Ocean Surface Topography Science Team Meeting, October 28-31, 2014, Konstanz, Germany

New mean dynamic ocean topography derived from a synthesis of satellite altimeter, gravity, and scatterometer data and trajectories of Lagrangian drifters

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OSTST 2004 St Petersburg, FL

THE DYNAMICS OF OCEAN SURFACE CIRCULATION STUDIED USING ALTIMETER, LAGRANGIAN DRIFTER AND WIND DATA

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Scripps Institution of Oceanography

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Absolute mean sea level from the balance of horizontal momentum

Momentum equation in the upper ocean:

$$dV/dt + f \times V = -\,g\,\nabla(\langle h\rangle + h') + \partial\tau / \partial z / \rho_0 + \text{H.O.T.}$$

Estimate of the time-mean sea level gradient from an instantaneous observation:

$$\nabla\langle h\rangle \sim \boxed{\underline{G} = -(dV/dt + f \times V)/g \qquad -\nabla h' \qquad +\partial\tau / \partial z / (\rho_0 g)}$$

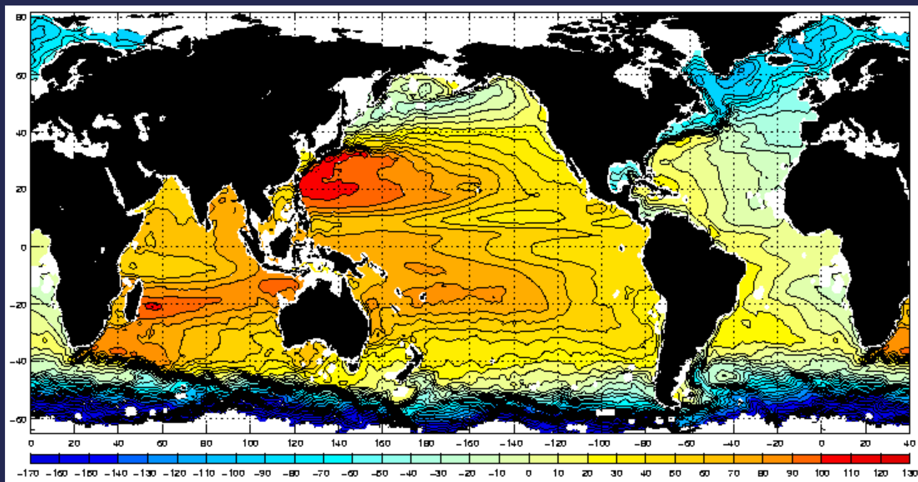
SVP drifters	Aviso/Enact	NCAR/NCEP
$V_{15m} \cong dr/dt$	grided altimetry	re-analysis wind
	$\langle h'\rangle=0$	RN99

Ralph & Niiler (1999) Ekman parameterization (for the Tropical and low-latitude Pacific) of Ekman velocity:

$V_E = A \cdot |f|^{-1/2} \cdot W \cdot \{i \cdot \varphi_o\}$, $\qquad \varphi_o = 54^0 \cdot \text{sign}(\theta)$, $\qquad A=7 \cdot 10^{-7}\ s^{-1/2}$

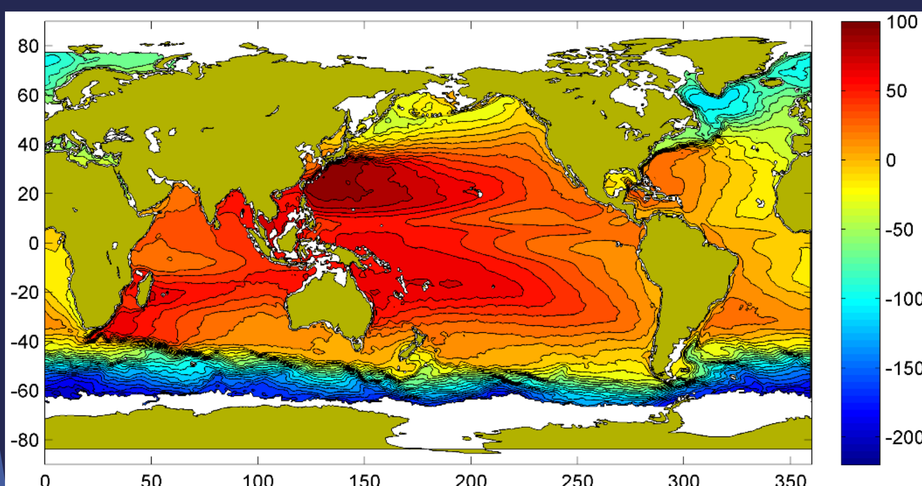
and $\qquad \partial\tau / \partial z / \rho_0 = f \times V_E$

1992-2002 mean dynamic ocean topography on ½ degree grid



Niiler, Maximenko, McWilliams (2003)

Ekman parameterized using GRACE-based MDOT



Maximenko, Niiler, Zlotnicki, Chambers (2005)

Drifter- and GRACE-based MDOTs synthesized

Technology of synthesis:

Input:

- MDOT gradient estimates from momentum equation

$$\nabla\langle h\rangle = -(dV/dt + f \times V)/g \quad - \quad \nabla h' + \quad f \times \mathrm{Vekman}/g$$

drifters altimetry parameterizations

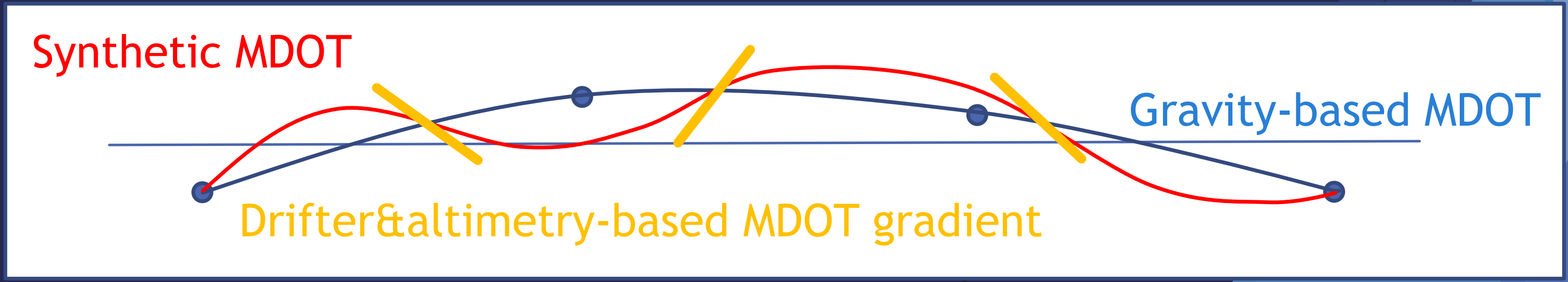
- MDOT estimates <h> from gravity-based products

Important difference from CLS MDOT: Argo & CTD profiles are not used

Cost function:

$$CF = \sum (\nabla\, MDOT - \nabla\langle h\rangle)^2 + A^* \sum (MDOT - \langle h\rangle)^2 + B^* Smoothing$$

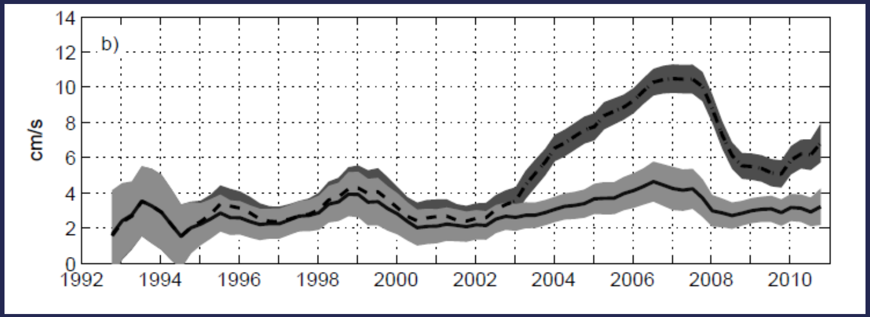
Coefficients A & B define scale separation



Important changes since 2005

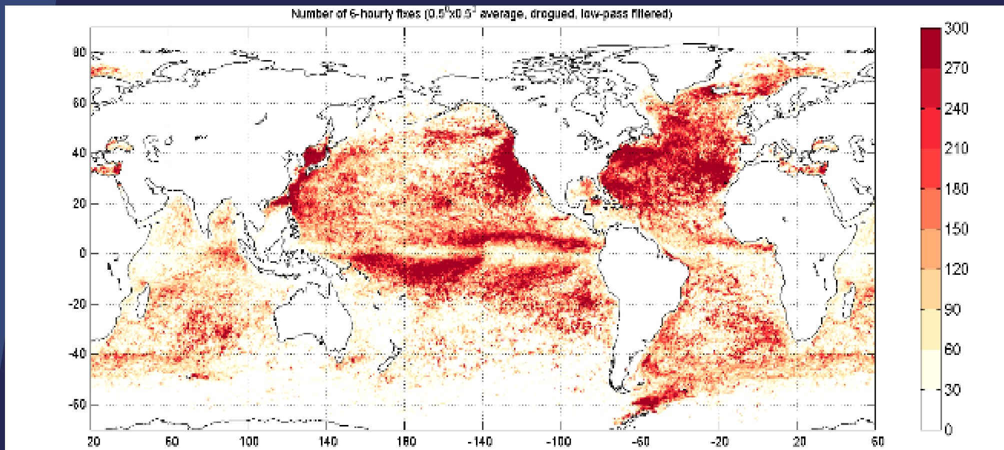
- Altimetry dataset nearly doubled
- Drifter dataset nearly doubled
- GOCE significantly improved the geoid model
- Reprocessed drifter drogue sensor data

Ageostrophic drifter velocities in ACC (40-60S) before and after correction

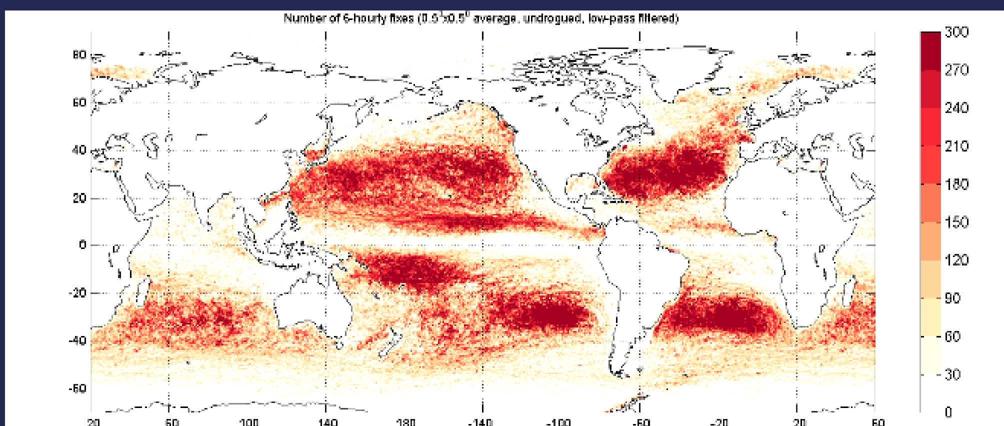


(Lumpkin, Grodsky, Centurioni, Rio, Carton, Lee, 2013)

In new classification more than 50% of information are from undroqued drifters



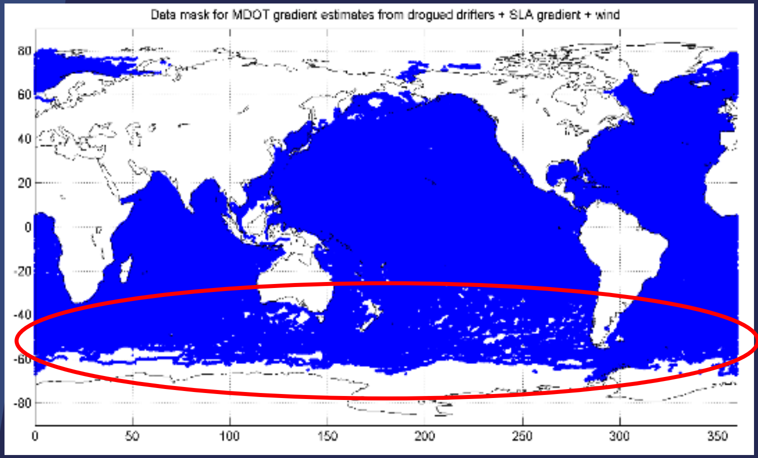
Data density of drogued drifters corresponds with regional deployments



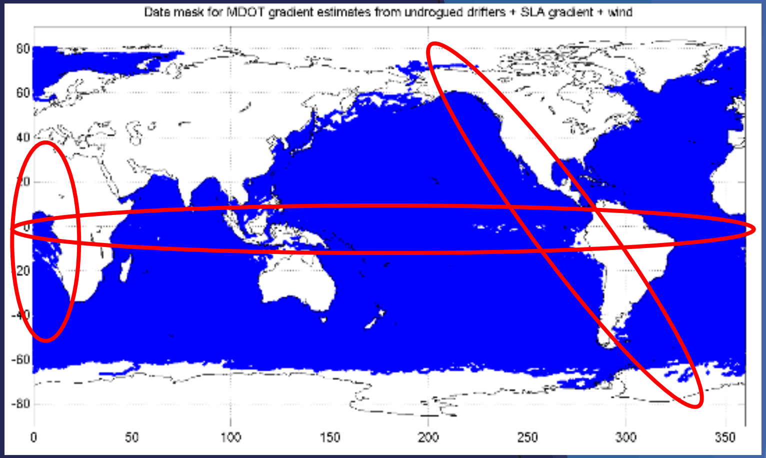
Data density of undrogued drifters excellently highlights “garbage patches”, collecting marine debris

Data masks for:

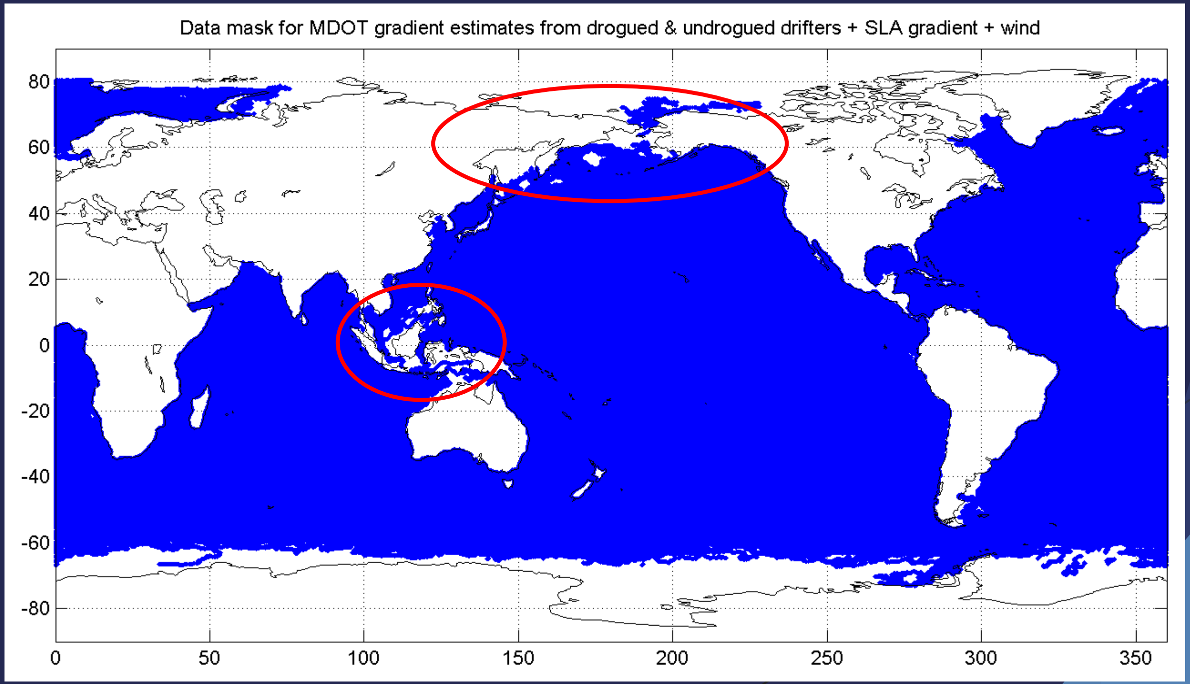
drogued



undrogued



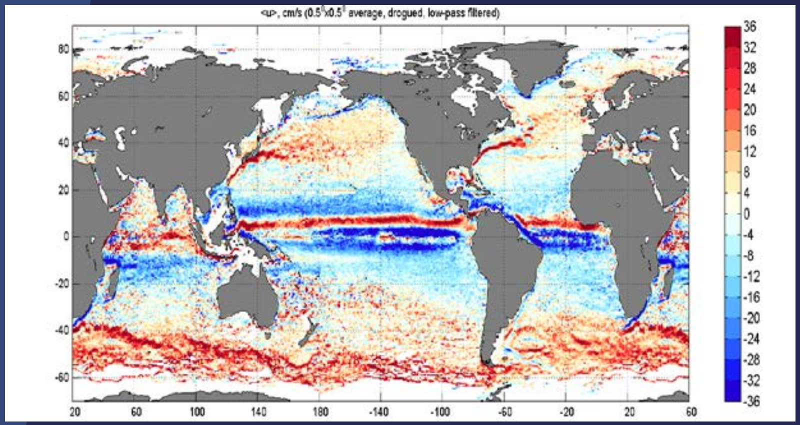
Combined coverage is satisfactory if the bias can be corrected

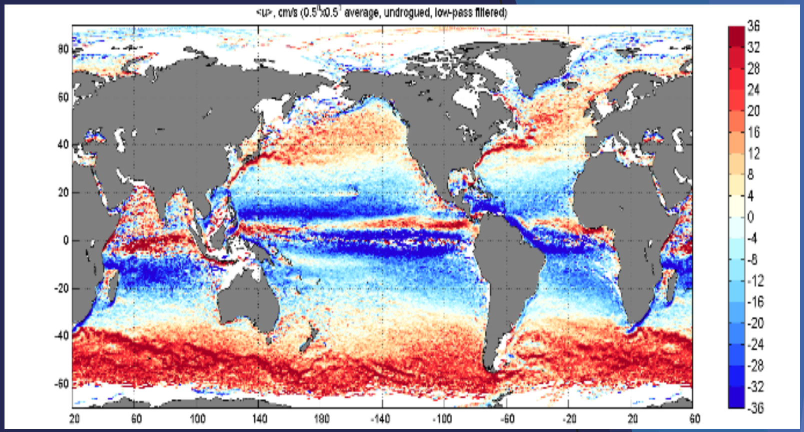


Mean zonal drifter velocities

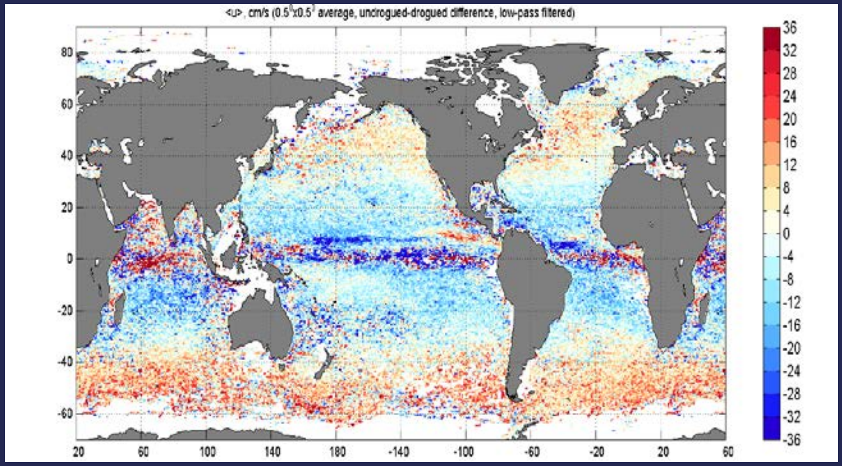
drogued

undrogued





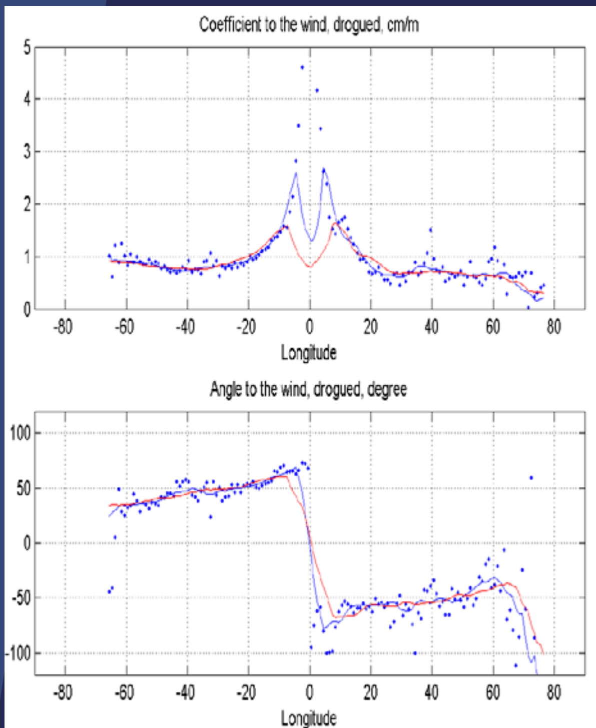
difference



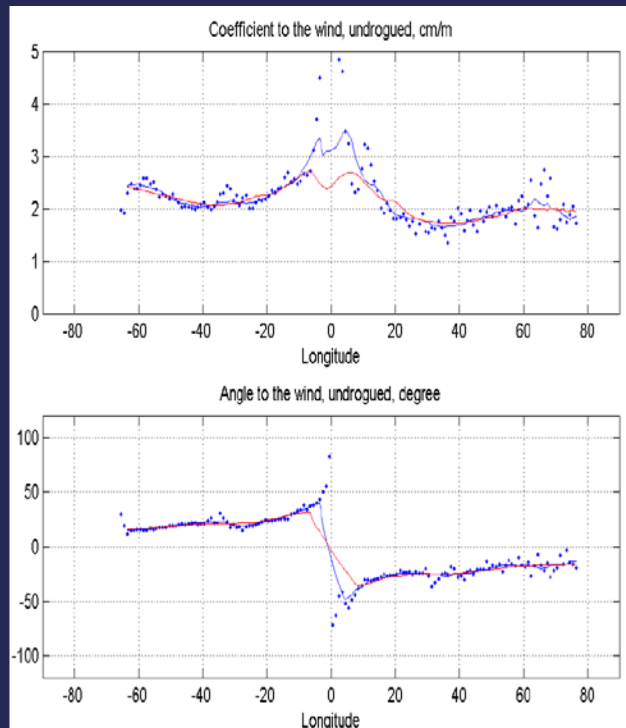
The difference is significant

Coefficients (top) & angles (bottom) in 1-degree latitude bands

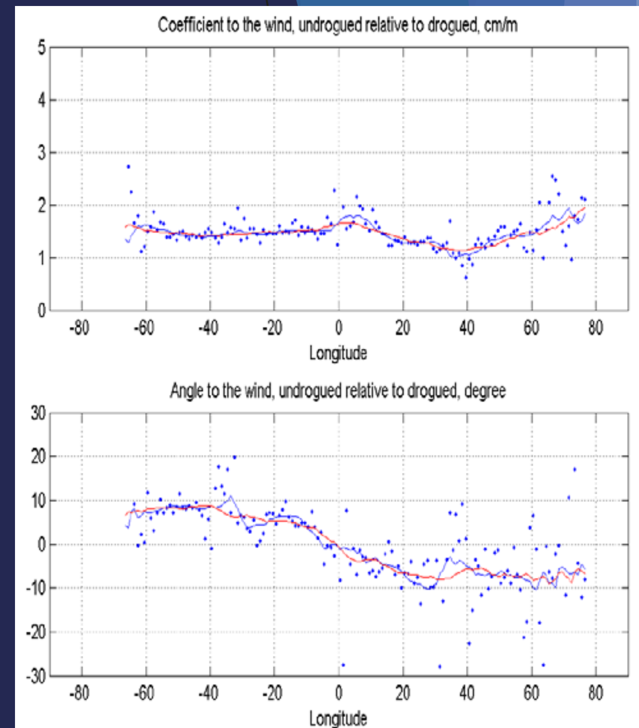
drogued to wind



undrogued to wind



unrogued to drogued

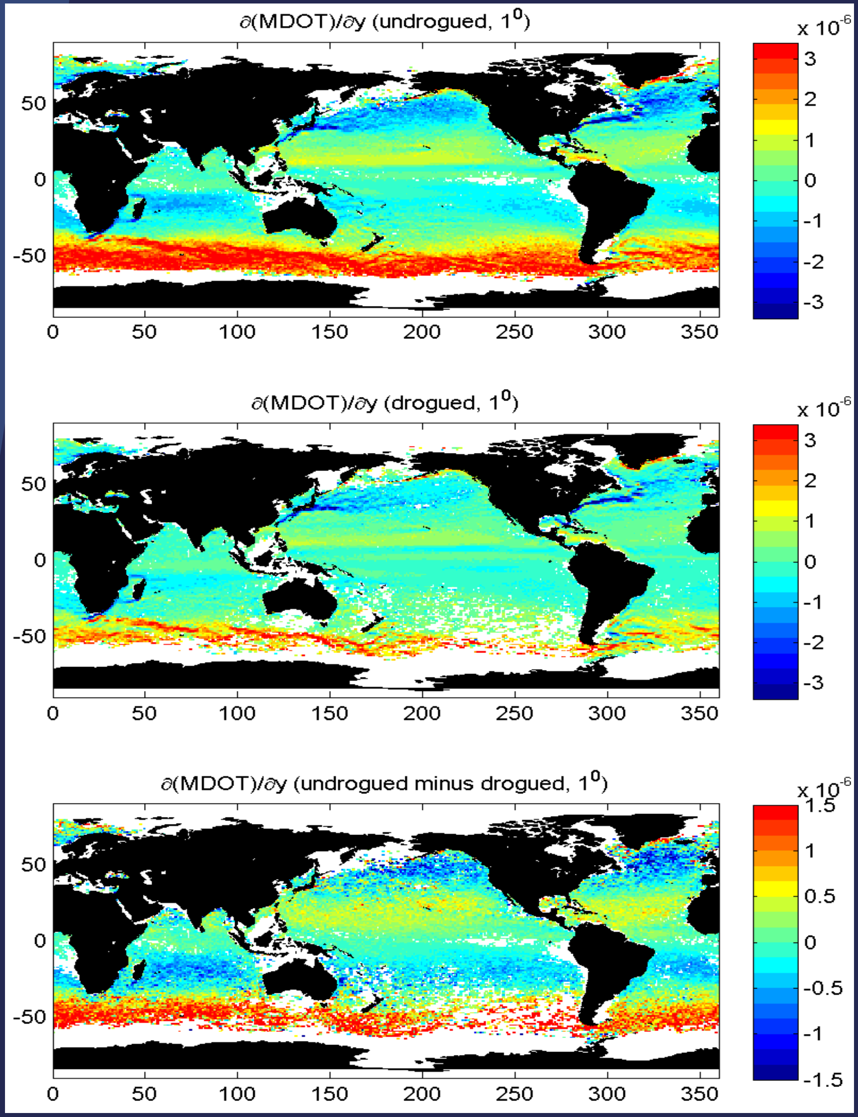


latitude

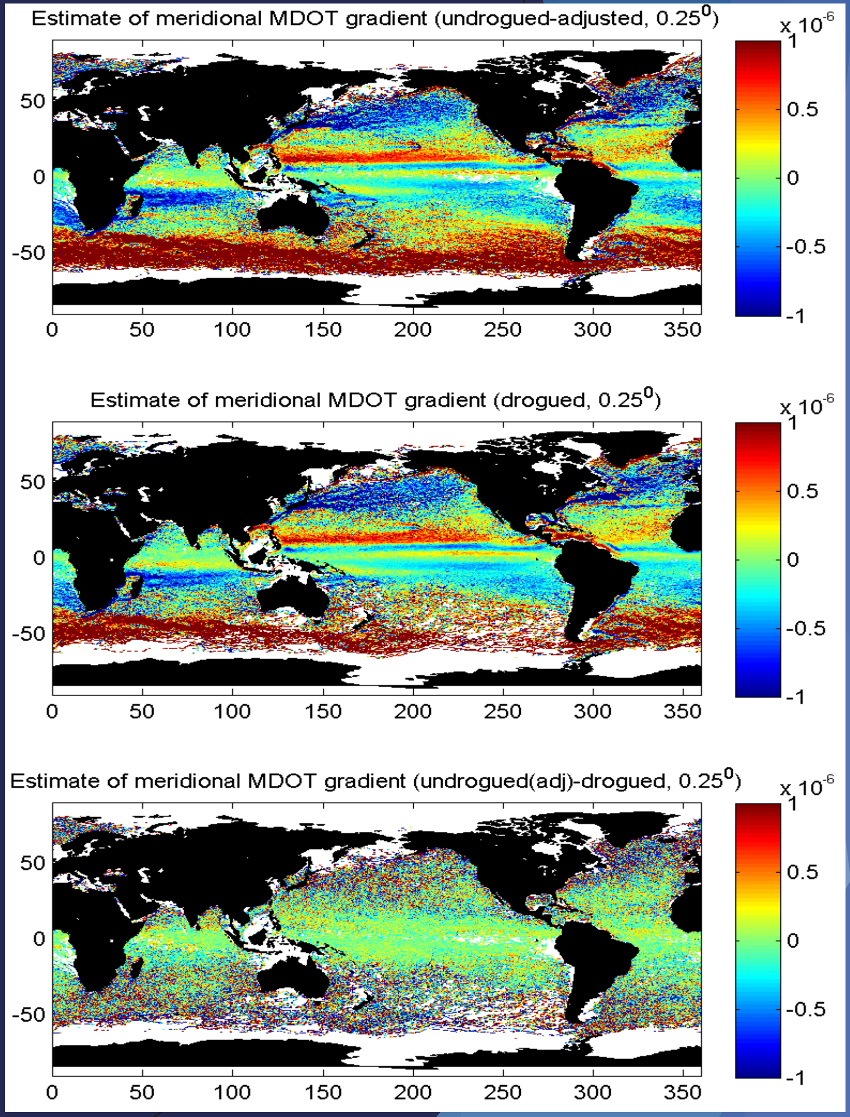
Coefficients and angles are consistent with the Ekman spiral and down-wind slip

Comparison between estimates of zonal MDOT gradient from undrogued (top) and drogued (middle) drifters before (left) and after (right) unbiasing their response to the wind

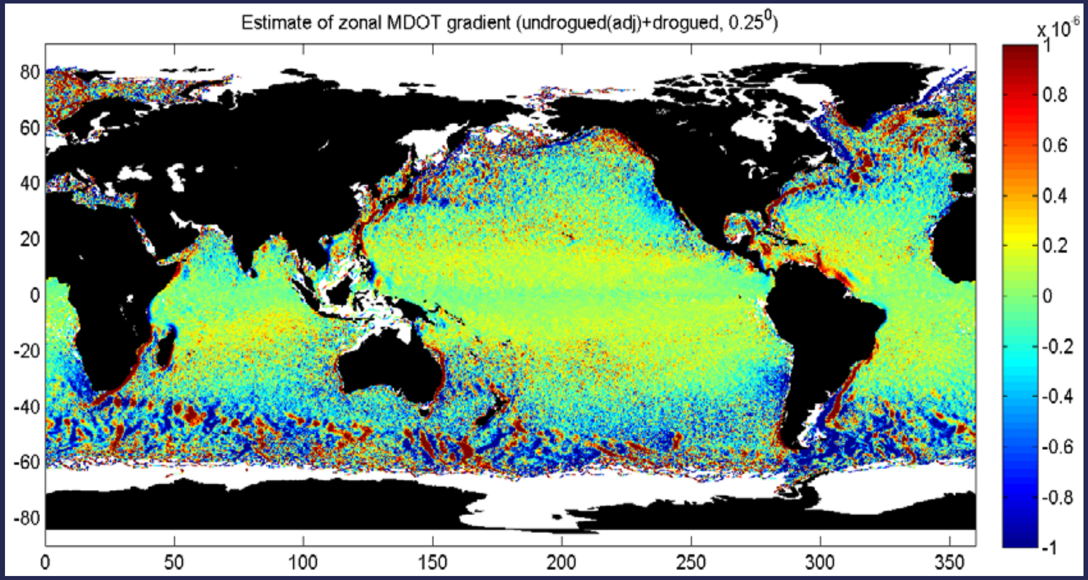
Before unbiasing



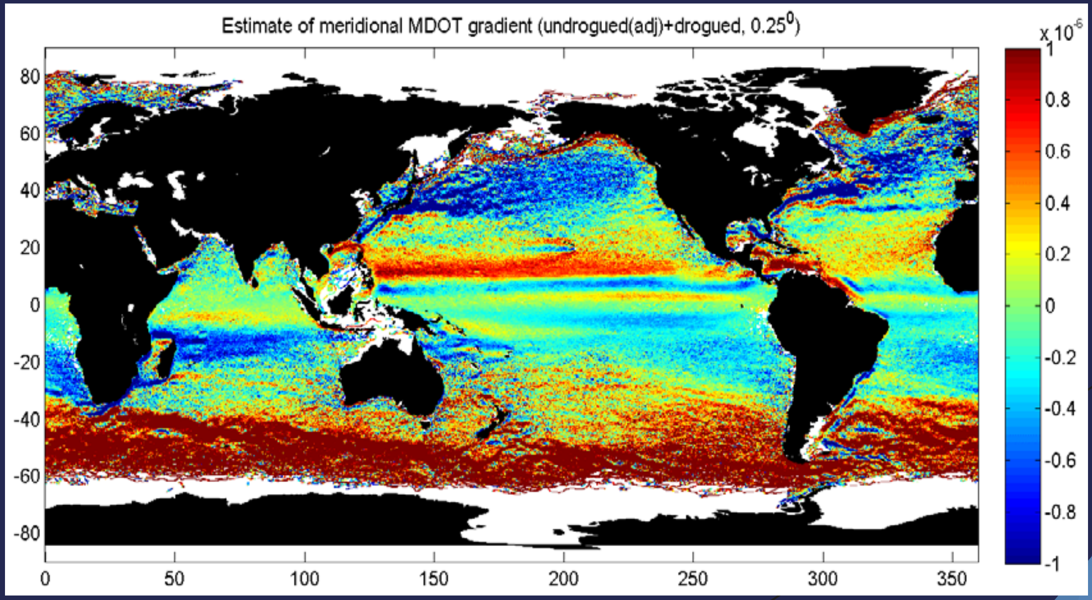
After unbiasing



MDOT gradient estimates after unbiasing, without Ekman elimination

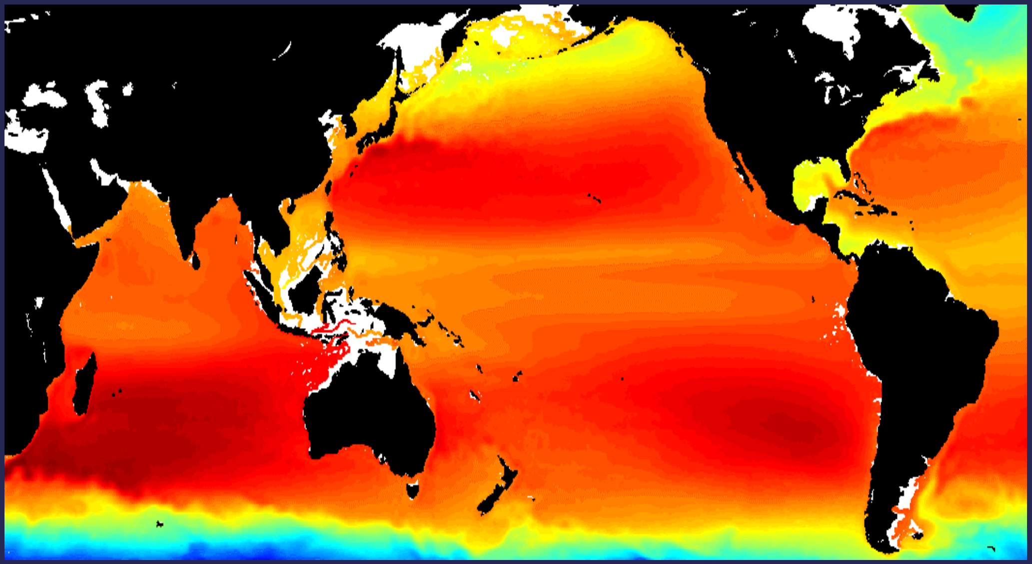


zonal

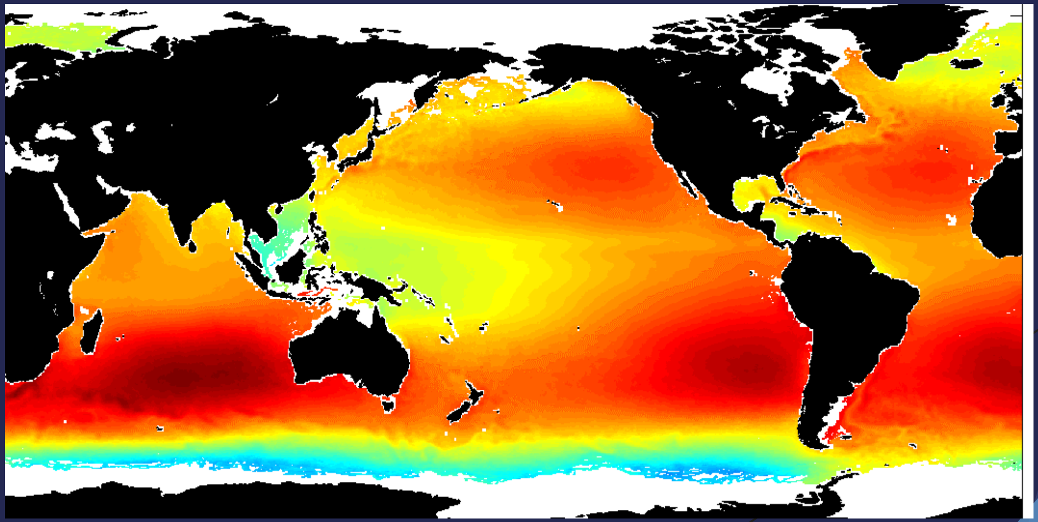


meridional

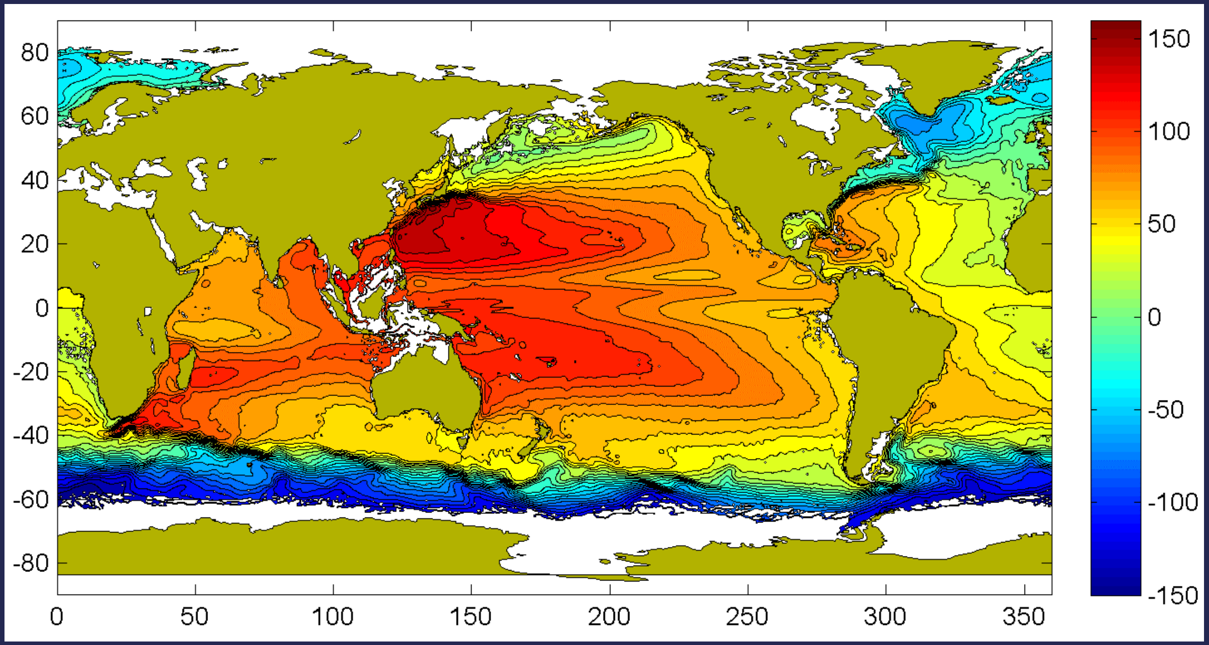
MDOT, calculated from gradient estiamtes on the previous slide



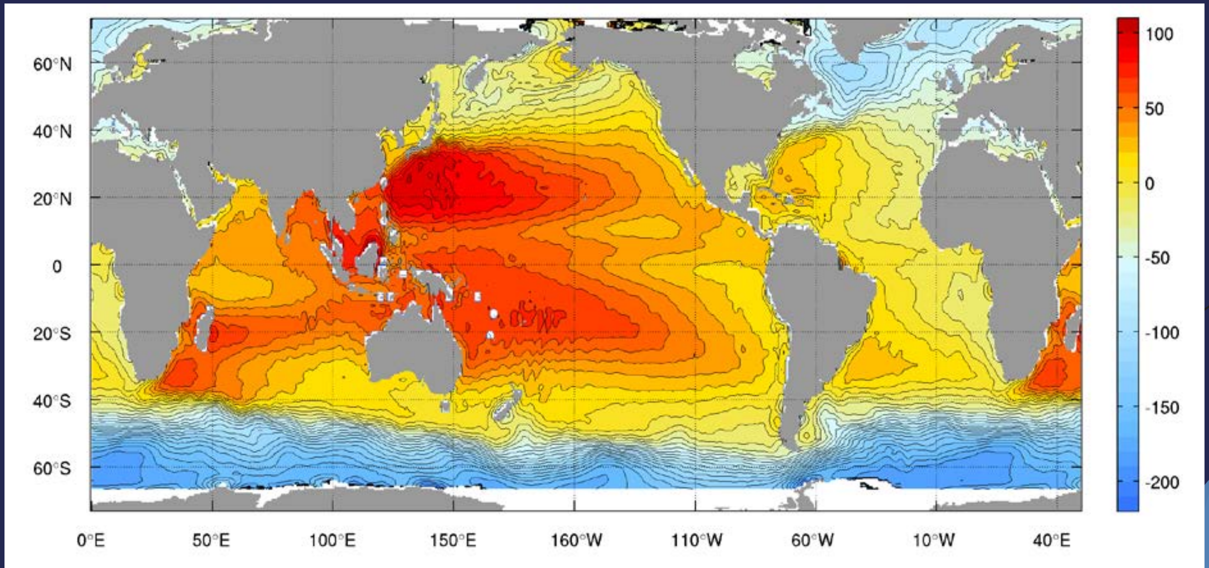
Difference from the GOCE-based MDOT



GOCE – based MDOT (P.Knudsen & O.Andersen, 2013)

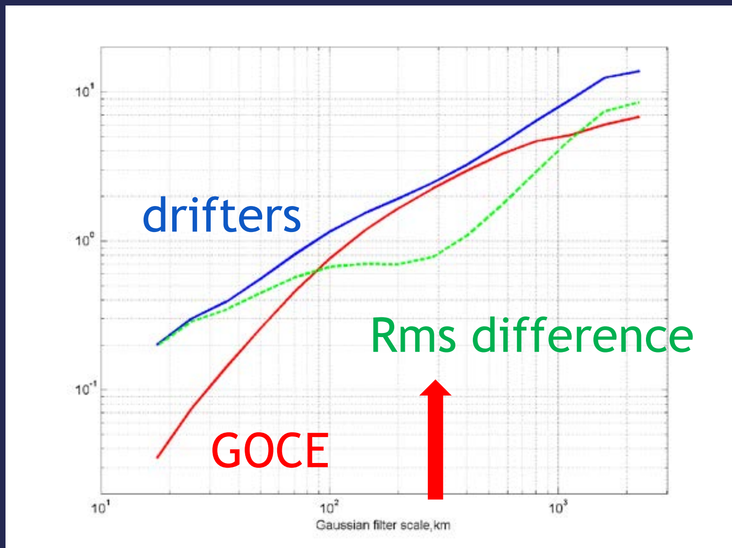


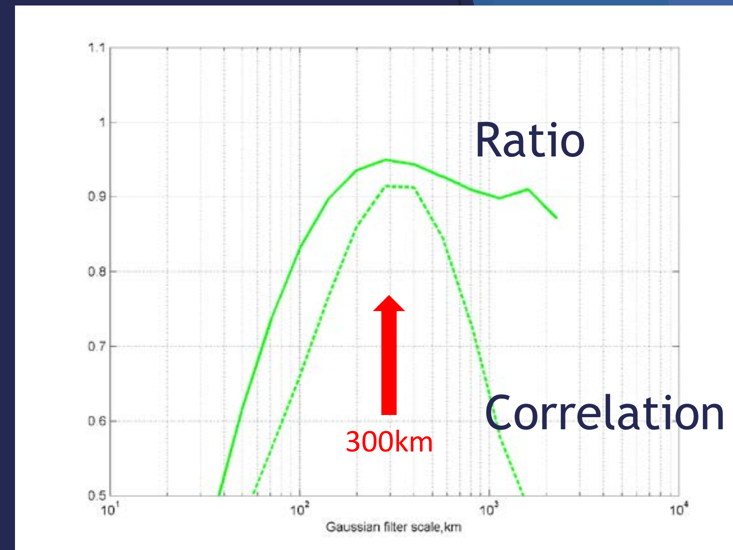
GRACE – based MDOT (D. Chambers & V.Zlotnicki, 2005)

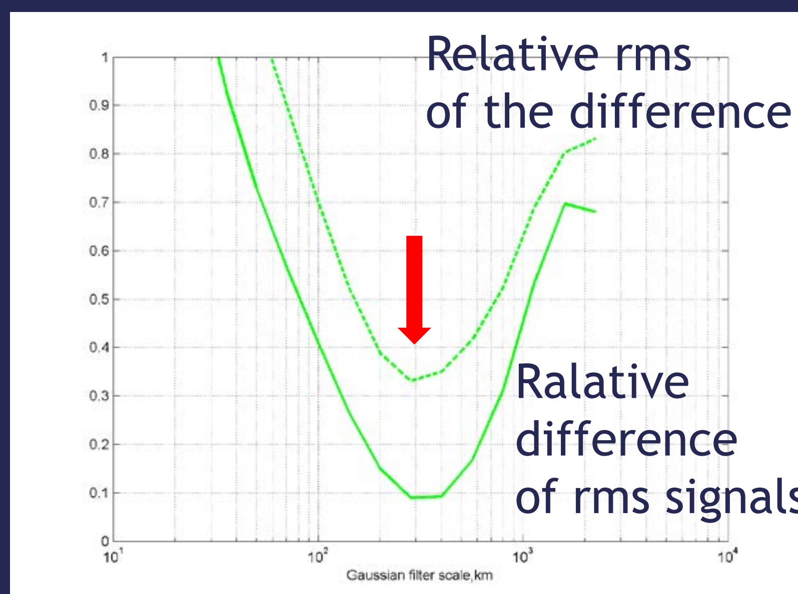


Choice of scale to synthesize drifter and GOCE products

RMS band-pass filtered signals



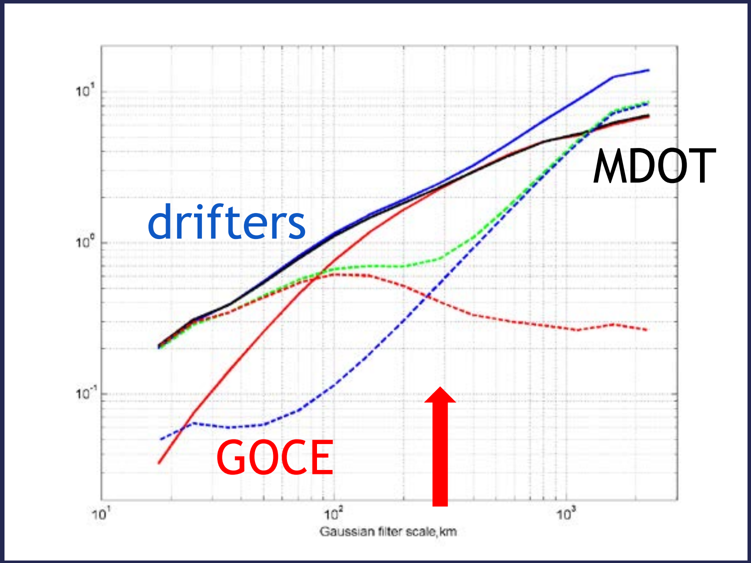


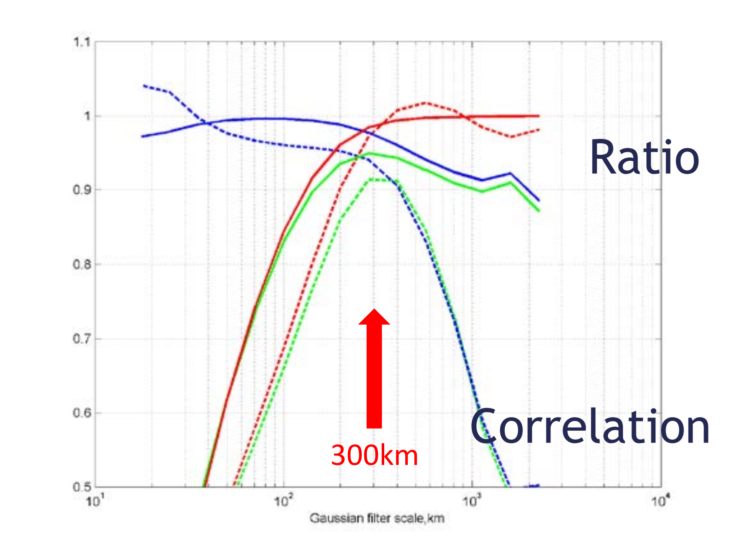


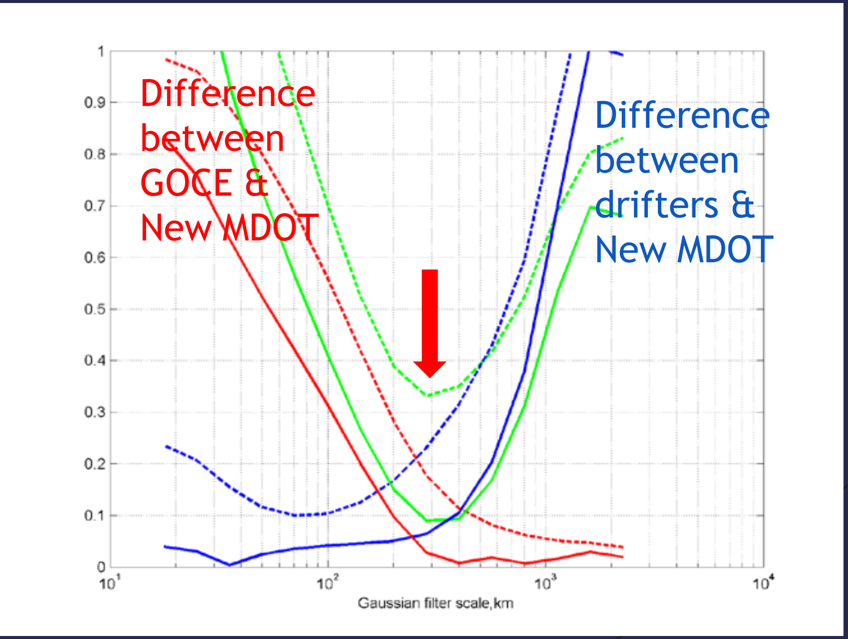
Best global correspondence between drifter- and GOCE-based MDOTs is on 300 km

Choice of scale to synthesize drifter and GOCE products

RMS band-pass filtered signals

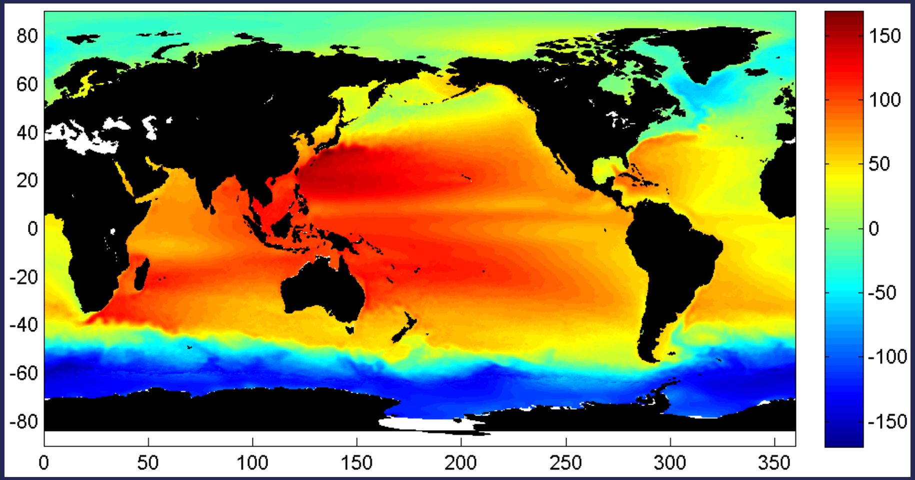




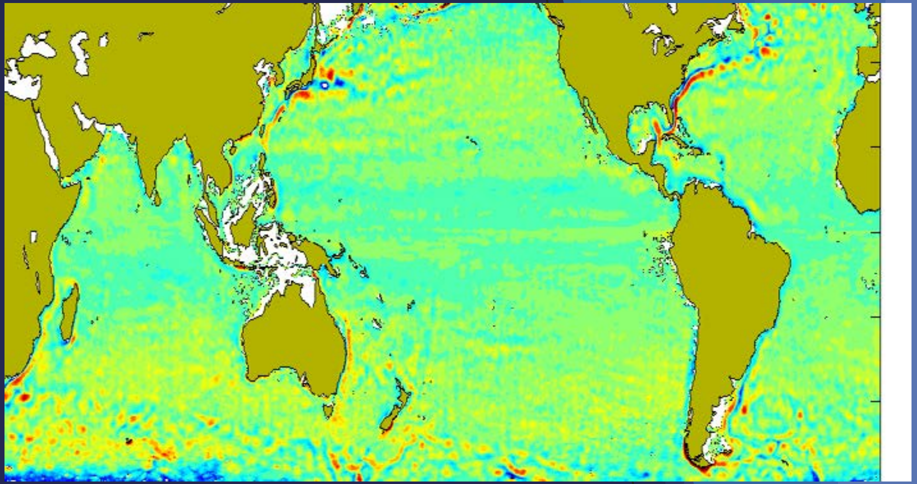


Best global correspondence between drifter- and GOCE-based MDOTs is on 300 km

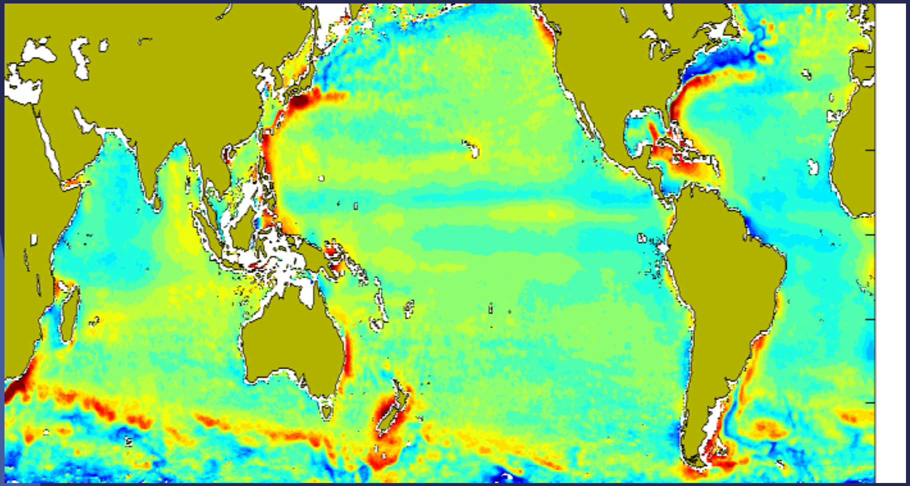
New MDOT



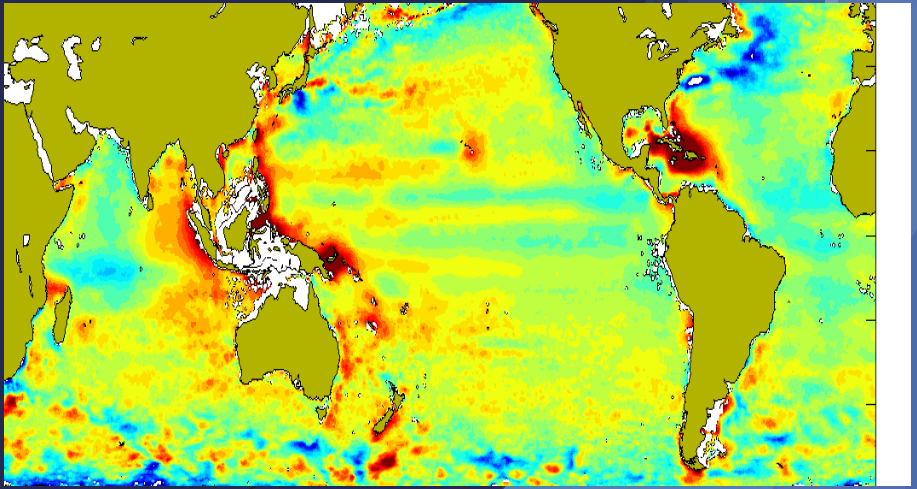
Difference from GOCE-based MDOT



Difference from previous version of MDOT



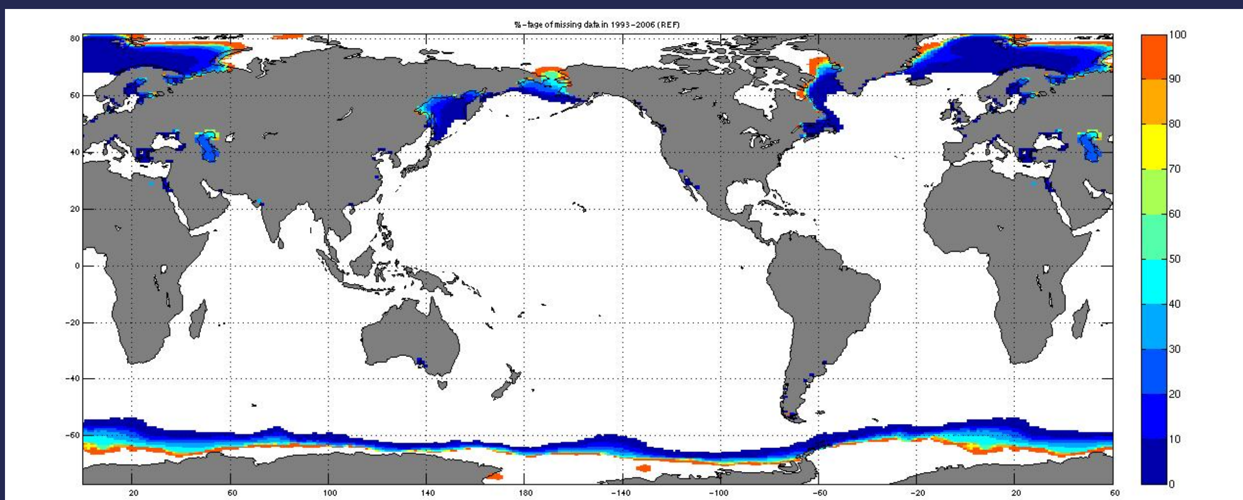
Difference from CNES-CLS09



Units are dyn. cm

Challenges for Future MDOTs:

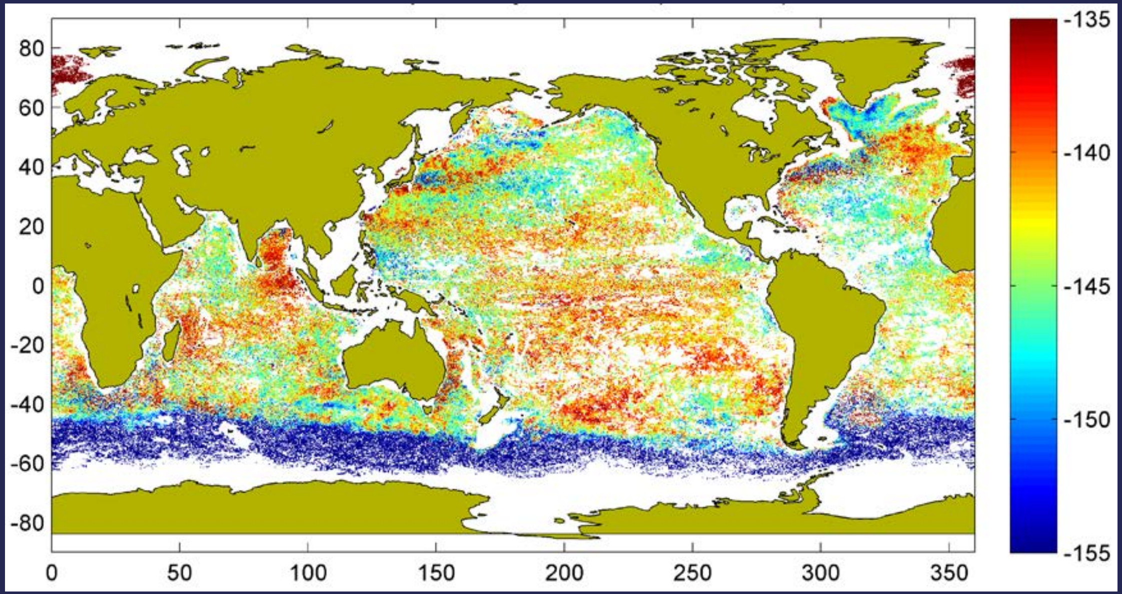
- Coastal areas and islands
- Submesoscale
- Sea ice



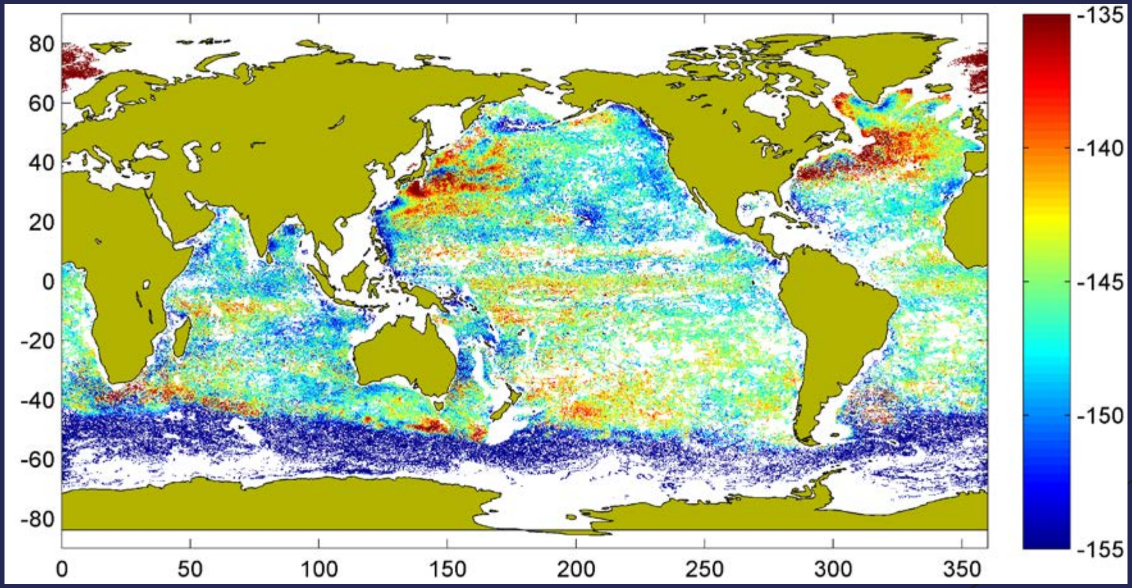
Fraction of missing SLA data

- Subsurface geostrophic circulation

Mean absolute dynamic height at 2000m, derived from Argo profiles

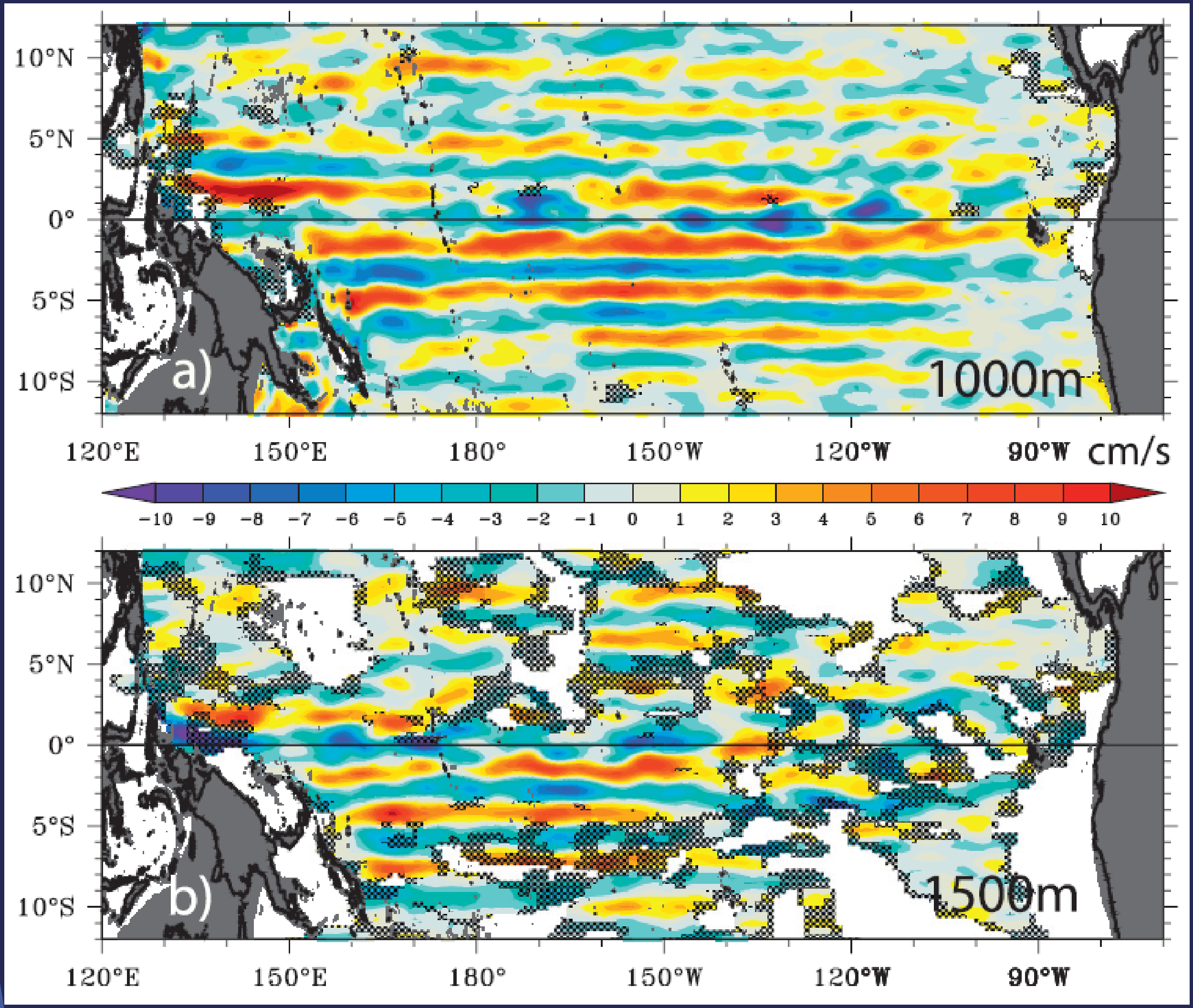


Referenced to new MDOT



Referenced to CNES-CLS09

Deep zonal jets in the Equatorial Pacific in trajectories of Argo floats



1000m

1500m

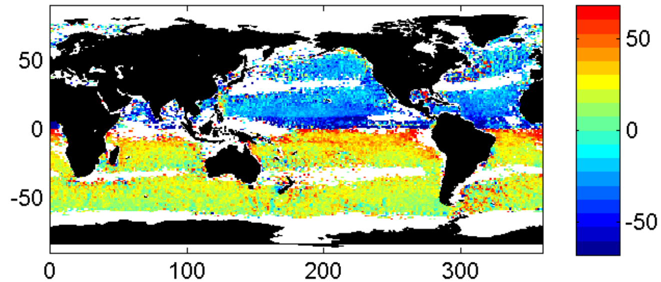
Cravatte, Kessler, Martin (2012)

Wrap-up:

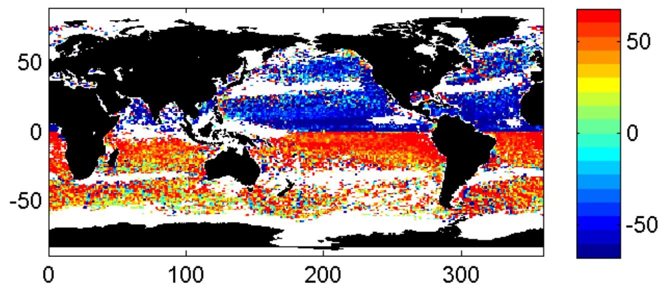
- New MDOT data and documentation will be made available for tests within a few weeks
- Postdoc position is available at IPRC, University of Hawaii in NASA OST-funded project

Extra slides

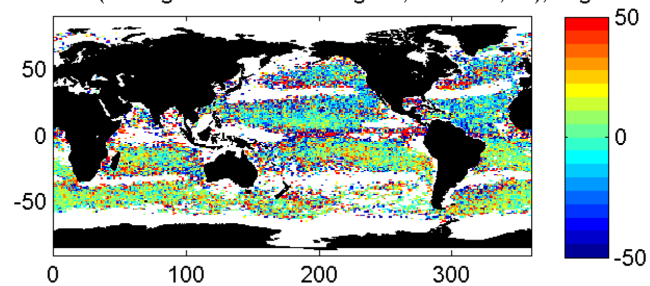
Angle to wind (undrogued, W>2m/s, 1^0), degree



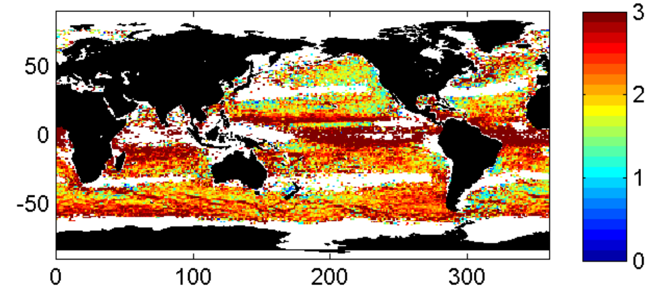
Angle to wind (drogued, W>2m/s, 1^0), degree



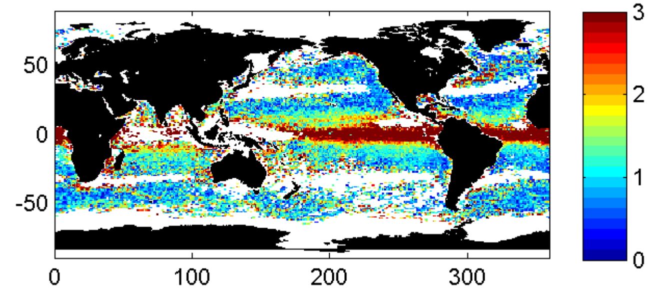
Angle to wind (undrogued relative to drogued, W>2m/s, 1^0), degree



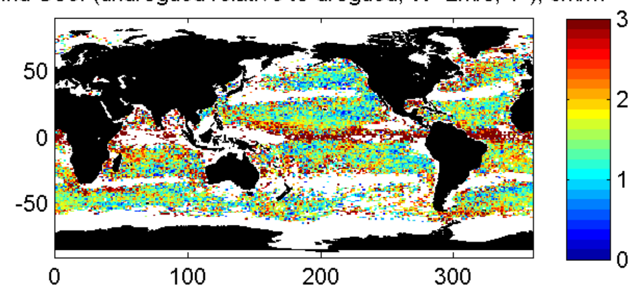
Wind Coef (undrogued, W>2m/s, 1^0), cm/m

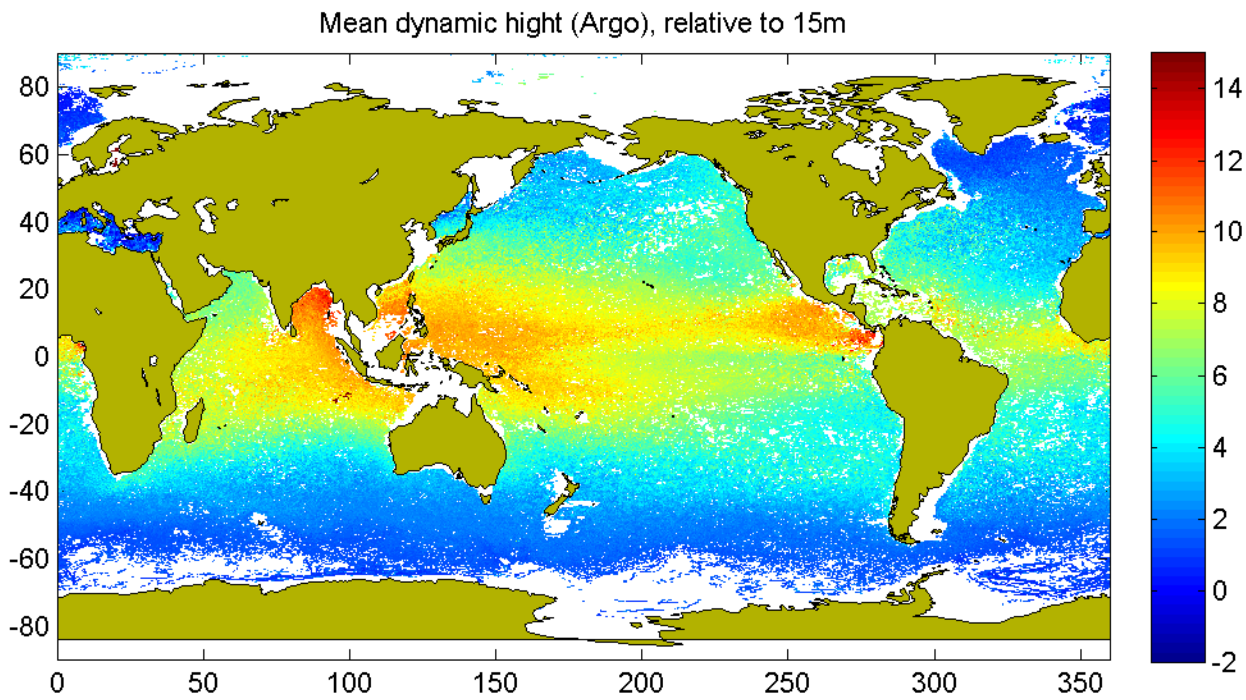


Wind Coef (drogued, W>2m/s, 1^0), cm/m



Wind Coef (undrogued relative to drogued, W>2m/s, 1^0), cm/m





Mean dynamic hight (Argo), relative to 15m
80
60
40
20
0
-20
-40
-60
-80
0
50
100
150
200
250
300
350
14
12
10
8
6
4
2
0
-2