Ocean current variability in the Sub-tropical North Atlantic in 2012-2013

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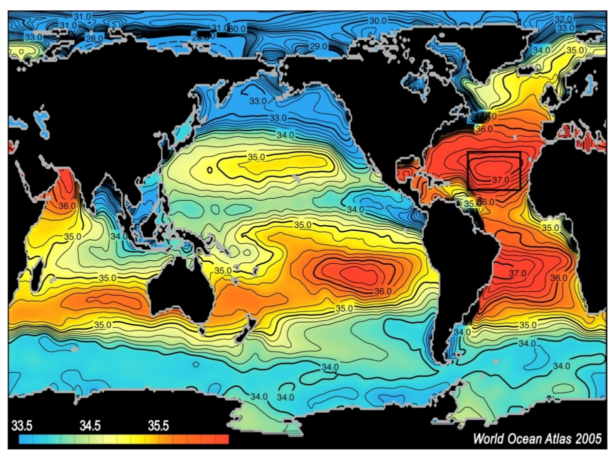
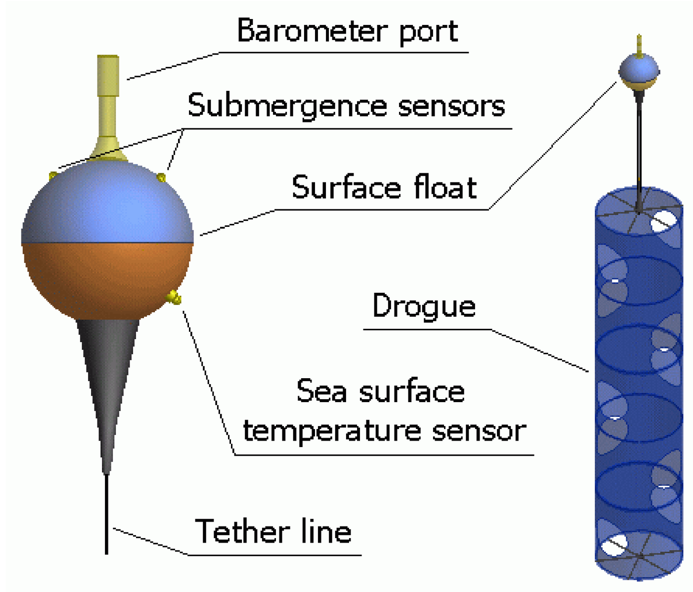
Introduction

We investigate the sea surface variability based on drifter data in the subtropical gyre of the North Atlantic (18-32N, 310-340W) for the period from August 2012 to September 2013. This region was instrumented during the international experiment SPURS and STRASSE, its French component, with more focused work in a small region near the salinity core. Around 150 drifters of SVP were deployed in this region. The velocities of drifters with the drogue centered at 15m are used to estimate the total current components: Ekman current and geostrophic current.

Data sets

SVP-S : PG (77), ICM (11)





The drifters have a battery pack, a satellite transmitter, SST and SSS sensors, located at the base of the float to avoid direct radiative heating. Most of the drifters have a sensor to identify the presence of the drogue.

Methodology

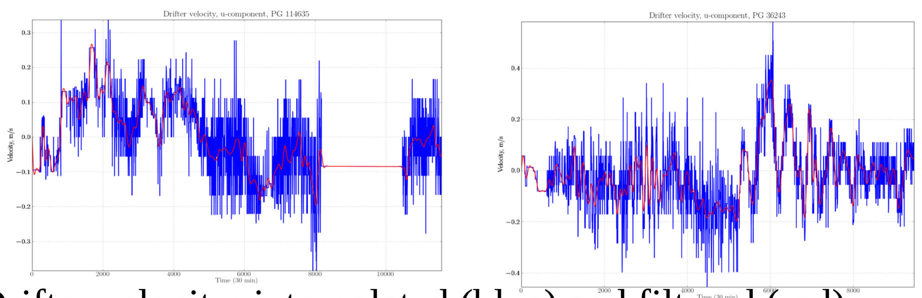
$$U_{drifter} = U_{Ekman} + U_{geostr} + U_{ageostr}$$

Wind Era-Interim (→ U_{Ekman})

AVISO/ MERCATOR geostrophy (→ U_{geostr})

30 hours Filtering (→ $U_{ageostr}$)

Pre-processing



- Linear interpolation
- Filtering (cut-off frequency ~30h)
- Using only the drogued drifters

Drifter velocity: interpolated (blue) and filtered (red)

Ekman current and Mixed Layer Depth

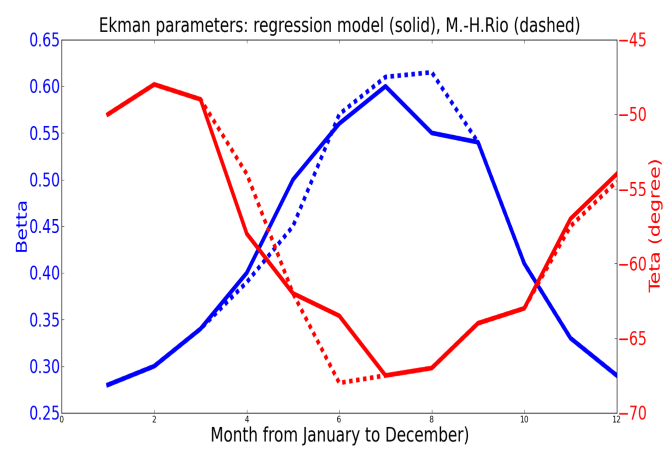
Ekman model (M.-H. Rio 2012) (dashed lines)

$$u_e = \beta\tau e^{i\theta}$$

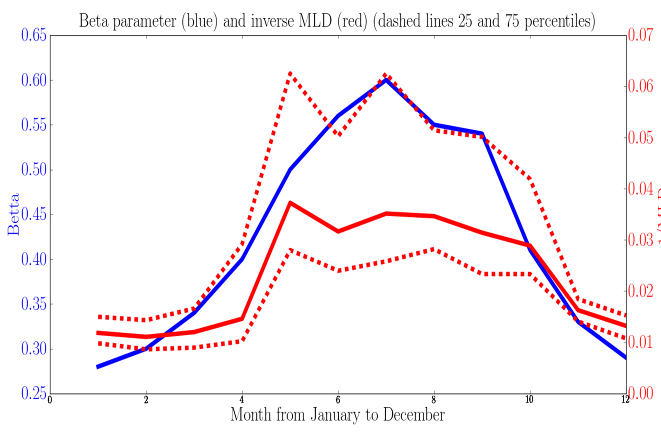
Era-Interim to calculate wind stress

$$\beta = \frac{\pi\sqrt{2}}{\rho f D_e} e^{\frac{\pi}{D_e} z} \qquad \theta = \frac{\pi}{D_e} z - \frac{\pi}{4} \qquad D_e = \sqrt{\frac{2\nu}{f}}$$

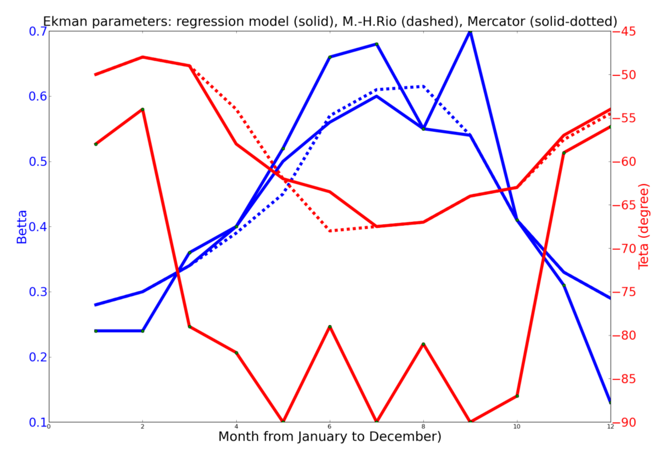
Regression method (solid lines): parameters obtained by minimizing the correlation between wind stress and residual drifter velocity (after removing Ekman and geostrophic currents)



Parameter β is inversely proportional to an Ekman depth. Mixed layer depth is estimated with thresholds to 10m depth properties (Salinity threshold: 0.03, Temperature threshold: 0.1). Comparison of β (blue) with inversed mixed layer depth (red) from Argo floats shows strong and in phase seasonal cycles. There is an disagreement in May, a month with strong effect of SST on estimated MLD, with often moderate stratification below, which might not prevent deeper mixing



In order to check whether combining drifters, winds and geostrophic currents from different data sets might influence the estimates, we checked model simulations to calculate Ekman and geostrophic component . We use daily Mercator PSY2V4 simulation with the 1/12 degrees resolution. Mercator level data were interpolated onto a one-meter grid. Results show that Mercator MLD is shallower than Argo floats MLD. Mercator presents a larger Ekman β parameters, and the Ekman angle indicates a stronger rotation with the wind.



Ekman current from Mercator is calculated as the difference between current at 15m (where the drogue is centered) and current at 50m (what we take as geostrophic current, more details see below).

The results on Ekman currents from the Mercator simulation:

- Accordance between Ekman amplitude and inverse of MLD (as in the data)
- Fast changes of SST in May with similar response in MLD
- Mercator simulation produces more viscous model
- Mercator reproduces too strong rotation with the wind

Geostrophic current

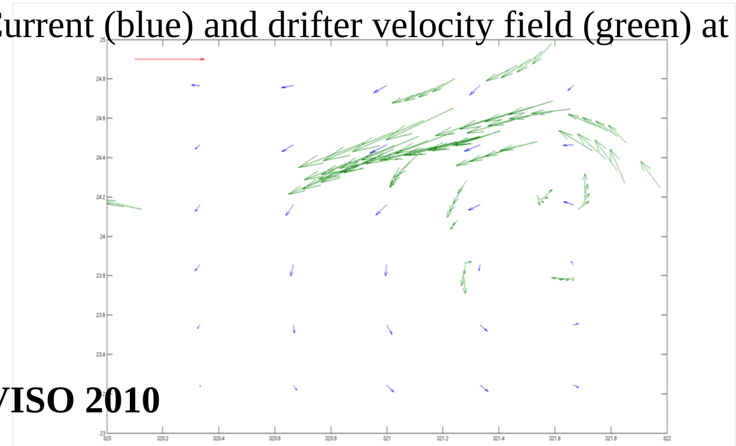
Ssalto/Dacs AVISO geostrophy is used. Two data sets are considered: daily AVISO 2010 altimetry with 1/3 degrees resolution, daily AVISO 2014 regional product with 1/8 degrees resolution. For Mercator the current at 50m is chosen as geostrophic current (cf details below).

Table of RMS for different product

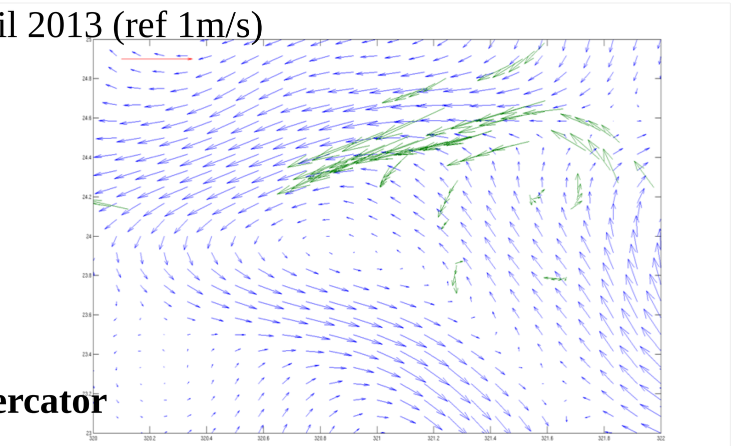
original drifter velocity (u)	original drifter velocity (v)	D(u) Drifter–Mercator	D(v) Drifter–Mercator	D(u) Drifter–AVISO 2010	D(v) Drifter–AVISO 2010	D(u) Drifter–AVISO 2014	D(v) Drifter – AVISO 2014
0.10294	0.09518	0.10434	0.09398	0.08356	0.07970	0.0807	0.0762

In the statistics of the differences with the drifters, residuals with AVISO 2010 have a little more variability than with the new AVISO regional product. In both cases, these are less than in the original drifter velocities. On the other hand, the removal of Mercator velocity fields does not reduce the variability of original drifter velocity. Mercator PSY2V4 velocity field present more eddies than in the AVISO products, but that are often not confirmed by drifter movements. Altogether, the Mercator Kinetic Energy (~0.0064) is stronger than AVISO 2010 KE (~0.0049). The new AVISO regional product also shows higher level of energy (~0.0068).

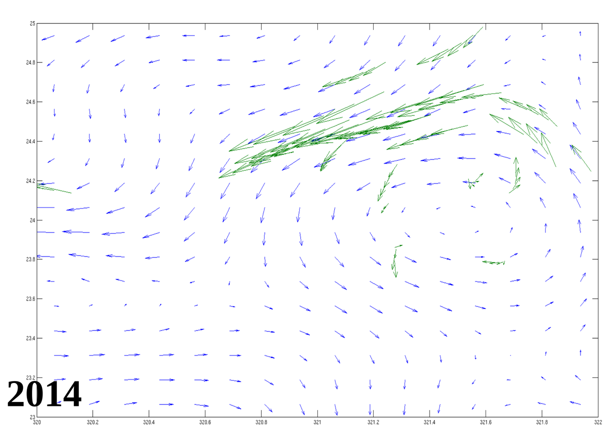
Current (blue) and drifter velocity field (green) at 2nd April 2013 (ref 1m/s)



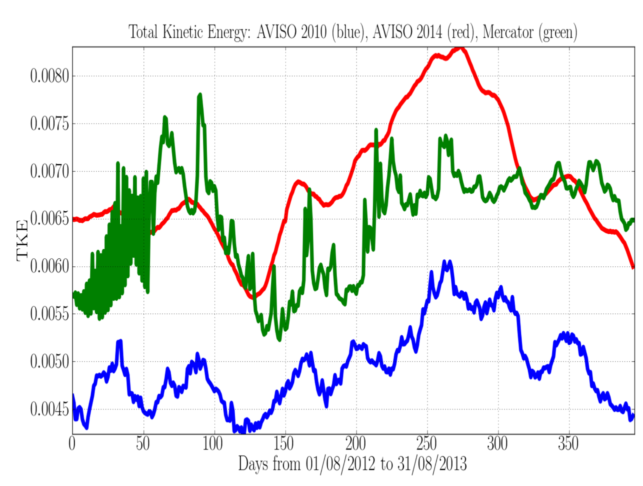
AVISO 2010



Mercator



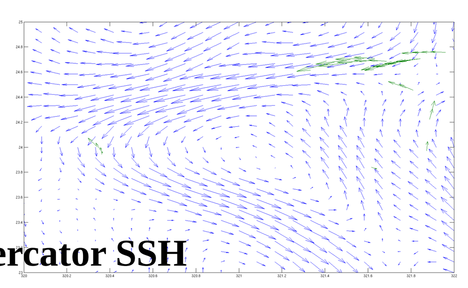
AVISO 2014



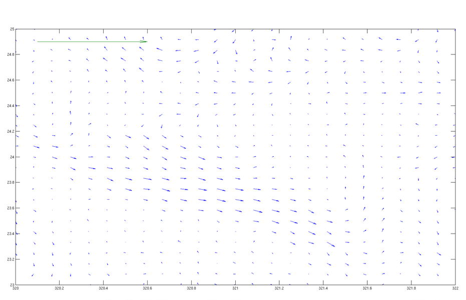
Mercator geostrophy

Mercator current at 50m (after calculation of shear stress) is chosen as geostrophic current. We also calculated geostrophic current by using SSH of Mercator simulation. We found small difference (maximum 0.1 m/s) between “SSH geostrohic current” and current at 50m, compatible with the small velocity shear expected from surface density fields.

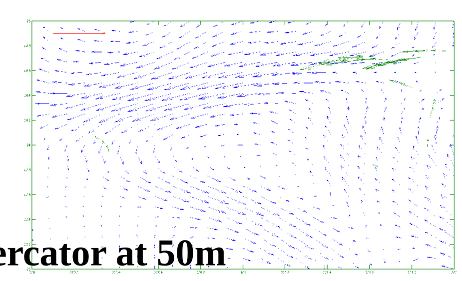
Current (blue) and drifter velocity field (green) at 31st March 2013 (ref 1m/s)



Mercator SSH



Mercator SSH – Mercator at 50m



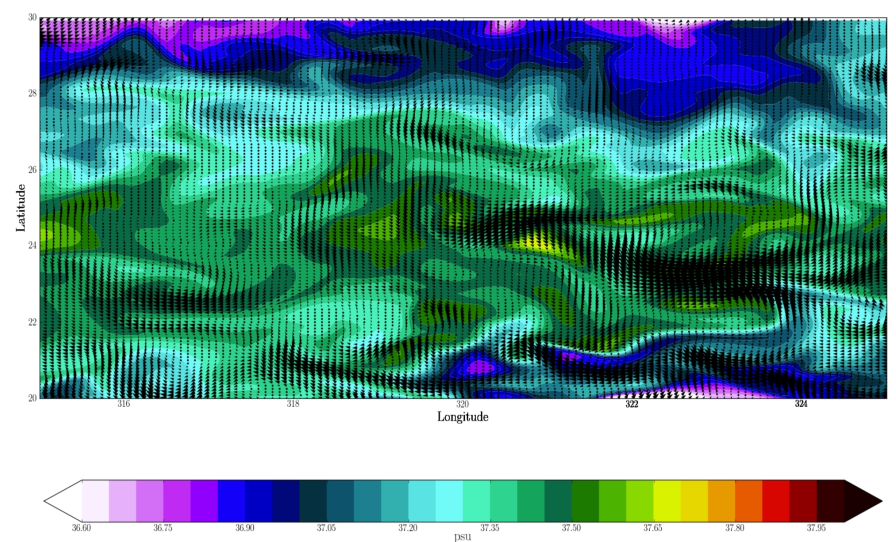
Mercator at 50m

Geostrophic current from SSH data and from current at 50m have similar structures: the main eddies are at the same position. But the difference map also present some regions with an amplitude that can have influence on the calculation of Ekman parameters.

Sea surface salinity

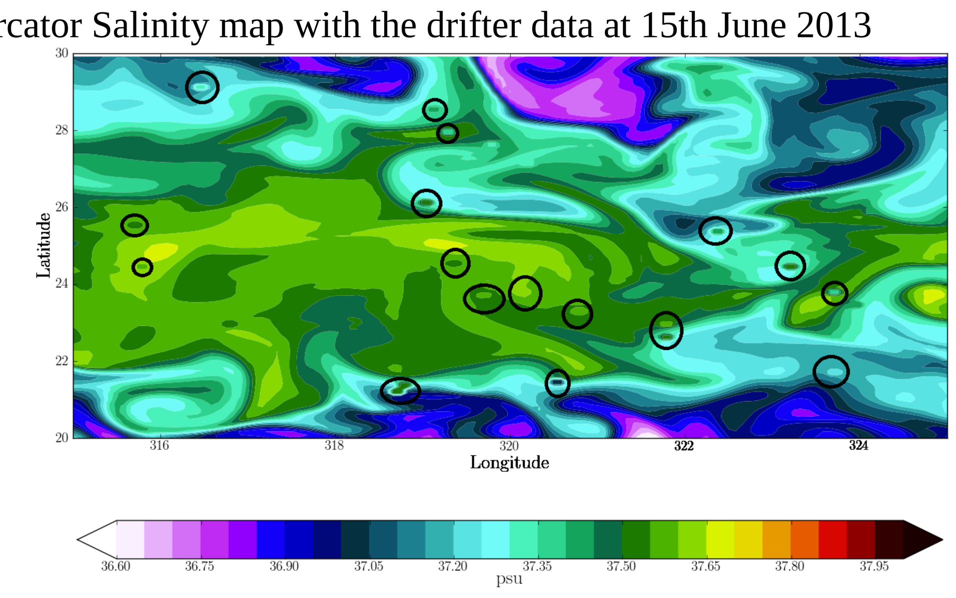
The influence of surface current on the salinity distribution is investigated. We use Mercator PSY2V4 simulation. The salinity field is are taken at the top depth and velocity is at 15m).

Salinity and current map at 4th April 2013



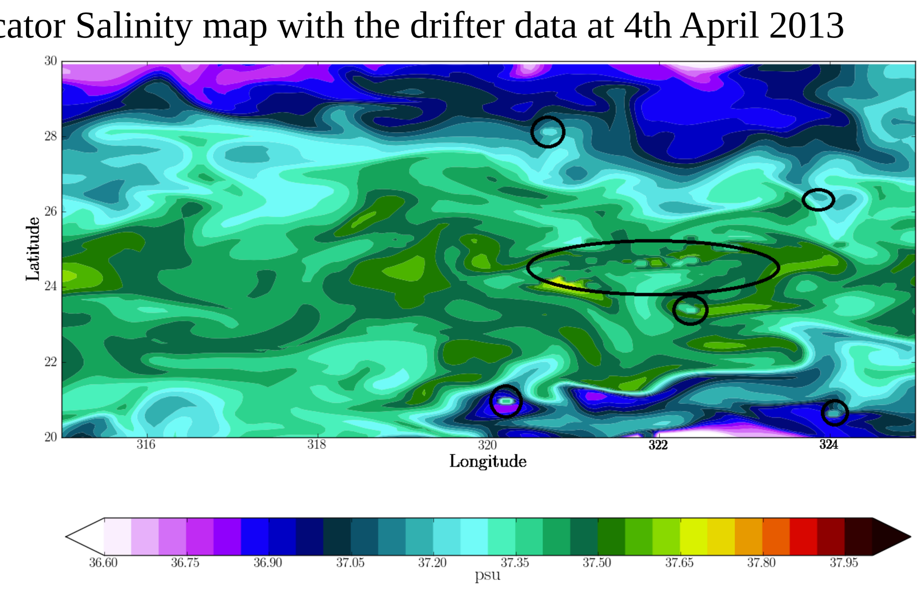
The stronger currents are at the edges of region with strong salinity contrast, especially at the southern part of the domain during spring time. Also it seems that the strongest ocean currents come from less salty region.

Mercator Salinity map with the drifter data at 15th June 2013



The comparison of sea surface salinity distribution from Mercator and drifter data (ellipses region) shows some biases. The drifter salinity is located in close proximity to the region with the same level of salinity in the Mercator simulation, but with some difference that might be linked with the shift in the currents that we commented before.

Mercator Salinity map with the drifter data at 4th April 2013



Conclusion

Wind-response component

Ekman current estimated from *drifter velocity* shows well-pronounced seasonal cycle.

The amplitude of Ekman velocity is a little bit less than found in previous work (Rio, 2012), which can result from the different data set or method of investigation.

The amplitude of Ekman currents is inversely proportional to MLD, which could be interpreted as a scaling of Ekman depth on MLD

***Mercator simulation* shows shallower MLD and as a consequences stronger Ekman parameters, but also a similar seasonal cycle.**

Geostrophic component

***Drifter data* are closest to the new *regional AVISO product*, than to the earlier one or the *Mercator simulation*.**

On energetic level *Mercator* is close to the new *AVISO product* but *Mercator model* that assimilates altimetry data (SLA, SST, Wind stress) shows shifts in velocity fields and as a result in salinity distribution.

Bibliography

- Hernandez O., Boutin J., Kolodziejczyk N., Reverdin G., Martin N., Gaillard F., Reul N and Vergely J.L. SMOS salinity in the subtropical north Atlantic salinity maximum: Part I: Comparison with Aquarius and in situ salinity
- Lumpkin R., Pazos M. Measuring surface currents with surface velocity program drifters: the instrument, its data, and some recent results. Cambridge University Press, 2007
- Rio M.-H. 2012. Use of altimeter and wind data to detect the anomalous loss of SVP-type drifter's drogue. American Meteorological Society, Vol. 29, No. 11, pp 1663-1674

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