Use of surface drifters to increase resolution and accuracy of oceanic geostrophic circulation mapped from satellite only (altimetry and gravimetry)

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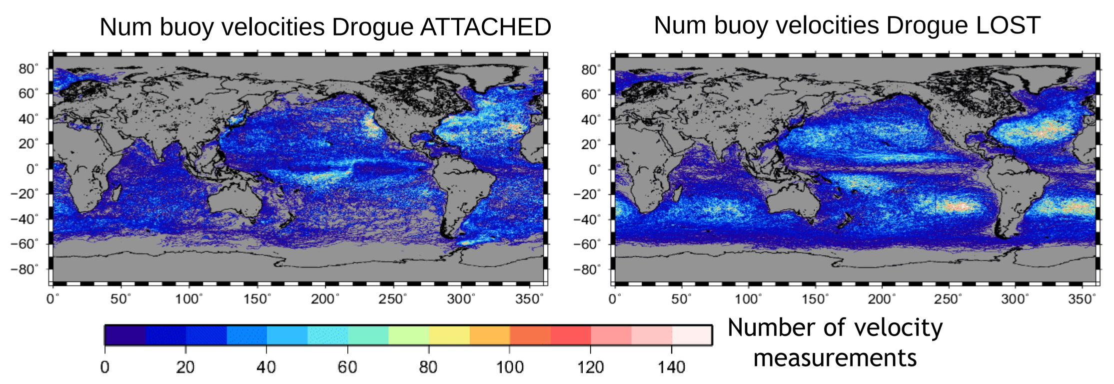
Strong improvements have been made in our knowledge of the surface ocean geostrophic circulation thanks to satellite observations. For instance, the use of the latest GOCE (Gravity field and steady-state Ocean Circulation Explorer) geoid model with altimetry data gives good estimate of the mean oceanic circulation at spatial scales down to 125 km. However, surface drifters are essential to resolve smaller scales, it is thus mandatory to carefully process drifter data and then to combine these different data sources.
In this framework, the global ¼° CNES-CLS13 Mean Dynamic Topography (MDT) and associated mean geostrophic currents have been computed (Rio et al, 2014). First a satellite only MDT was computed from altimetric and gravimetric data. Then, an important work was to pre-process drifter data to extract only the geostrophic component in order to be consistent with physical content of satellite only MDT. This step include estimate and remove of Ekman current and wind slippage. Finally drifters and satellite only MDT were combined. Similar approaches are used regionally to go further toward higher resolution. A case study in the Gulf of Mexico intends to use drifters in the same way to improve weekly geostrophic current estimate.

Drifters processing

Rio et al., 2014

❑ SVP drifters (with and without the drogue) and Argo float (YOMAHA, Yoshinari et al, 2006)



STRONG interest of using undrogued buoy velocities to improve data coverage. However, undrogued buoys are advected by

- **Surface** (not **15m**) Ekman currents
- **the direct action of wind (wind slippage)**

These 2 effects are modeled and removed

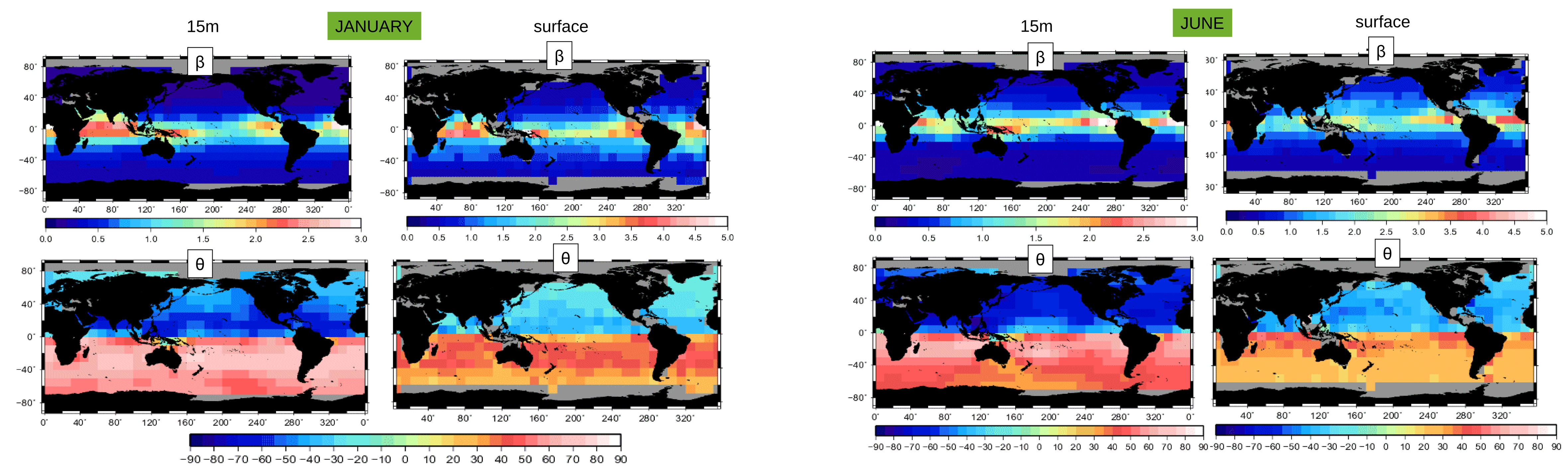
• **Ekman model**

Rio and Hernandez, 2003

$$\vec{u}_e = \beta \vec{\tau} e^{i\theta}$$

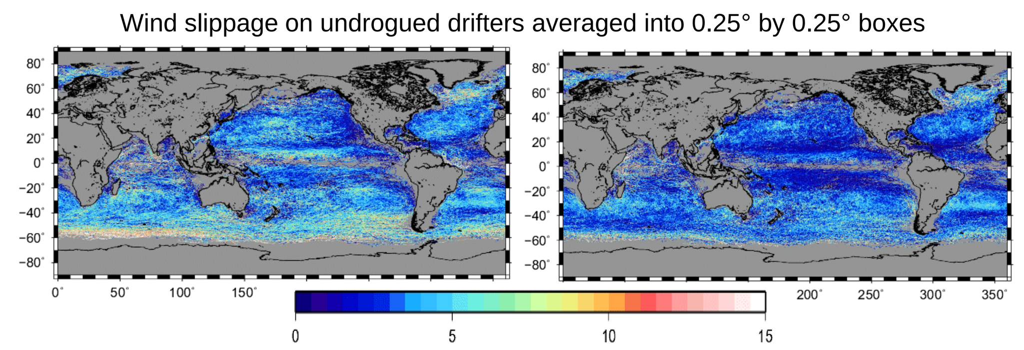
$\vec{u}_{buoy} - \vec{u}_{alti}$; Wind stress from ERA INTERIM

β and θ are estimated through least square fit by month and by boxes using Argo float (drifting at the surface from YOMAHA databse) because Argo float are less sensible to wind slippage



→ **Consistent with Ekman spiral theory (angle ϴ smaller at the surface and intensity β higher at the surface)** ***Rio et al., 2014***

• **Wind slippage correction**



Wind slippage correction of zonal and meridional velocity is estimated following Rio, 2012 method. The total drifter velocity U_d is decomposed into different contributions: geostrophic current U_g ; Ekman current U_e ; ageostrophic current U_a, including wind slip.
When the drogue is lost, the drifter goes back to the surface and is directly under the influence of the wind stress. Using DUACS geostrophic current (DUACS/Aviso team; 2014) and Ekman model, a residual current U_r is computed

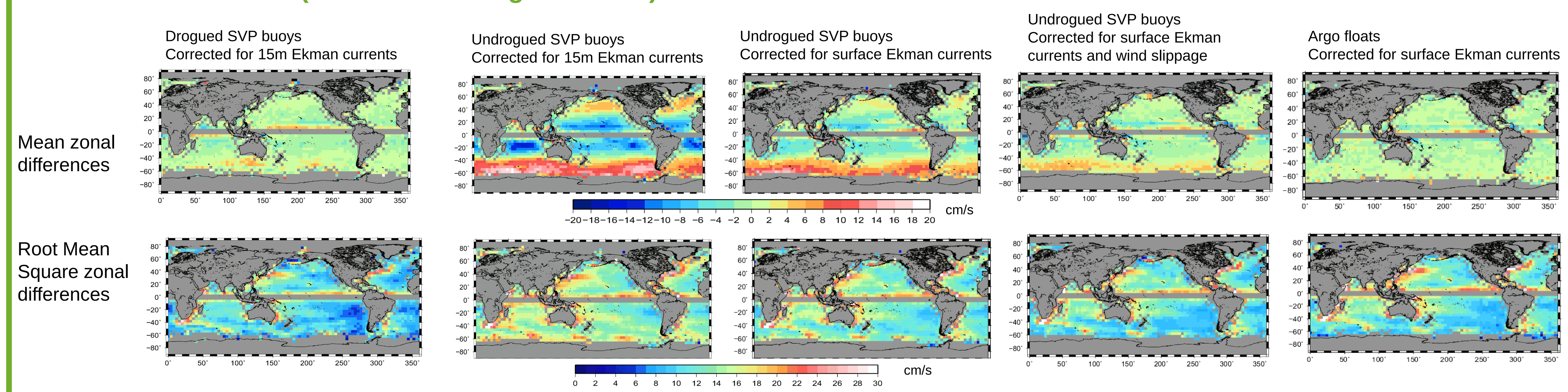
$$U_r = (U_d - U_g - U_e)_f - U_s$$

where f stands for a 3-day low pass filter to remove inertial oscillation, tidal and high frequencies. The wind slippage correction U_s is then computed as:

$$U_s = \alpha \mathbf{W}$$

where α is a coefficient which minimizes the correlation between the wind speed **W** and the residual drifter velocity U_r.

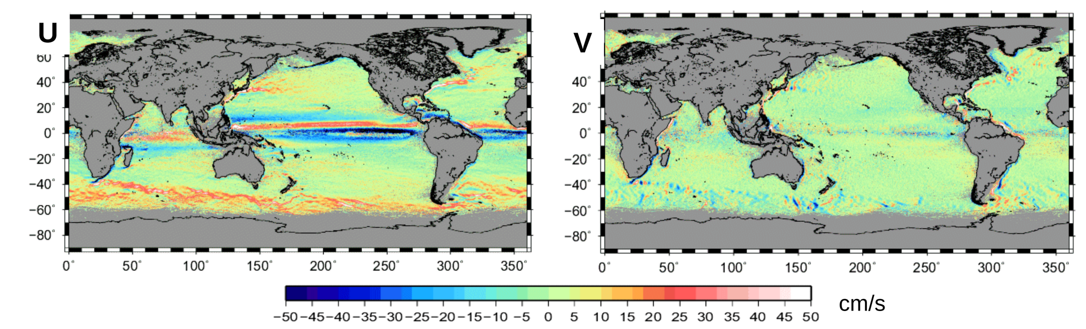
• **Comparison between drifting buoy velocities and altimeter velocities (from SLA+first guess MDT)**



→ **Better agreement with geostrophic altimetric velocities when undrogued SVP are corrected from surface Ekman current and wind slippage**

• Mean current from SVP-DROGUE ON + SVP-DROGUE OFF+ARGO

These maps are used to improved first guess MDT



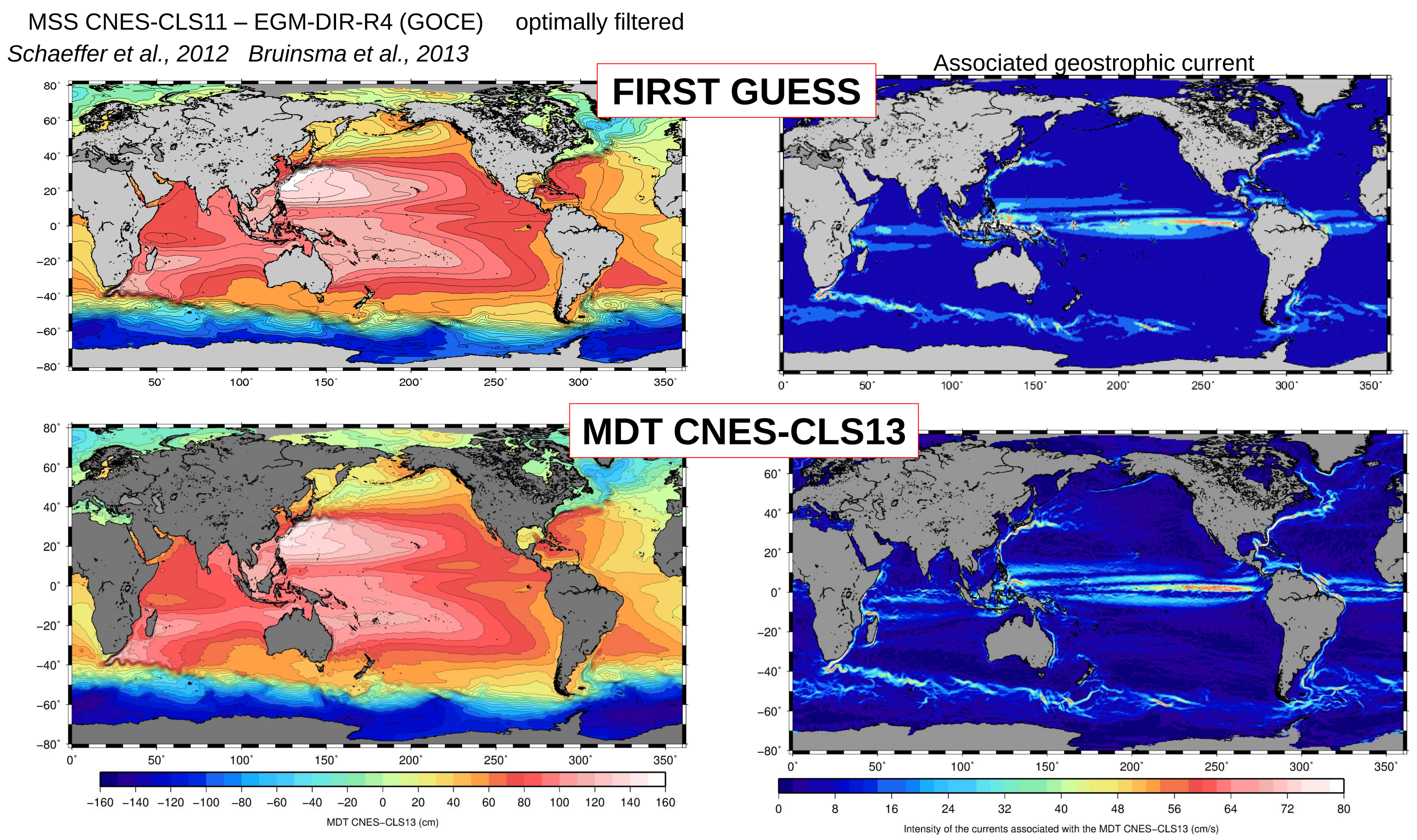
Combination of the first guess and in-situ data through objective analysis (drifters + T/S profiles) → MDT CNES-CLS13

•« Large » scales (> around 100-125 km) are given by GOCE and the short scales of the MDT (and corresponding geostrophic currents) are estimated by in-situ data

• Thus the use of in-situ data improve comparison with independant SVP velocities (Table 1)

Table1: RMS differences between independant SVP velocities (aquired in real time from September 2012 to September 2013 and corrected from Ekman and wind slippage) and MDT+SLA derived velocities (expressed in % of drifter velocity variance) – 1.425.190 velocities

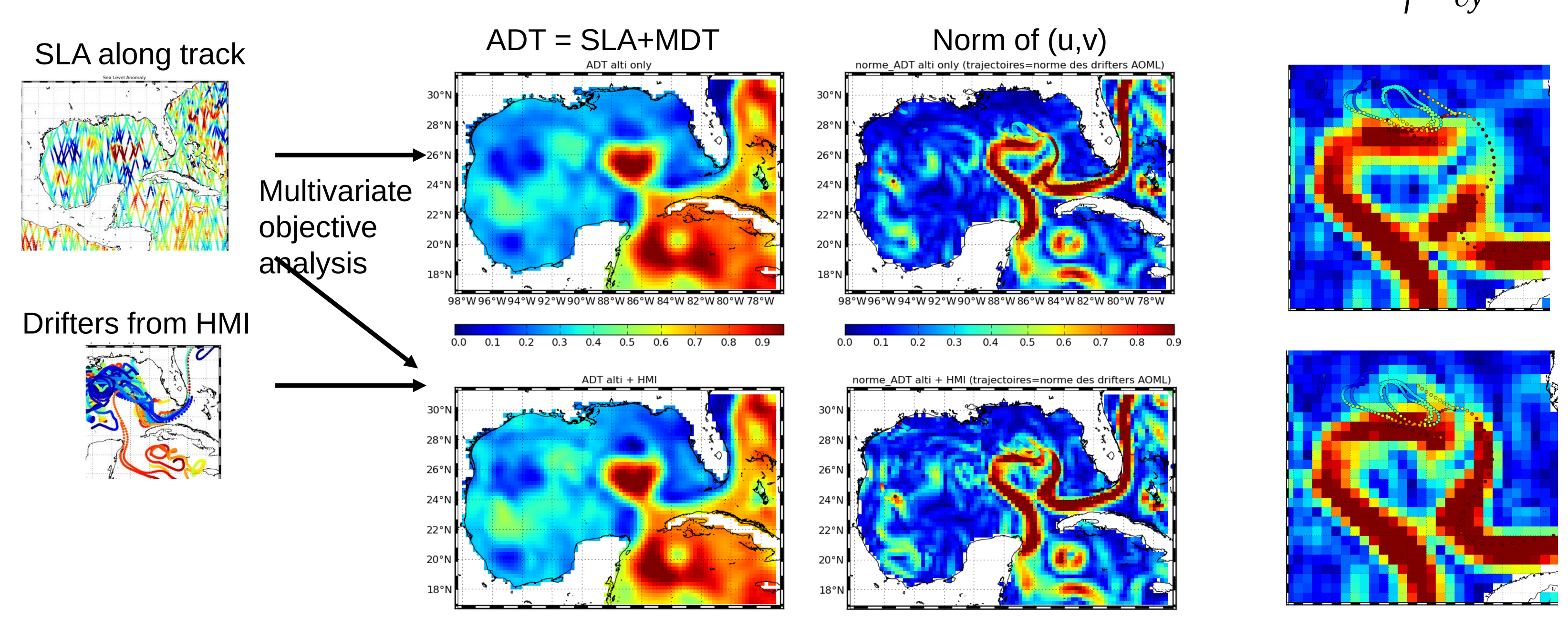
	MDT-CNES-CLS13	MDT GOCE (First Guess)
RMS U	42.17	44.31
RMS V	46.48	49.54



Use case in the Gulf of Mexico using drifters deployed by Horizon Marine Inc. (HMI)

- Mapping Height/geostrophic current on 21-05-2014

$$u = -\frac{g}{f}\frac{\partial ADT}{\partial y} \qquad v = \frac{g}{f}\frac{\partial ADT}{\partial x}$$



→ Map that includes HMI's drifters
= better agreement with **independante** AOML's drifters
= better resolution of the loop current

- Validation of the time serie (9-04-2014 to 31-12-2015)

Comparison with independant SLA from Cryosat2 tracks

	HMI + alti	Alti only
RMSD (cm)	5.8	6.2

Comparison with independant velocities from not used HMI's drifters (odd ID)

	HMI (even ID) + alti	Alti only
RMSD U (cm^2)	16.9	18.5
RMSD V (cm^2)	17.8	21.5

→ **Using drifters to map SLA and associated geostrophic current improved comparison with independant data**

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