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Improving operational oceanography for drift applications

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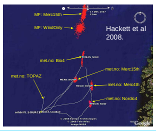
Frame and motivation

Nowadays, many authorities in charge of rescue operations lean on operational oceanography products to outline research areas. More or less complex drifting model can use operational system outputs as input forcing data (Figure 1), and this implies the necessity of an accurate sea state forecast, with a mastered level of confidence of use.
As background context of these works, Meteo France, (operator in case of crisis for the French territory), uses Mercator outputs as an additional forcing term for its 2D wind response surface drift model MOTHY. That addition permits to take into account oceanic 3D behaviour features and the oceanic general circulation, prior not present in the system.



Primary works showed that the meso-scale activity plays a key role in the succeed of a drift forecast. We try here to investigate the potential of improvement of operational oceanography for drift applications inside Mercator System for these applications.

Figure 1: Oil spill drift simulations stemming from the offshore platform Statfjord A (Norvegian Sea). Two operationnal drift models are evaluated (Météo-France and Met-no), using different oceanic forcings (Mercator-Ocean, TOPAZ, Bio4 and Nordic 4)

Method and data

We try to reproduce the underlying physic of two study cases, where some surface drifters were released in the Mediterranean sea, close to the Azur Coast (winter 2007, six buoys) and along the Angola shore, near the Congo river plume (winter 2008, two drifters) (Figure2). The drifters were calibrated to reproduced the physic of a drifting oil slick.

Modified regional configurations nested into Mercator 1/12° operational system PSY2V3 (benefit of data assimilated structures injection at boundaries) allow to conduct sensitivity studies over physical and numerical modelling options. Three imbricated configurations (Table 3) were developed to generate daily current fields, then used for the advection. This later is made with an offline lagrangian tool (Ariane, LPO Brest).

Initial grouping of particles are initialise as circular slicks of 5 km of radius and composed of 3600 independent particles. To outdraw some average behaviours, a large amount of simulations is launch following the drifters trajectories. The typical forecast time scale that we are interested in is of the order of a day, and therefore 3 days forecasts are carried out every 48 hrs. (Fig 4). That frequency is priori sufficient to study different drift regimes or geographical conditions.

Score are set up statistically or regionally between the center of the particles cloud and the corresponding observed drifter, each hour, in term of distance, direction or speed error (Fig 5)

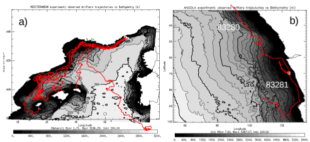


Figure 2: Surface drifters trajectories (red) vs model bathymetry (colored field). White squares label initial positions.

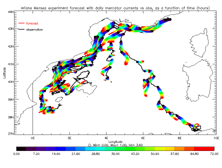
a) Mediterrean sea: six buoys travelling from Azur coast (10 Oct. 2007) to the Baleares area, two month of duration.

b) Angola area: two surface drifters released at two days of interval: 83280 (01 March 2008); 83281 (02 March 2008), approximatly twenty days of duration.

	PSY3V3 (Operational)	*Medwest 12 (Nested)*	*Angola 12 (Nested)*	*Angola 36 (Nested)*
Spatial resolution	1/12°	1/12°	1/12°	**1/36°**
Atmospheric forcing (CEP)	Daily	**3 hrs**	**3 hrs**	**3 hrs**
Vertical mixing scheme	TKE	TKE2	**K ε**	**K ε**
Advective scheme	Centered	**Quickest**	**Quickest**	**Quickest**
Additional physical processes			**Tide Runoff BDY Diurnal cycle Pressure Variable volume**	

Table 3: Configurations and associated modeling options used for theses experiments. The ocean modelling code is based on OPA/Nemo with 50 vertical z levels (1m at surface, 400 m at bottom)

Figure 4: Particle patch advection obtained with Medwest12. The color bar refers to the particles age (hours)



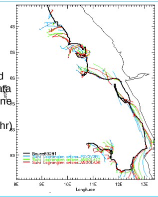
Perspectives:

- Precise sensitive studies over the parametrisation of physical processes impacting the surface layer dynamic (vertical mixing, stockes drift, etc..)

- Achievement of ensemblist forecasts with perturbed physical model field (wind or currents, to assess the impact of uncertainties over the model.

Figure 5:

Drift results obtained by PSY2V3, Angola12 and Angola36. Data are in black line whereas forecasts (48hr) are in color.



Seeding experiments (Med.)

We conduct a full time advection (2 months) without any repositioning, in order to see if the different advective paths are modelised in Medwest12. Producing a determinist run – 1 particle per drifter - (figure 6.a) doesn't permit to represent the southward advection, whereas a massive seeding of particles, with a larger spatial covering, exhibits a closer behavior. It's a way to assess the most probalistic results, taking into account model errors or uncertainities on datas

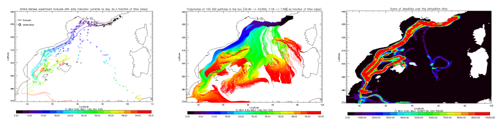


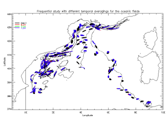
Figure 6.a: Two months forecasts vs obs., six particles, the color refers to days of advection.

Figure 6.b: Two months forecasts with an initial box of 100 000 particles covering all the drifters initial positions.

Figure 6.c: Summation of the density of particles per mesh all over the advective duration for 6.b

Frequential studies (Med.)

It is of great interest to know what frequencies are critical for the oceanic drift (daily outputs are generally used for operational). Here we degrade the oceanic signal, averaging high frequencies outputs of Medwest12 over 1 hr, 3hr, 6hr and finally a day. Unfortunately, using high frequencies have negative consequences on particles advection fate for this particular case. This shows that models have difficulties to represent the high frequency variability on a real case study.



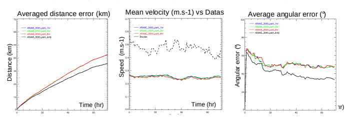
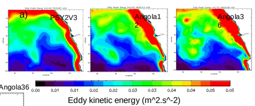


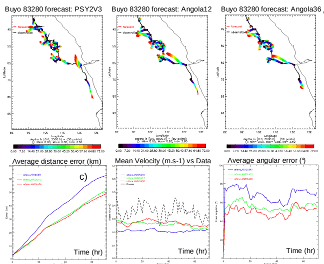
Figure 7.a: Particules final position using different temporal meanings

Figure 7.b: Average scores over the 110 simulations with different forcing frequencies

Impact of resolution (Angola)

Increasing the resolution between Angola12 and Angola36 implies more energetic currents and more meso-scales features. This leads to improve the average results, althought some degradations at some specific locations exist.





Figures 8

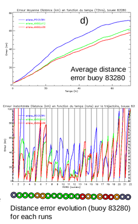
Up a) Eddy kinetic energy calculated for April 2008

Left b) Particles trajectories for buoy 83280

Left c) Average scores

Right d) : Average distance error for buoy 83280

down: Distance error evolution for buyo 83280



River discharge input (Angola)

Angola12 and Angoal36 have a flux condition (BDY runoff) for the Gongo river discharge, which is represented like rain in PSY2V3. Great benefits are obtained for drifting material tracked inside a river system with that new modeling. An increase in resolution also permits to better describes the complexity of the plume variability.

Figure 9: Right: River plume variability (surface salinity section at 12°E)

Fig 9: Bottom: modelised particles trajectories close to the river discharge (PSY2V3, Angola12, Angola36). Each plot represent a day, with the associated average field of each configurations in colored vectors. Previous trajectories are in dotted lines, whereas solid lines represent the trajectory for the given day. The observed drifter is in black.