2017 Ocean Surface Topography Science Team Meeting
October 23-27, 2017, Miami, Florida

Comparison and synthesis of geodetic and oceanographic data to improve mean dynamic topography products

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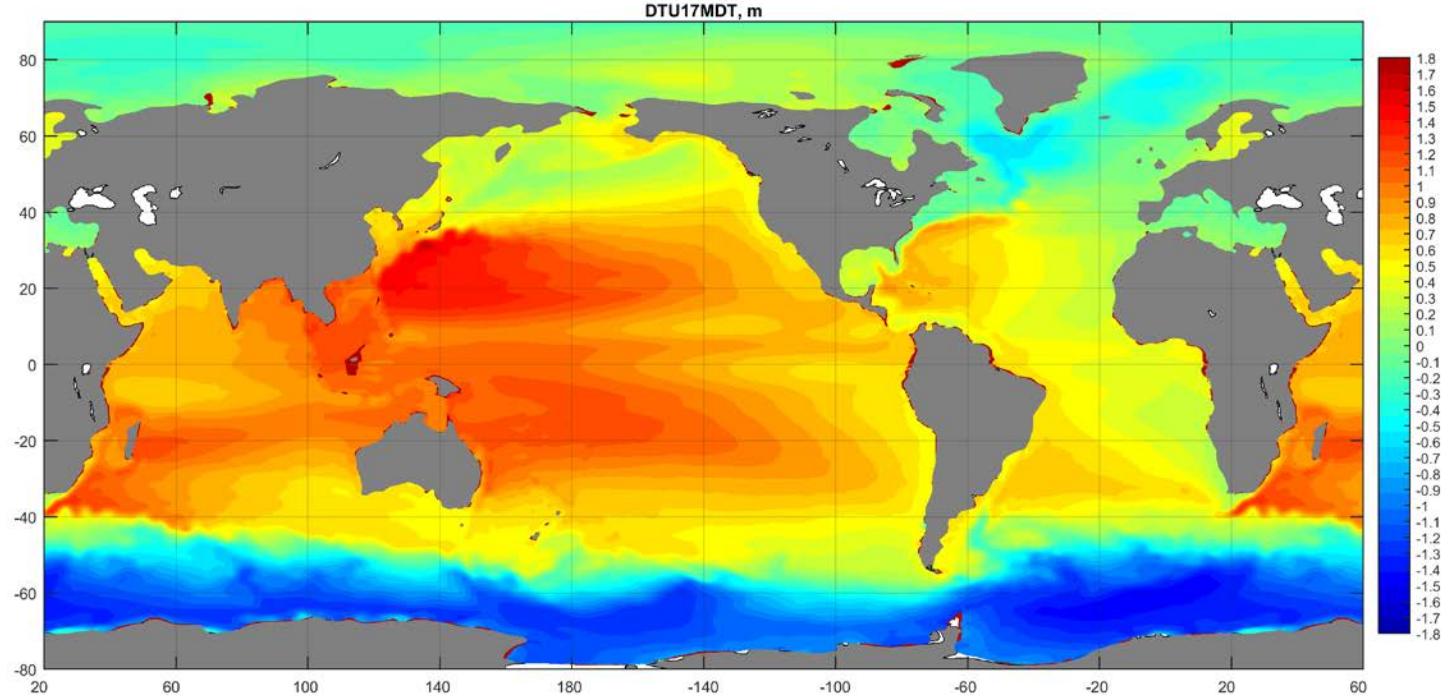
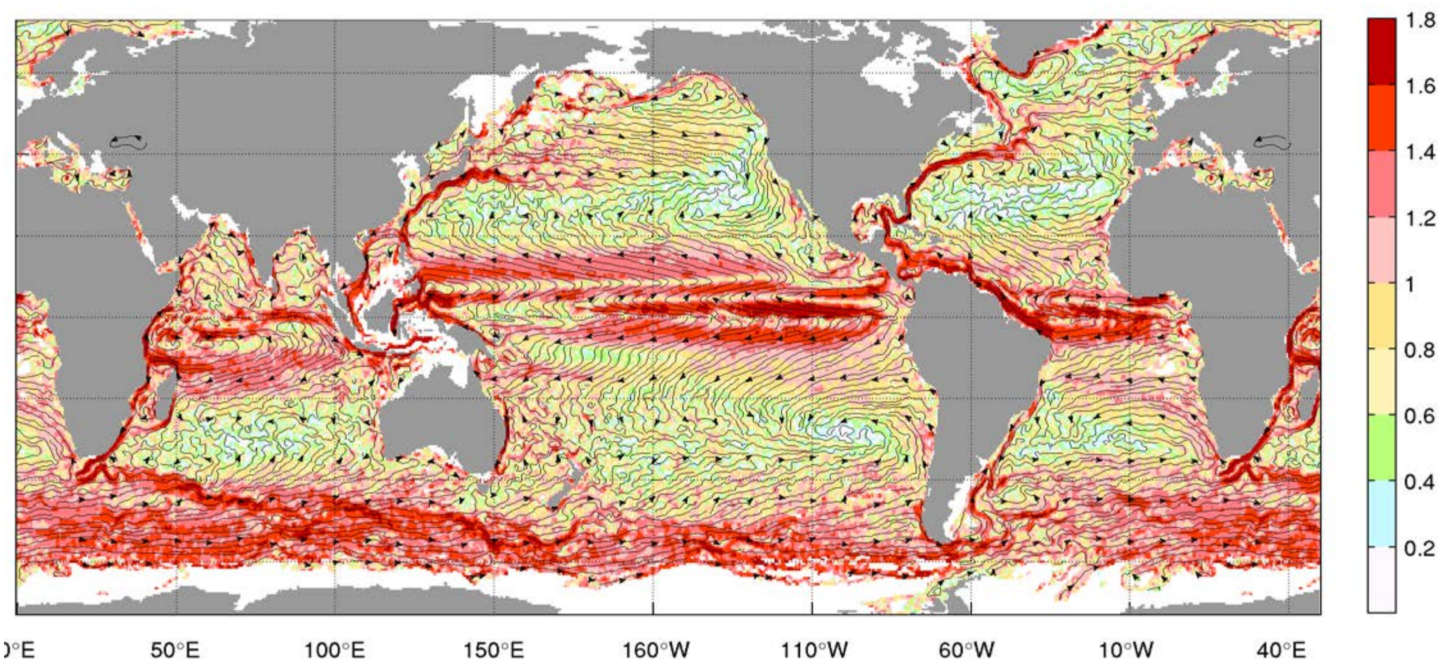
Acknowledgement: Luca Centurioni



DTU17MDT: geodetic MDT, derived from GOCE gravity.

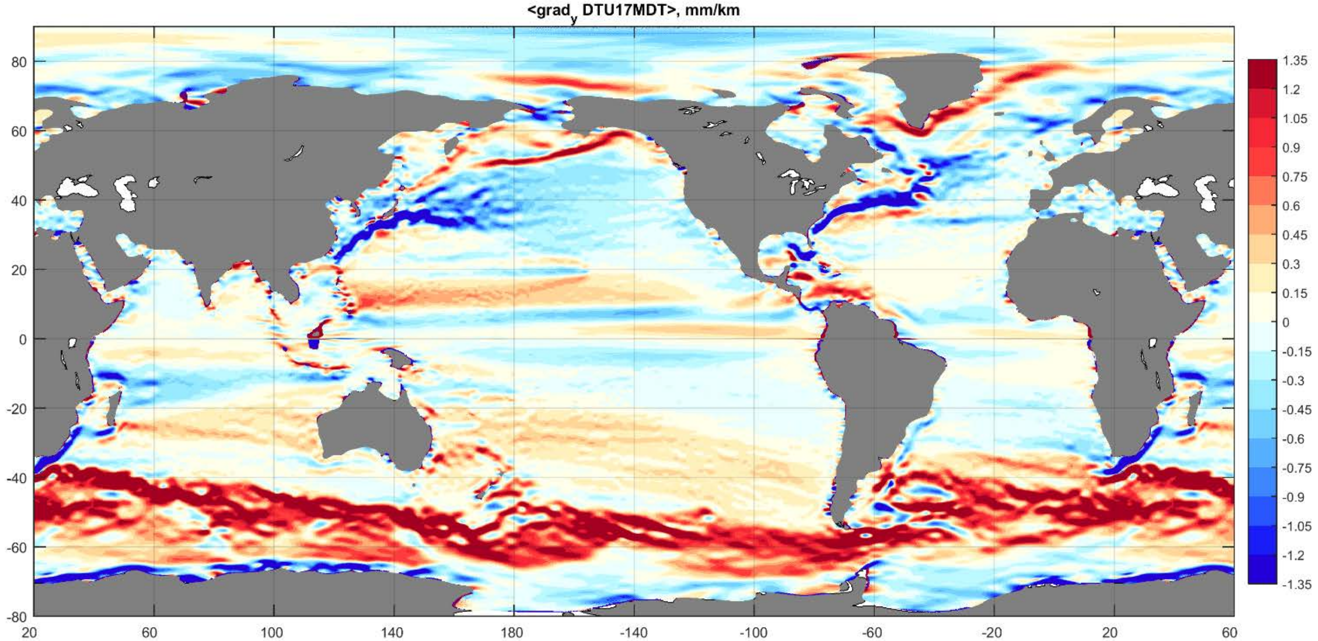


GDP drifters (drogued): ensemble-mean velocity streamlines

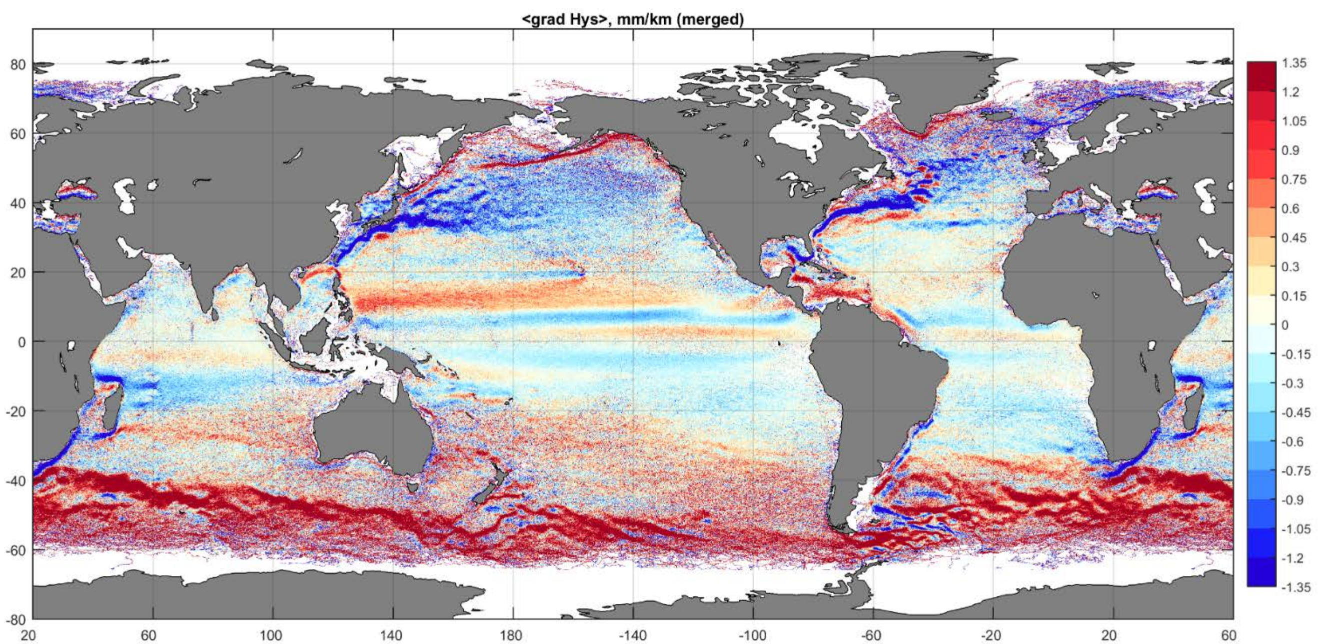
Simplified momentum equation near sea surface:

$$d\mathbf{V}/dt + \mathbf{f} \times (\mathbf{V} - \mathbf{V}_{\mathbf{ekman}}) \approx - g \cdot \boldsymbol{\nabla} (MDT + SLA)$$

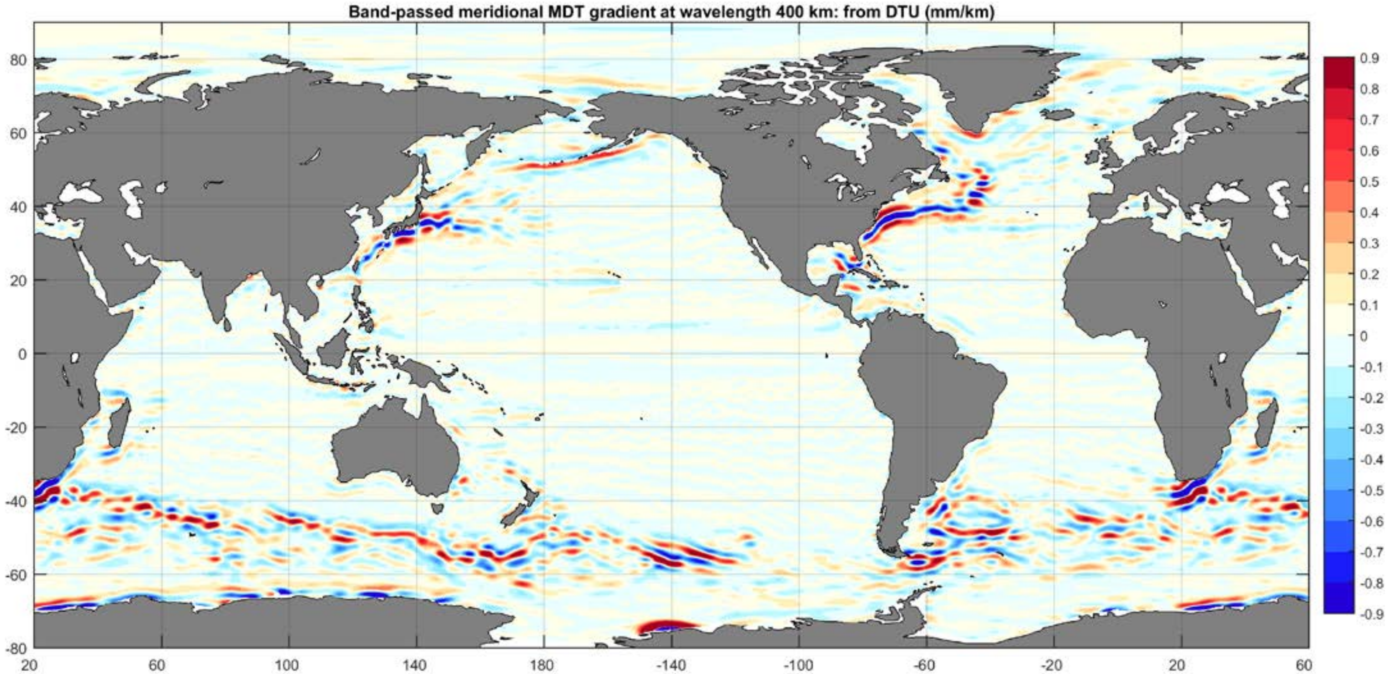
$$\boldsymbol{\nabla} MDT \approx - (d\mathbf{V}/dt + \mathbf{f} \times (\mathbf{V} - \mathbf{V}_{\mathbf{ekman}}))/g - \boldsymbol{\nabla} SLA$$



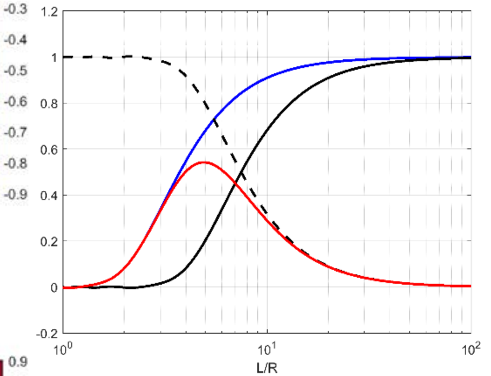
Geodetic $\frac{\partial MDT}{\partial y}$



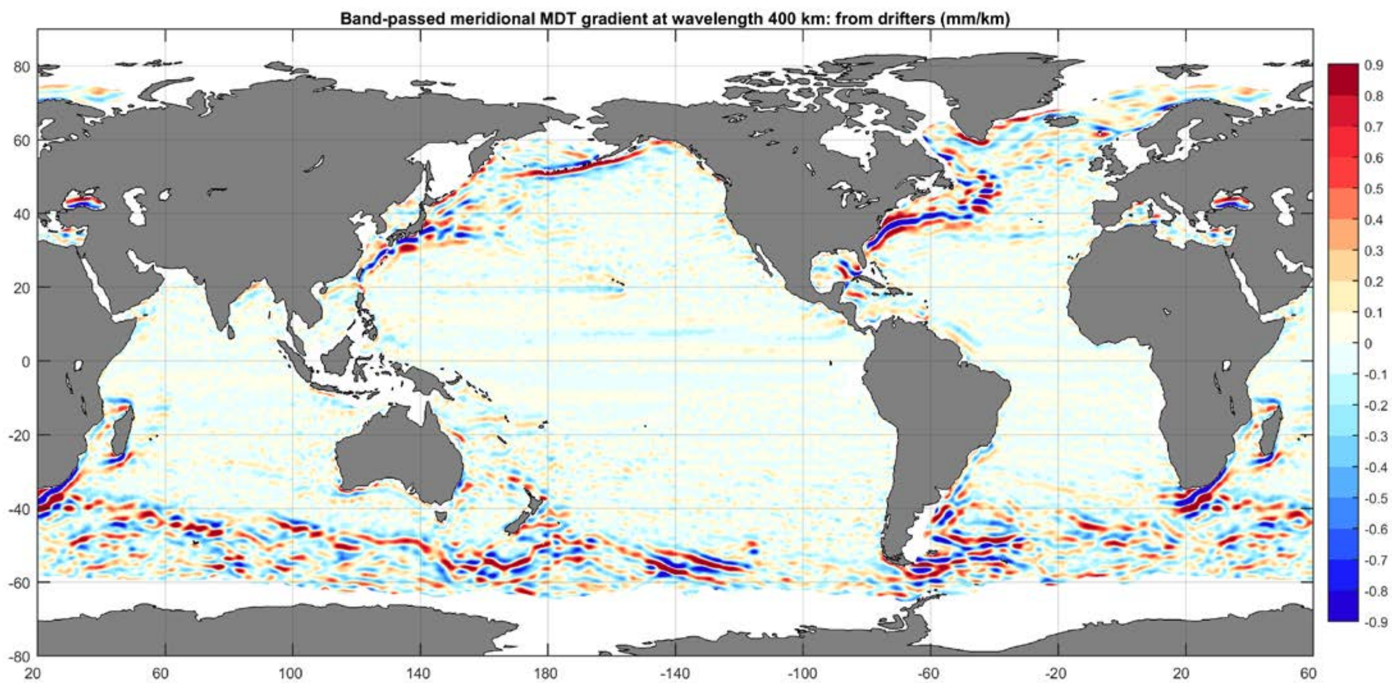
Oceanographic $\frac{\partial MDT}{\partial y}$



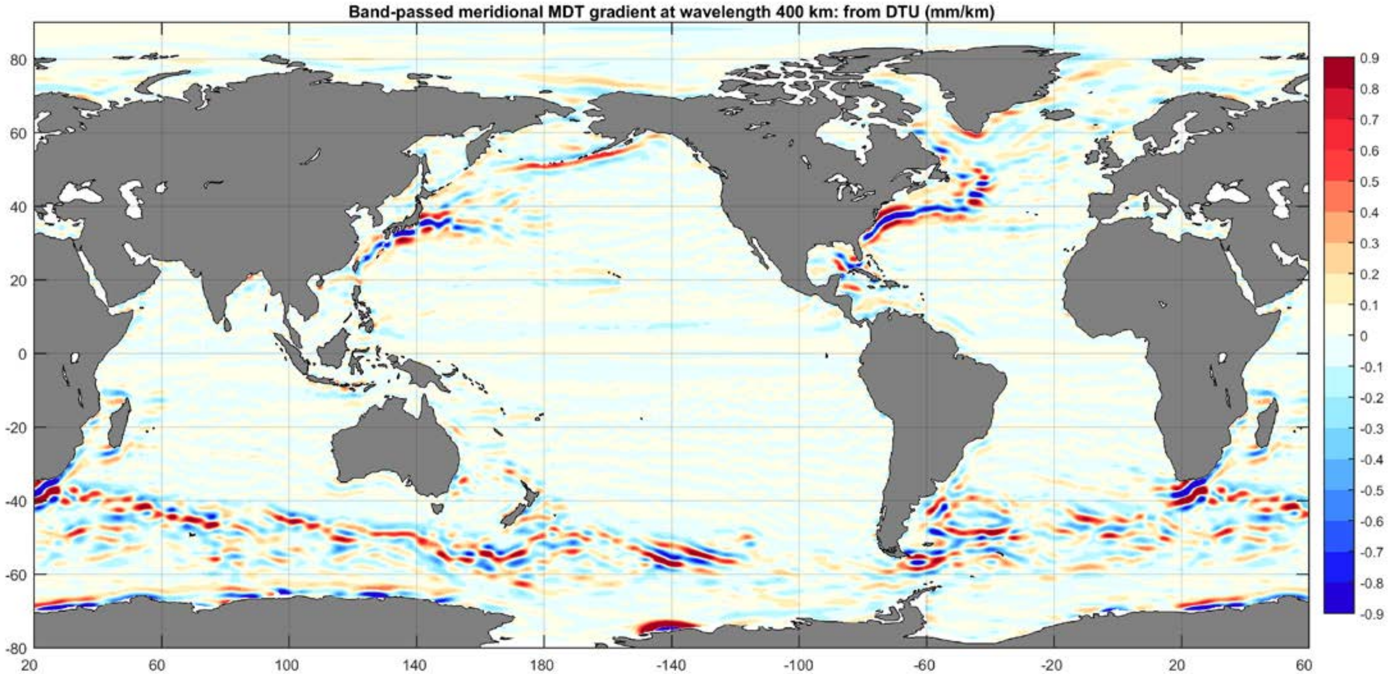
Band-pass filtered (400km wavelength) meridional gradient of geodetic MDT.



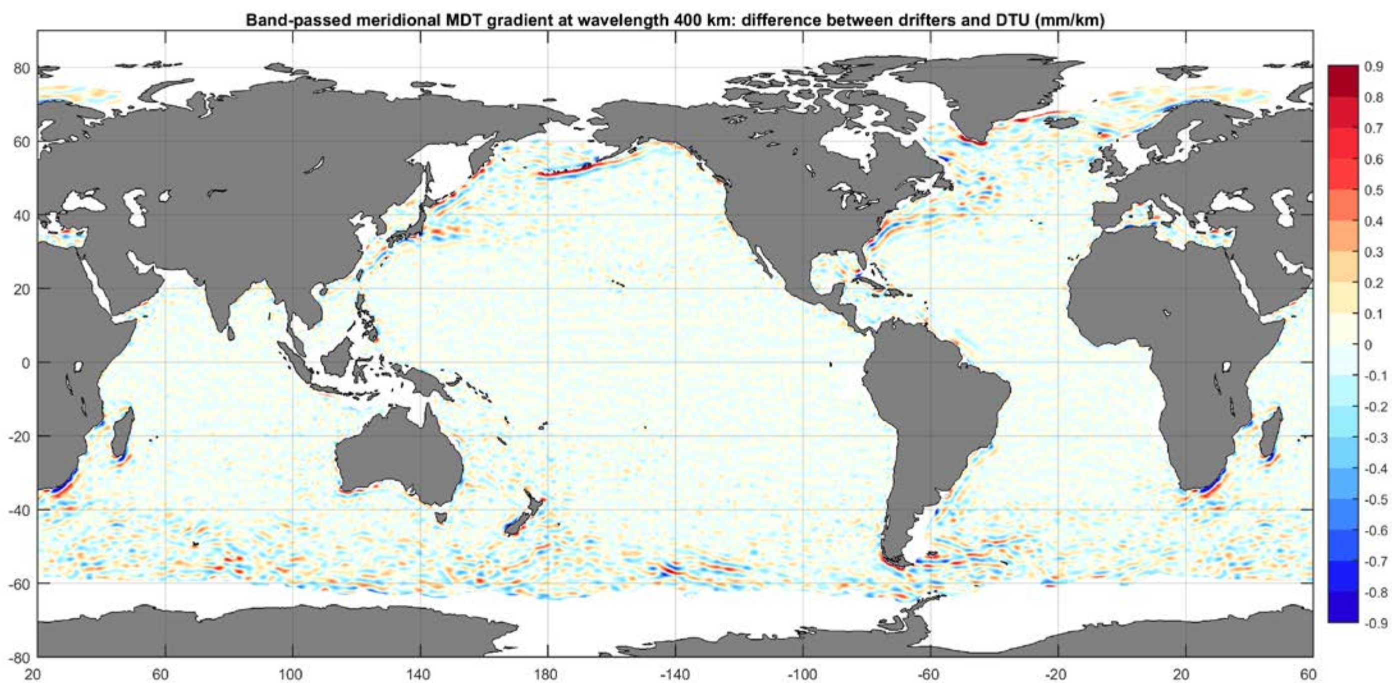
Band-pass Gaussian filter with HP and LP wavelength ratio = 2.



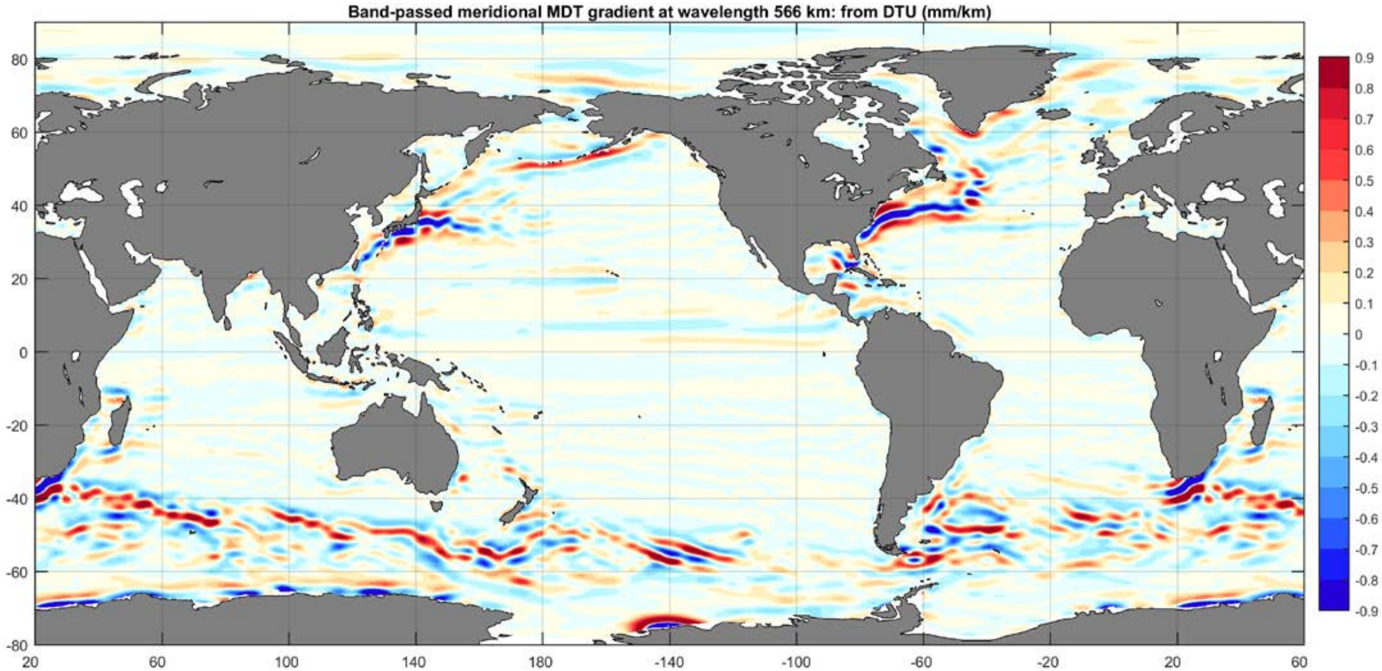
Band-pass filtered (400km wavelength) meridional gradient of oceanographic MDT.



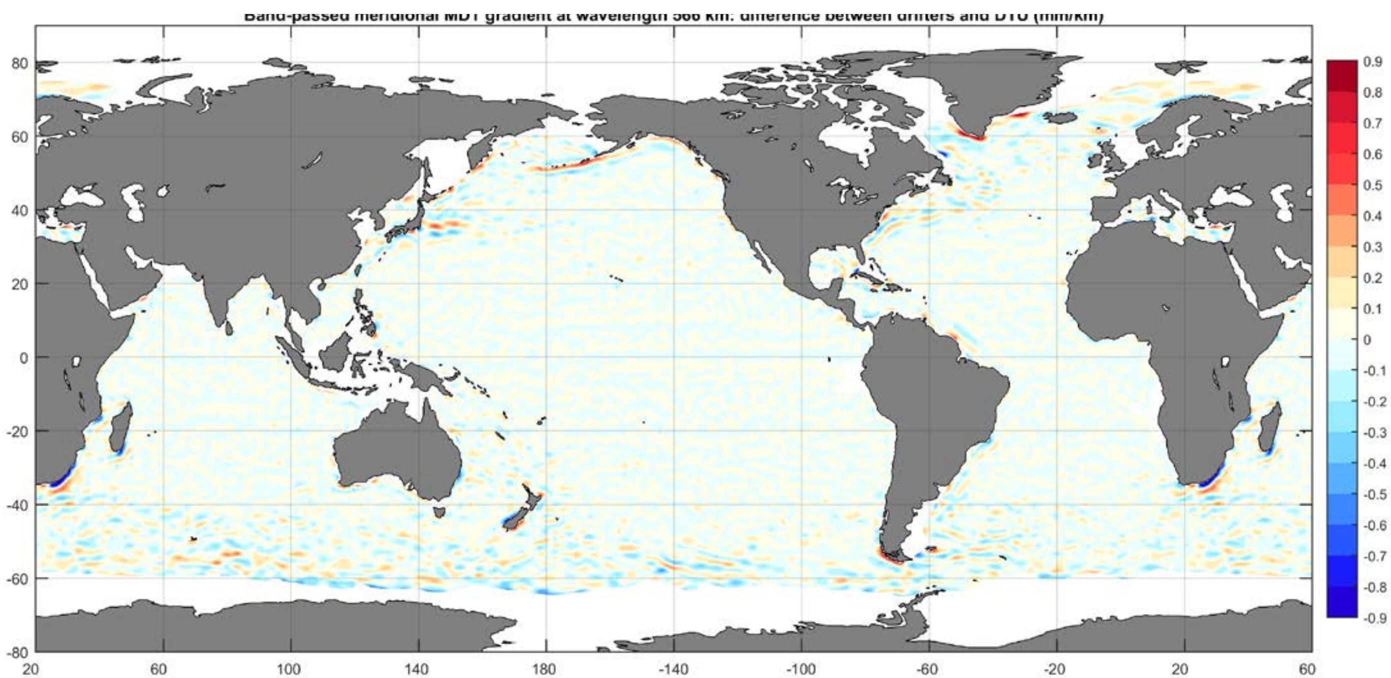
Band-pass filtered (400km wavelength) meridional gradient of geodetic MDT.



Difference between band-pass filtered (400km wavelength) meridional gradient of oceanographic and geodetic MDT.



Band-pass filtered (566km wavelength) meridional gradient of geodetic MDT.



Difference between band-pass filtered (566km wavelength) meridional gradient of oceanographic and geodetic MDT.

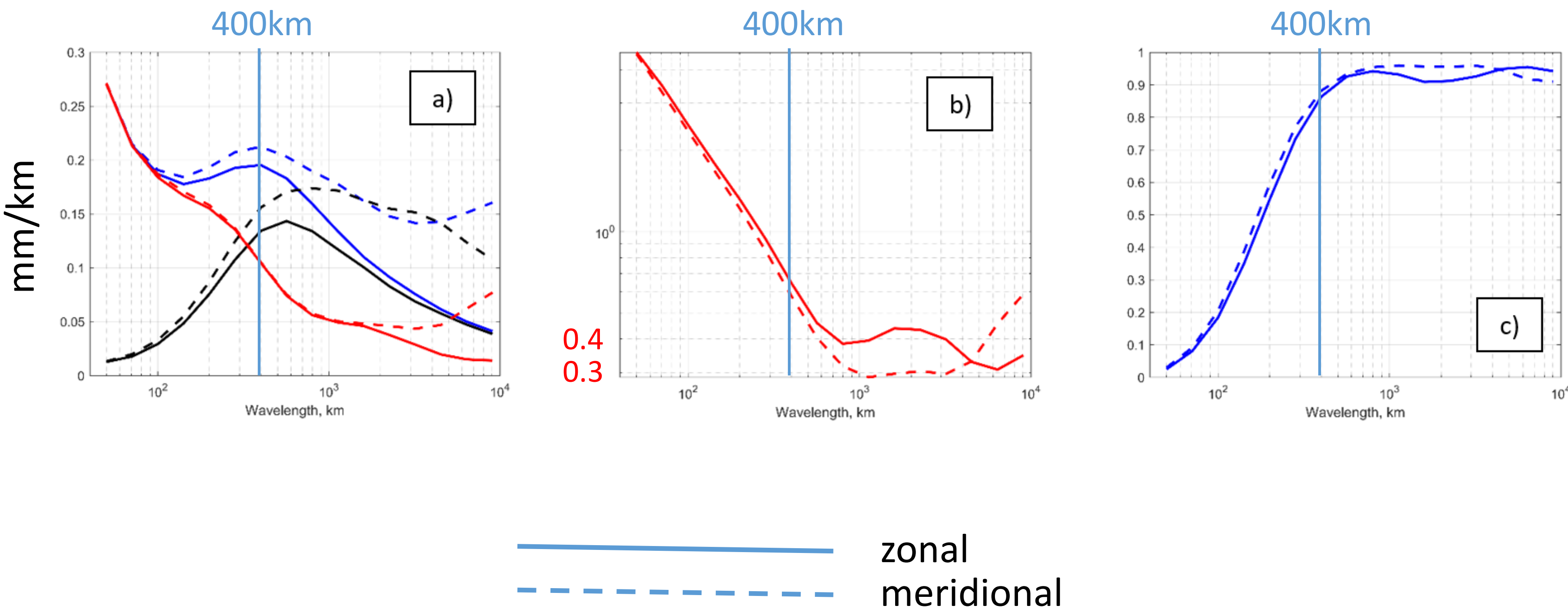
Comparison between band-pass filtered gradients of geodetic and oceanographic MDTs

RMS MDT gradient signals and differences:
geodetic,
oceanographic,
difference.

Relative rms difference:

$$\mathrm{r.m.s.}(MDT_{DTU} - MDT_{oceanographic}) / \mathrm{sqrt}(\mathrm{r.m.s.}(MDT_{DTU}) \cdot \mathrm{r.m.s.}(MDT_{oceanographic}))$$

Correlation coefficients



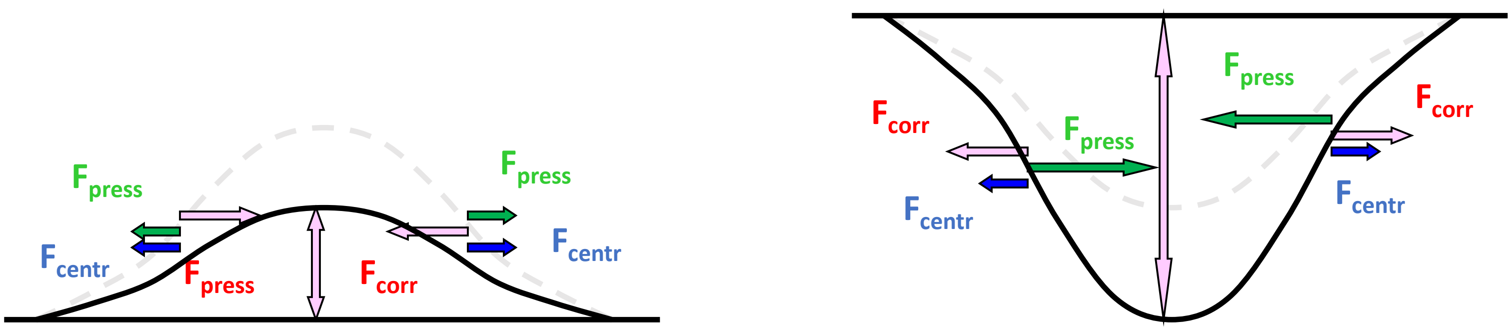
$$\nabla \, MDT \approx -(dV/dt + f \times (V - V_{ekman}))/g - \nabla \, SLA$$

Centripetal acceleration amplifies SLA signal in cyclonic eddies and suppresses it in anticyclones.

Anticyclonic eddy | Cyclonic eddy

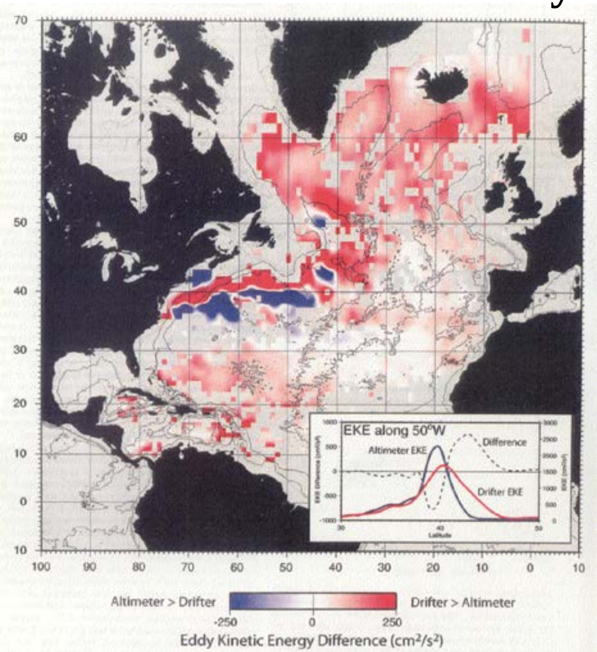
Geostrophic balance

Cyclostrophic balance for same V



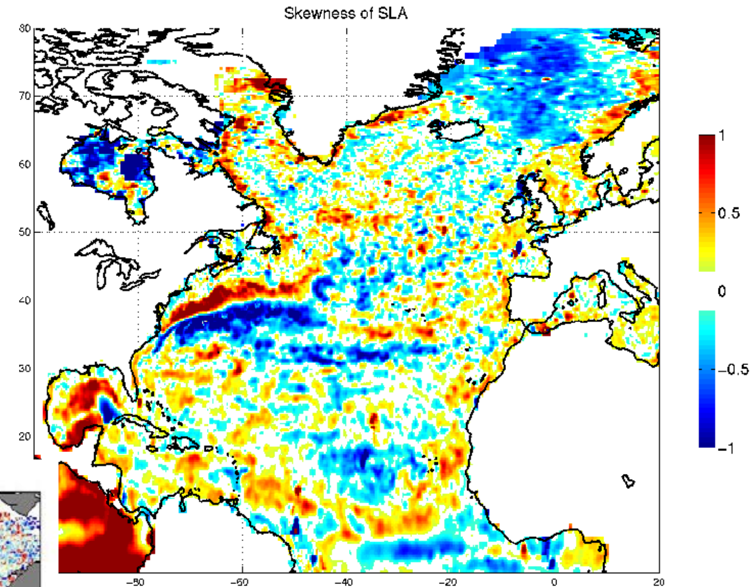
∇ MDT ≈ - ($\mathbf{dV}/dt$ + $\mathbf{f} \times (\mathbf{V} - \mathbf{V}_{ekman})$)/g - ∇ SLA

Eddy kinetic energy difference: drifters - altimetry



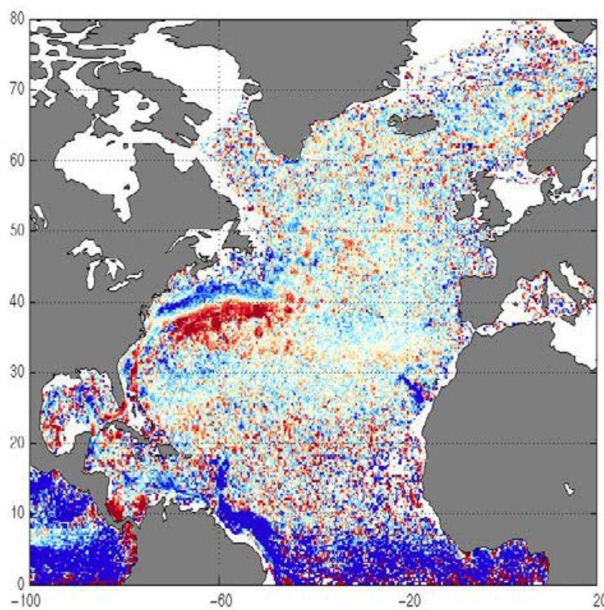
Fratantoni, 2002

Skewness of probability density of SLA



$<h'^3>/<h'^2>^{3/2}$

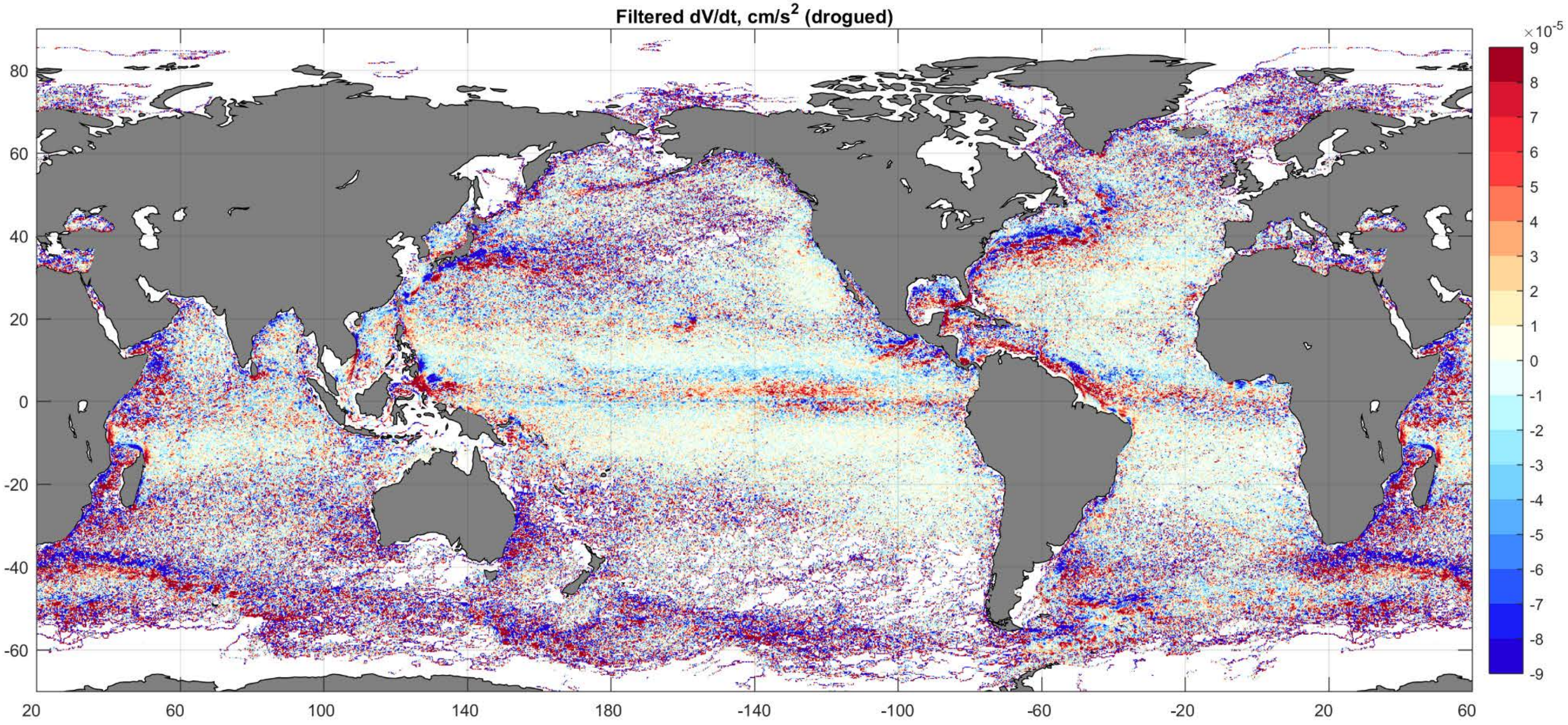
ω_E / f



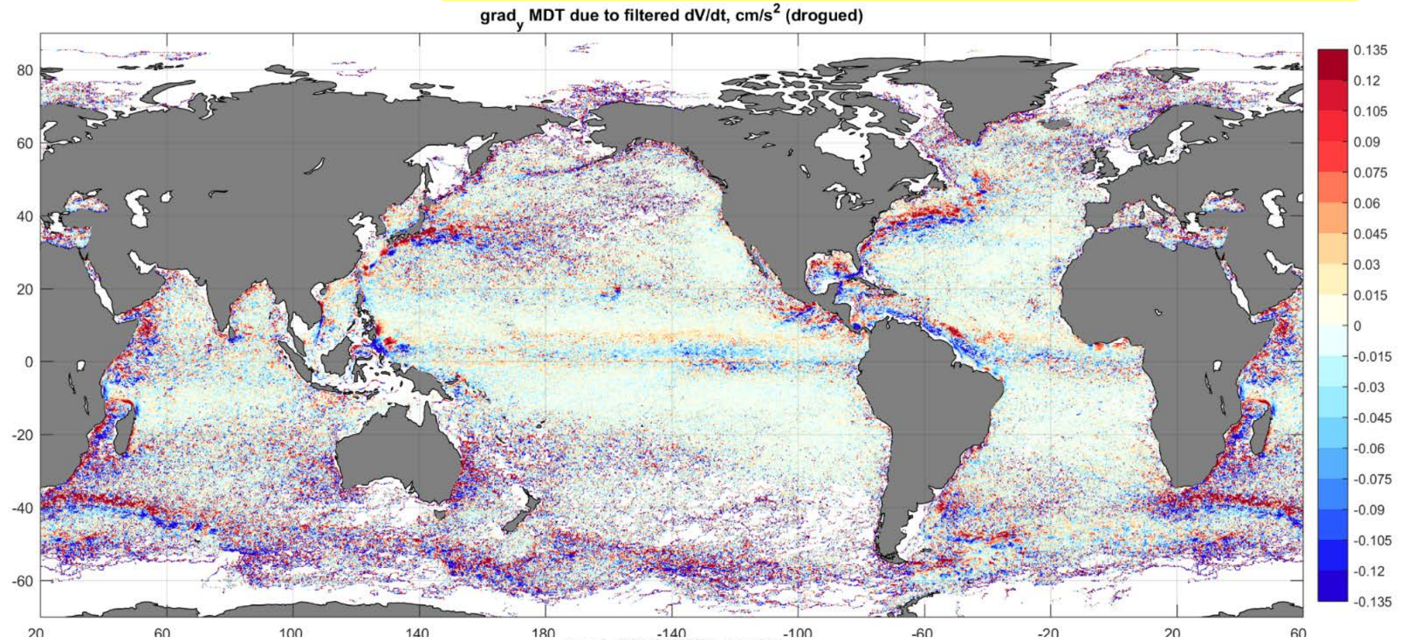
$$\omega_E = < \mathbf{V} \times d\mathbf{V}/dt > / < \mathbf{V}^2 > =$$
$$= < \omega\, E > / < E >$$

∇ MDT ≈ - (dV/dt + $\mathbf{f} \times (\mathbf{V} - \mathbf{V}_{ekman})$)/g - ∇ SLA

Ensemble-mean dV/dt, calculated from trajectories of drogued drifters

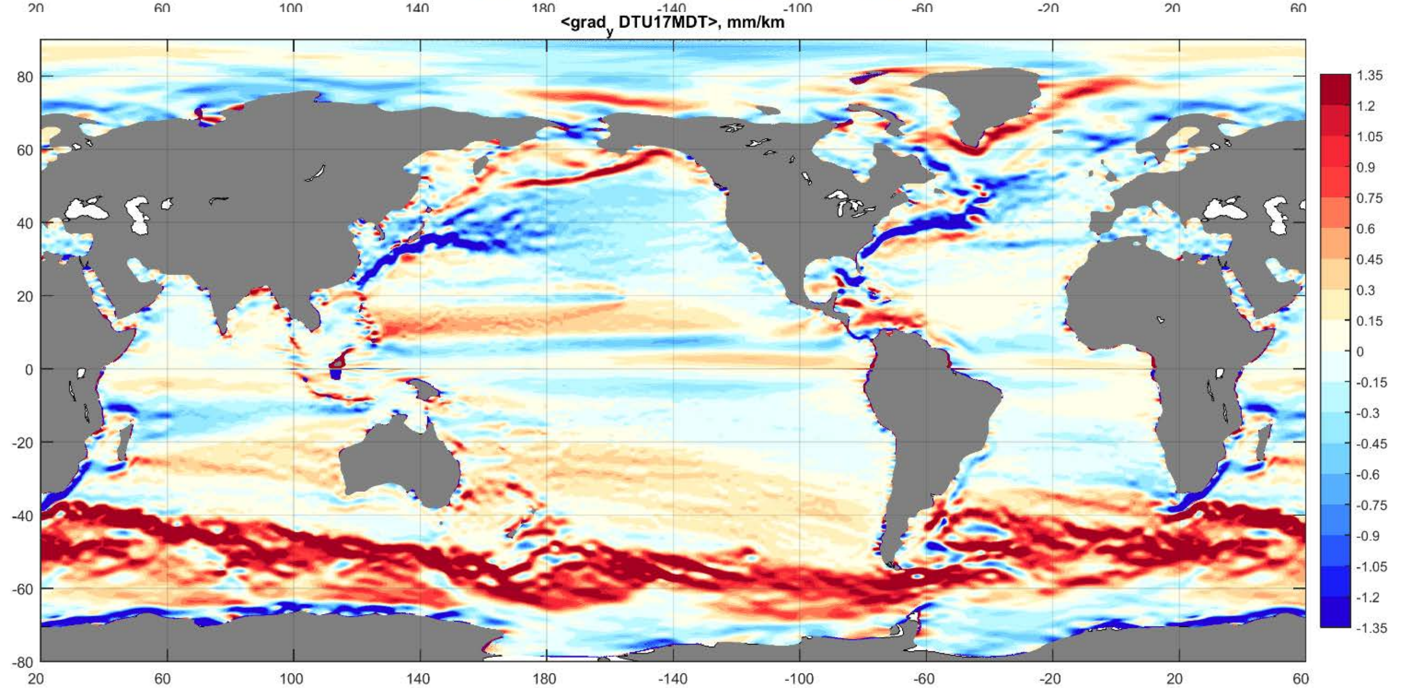


$$\nabla \, MDT \approx -(dV/dt + f \times (V - V_{ekman}))/g - \nabla \, SLA$$



$$\frac{\partial MDT}{\partial y} \approx$$

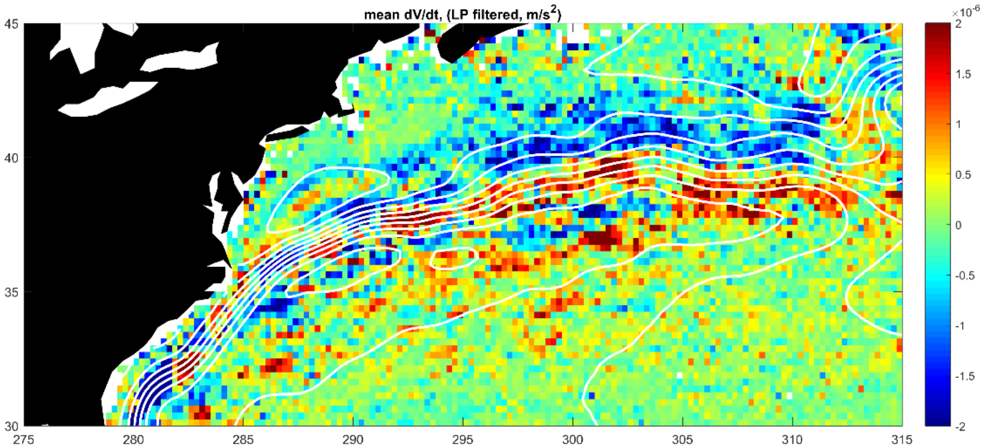
$$\approx -(dV/dt)/g$$



Maximum contribution: 5-10%

Geodetic $\frac{\partial MDT}{\partial y}$

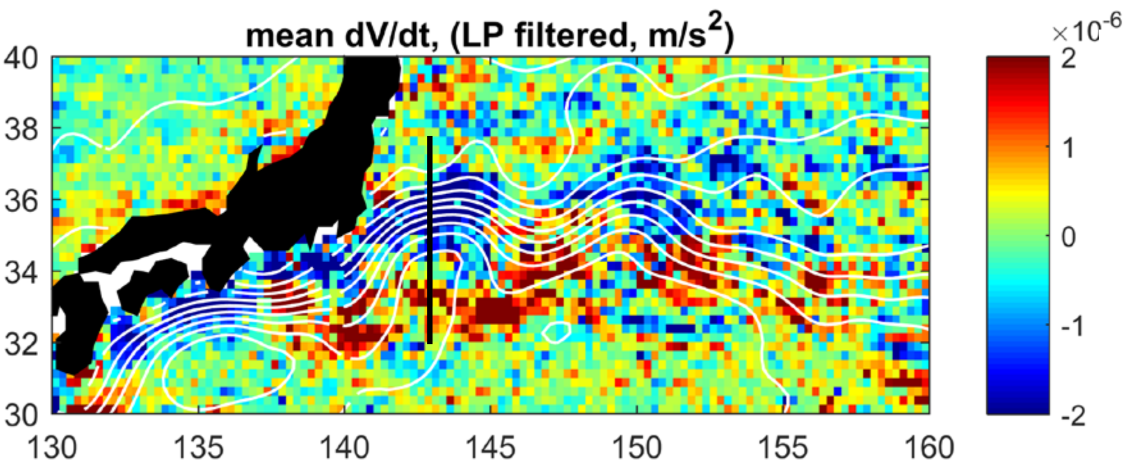
$$\nabla \, MDT \approx -\left(dV/dt + f \times (V - V_{ekman})\right)/g - \nabla \, SLA$$



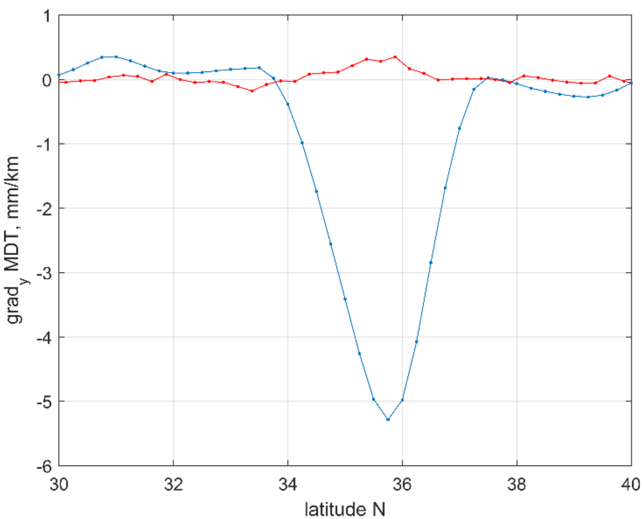
$dV/dt \approx V \cdot \nabla V$

Largangian acceleration/
eddy fluxes sharpen mean GS

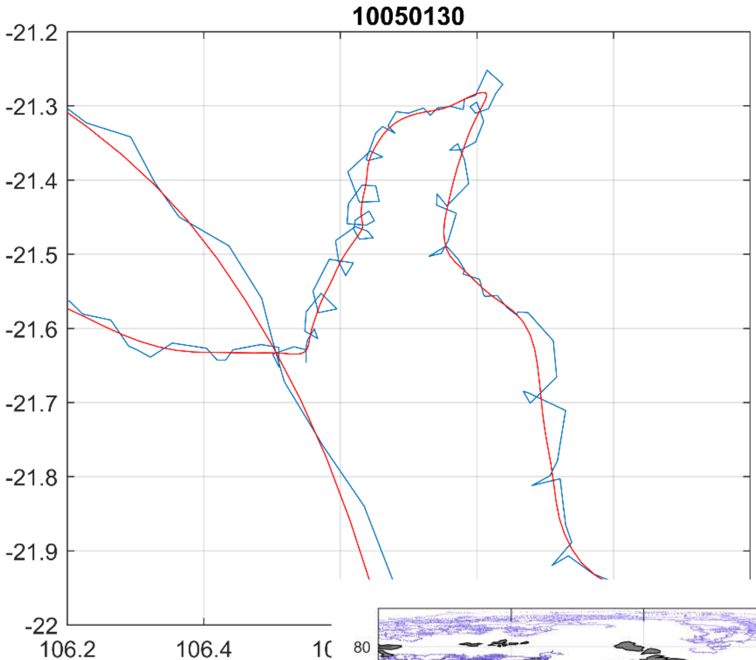
Accuracy of drifter trajectories in eddies is important



$$\frac{\partial MDT}{\partial y} \; at \; 143E$$



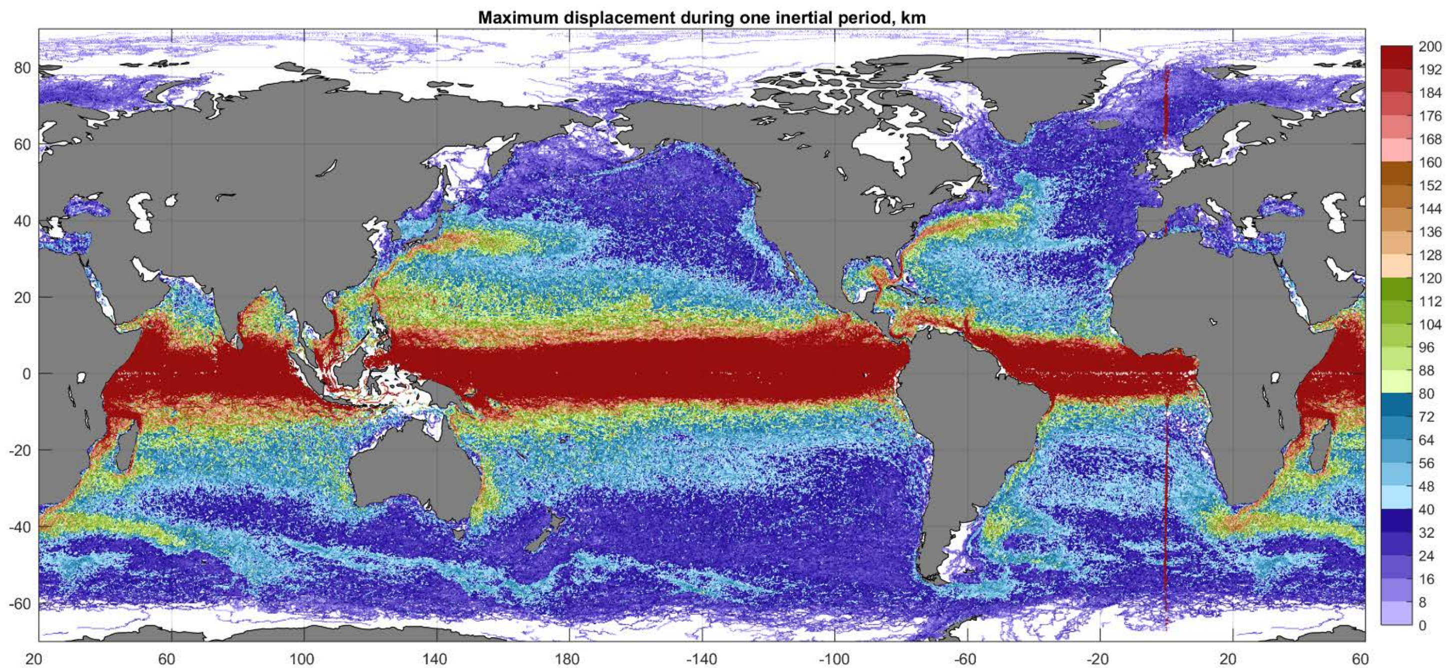
$$\nabla MDT \approx -(d\mathbf{V}/dt + \mathbf{f} \times (\mathbf{V} - \mathbf{V}_{ekman}))/g - \nabla SLA$$



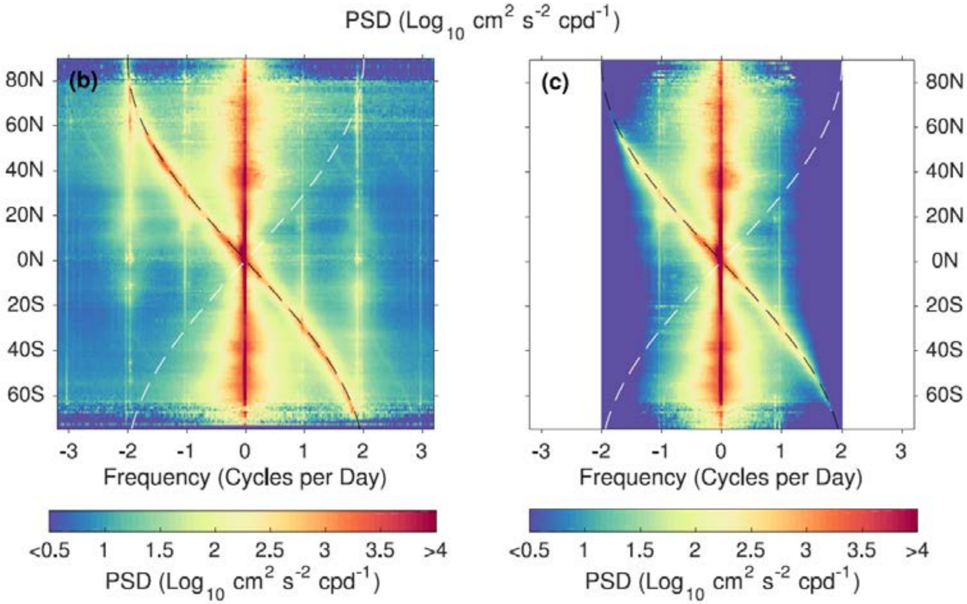
Inertial oscillations in drifter trajectories

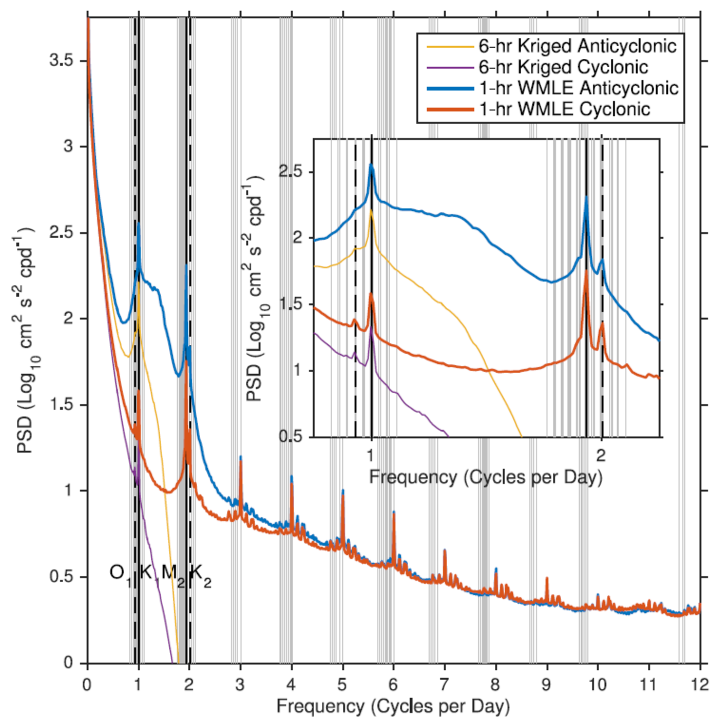
Filtered trajectory

Maximum observed displacement of drogued drifters after one inertial period



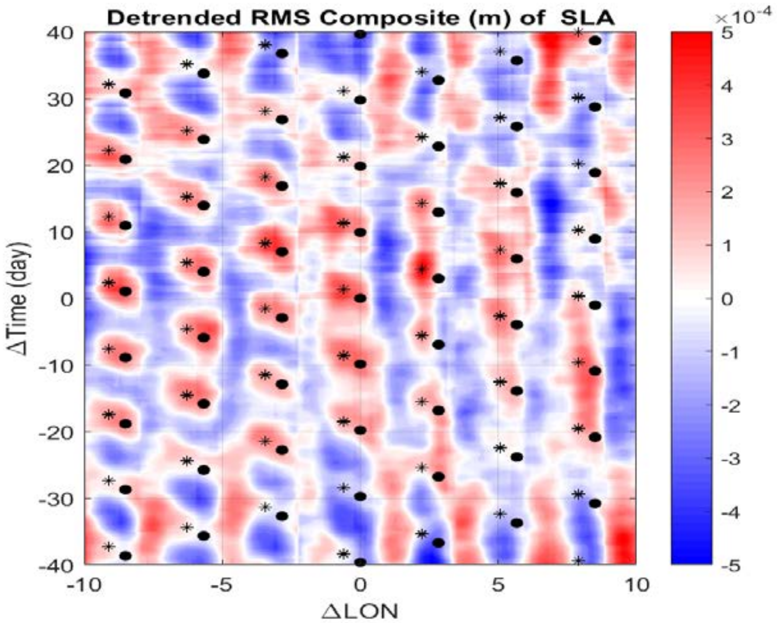
$$\nabla \mathrm{MDT} \approx -\left(d\mathbf{V}/dt + \mathbf{f} \times (\mathbf{V} - \mathbf{V}_{ekman})\right)/g - \nabla \mathrm{SLA}$$

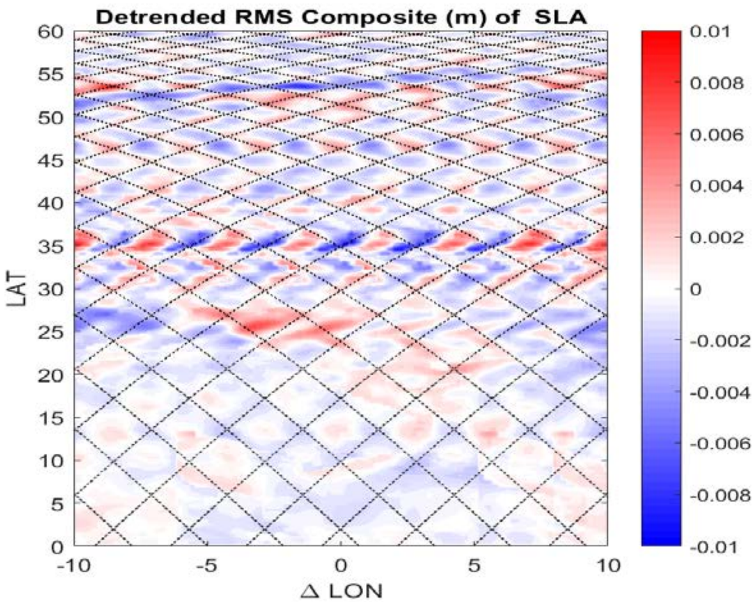




Elipot et al., 2016

∇ MDT ≈ - (d**V**/dt + **f** × (**V** – V_{ekman}))/g - ∇ SLA





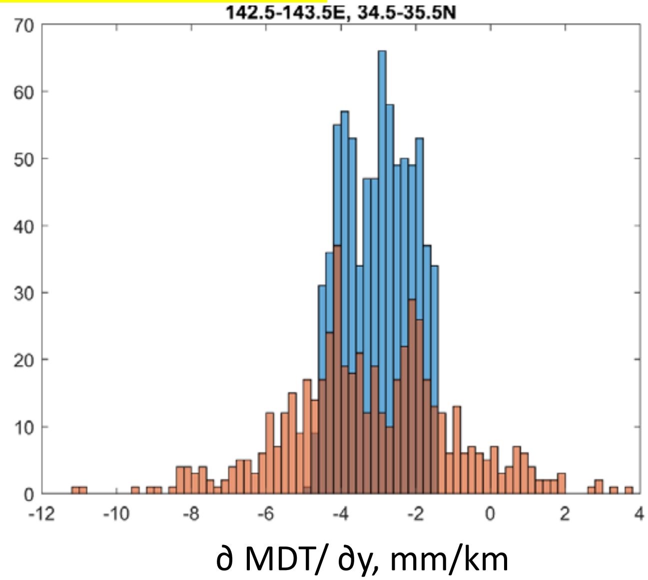
Roach and Maximenko, OSTST 2017 poster

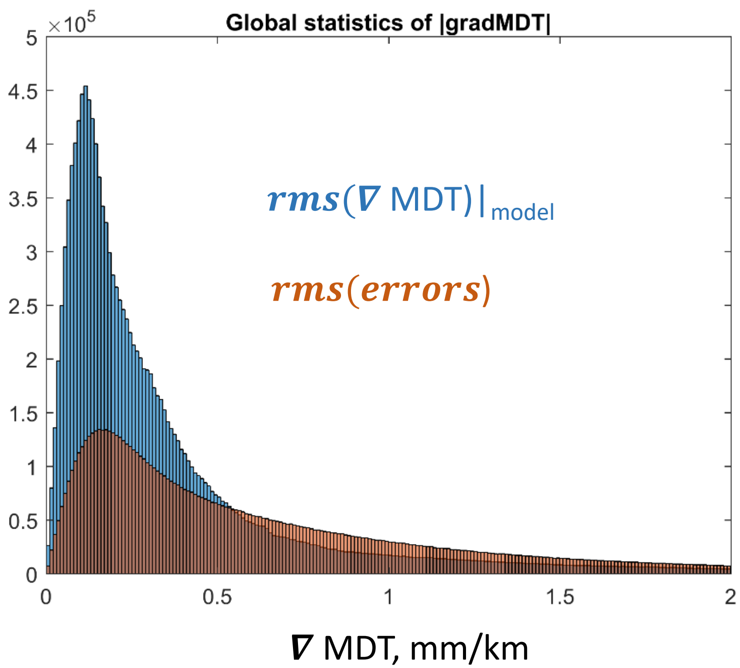
Current gridded AVISO SLA, based on short time-space correlations has higher energy on satellite tracks and passing times.

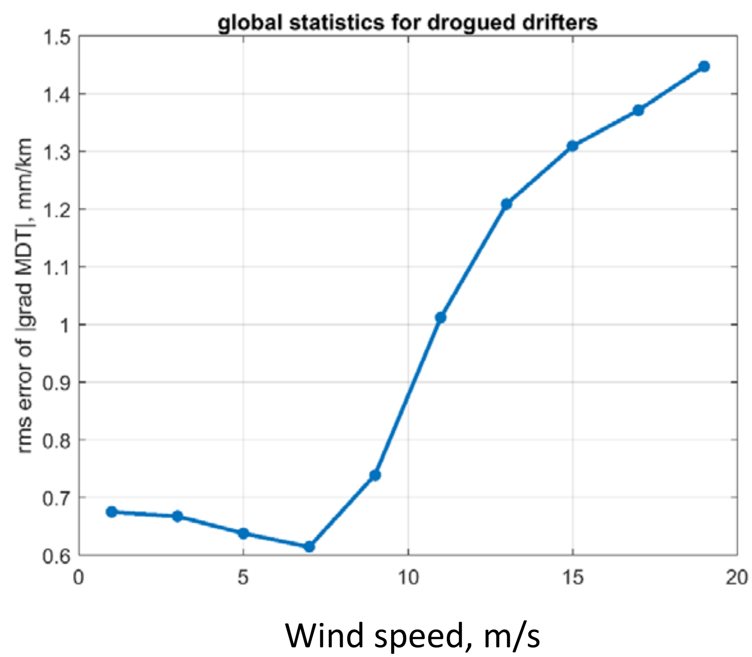
Technique of interpolation over large gaps needs to be improved.

Improved coverage in future satellite missions (SWOT).

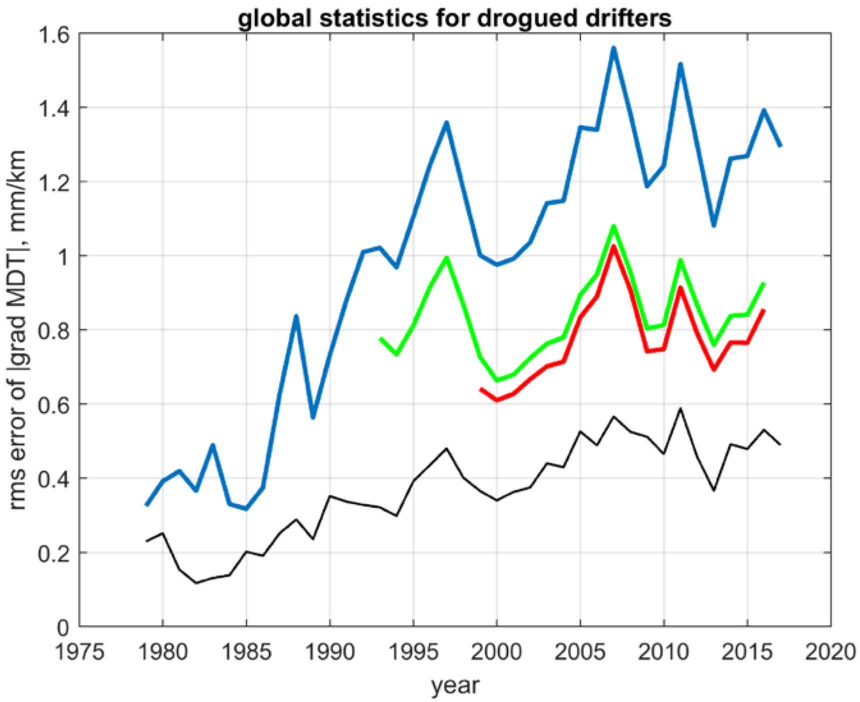
$$\nabla\ \mathrm{MDT} \approx -\left(d\mathbf{V}/dt + \mathbf{f} \times (\mathbf{V} - \mathbf{V}_{ekman})\right)/g - \nabla\ \mathrm{SLA}$$

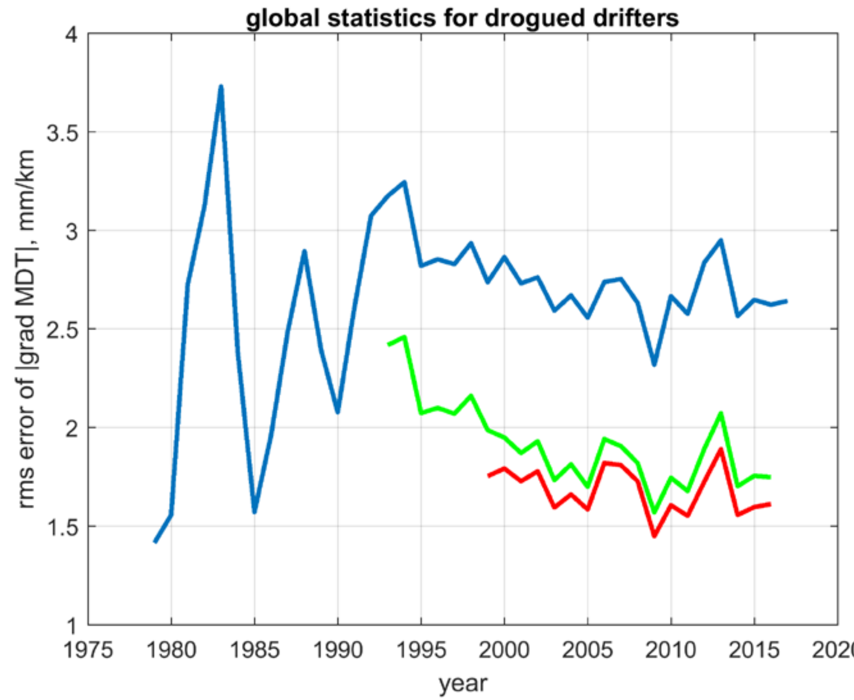




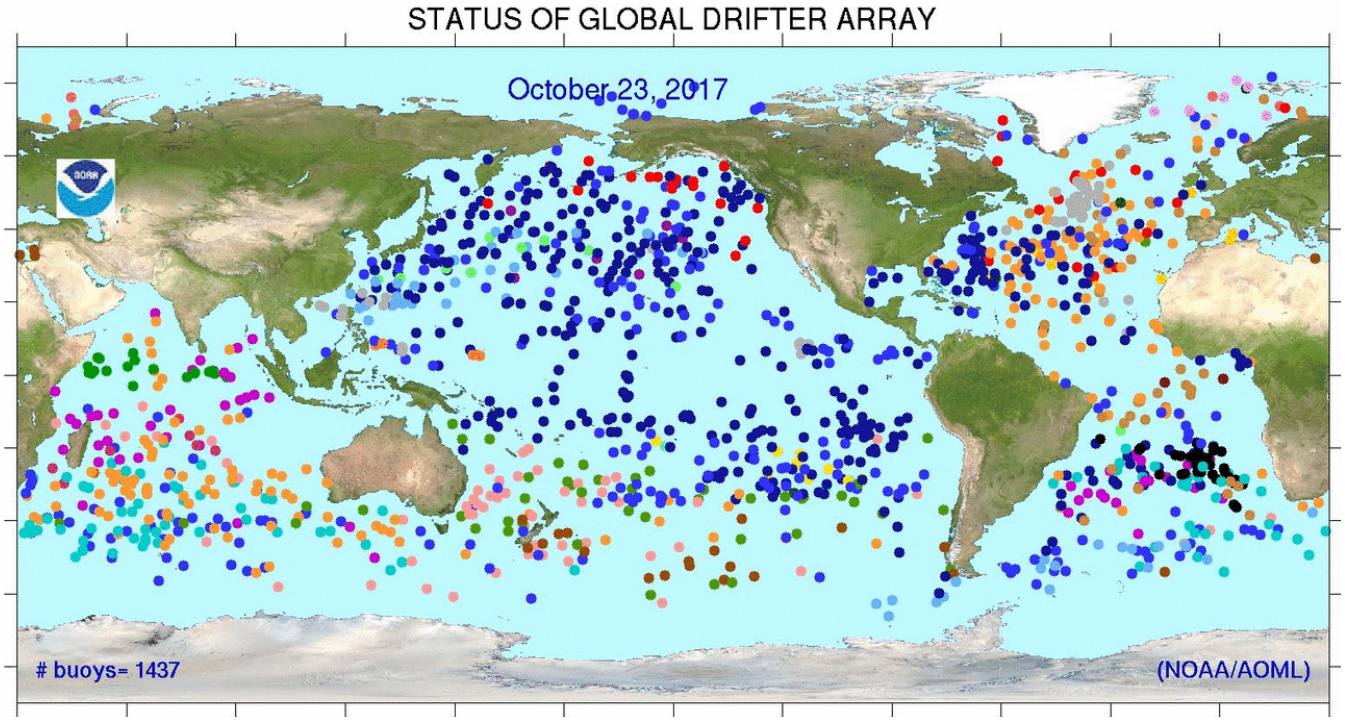


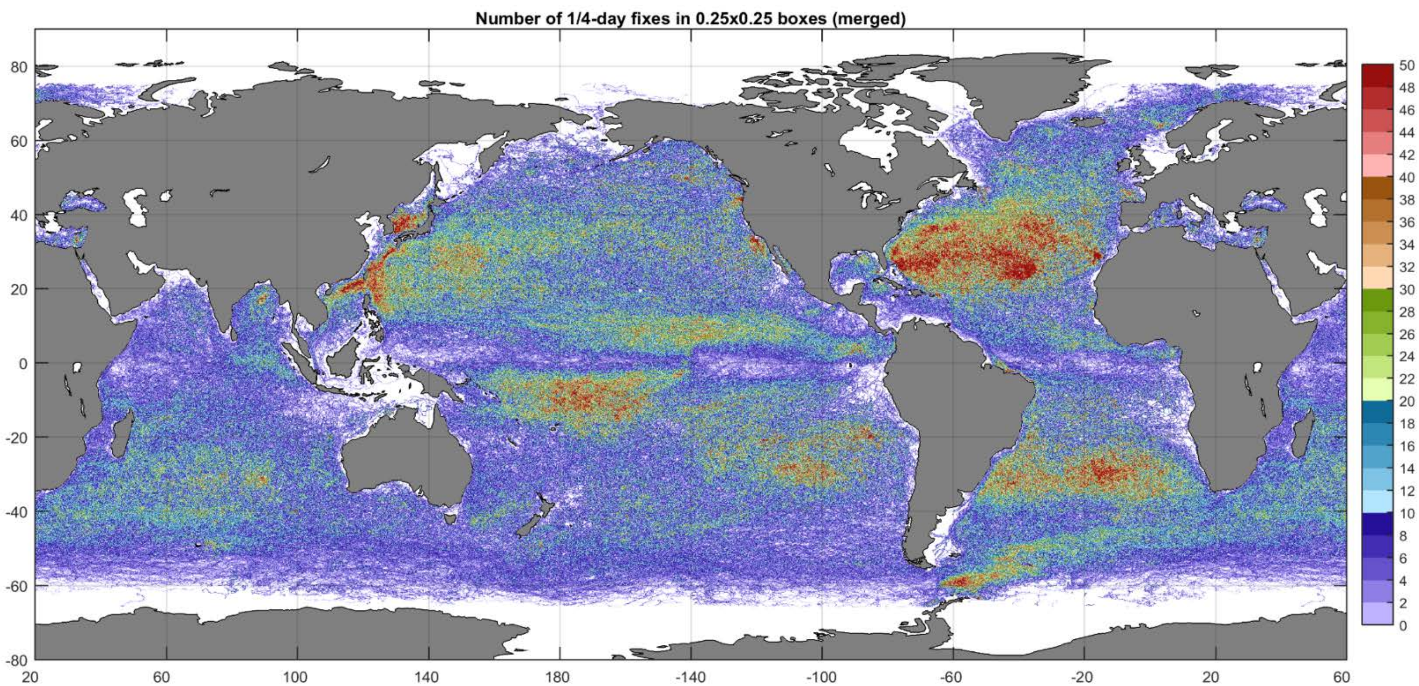
$$\nabla MDT \approx -(dV/dt + f \times (V - V_{ekman}))/g - \nabla SLA$$

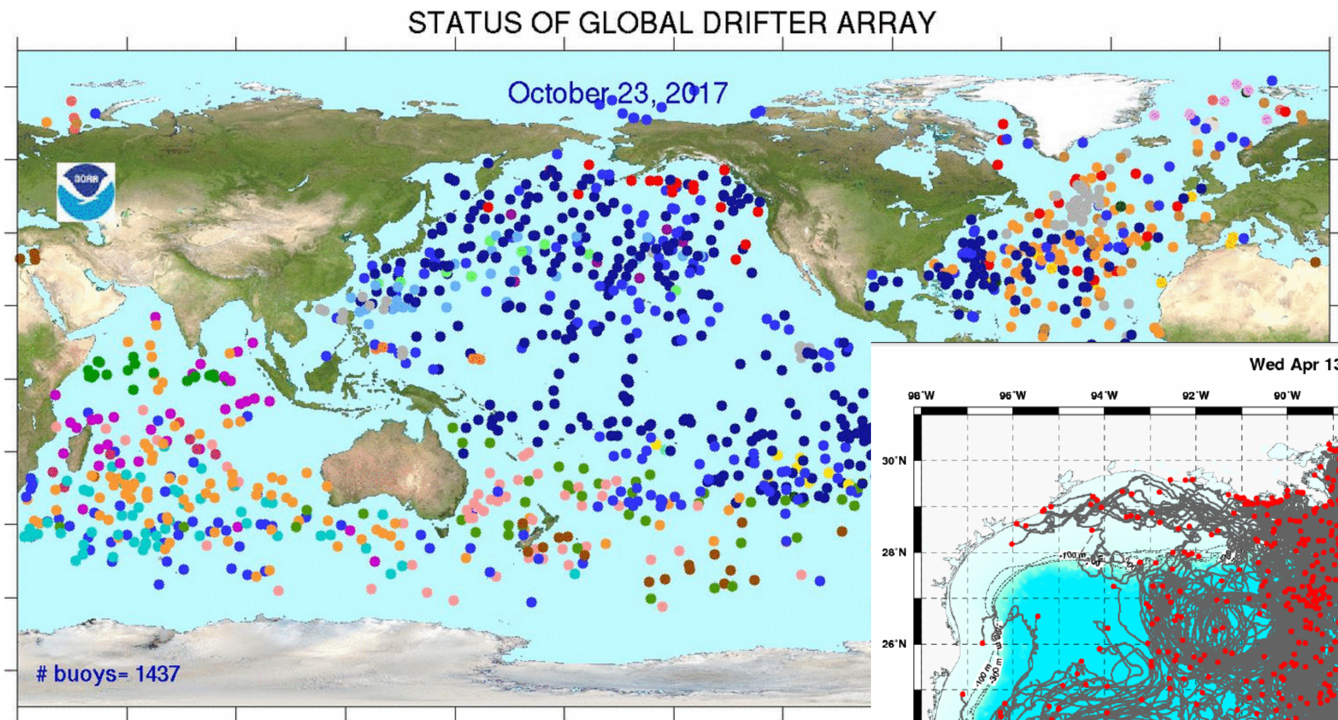


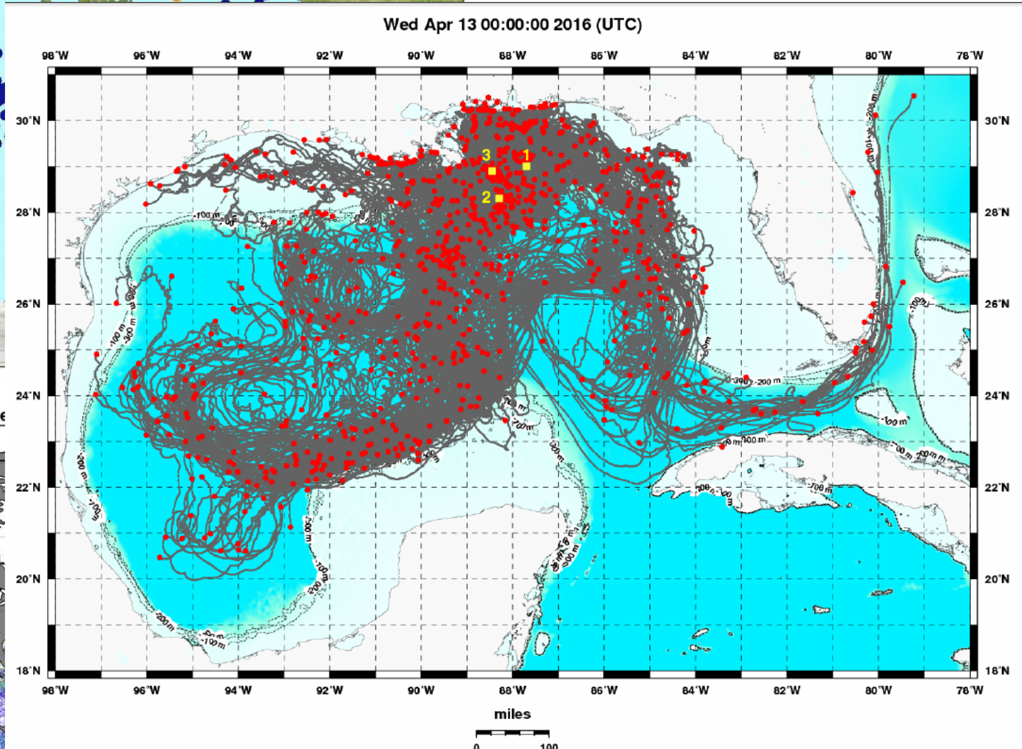


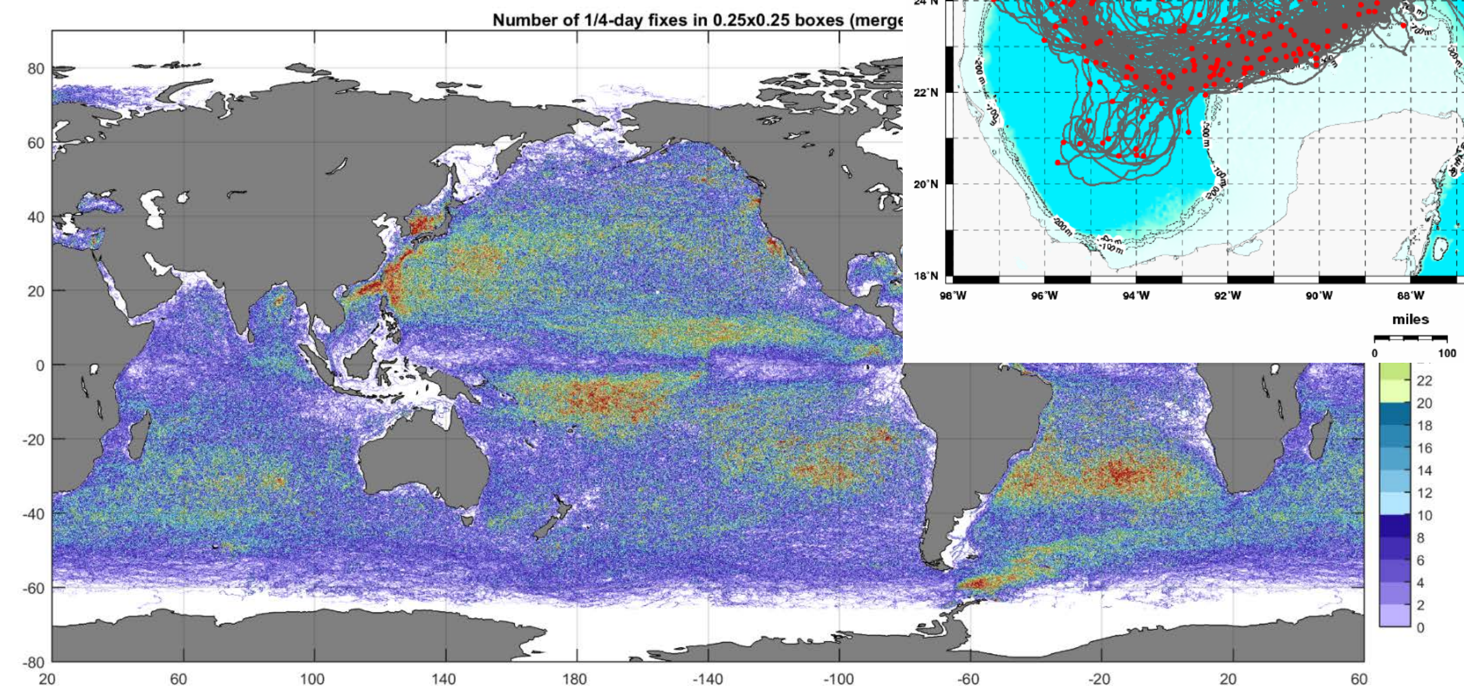
Gaps in coverage











Novelli et al., 2017

Take-home message:

New geodetic MDT products are nearly "perfect" in the global geostrophic framework.

To exceed their quality, oceanographic observations (such as drifter trajectories) need to be carefully planned and processed, including:

- **Accuracy and frequency of fixes**
- **Density and timing of deployments**
- **Quality of ancillary data (such as collocated SLA, wind, etc.)**
- **Filters and parameterizations**