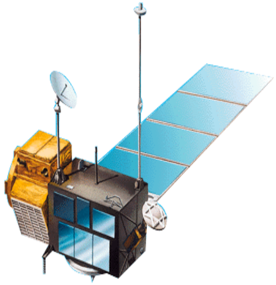


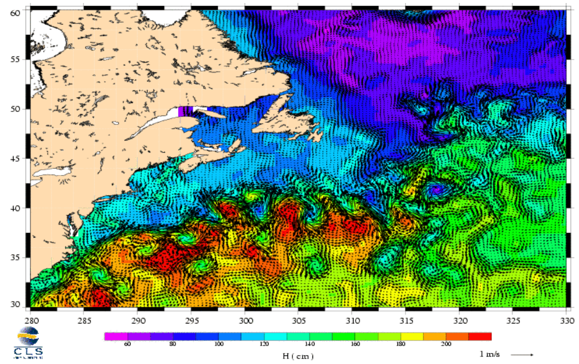
Use of altimeter and wind data to detect the anomalous loss of SVP-type drifters drogue

M-H Rio

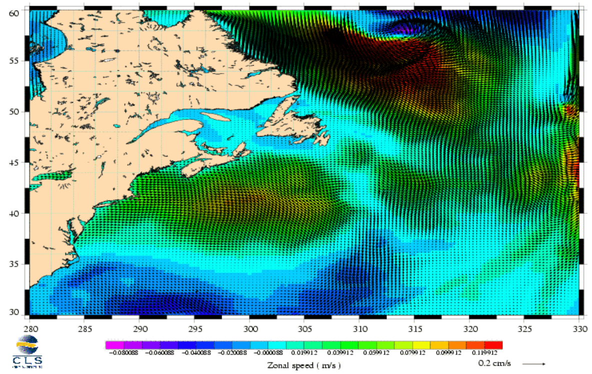
GLOBCURRENT- March 7th, 2012, Brest

CONTEXT : The global SURCOUF current products

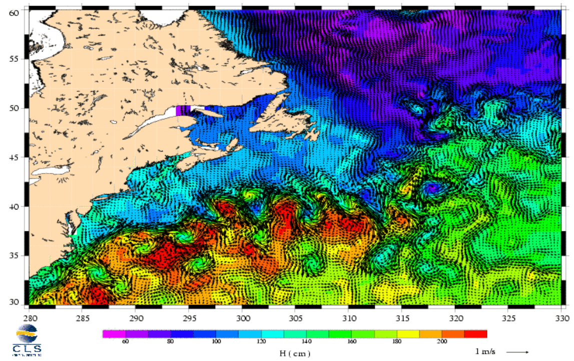
Geostrophic currents



+ Ekman Currents



= Total surface currents

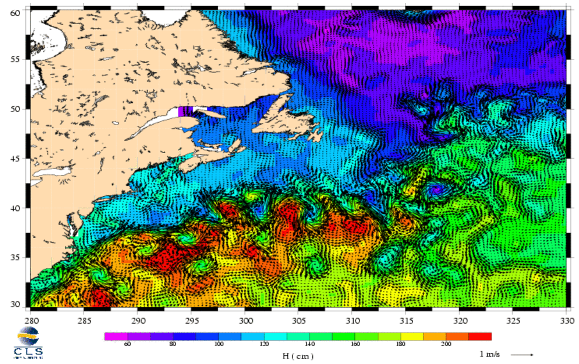


Global maps (1/3°) of dayly geostrophic currents, 6-hourly Ekman currents (+ daily means) and Total currents (geostrophic+Ekman)

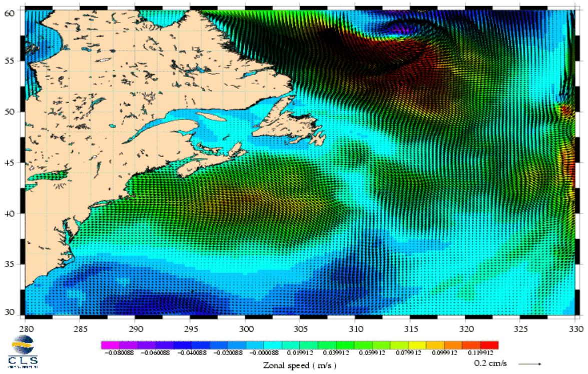
- **Real time**
- **Delayed-time products for the period ranging from January 1993 to January 2011**
- **A Regional product is available in the Kerguelen Islands region (KEOPS project)**

CONTEXT : The global SURCOUF current products

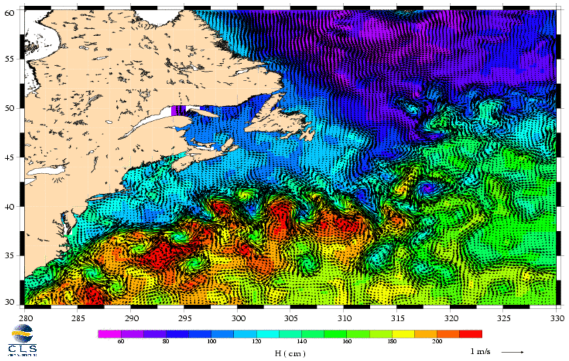
Geostrophic currents



+ Ekman Currents

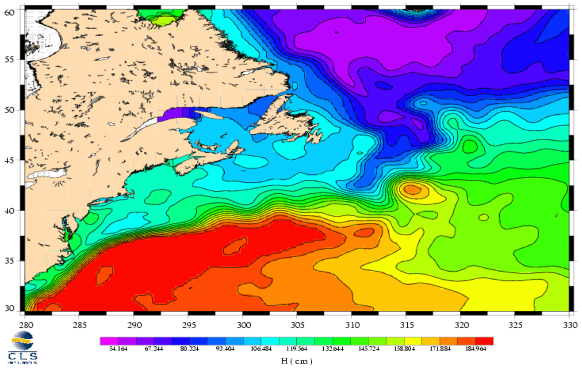


= Total surface currents



Estimation of Ekman currents needed

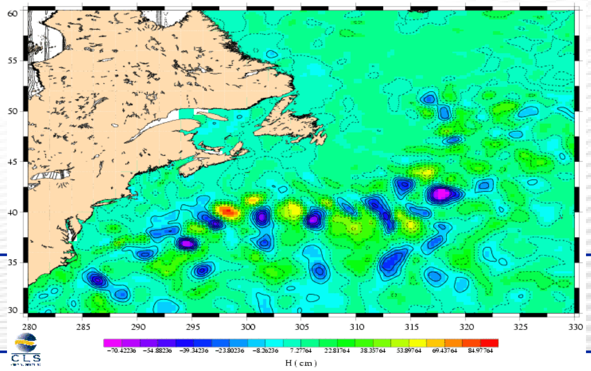
= Mean Dynamic Topography



The MDT used (CNES-CLS09 for the global products, dedicated regional MDT in the Keops area) are based on the combination of:

- ☐GRACE/GOCE data
- ☐ altimeter measurements
- ☐ hydrological profiles (ARGO floats, CTD)
- ☐ **and in-situ drifting buoy velocities**

+ Altimeter Sea Level Anomalies



Processed to extract the geostrophic component only

Estimation of Ekman currents needed

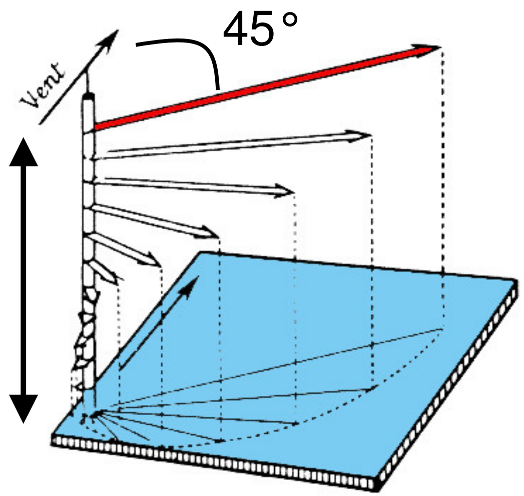
Modelling Ekman currents

Ekman theory

$$u_e = \pm \frac{\pi\sqrt{2}}{\rho f D_e} e^{\frac{\pi}{D_e}z} * \tau * \cos\left(\frac{\pi}{4} + \frac{\pi}{D_e}z\right)$$

$$v_e = \frac{\pi\sqrt{2}}{\rho f D_e} e^{\frac{\pi}{D_e}z} * \tau * \sin\left(\frac{\pi}{4} + \frac{\pi}{D_e}z\right)$$

β θ



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

Band pass filtered 30 hours – 20 days

β and θ are estimated through least square fit

Dataset used: 6-hourly drifting buoy velocities quality controlled, krigged and distributed by AOML

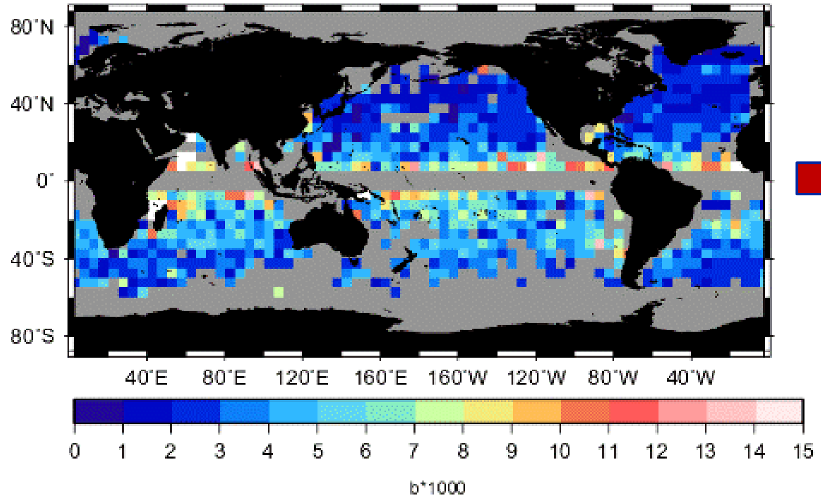
Modelling Ekman currents

Oct-Nov-Dec

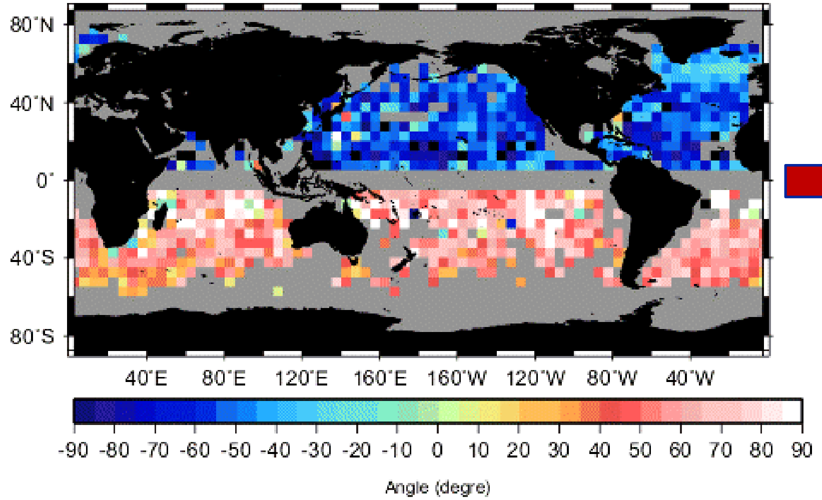
Rio and Hernandez, 2003

1993-1999

β



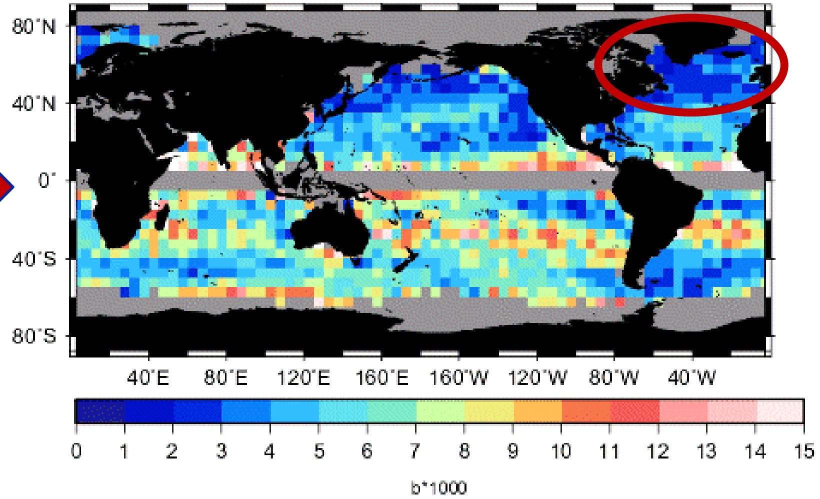
θ



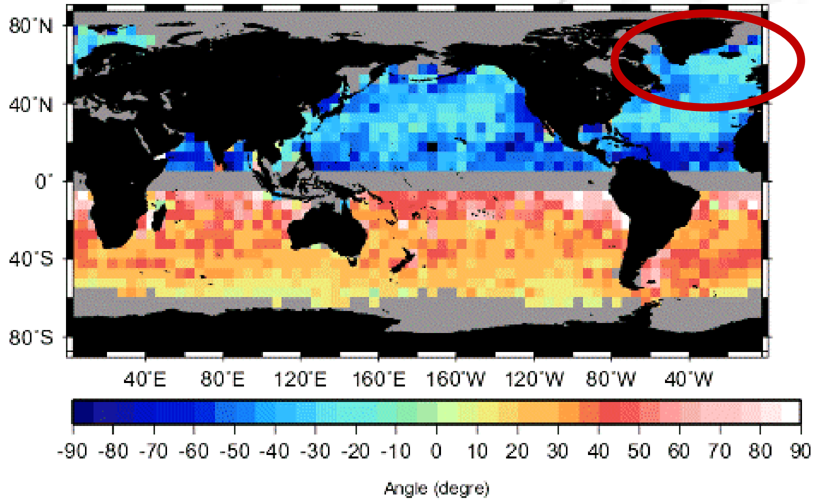
Rio et al, 2011

1993-2008

β



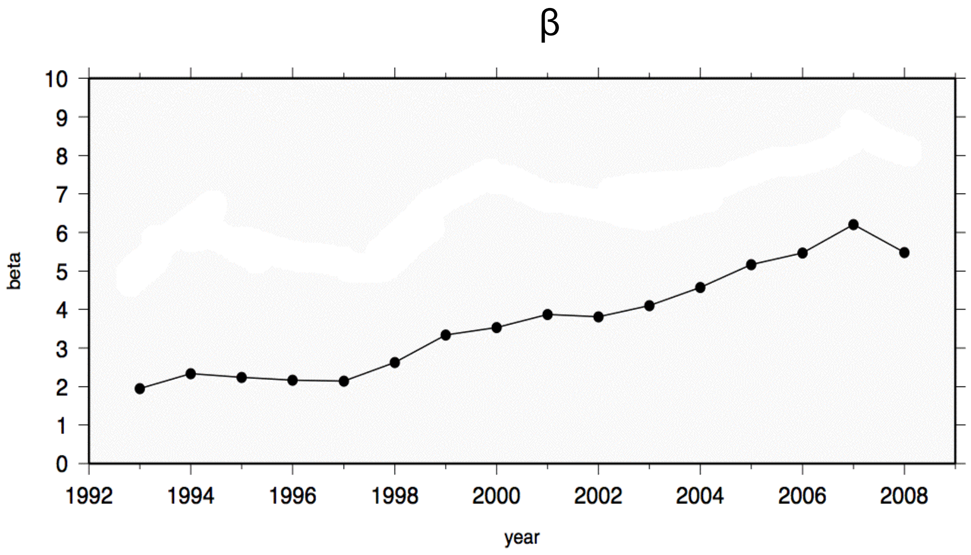
θ

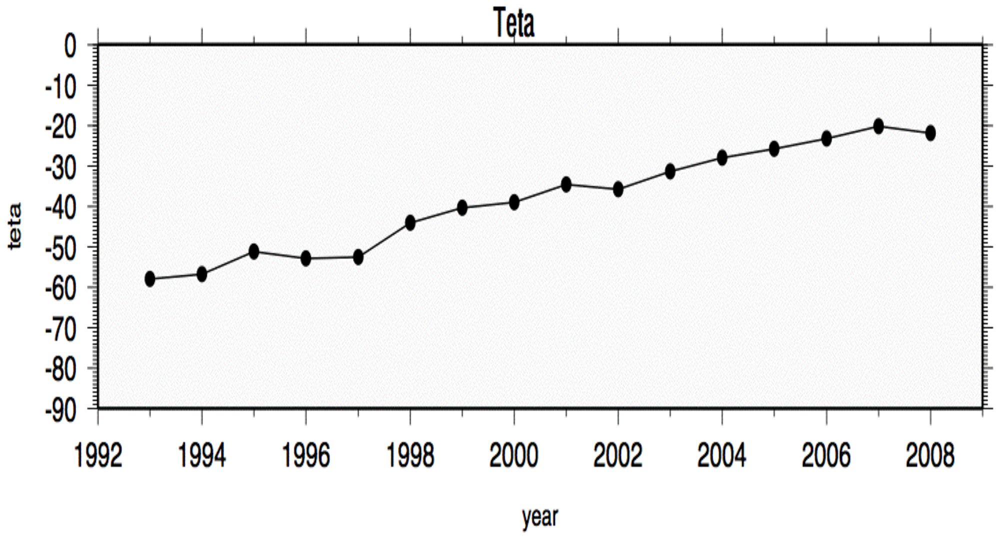


β increases and θ decreases everywhere Except maybe in the North Atlantic sub-polar gyre and the Northern Pacific coastal areas

Modelling Ekman currents

1993-2008 : β and θ computed over the global ocean by year





Strong dependency of β and θ parameters with time

- ✓ Increase with time of parameter β
- ✓ Decrease with time of |θ| - Direction of Ekman currents closer to wind direction

Rio et al, 2011

GEOPHYSICAL RESEARCH LETTERS, VOL. 38, L10606, doi:10.1029/2011GL047393, 2011

Spurious trends in global surface drifter currents

Semyon A. Grodsky,[1] Rick Lumpkin,[2] and James A. Carton[1]

Received 7 March 2011; revised 13 April 2011; accepted 14 April 2011; published 26 May 2011.

be attributed to differences in the vertical scale of wind-driven currents in the tropics and mid-latitudes (easterly and westerly winds, respectively).

[17] Examination of α^d for different years shows that the problem of unidentified undrogued drifters in the "drogue-on" data set arose sometime around late 2003 to early 2004 and steadily become worse until 2006–2007 (Figure 3). Then, very likely due to the phase-in of tether strain gauge technology, the problem gets better by end 2009. Interestingly, the time series of anomalous currents in Figure 2 also indicates significant changes in drifter currents during that same time period. Ultimately, these drifter current changes during the 2000s are the major cause of the spurious temporal trends evaluated over longer periods. Also note that the anomalous behavior of drifter currents does not seem to depend on the particular drogue manufacturer. We suspect, although cannot yet verify, that the reduced effectiveness of the submergence drogue detection technique is in fact a result of the switch to the smaller mini-drogue design.

4. Summary

[18] The Global Drifter Program has been providing

authors will focus on the reasons for the 2000s drogue detection failure and exploring ways to correct these data. Until this reassessment is complete, we recommend that users interested in exclusively drogue-on data use only the first 90 days of data for drifters in the time period January 2004 through December 2008.

[21] **Acknowledgments.** This research is supported by the NOAA/CPO/CCDD. We appreciate comments by P.-M. Poulain and anonymous reviewer.

[22] The Editor thanks Pierre-Marie Poulain and an anonymous reviewer for their assistance in evaluating this paper.

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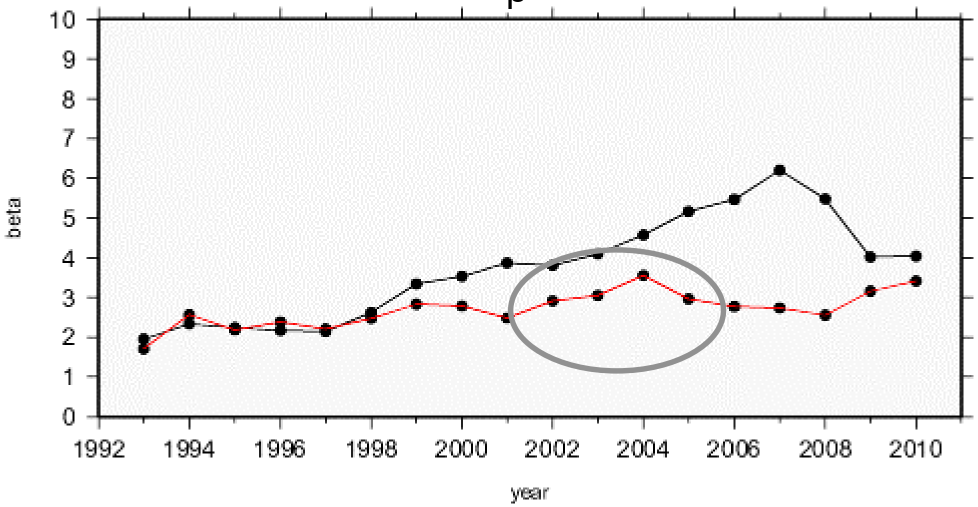
Bonjean, F., and G. S. E. Lagerloef (2002), Diagnostic model and analysis of the surface currents in the tropical Pacific Ocean, *J. Phys. Oceanogr.*, *32*, 2938–2954.

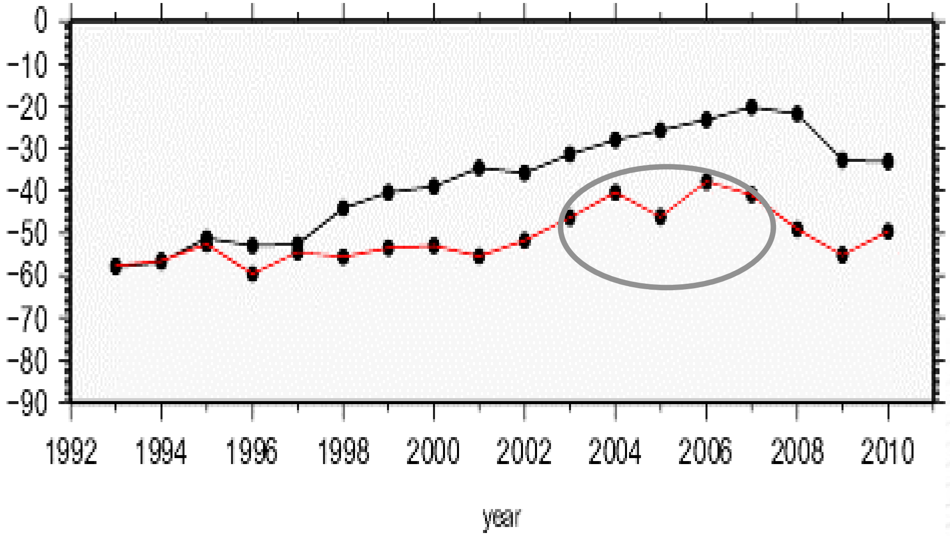
Carton, J. A., and B. S. Giese (2008), A reanalysis of ocean climate using Simple Ocean Data Assimilation (SODA), *Mon. Weather Rev.*, *136*, 2999–3017, doi:10.1175/2007MWR1978.1.

Modelling Ekman currents

β and θ computed over the global ocean by year

β





— ALL

— First three months of each trajectory only (Grodsky et al, 2011)

9 057 338 data

↓

955 337 data

Only 10% of the data kept!

Need for cleaning the AOML drifting buoy dataset for undetected undrogued drifter

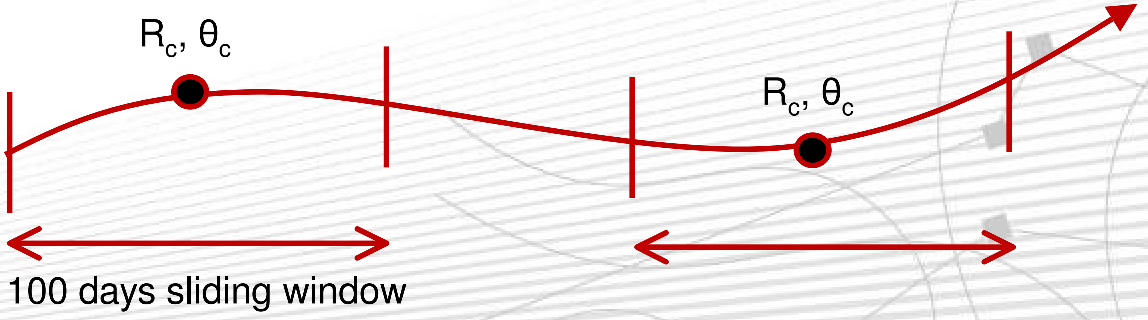
Detecting the drogue loss: Method

✓Ekman currents are subtracted fom the drifter currents -> 'residual' drifter velocity

✓A new Ekman model (β, θ) is computed based on the first three months of the AOML drifter trajectories (by latitudinal band and by month to take into account the spatial and seasonal change in stratification)

✓Altimetric geostrophic currents (AVISO) are subtracted from the drifter velocities
-> 'Ageostrophic' drifter velocities

✓Vectorial correlation between the 'residual' drifter velocity and the wind is computed along the drifter trajectories (only trajectories longer than 200 days are considered)



Detecting the drogue loss: Example

— 'Ageostrophic' drifter velocity vs Wind

'Ageostrophic' velocities = Vbuoy-Valti

Correlation > 0.3
Ekman angle ~60°

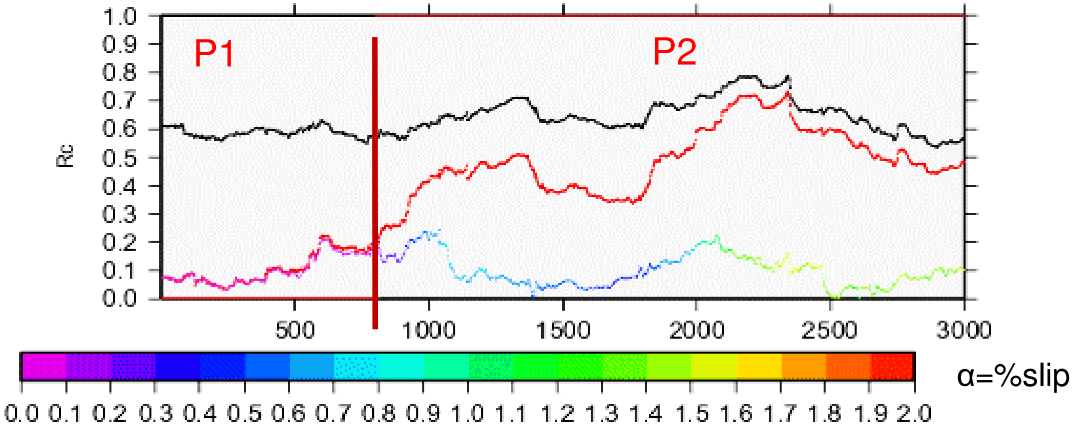
— 'Residual' drifter velocity vs Wind

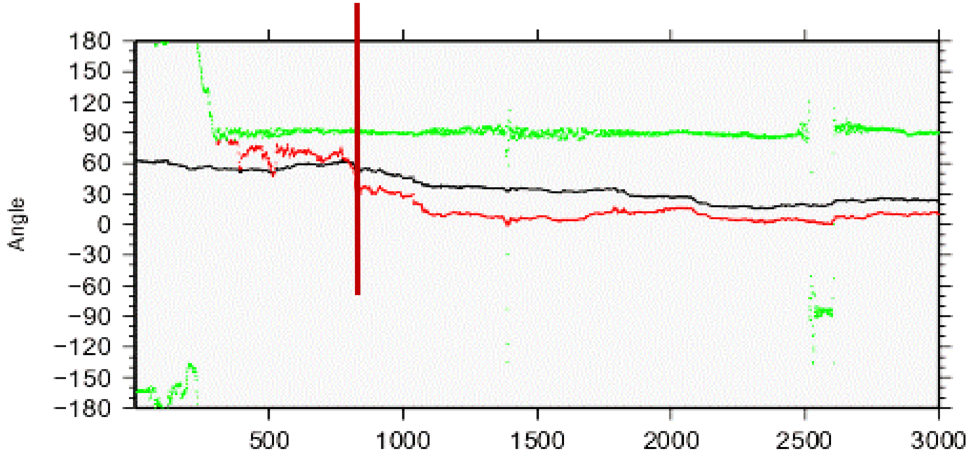
'Residual' velocities = Vbuoy-Valti-Vekman

P1: Correlation coefficient low(<0.3)
Correlation angle uncoherent

P2: Correlation coefficient increases
Correlation angle nearly 0

We are confident that the drogue is ON during P1 and is off during P2





Residual' velocities = Vbuoy-Valti-Vekman-αWind

α ranging from 0% to 2%

— Vbuoy-Valti-Vekman-α_{best}Wind vs Wind

We determine **$\alpha = \alpha_{best}$** that **minimizes the vectorial correlation between the 'residual' velocity and the wind**.

Simple detection method of the drogue loss

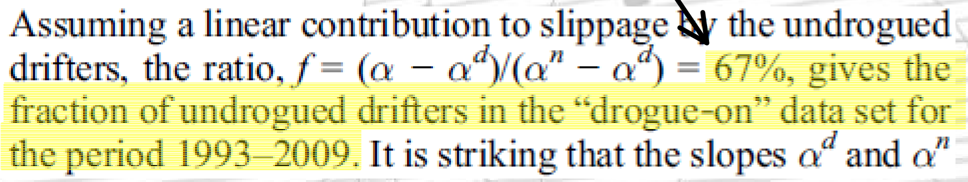
The drogue is considered lost when **$\alpha > 0.3\%$**

Validation of the method: The AOML drifting buoy velocities database including drogued and undrogued data is used

Number of velocity measurements						
All trajectories	Trajectories>200 days	Trajectories >200 days Excluding the first/last 50 days	Flag AOML=1		Flag AOML=0	
			4,441,197		8,117,287	
			Flag$_\alpha$=1	Flag$_\alpha$=0	Flag$_\alpha$=1	Flag$_\alpha$=0
18,065,924	15,009,040	12,558,484	4,073,332 (92%)	367,865 (8%)	4,470,821 (55%)	3,646,466 (45%)

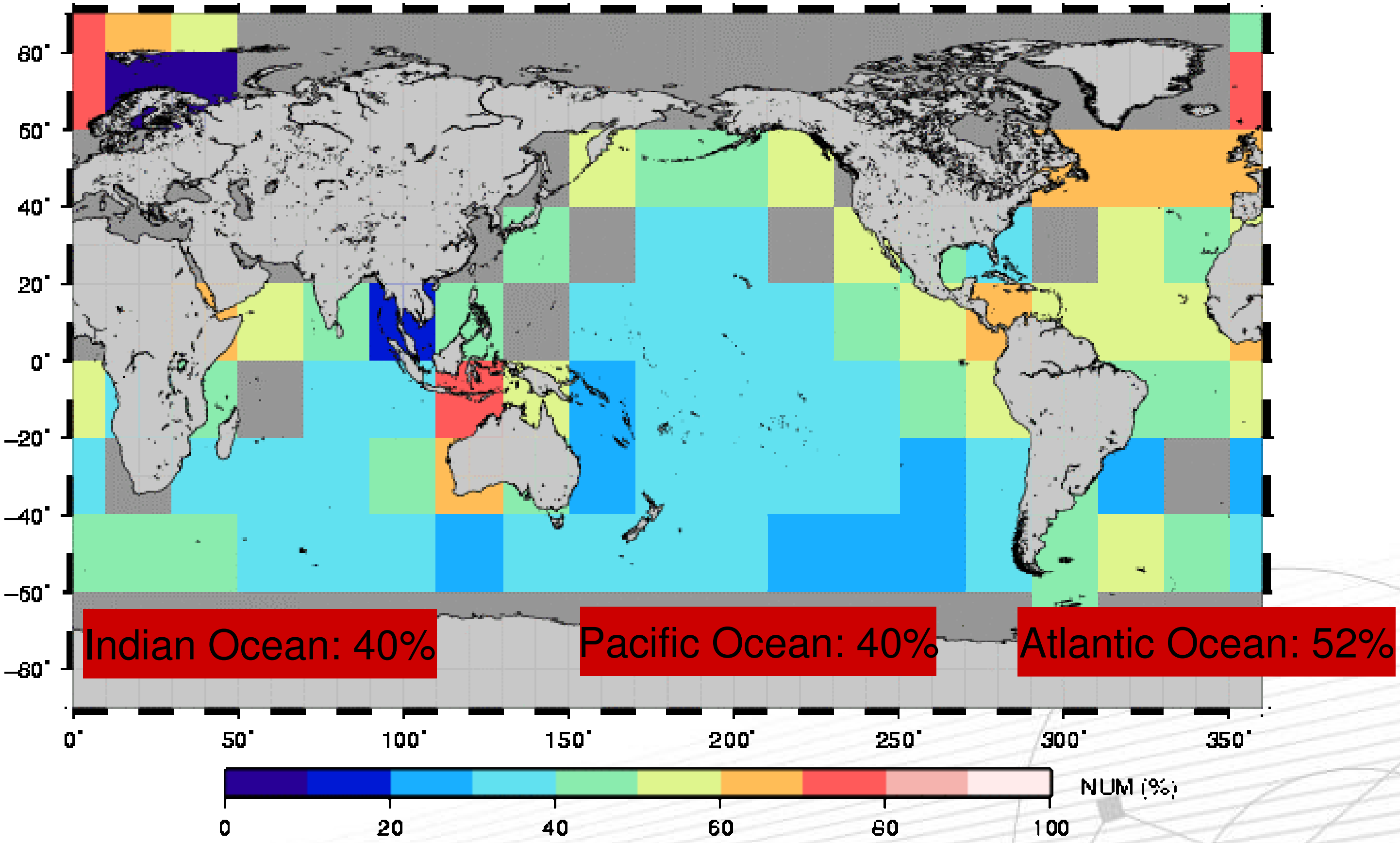
Flag AOML=1: The drogue loss was detected through classical tests (submergence or tether strain gauge)
Flag$_\alpha$ =1: The drogue loss was identified using the method described previously

Grodsky et al, 2011:



Assuming a linear contribution to slippage by the undrogued drifters, the ratio, $f = (\alpha - \alpha^d)/(\alpha^n - \alpha^d) = 67\%$, gives the fraction of undrogued drifters in the "drogue-on" data set for the period 1993–2009. It is striking that the slopes α^d and α^n

Percentage of « drogued » AOML buoy velocities flagged as « drogued » by our methodology



Indian Ocean: 40%

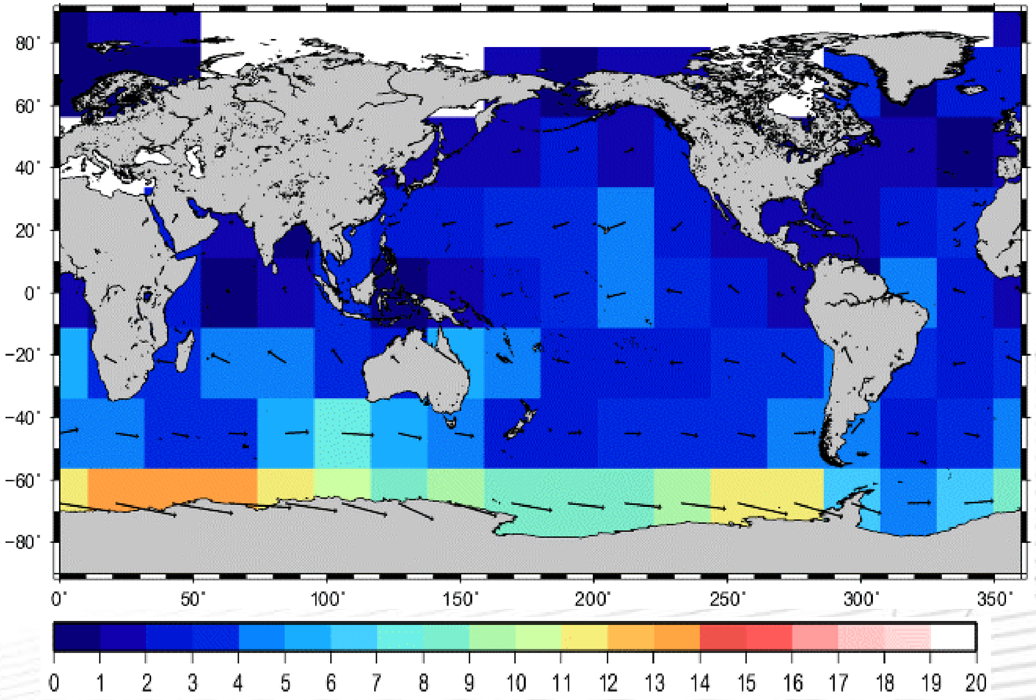
Pacific Ocean: 40%

Atlantic Ocean: 52%

Grodsky et al, 2011: There are regional variations in the magnitude of the fraction of truly drogued drifters. The fraction is higher in the Atlantic and Pacific and lower in the Indian Ocean. This regional difference suggests that drogue life varies among manufacturers, since their deployment is not homogeneous from one basin to the next. We also note

Corrective term due to the direct action of the wind on an undrogued buoy: α_{best}Wind

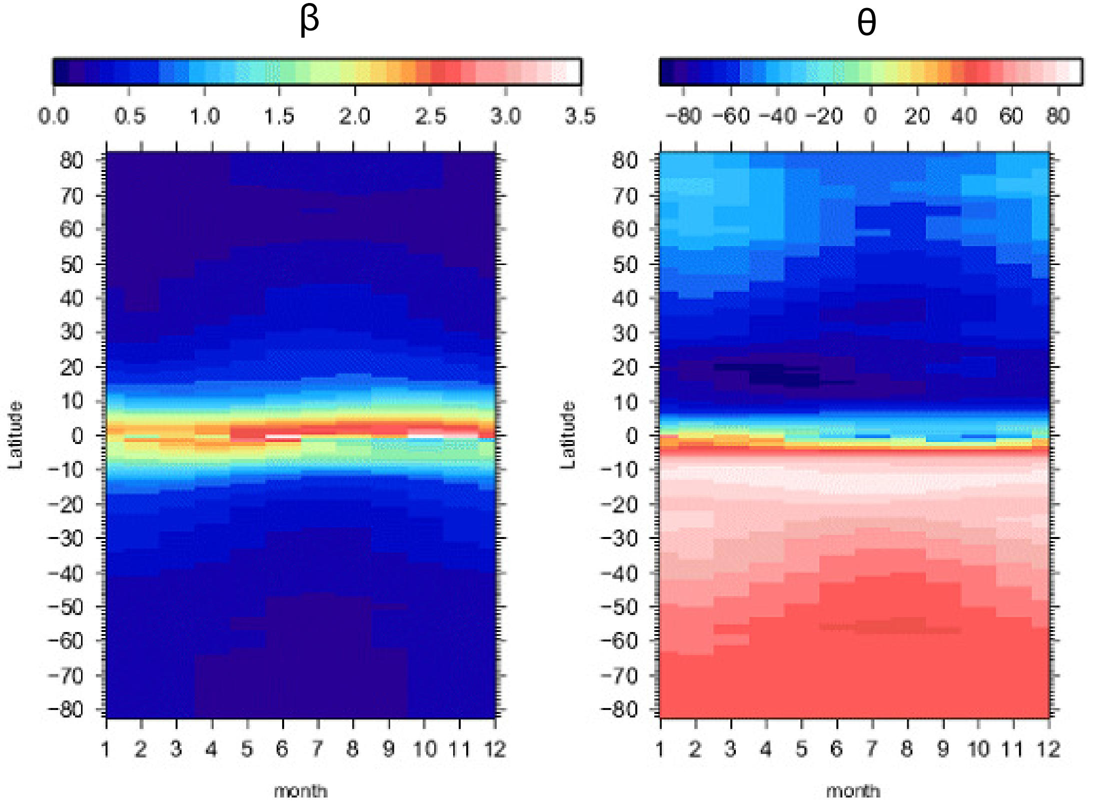
Averaged over the 1993-2010 period into 20° by 20° boxes



cm/s

Use of the « cleaned » velocity dataset to compute a « steady » Ekman model

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

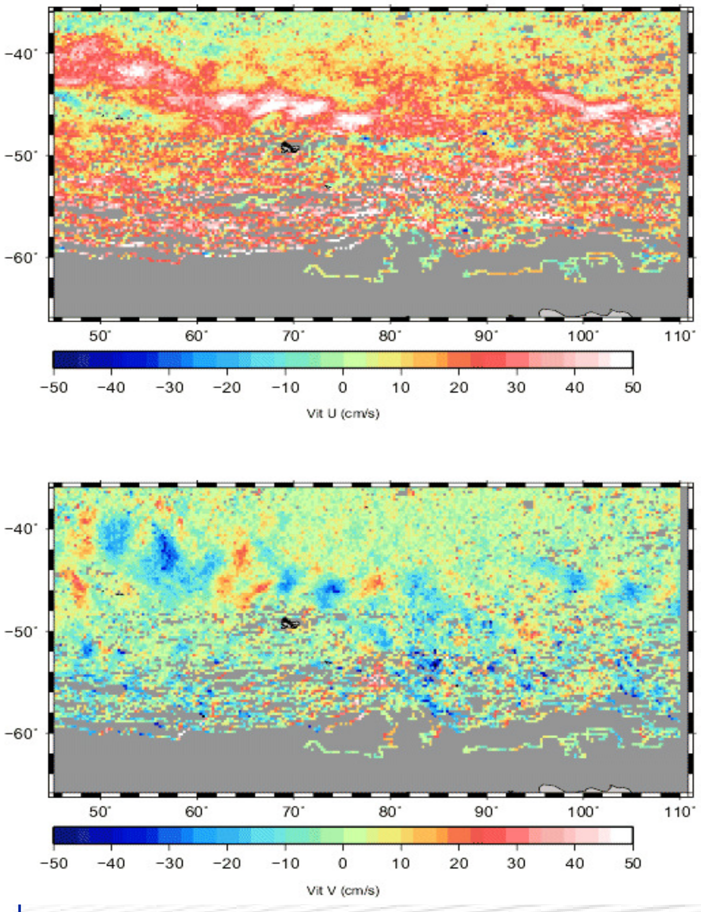


In summer/ at low latitudes,
ocean is more stratified => De decreases => $\beta = \frac{\pi\sqrt{2}}{\rho f D_E} e^{\frac{\pi}{D_E}z}$ increases

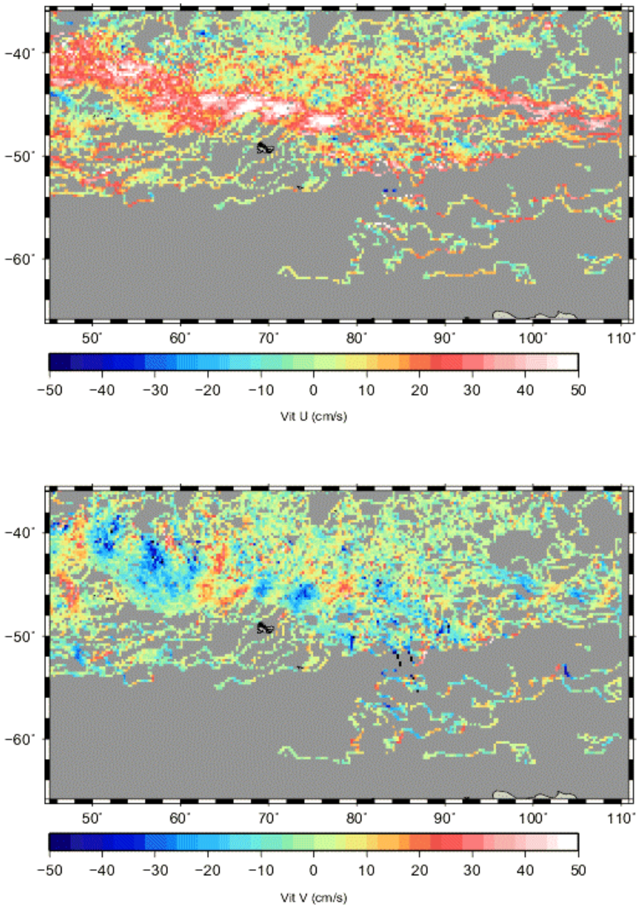
=> $|\theta| = \left(\frac{\pi}{4} + \frac{15}{D_e}\right)$ increases

KEOPS project: Mean geostrophic velocities in the ACC around the Kerguelen island: Impact of using the corrected velocity dataset

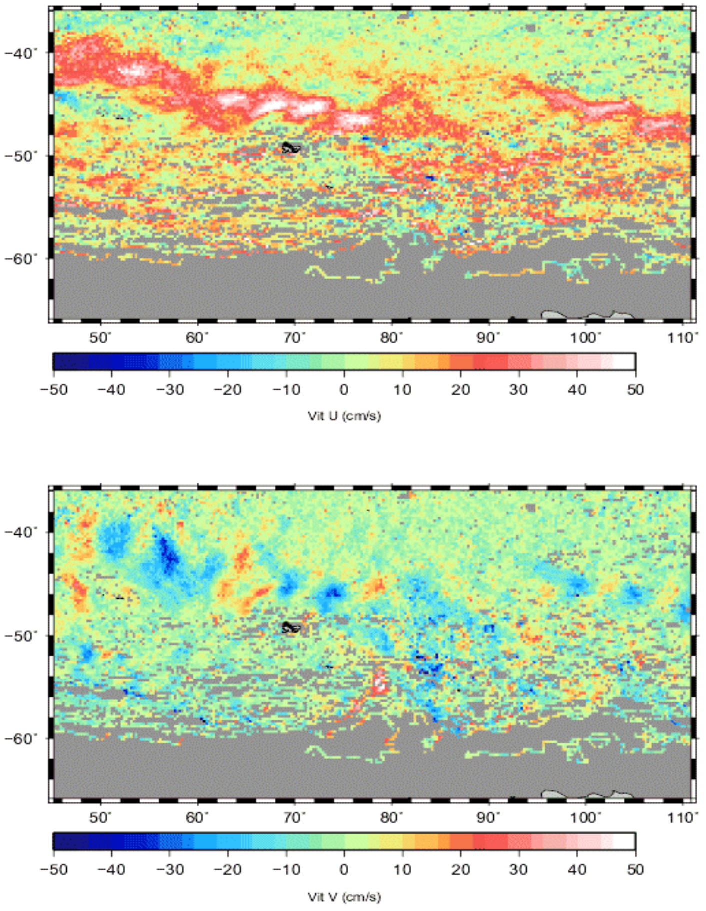
New Ekman model
All buoys (drogued and undrogued)



New Ekman model
Drogued buoys only



New Ekman model
+ wind slippage correction
All buoys (drogued and undrogued)



CONCLUSIONS

❑ A method was developped that allows **detecting the drifter drogue loss** and **providing an estimate of the wind slippage to be used as a velocity correction**.

❑ Our approach removes 55% of the velocity measurements from the AOML “drogued” dataset with spatial variations (less undetected undrogued velocities in the Atlantic ocean and the North Pacific coastal areas)

❑ The ‘truly’ drogued data were then used to estimate a new Ekman model for the global ocean (by latitudinal band and by season) that is stable over the 1993-2010 period.

❑The method was tested and applied on delayed-time data. Further developments are needed to detect the drifters drogue loss in real-time.

❑The SVP drifters are a key dataset for oceanographers, often used as reference in validation procedures and that will be assimilated into ocean operational forecasting systems in the future. **The availability of a clean dataset is therefore a crucial need for the current products providers/users, both in delayed-time and in real-time**.

CONCLUSIONS

❑ The computation of Ekman currents is a key component of the SURCOUF surface currents products computed at CLS:
-Maps of altimeter geostrophic currents: Extraction of the geostrophic component from the drifting buoy velocities entering in the computation of the ocean Mean Dynamic Topography
-Computation of Ekman currents maps to be added to the altimeter geostrophic velocity maps (= total surface currents)

❑Recent and repeated failures in the SVP-type drifter drogue loss detection system (based on tether strain gauge or submergence tests) have led to an increasing number of undrogued drifters into the “drogued” drifters dataset distributed by AOML (Grodsky et al, 2011).

❑This problem is found to fully explain the anomalous decennial variability of the Ekman response to wind stress detected by (Rio et al, 2011).