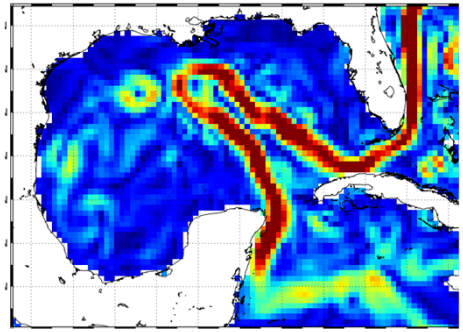
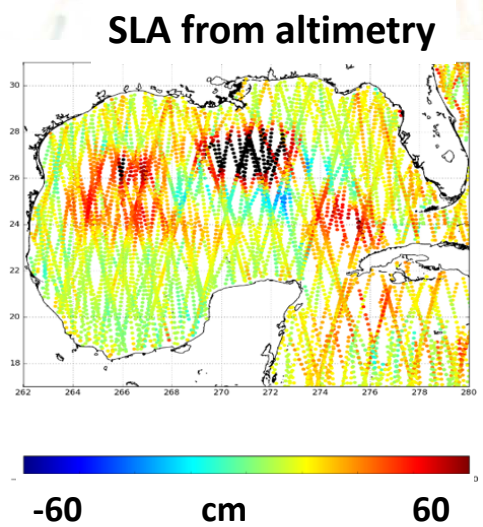
Synergetic use of altimetry and surface drifters to increase resolution and accuracy of sea level anomaly and geostrophic current maps in the Gulf of Mexico

Sandrine Mulet, Hélène Etienne, Maxime Ballarotta, Yannice Faugere, Gérald Dibarboure, Nicolas Picot



Outline



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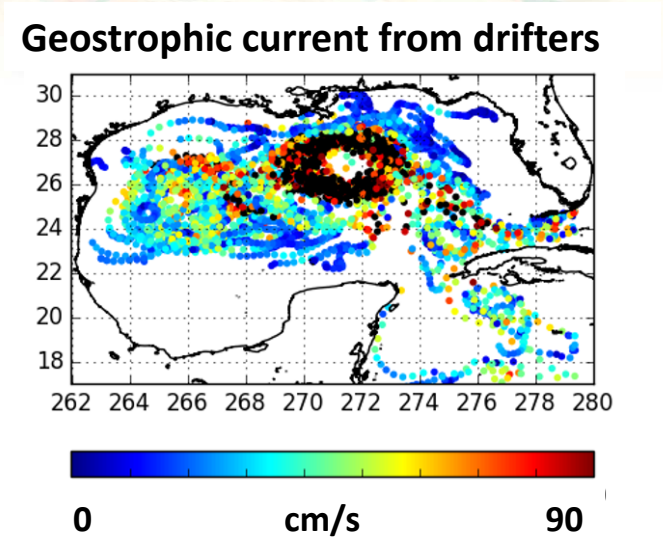

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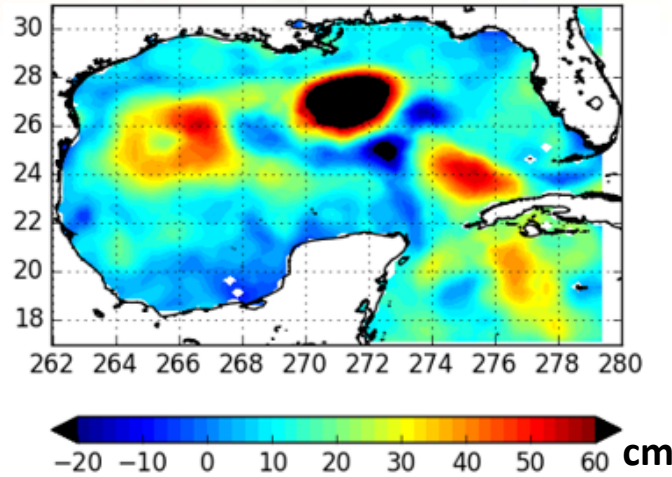
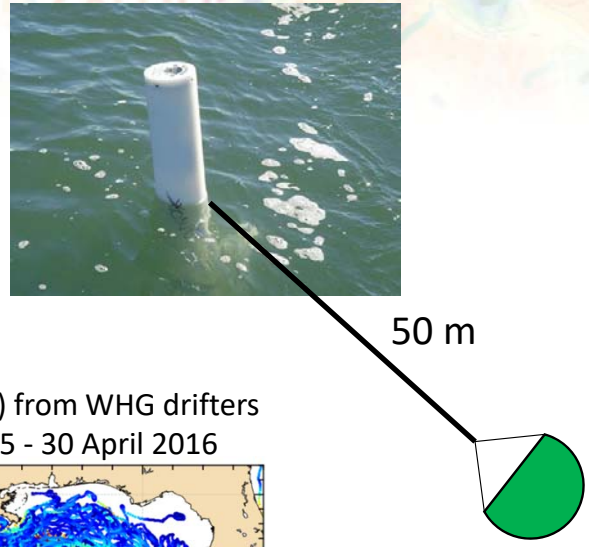


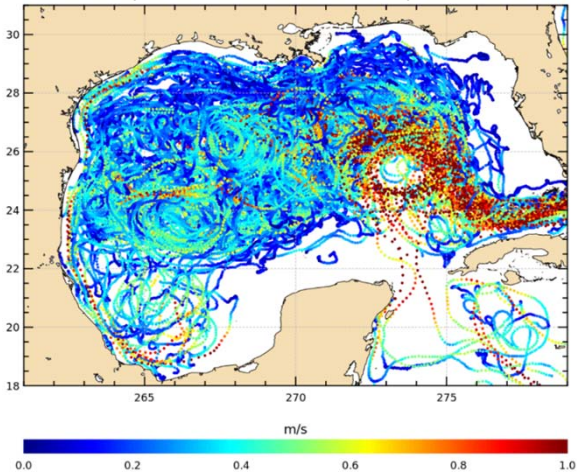
- Drifters (Wood Hole Group, CARTHE/LASER)
- Combination WHG drifters + along-track altimetry
- Validation against independent along-track SLA and LASER drifters
- Conclusions

Drifters from Woods Hole Group (WHG)

Sharma et al., 2010



Drifter velocity (m/s) from WHG drifters
1 September 2015 - 30 April 2016



➢ Drifters Processing :

1- Editing (Hansen and Poulain; 1996)

2- Interpolation with regular frequency (6h00)

3- Computation of the velocities

4- Data are processed to match the physical content of the altimetric measurement, i.e.: geostrophy

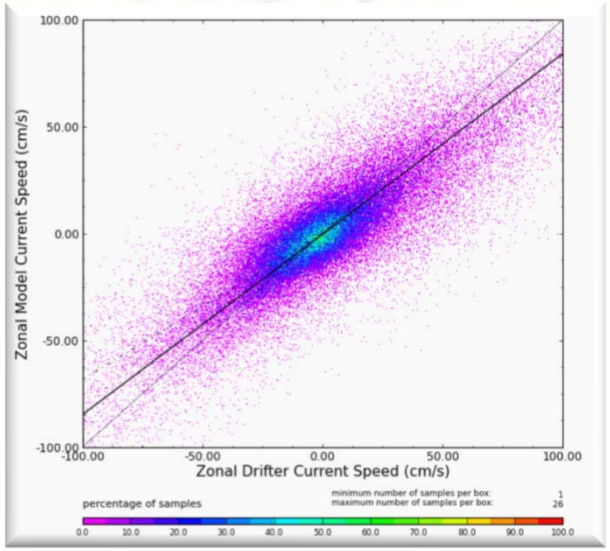
- 3 days filter to remove high frequency ageostrophic signal
- Remove Ekman current (Rio et al., 2014)
- Remove MDT CNES-CLS13 to estimate anomalies

Sharma, N., P. Brickley, G. Owen, and P. Coholan, 2010: Use of air-deployed drogued drifting buoys for oil spill tracking. OCEANS 2010, IEEE, 1–9.

Comparaison with altimetry

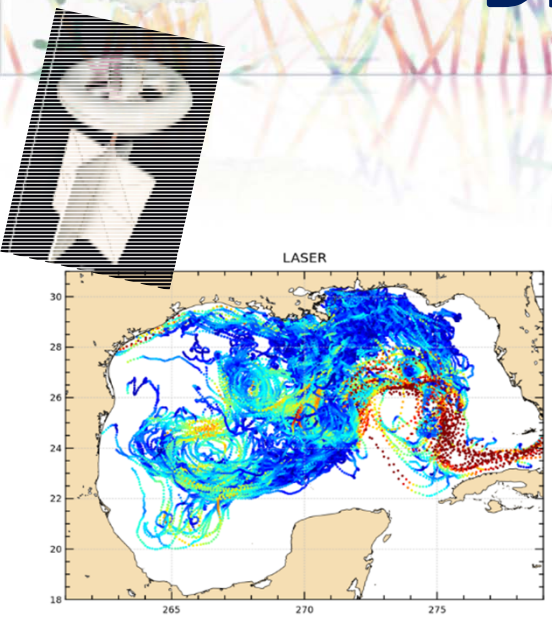
Correlation coefficient for AOML and WHG drifters compared with DUACS/CMEMS DT2018 (20 January to 30 April 2016)

	component	Drogued AOML	WHG
Correlation coefficient	Zonal	0.83	0.83
	Meridional	0.85	0.80



- Similar results than well known AOML SVP drifters

Drifters from CARTHE/LASER



The **LAgrangian Submesoscale ExpeRiment (LASER)** (D'Asaro et al., 2017) took place in the Gulf of Mexico during the **winter of 2016** (from 20 January to 30 April 2016).

- Designed to study pollutant (oil spill) dispersion due to submesoscale processes
- **measure the upper 60 cm** of the ocean in nominal use, but are limited to the upper 5 cm when the drogue is lost
- interpolated to a uniform 15-minute interval

For this study, like for the WHG dataset:

- LASER drifters are interpolated at a 6-hour frequency
- 3 days filter to remove high frequency ageostrophic signal
- Remove Ekman current (Rio et al., 2014)
- As suggested by Novelli et al., 2017, the Stokes drift (Rascle and Ardhuin, 2013) is removed only from the undrogued LASER drifters.
- Remove MDT CNES-CLS13 to estimate anomalies

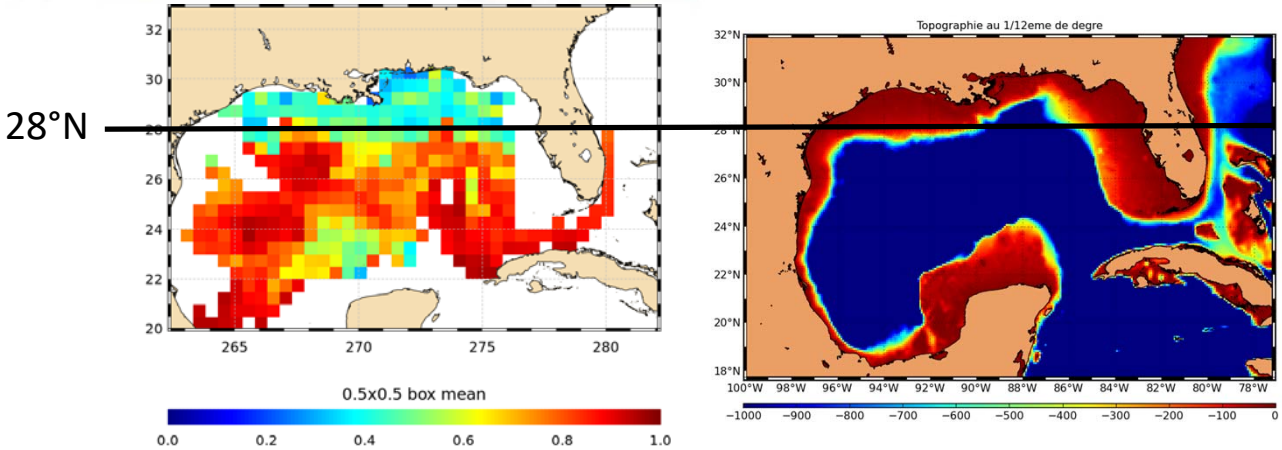
D'Asaro Eric, Cedric Guigand, Angelique Haza, Helga Huntley, Guillaume Novelli, Tamay Özgökmen, Ed Ryan (2017) Lagrangian Submesoscale Experiment (LASER) surface drifters, interpolated to 15-minute intervals. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University-Corpus Christi. doi:10.7266/N7W0940J

Novelli, G., C. M. Guigand, C. Cousin, E. H. Ryan, N. J. M. Laxague, H. Dai, B. K. Haus, T. M. Özgökmen, 2017. Biodegradable Surface Drifter for Ocean Sampling on a Massive Scale. J. Atmos. Oceanic Techn., (34), 2509-2532, doi.org/10.1175/JTECH-D-17-0055.1

Rascle, N., F. Ardhuin, 2013: A global wave parameter database for geophysical application. Part 2: Model validation with improved source term parameterization. Ocean Modell, http://dx.doi.org/10.1016/j.ocemod.2012.12.001

Comparaison with altimetry

- Vector correlation of geostrophic velocity from LASER drifters compared with DUACS/CMEMS DT2018



- Less agreement over the shelf
- May be due to residual ageostrophic signal in LASER drifters

Comparaison with altimetry

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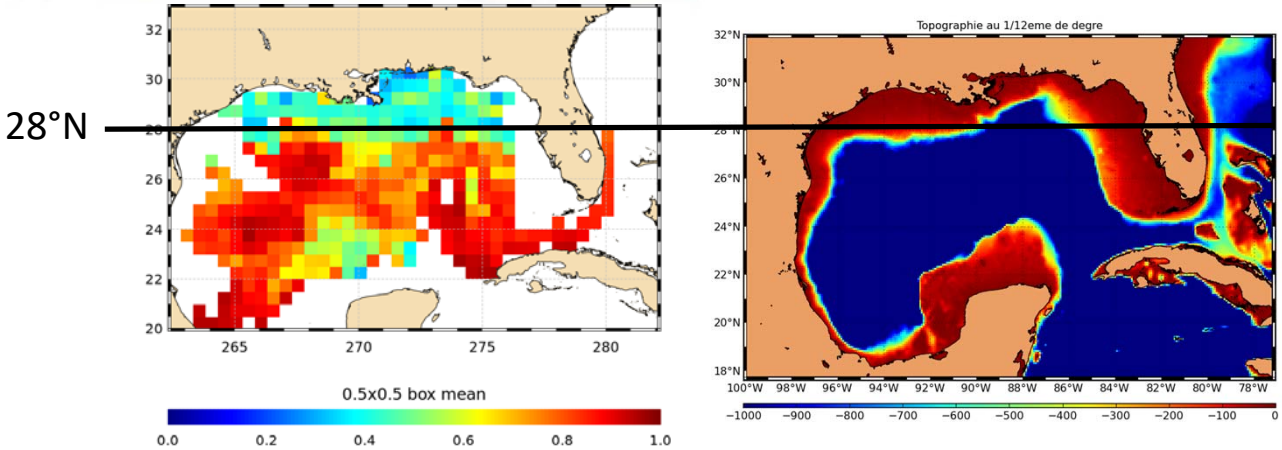


- Less agreement over the shelf
- May be due to residual ageostrophic signal in LASER drifters

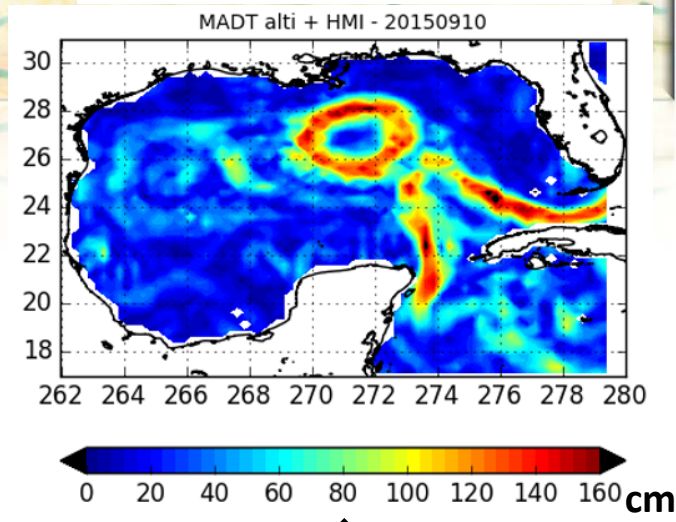
- Correlation coefficient for AOML, WHG and LASER drifters compared with DUACS/CMEMS DT2018 (20 January - 30 April 2016)

	component	Drogued AOML	WHG	LASER (lat<28°)	LASER
Correlation coefficient	Zonal	0.83	0.83	0.81	0.7
	Meridional	0.85	0.80	0.81	0.7

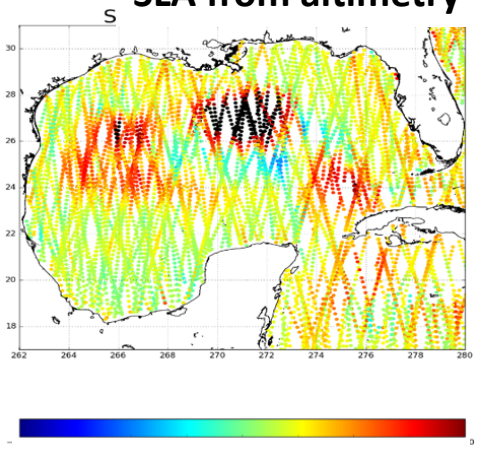
Merging drifters with along-track SLA

- multivariate objective analysis (Rio et al., 2014, 2011)

Improved Geostrophy



SLA from altimetry



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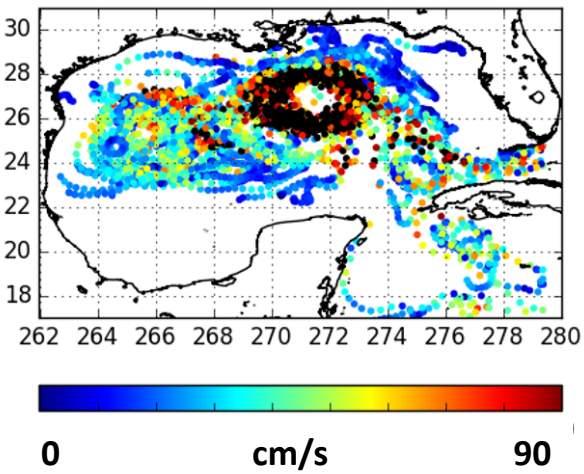
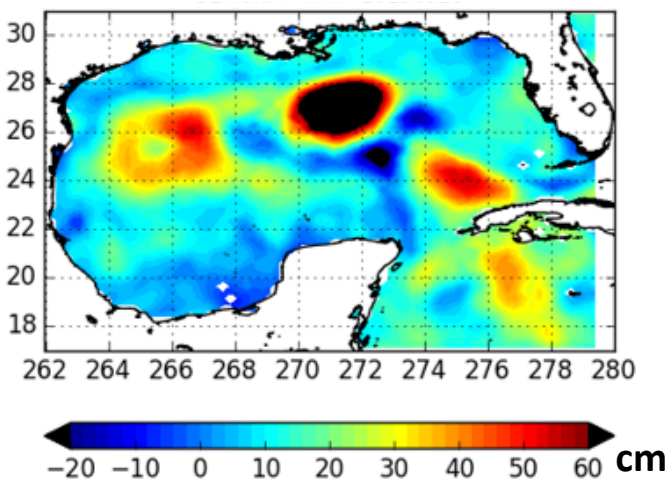
Geostrophic part of WHG drifters



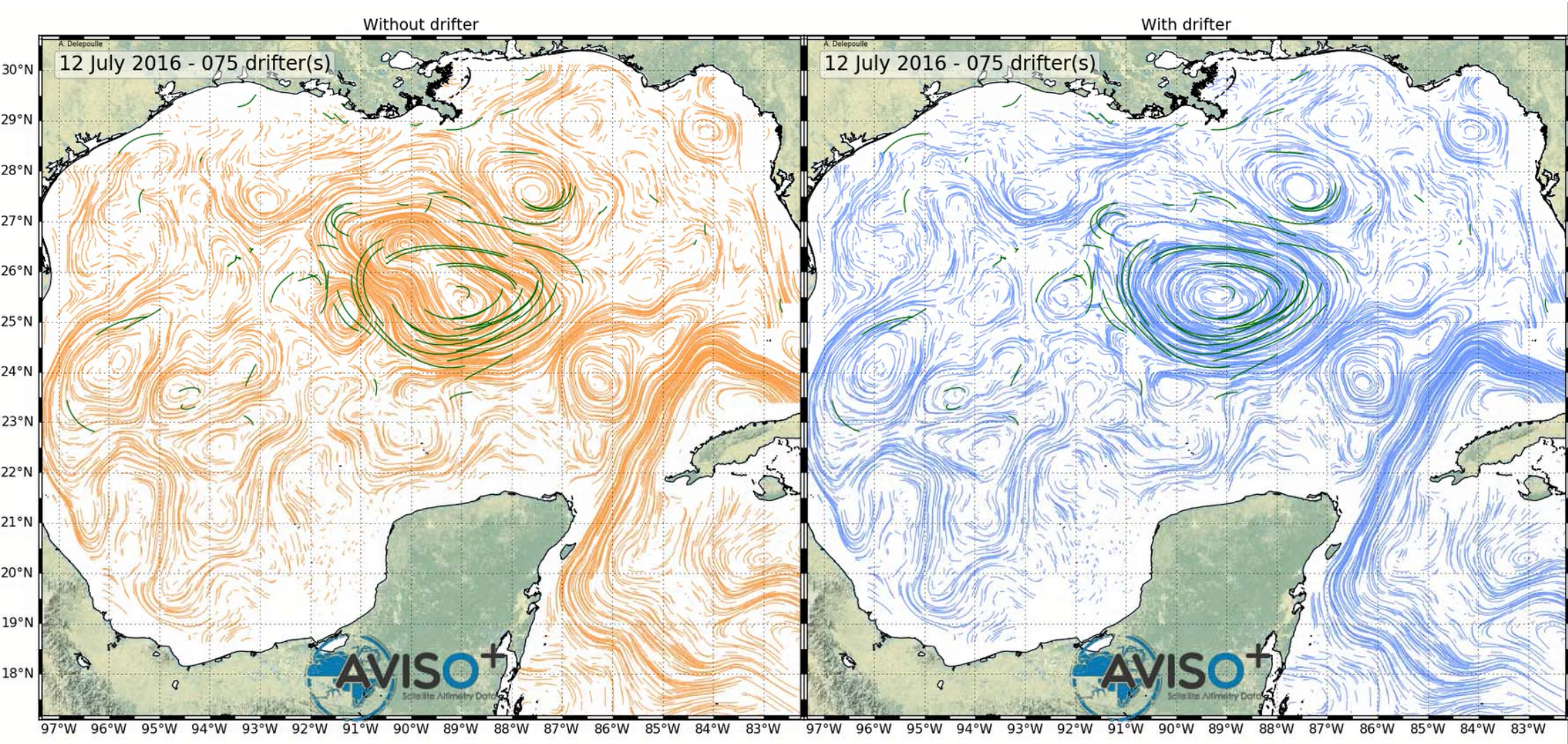
Improved SLA



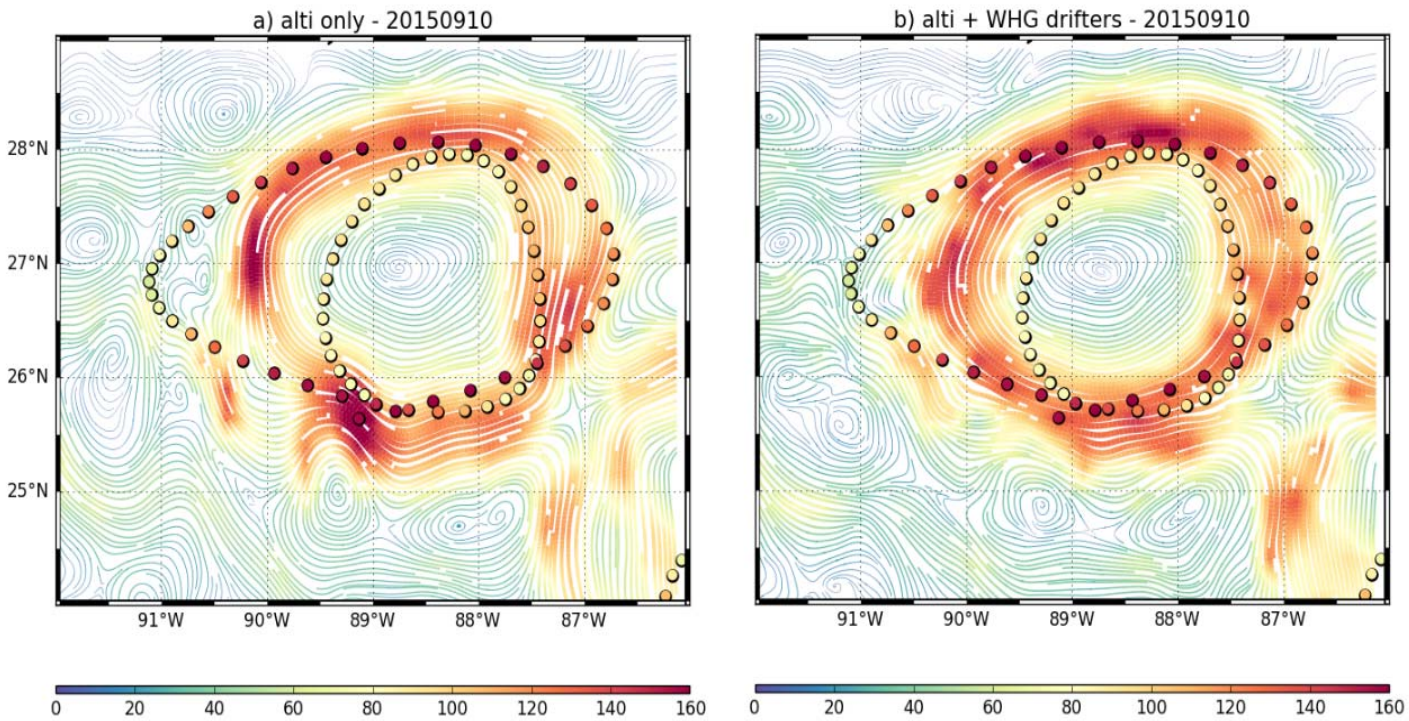
Filament derived from alti only (2 sat) geostrophic current maps

Trajectories of WHG drifters

Filament derived from alti (2 sat) + geostrophic current drifters maps



4 sat – comparison with independant AOML drifters

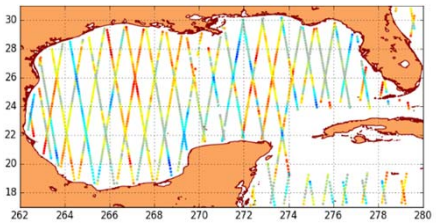


Streamlines and intensity of the geostrophic current (cm/s) on 10/09/2015 computed (a) from along-track SLA only and (b) from along-track SLA and WHG drifters. The dots show the intensity of the geostrophic current estimated from AOML drifters.

Validation against independant Saral/Altika SLA dataset

- Computation of 2 time series of maps (1/09/2015 to 30/4/2016)
- Merged maps using 3 altimetric dataset (h2,j2 and c2) and WHG drifters
- Reference maps from altimetry only (h2,j2 and c2)

- Validation against independant along-track SLA and across track geostrophic current anomalies (u') from Saral/Altika



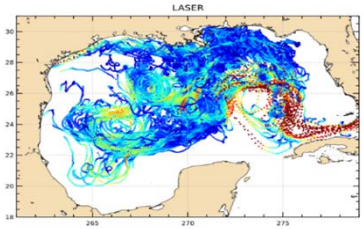
	Alti + Drifters	Alti only
RMSD SLA (cm)	5.7 cm	6.0 cm
SLA quadratic error (% RMS SLA al)	10.2 %	11.2 %
RMSD u' (cm/s)	14.6 $cm.s^{-1}$	14.9 $cm.s^{-1}$

➢ Alti+drifters give slightly better results than alti only.

Validation against independant LASER dataset

- Computation of 2 additional time series of maps (1/09/2015 to 30/4/2016)
- Merged maps using **4 altimetric** dataset (h2,j2,c2 and al) and WHG drifters
- Reference maps from altimetry only (h2,j2,c2 and al)

- Validation against independant geostrophic current anomalies estimated from LASER drifters



	Alti (4sat) + drifters	Alti only (4sat)	Alti (3sat) + drifters	Alti only (3sat)
RMSD U / V	13.94/14.62 cm.s^{-1}	14.37/16.27 cm.s^{-1}	14.09/14.78 cm.s^{-1}	15.45/18.05 cm.s^{-1}
CorU / CorV	0.66/0.73	0.64/0.66	0.66/0.72	0.60/0.59

→ The estimate from alti+drifters give better results than alti only **mainly for the meridional component**.

→ Using WHG drifters performs better than adding 1 satellite

Conclusions

- **The use of drifters helps to resolved slightly better SLA and zonal component of geostrophic current, same improvement than adding 1 satellite**

- **The use of drifters helps to improve a lot the meridional component of geostrophic current**

- **Experimental dataset (4sat+WHG drifters) over 1/09/2015 to 30/4/2016 available on AVISO website (www.aviso.altimetry.fr)**

Conclusions / Recommandations

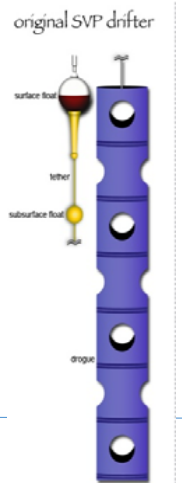
- **Improve the altimetry processing chain to improve the geostrophy component of the current**

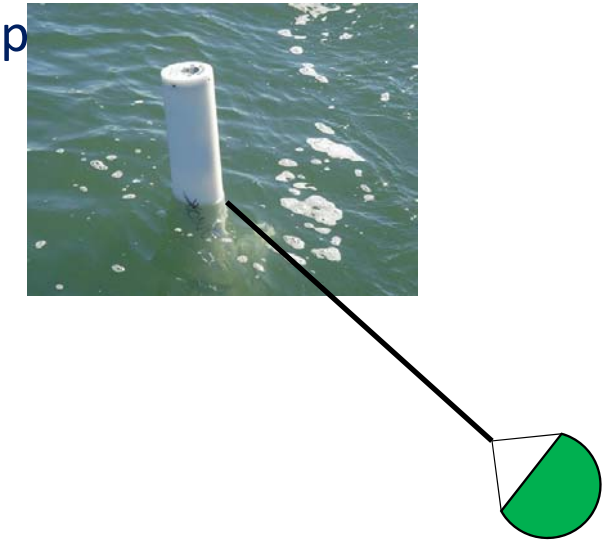
- **Improve mapping techniques :** multiscale/dynamic, multisensory/multivariate **=>** Continue to develop **both observed products and model products** : they are complementary!

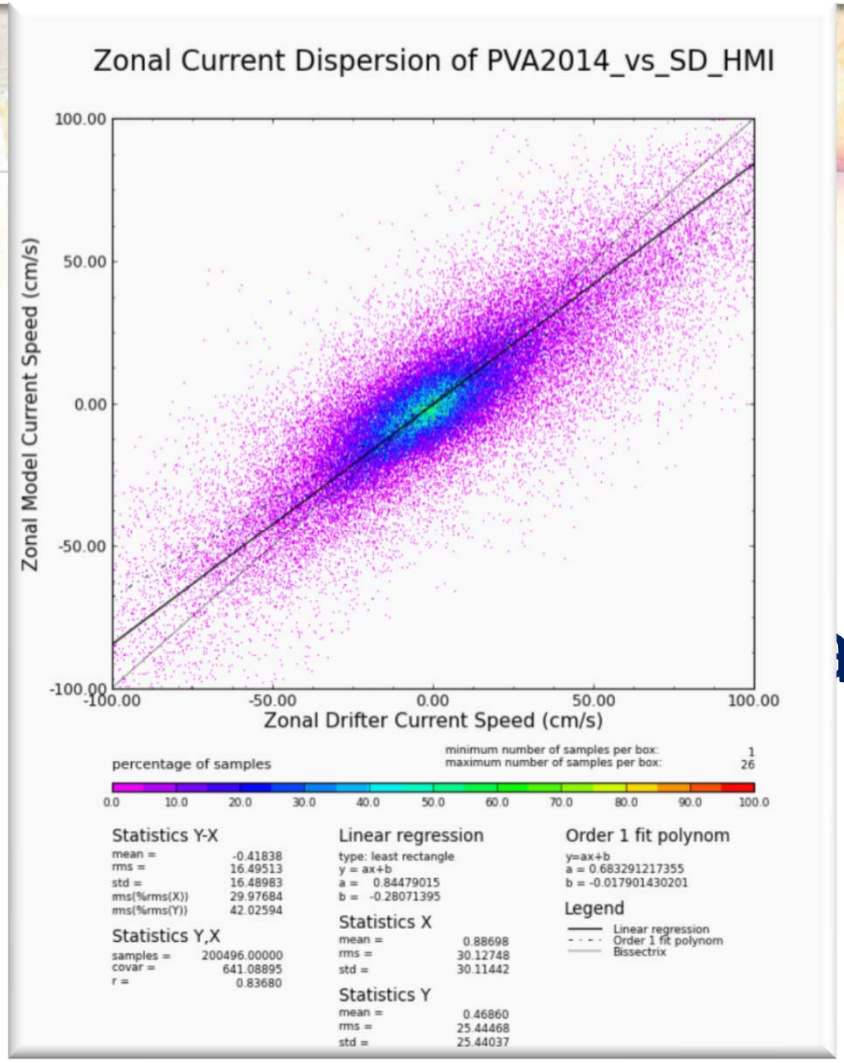
- **Regional priorities**: Arctic error budget is high (MSS, MDT,..)

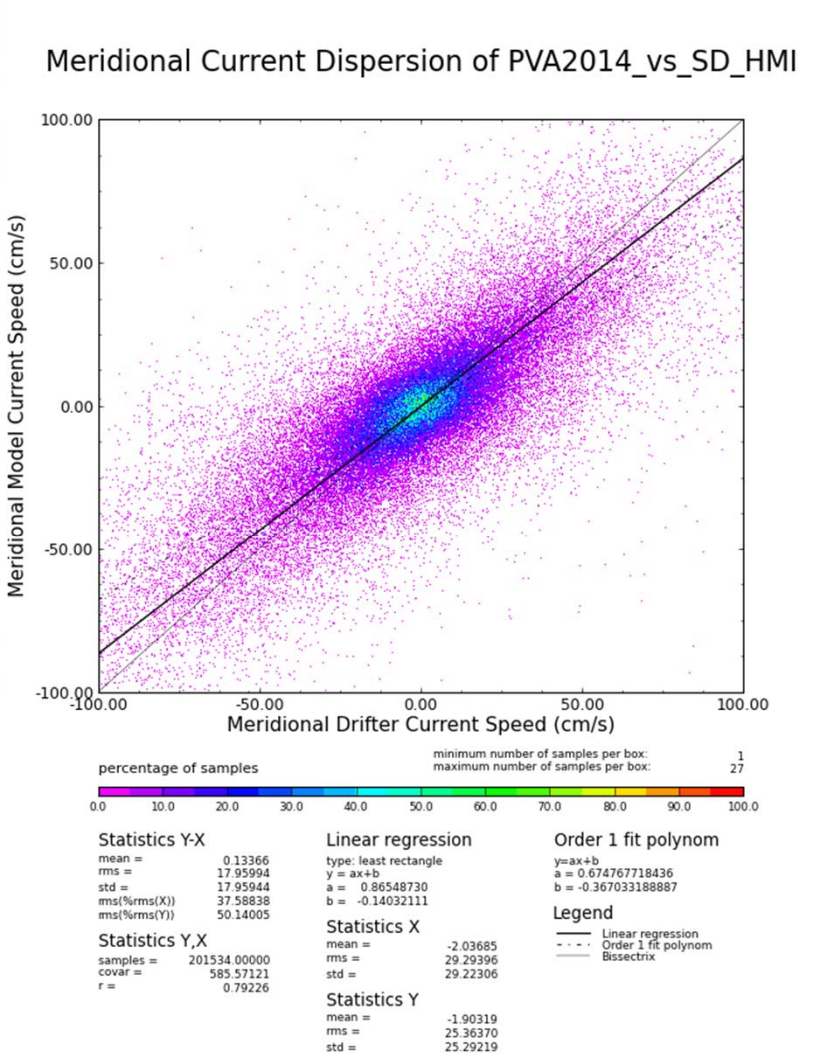
- **Easing user life**
  - Common langage between scientists, producers, downstream users.
  - Fullfill user need in terms of product errors (Static & dynamic)
  - Ease access to multisensory information: Eddy/ front / SST/ color/ TS profiles through new products and tools

- Bouées HMI dispo depuis 1985 mais densité conséquente que depuis 2000
- Nécessité de traiter les données HMI
  - la chaine de traitement existe
  - il reste des améliorations à faire dans le traitement et notamment sur la profondeur de la drogue et détection de sa p






Zonal Current Dispersion of PVA2014_vs_SD_HMI
Zonal Model Current Speed (cm/s)
Zonal Drifter Current Speed (cm/s)
100.00
50.00
0.00
-50.00
-100.00
-100.00
-50.00
0.00
50.00
100.00
percentage of samples
minimum number of samples per box: 1
maximum number of samples per box: 26
0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0
Statistics Y-X
mean = -0.41838
rms = 16.49513
std = 16.48983
rms(%rms(X)) 29.97684
rms(%rms(Y)) 42.02594
Statistics Y,X
samples = 200496.00000
covar = 641.08895
r = 0.83680
Linear regression
type: least rectangle
y = ax+b
a = 0.84479015
b = -0.28071395
Statistics X
mean = 0.88698
rms = 30.12748
std = 30.11442
Statistics Y
mean = 0.46860
rms = 25.44468
std = 25.44037
Order 1 fit polynom
y=ax+b
a = 0.683291217355
b = -0.017901430201
Legend
Linear regression
Order 1 fit polynom
Bissectrix


Meridional Current Dispersion of PVA2014_vs_SD_HMI
Meridional Model Current Speed (cm/s)
Meridional Drifter Current Speed (cm/s)
100.00
50.00
0.00
-50.00
-100.00
-100.00
-50.00
0.00
50.00
100.00
percentage of samples
minimum number of samples per box: 1
maximum number of samples per box: 27
0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0
Statistics Y-X
mean = 0.13366
rms = 17.95994
std = 17.95944
rms(%rms(X)) 37.58838
rms(%rms(Y)) 50.14005
Statistics Y,X
samples = 201534.00000
covar = 585.57121
r = 0.79226
Linear regression
type: least rectangle
y = ax+b
a = 0.86548730
b = -0.14032111
Statistics X
mean = -2.03685
rms = 29.29396
std = 29.22306
Statistics Y
mean = -1.90319
rms = 25.36370
std = 25.29219
Order 1 fit polynom
y=ax+b
a = 0.674767718436
b = -0.367033188887
Legend
Linear regression
Order 1 fit polynom
Bissectrix

	component	Drogued AOML $U_d \mid_{3\text{-day filtered}} - U_{ek(15m)}$	WHG $U_d \mid_{3\text{-day filtered}} - U_{ek(15m)}$	LASER (lat<28°) $U_d \mid_{3\text{-day filtered}} - U_{ek} (- U_{st})$	LASER $U_d \mid_{3\text{-day filtered}} - U_{ek} (- U_{st})$
Correlation coefficient	Zonal	0.83	0.83	0.81	0.7
	Meridional	0.85	0.80	0.81	0.7

Filament derived from alti only geostrophic current maps

Trajectories of WHG drifters

Filament derived from alti + geostrophic current drifters maps