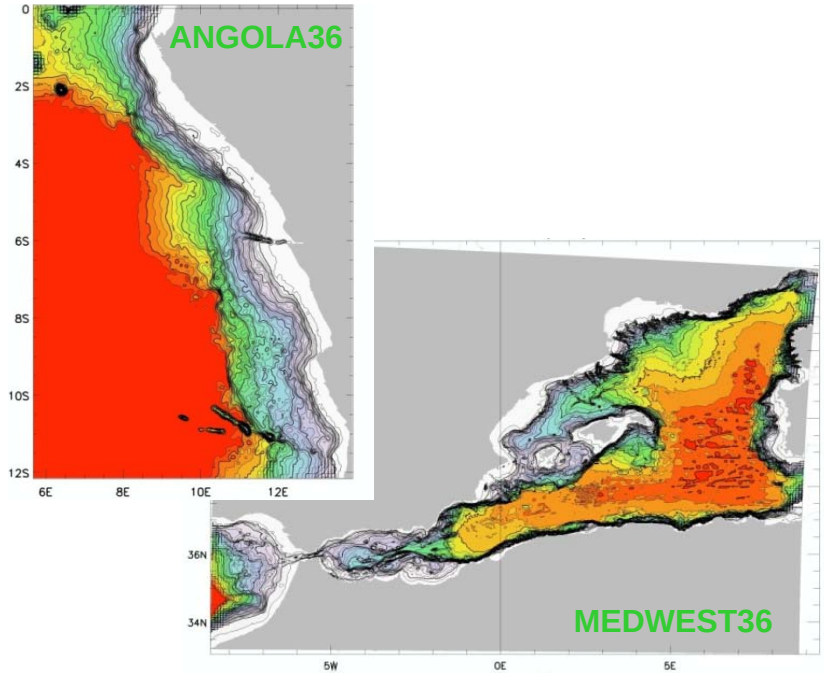


Oceanic simulations

NEMO v2.3 ocean engine

- **Ad hoc regional configurations** MEDWEST and ANGOLA (1/12° and 1/36°)

- Mercator's 1/12° Atlantic-Med **operational system PSY2**



Specifies	PSY2V3	MEDWEST and ANGOLA
Vertical grid	50 levels 1m at the surface, 450 m at the bottom	Identical to PSY2
Bathymetry	Etopo2 2007 June	Combined product based on Gebco2008-Etopo2009
Tide	No	Astronomic potential and TPXO tide model data at open boundaries
Vertical mixing modeling	TKE	K-ε
Atmospheric Forcing	Daily forcing with CLIO bulk formulation (ECMWF operational analyses)	High frequency (3h) forcing with CLIO bulk formulation (ECMWF)
Runoff	Climatological runoff as excess of precipitation (Dai et Trenberth)	Climatological runoff as open boundary condition (Dai et Trenberth)
Oceanic boundaries	Relaxation toward Levitus Climatology	Daily open boundaries from PSY2V3 system with temporal filtering
Initial condition	Levitus climatology	PSY2V3 analyzed state with 15 days of spin up
Data assimilation	Along-track SLA, in-situ T/S profiles and RTG SST maps	No

Drift forecasts: Lagrangian models

- **Two “modes” of use for the oceanic simulations :**

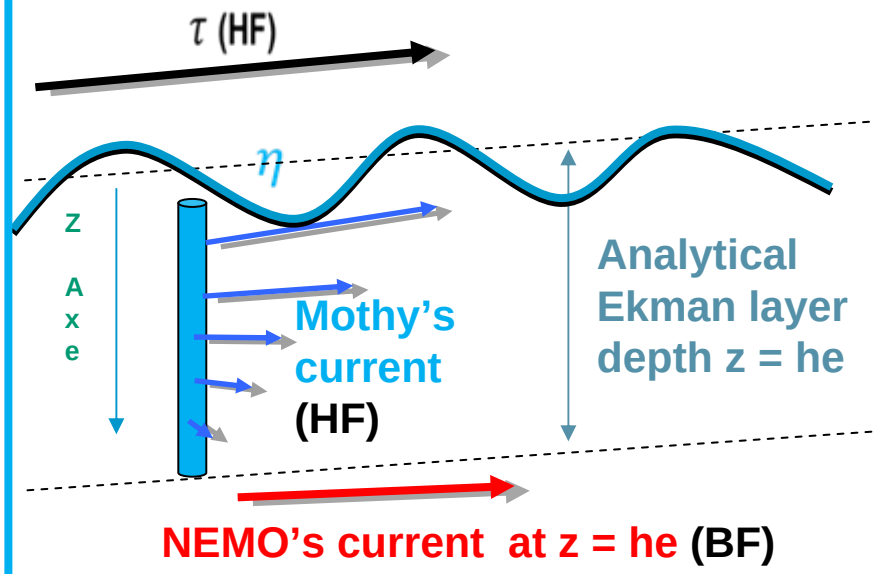
1/ surface current : Ariane

- Offline lagrangian tool (Blanke, 1997)
- 2D advection algorithm from stationary outputs.
- Forcing frequency : 3h with MEDWEST and ANGOLA, one day with PSY2V3

2/ background current : **Mothy**

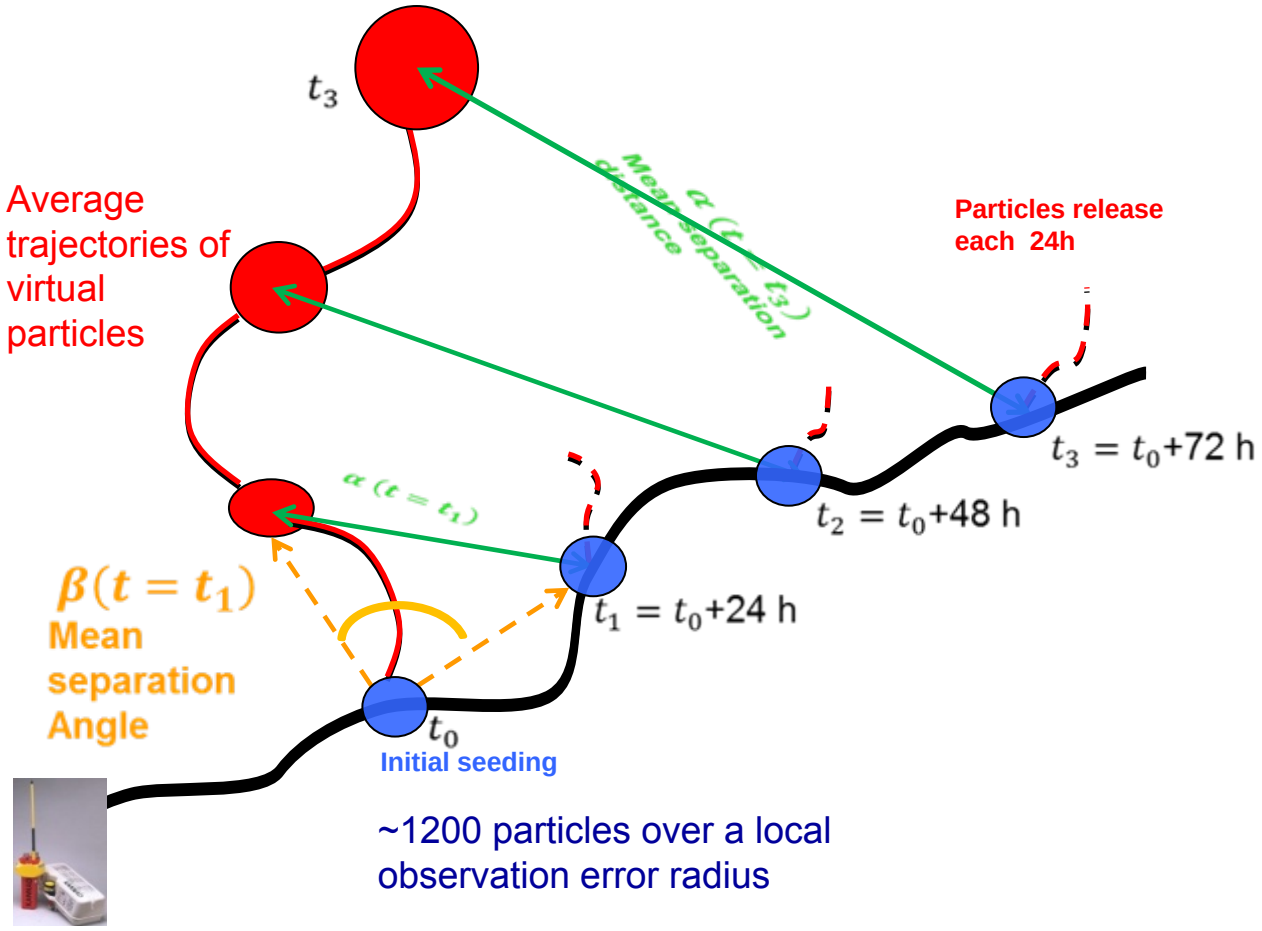
• Extraction of NEMO daily 1/12° velocities below the Ekman layer

•In background of Mothy’s improved Ekman-like model (Madsen, 1977)

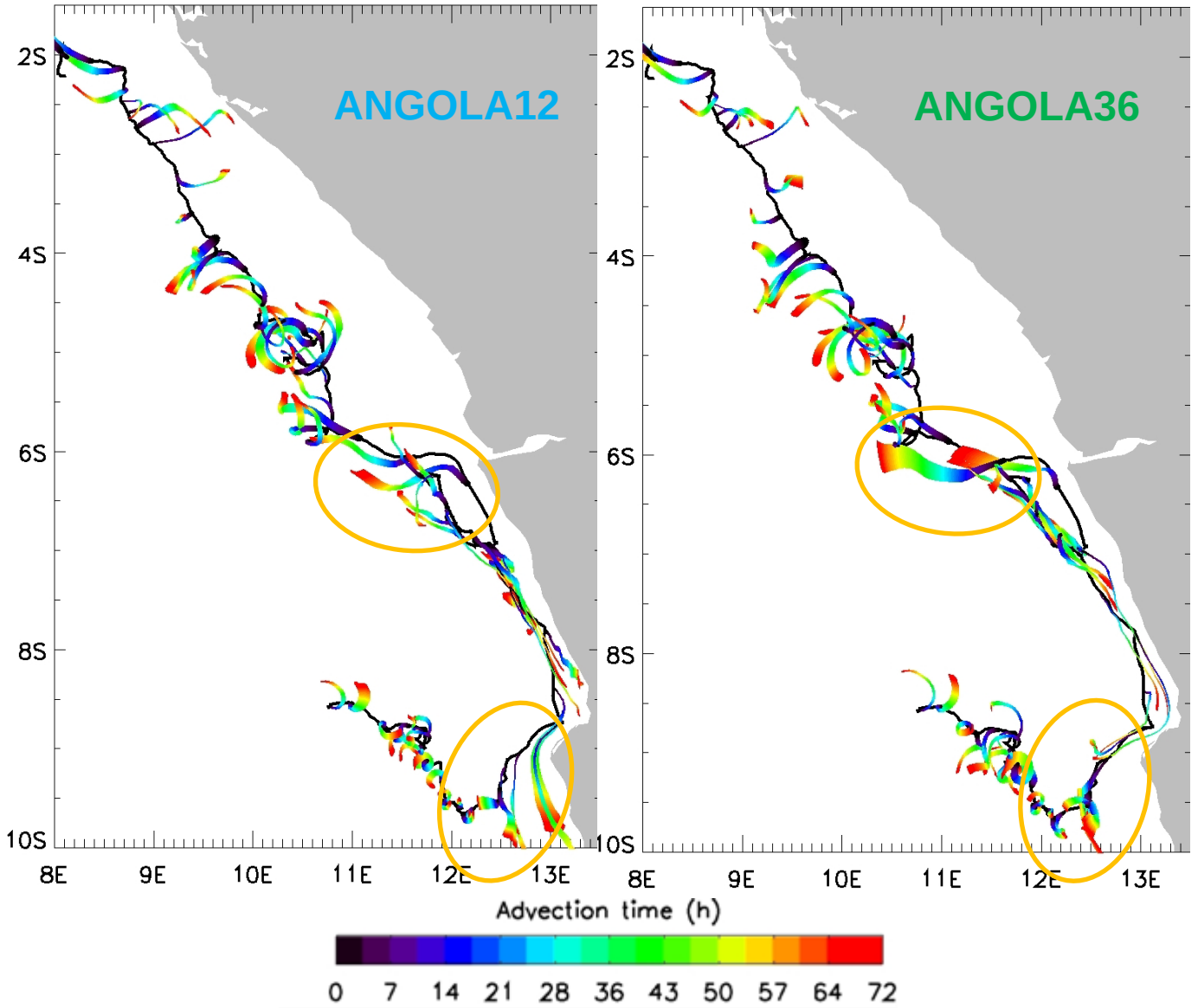


Drift forecasts : protocol of simulations and quality evaluation

- **1 drift forecast of 3 days length each day from the observed trajectory**



Trajectories for the Angola scenario

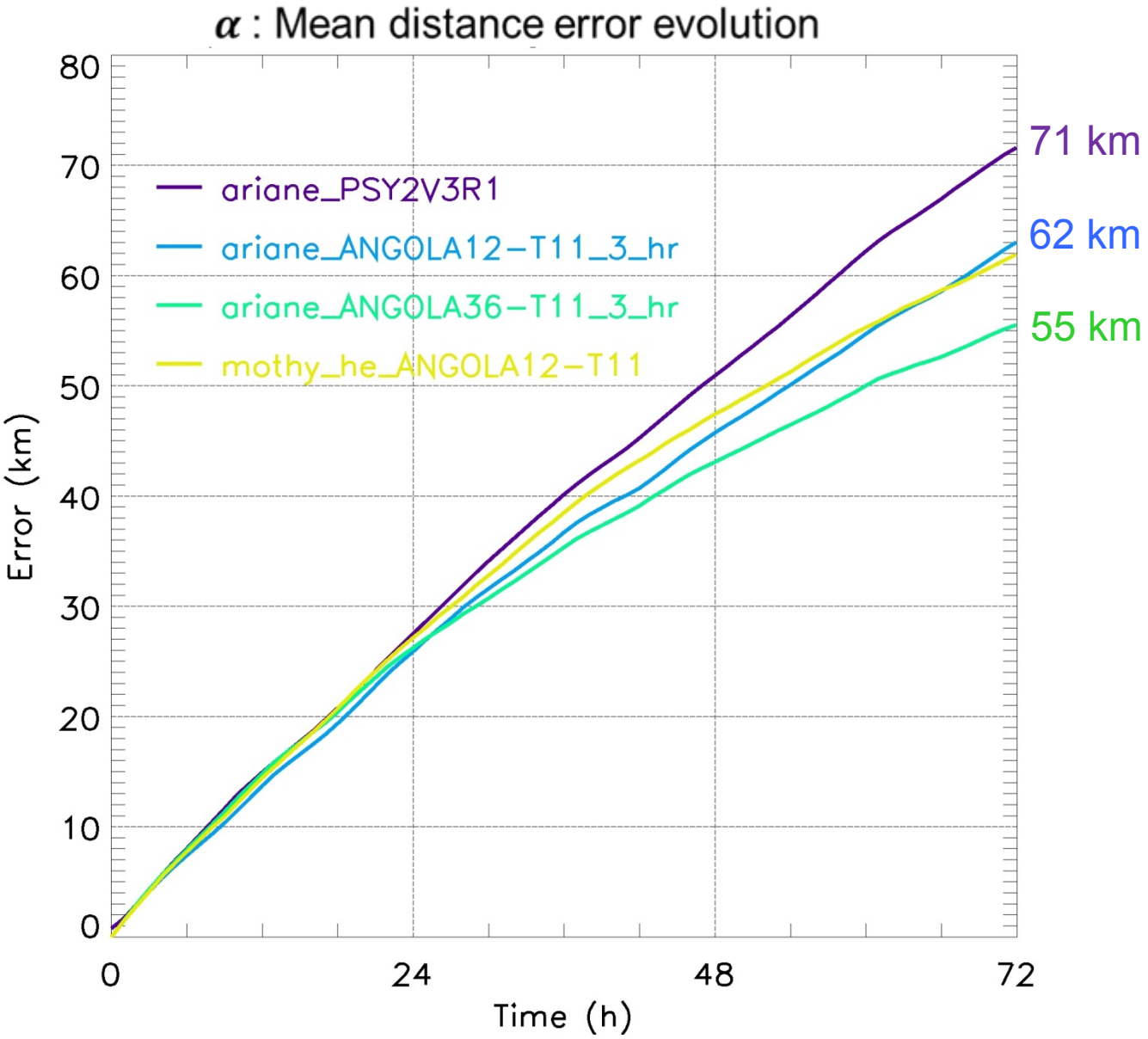


- Bad behavior of northern trajectories
- At 5°S : Inertial oscillations signature partially reproduced

<u>Differences :</u>

- Vicinity of Congo mouth
- Coastal current then offshore veering

Error ranges for the Angola scenario

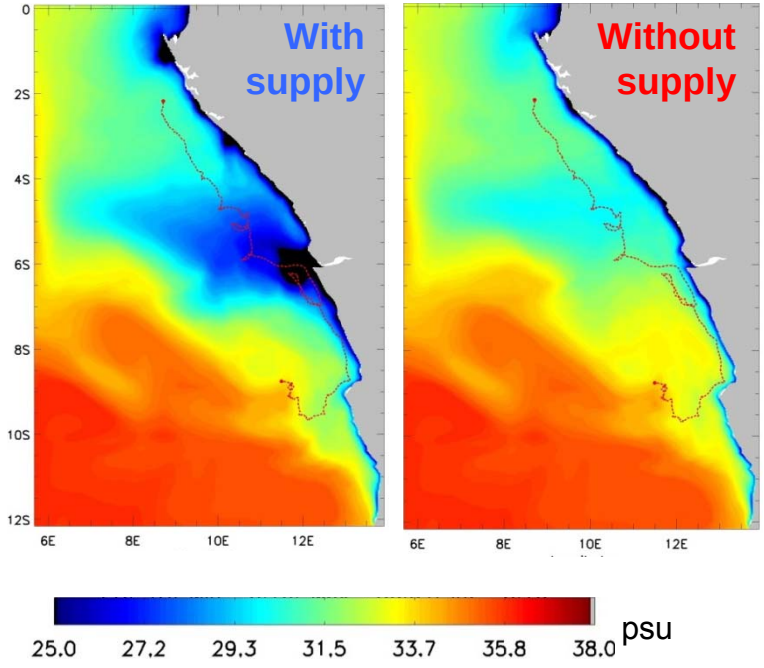


- Not so good results ☹
- Improvement with the ad-hoc configurations
- Improvement with resolution increasing for mid and long term forecast
- Mothy ~ Angola12

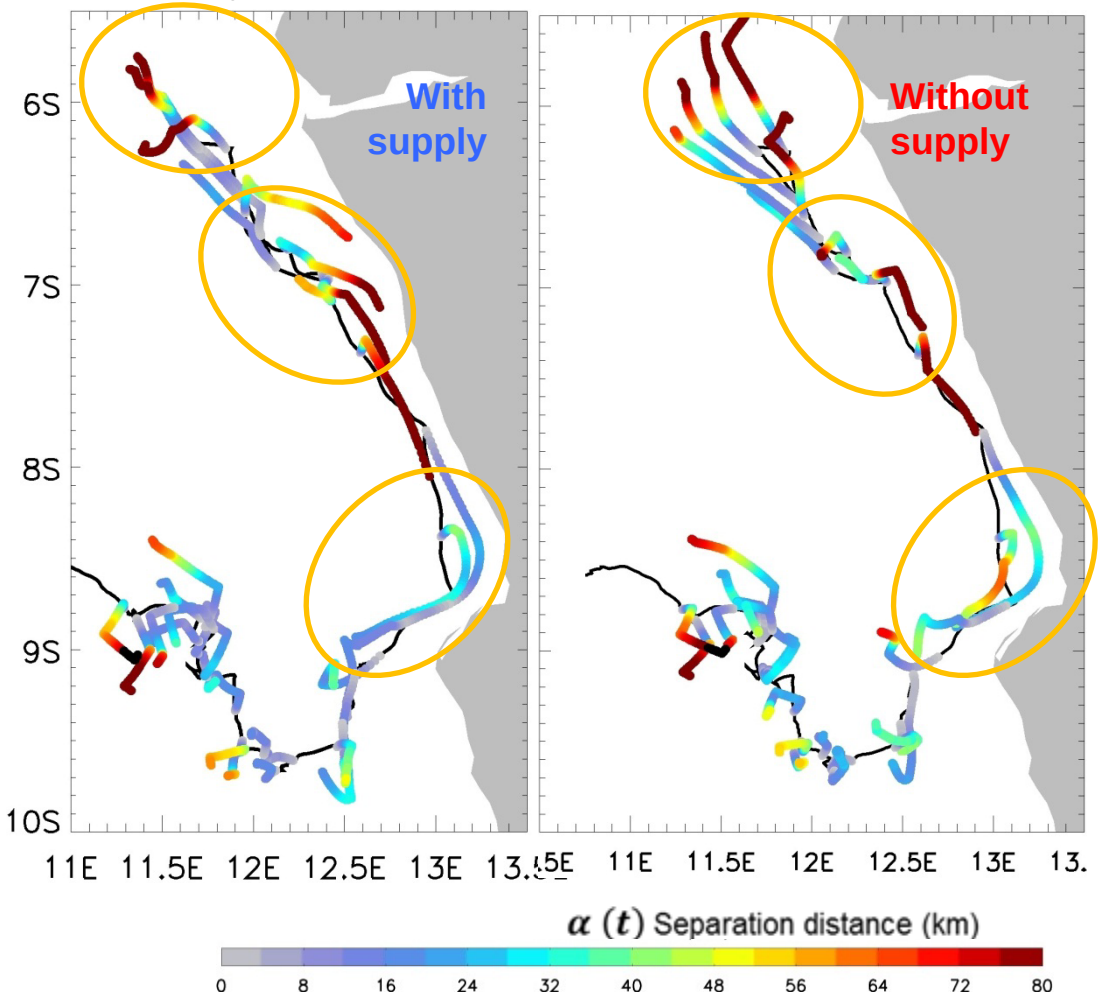
Congo River plume impact (ANGOLA36)

- Suppression of the river supply

Average SSS for march 2008

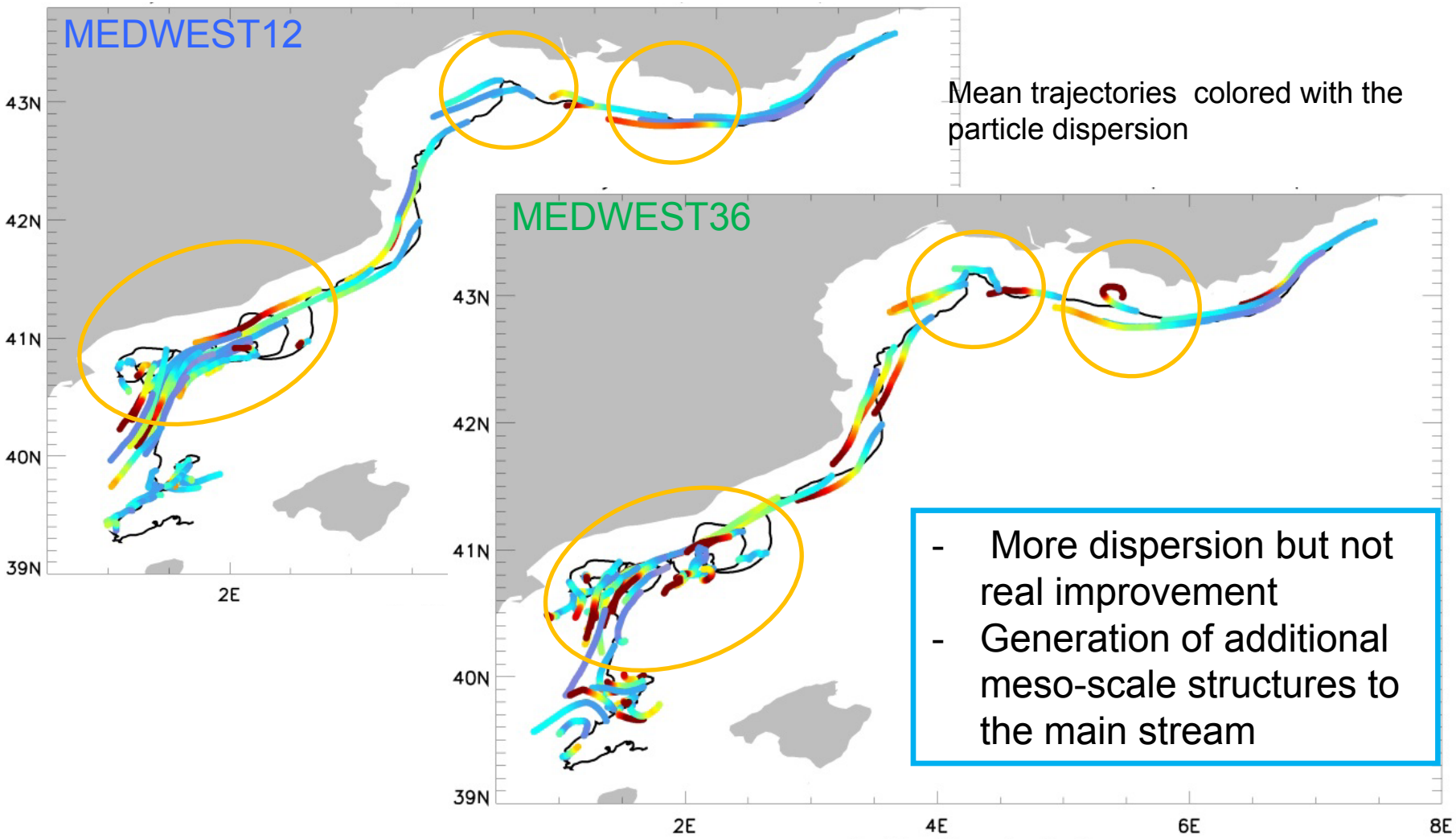


Mean trajectories colored with separation distance □ (□)



- Extension of the plume < 30 psu until 8°E
- Local and distant effect on trajectories near the coasts.

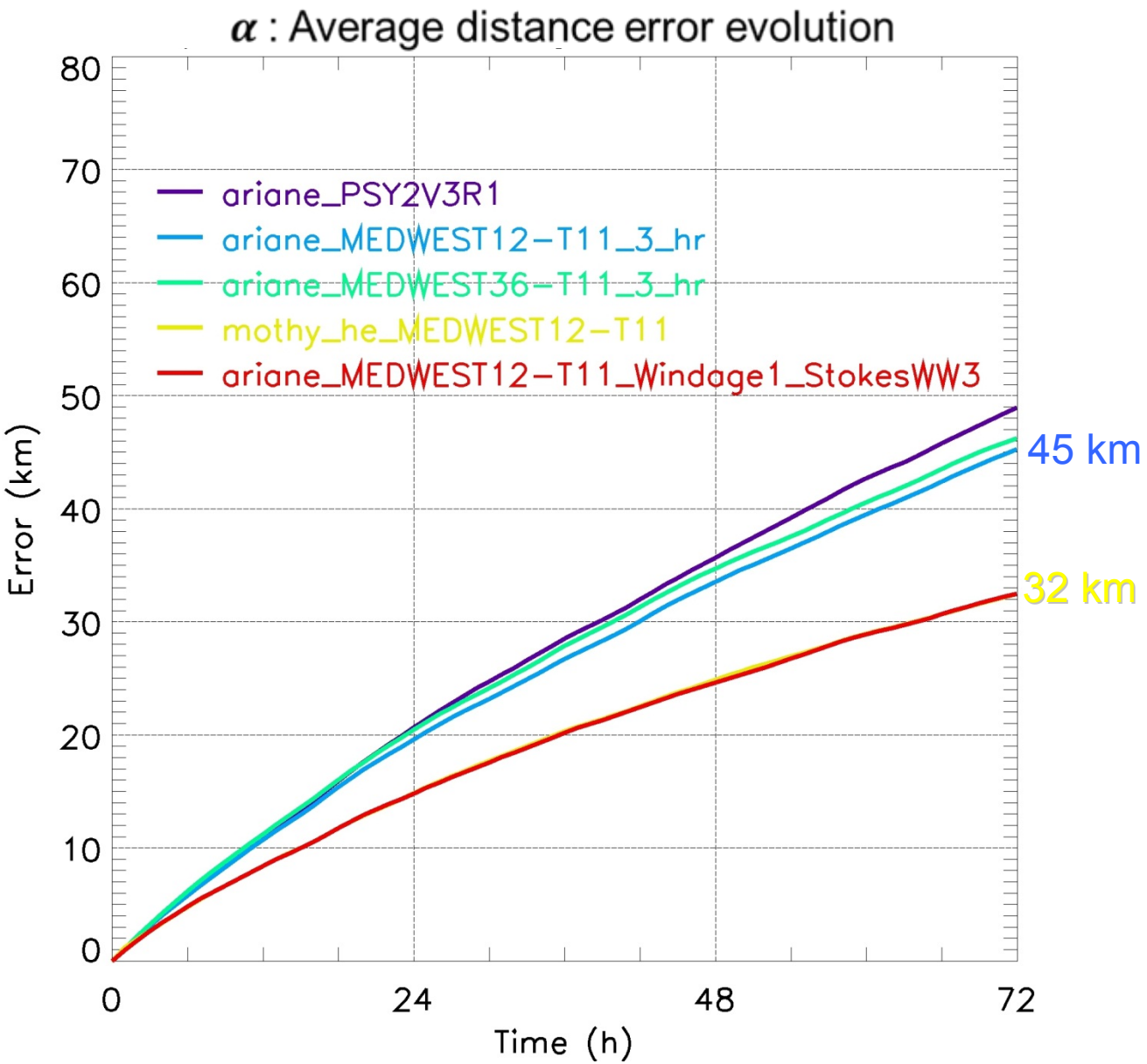
Trajectories for the Mediterranean scenario on the shelf



Mean trajectories colored with the particle dispersion

- More dispersion but not real improvement
- Generation of additional meso-scale structures to the main stream

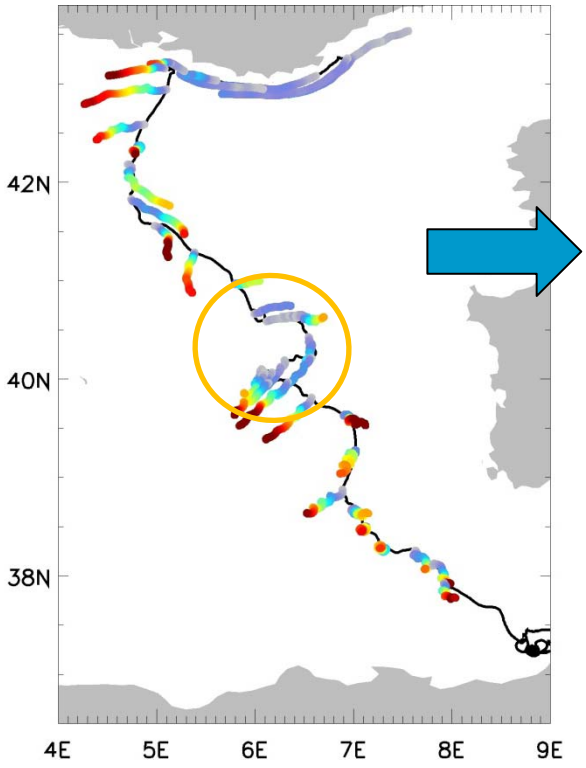
Average distance errors in Med



- Better results than Angola ≈ ☺
- Limited improvements with regional configurations and resolution refinement
- Very good behavior of Mothy → strong influence of wind

Offshore trajectories issues and correction with wind related effects

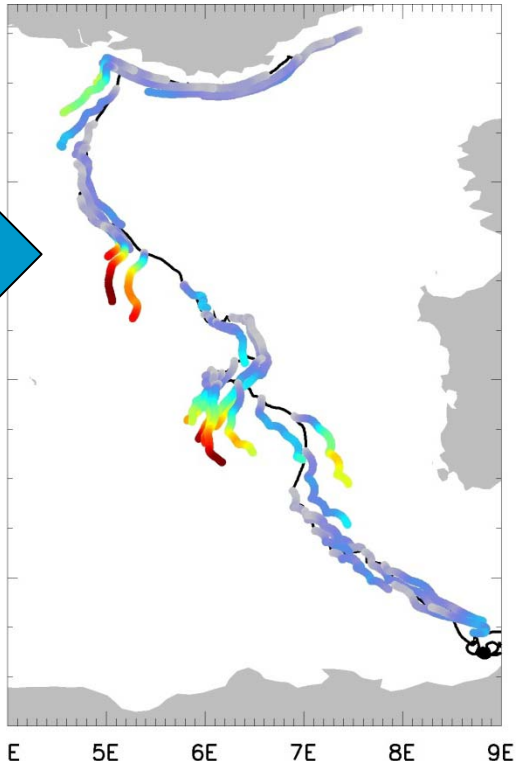
Medwest12



Other wind related effects ?

Offline inclusion of :
-Stokes velocities (WW3, 1/12°, 3h)
- a windage of 1% U10 (ECMWF, ¼°, 3h)

Medwest12 + Ustokes + 1% U10



$\alpha\ (t)$ separation distance (km)

« Offshore » statistics	MEDWEST12	MEDWEST12 + UStokes + 1% U10
$\alpha(t = 72h)$	62.8 km	35.8 km
$\bar{\beta} \pm \sigma_\beta$	50°± 4,7	10°± 4.6

Conclusions

- Operational oceanic systems are useful tools to provide currents for quasi Lagrangian application such as drift forecasts

- Developing regional configurations with specific and better physics was shown to improve the results.

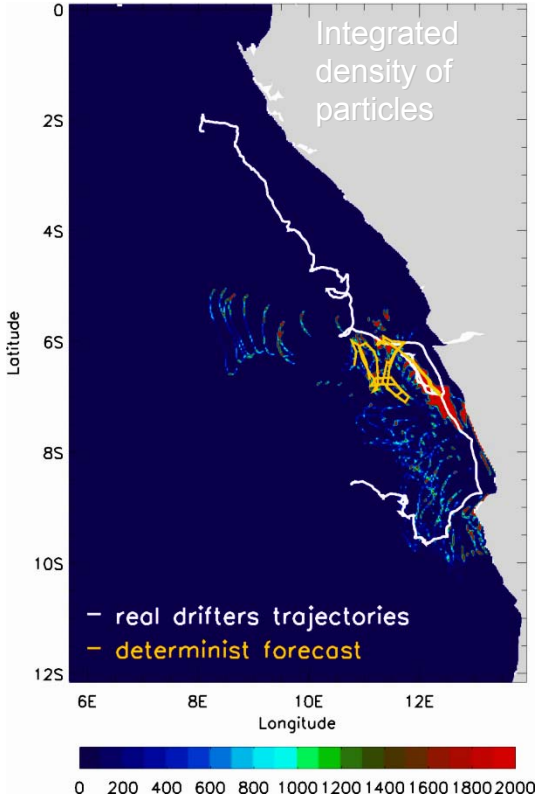
- Increasing of the horizontal resolution : positive impact in Angola, but slightly degrades the trajectories in Med. → Improvements in small-scale constraint are needed.

- Angola: - Importance of Congo river plume dynamic

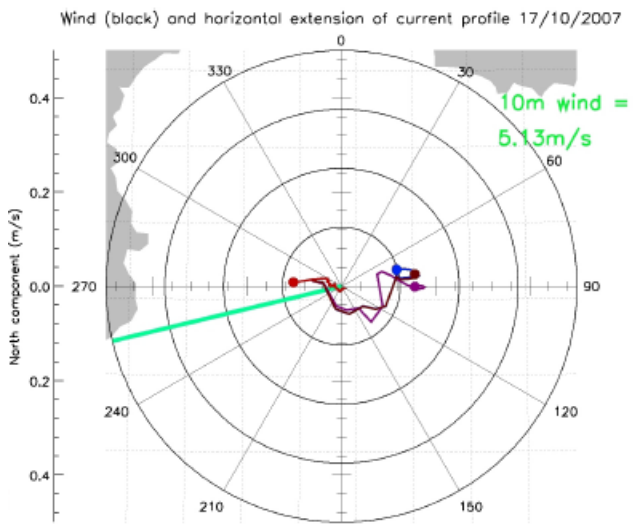
- Med: - slope current transport relatively well reproduced
  - offshore : interplay of different transport terms : general circulation, wave transport, wind.

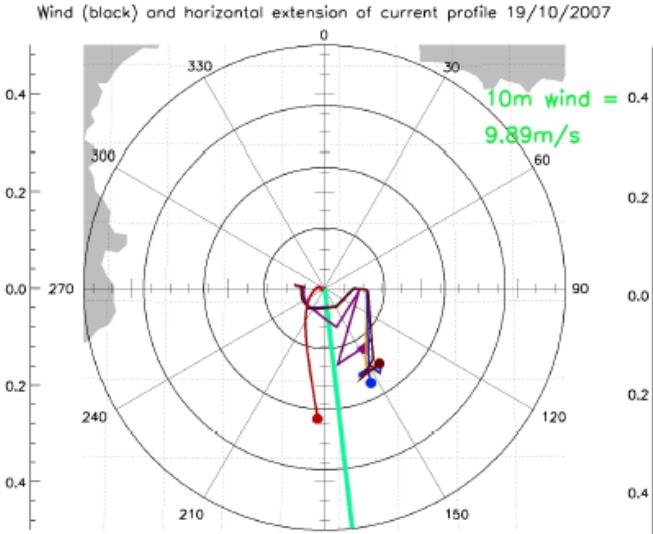
Perspectives

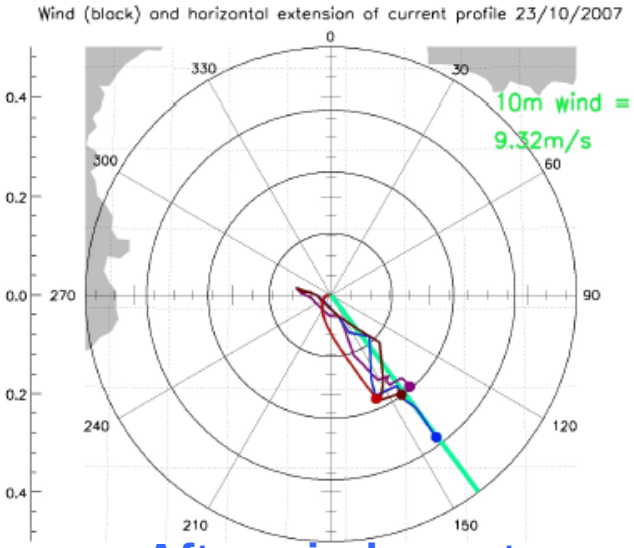
- Wave-current interaction
- Ensembles approaches
- Assimilation to improve the short space scales (e.g. HF radars data, SWOT wide-swath altimeter project, launch ca. 2020)



Vertical mixing and surface layers' response to wind







Before wind event

17/10/2007

During wind event

19/10/2007

After wind event

23/10/2007