Using an altimeter-derived internal tide model to remove tides from in situ data

Edward D. Zaron, Portland State University

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Overview

Objective: Validate an internal tide model using independent, non-SSH, data.

Test data sets:

1. Steric height from ARGO profiles near Hawaii
2. Steric height from XBT transects in the Tropical Atlantic
3. Surface currents from GDP drifters near Hawaii

(future) Objective: Use an internal tide model to de-tide ocean profile data.

Zaron, E. D., and R. D. Ray (2017), Using an altimeter-derived internal tide model to remove tides from in situ data, Geophys. Res. Lett., 44, 4241–4245

Steric height from vertical profiles

Steric height:

$$\eta_{\text{steric}} = \int_{z_r}^{0} \left(\frac{\rho_o}{\rho(z)} - 1 \right) dz \qquad (1)$$

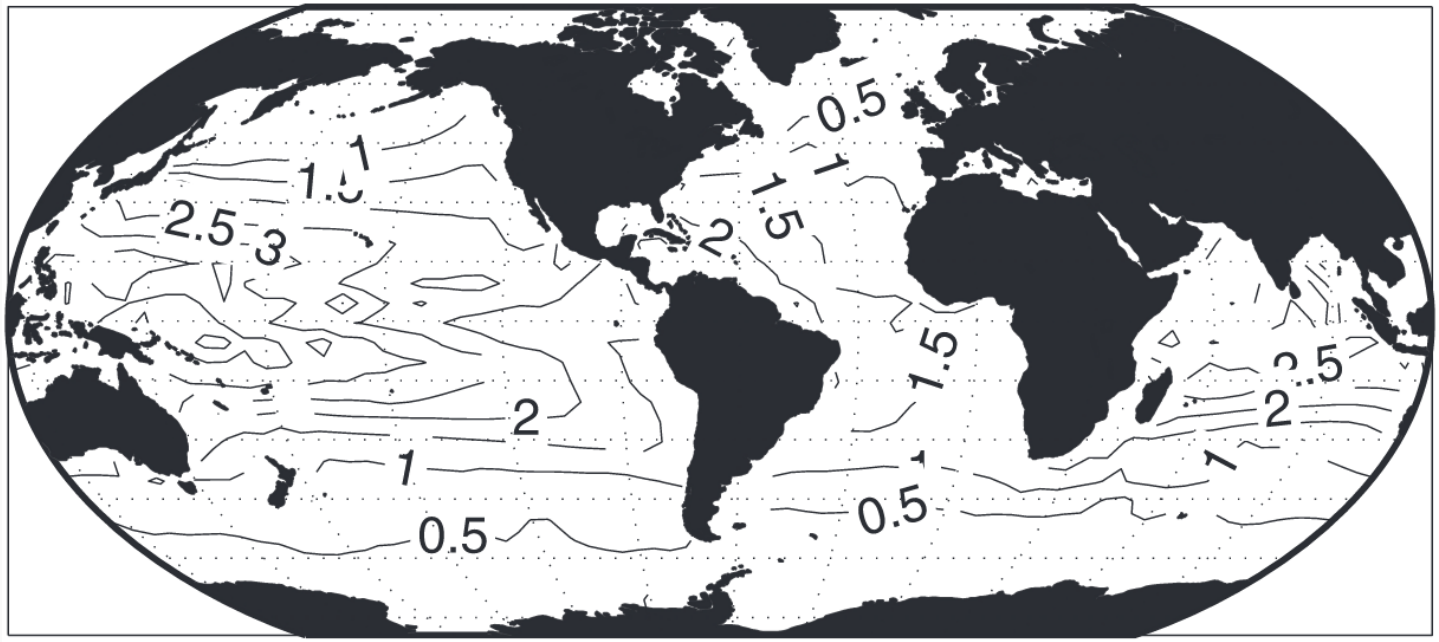


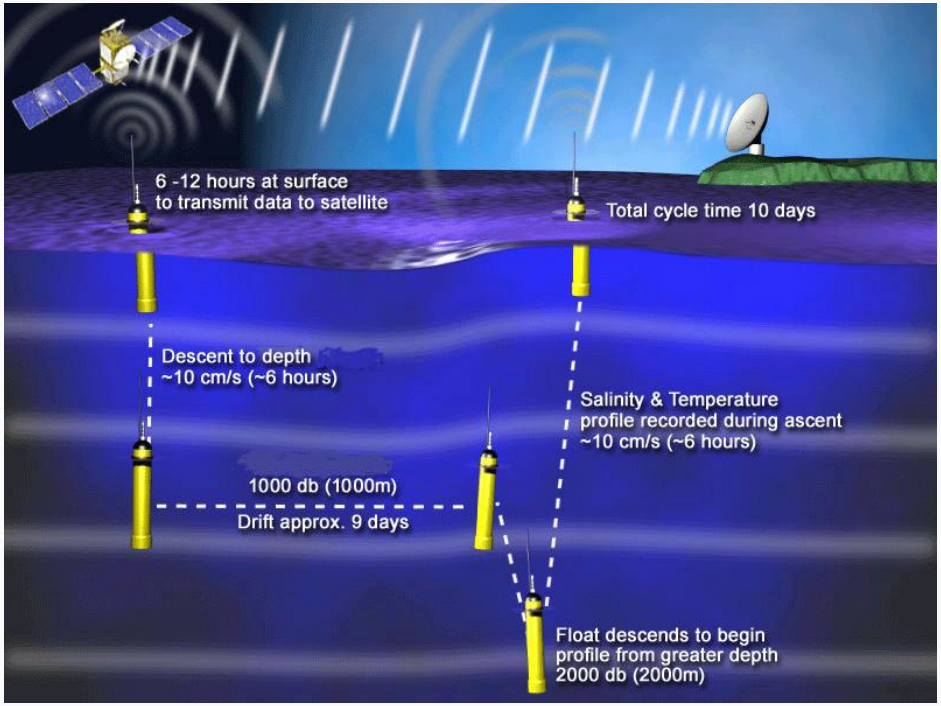
Figure from Wunsch (2013).

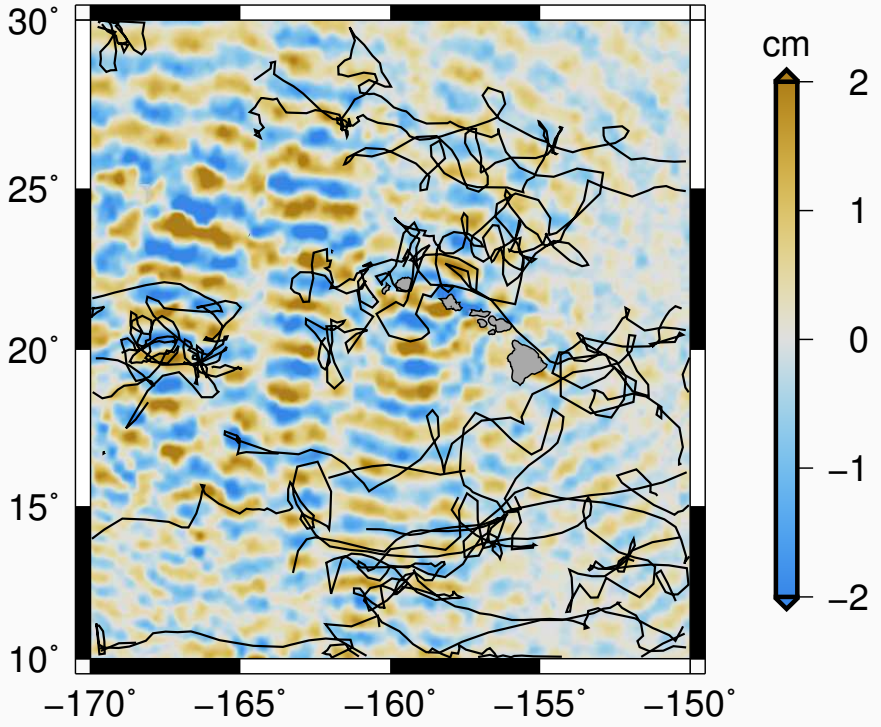
Ratio of mode-1 surface displacement to maximum subsurface displacement (units of mm/m).

Potential difficulties

- One cannot unambiguously determine the steric height anomaly (versus the mean profile).
- Profiles do not go all the way to the bottom (α factor).
- Salinity is not measured by XBT.
- Finite-duration of vertical profile.

Argo comparisons





Data help from Nathalie Zilberman, SIO.

$$N = 1497$$

$$\sigma^2_{\text{data}} = 107\text{cm}^2, \quad \sigma^2_{\text{model}} = 0.58\text{cm}^2, \quad \sigma^2_{\text{expl.}} = 0.35\text{cm}^2$$

With $\alpha = 0.8$, obtain $\sigma^2_{\text{expl.}} = 0.37\text{cm}^2$ and $\sigma^2_{\text{expl.}}/\sigma^2_{\text{model}} = 1.$

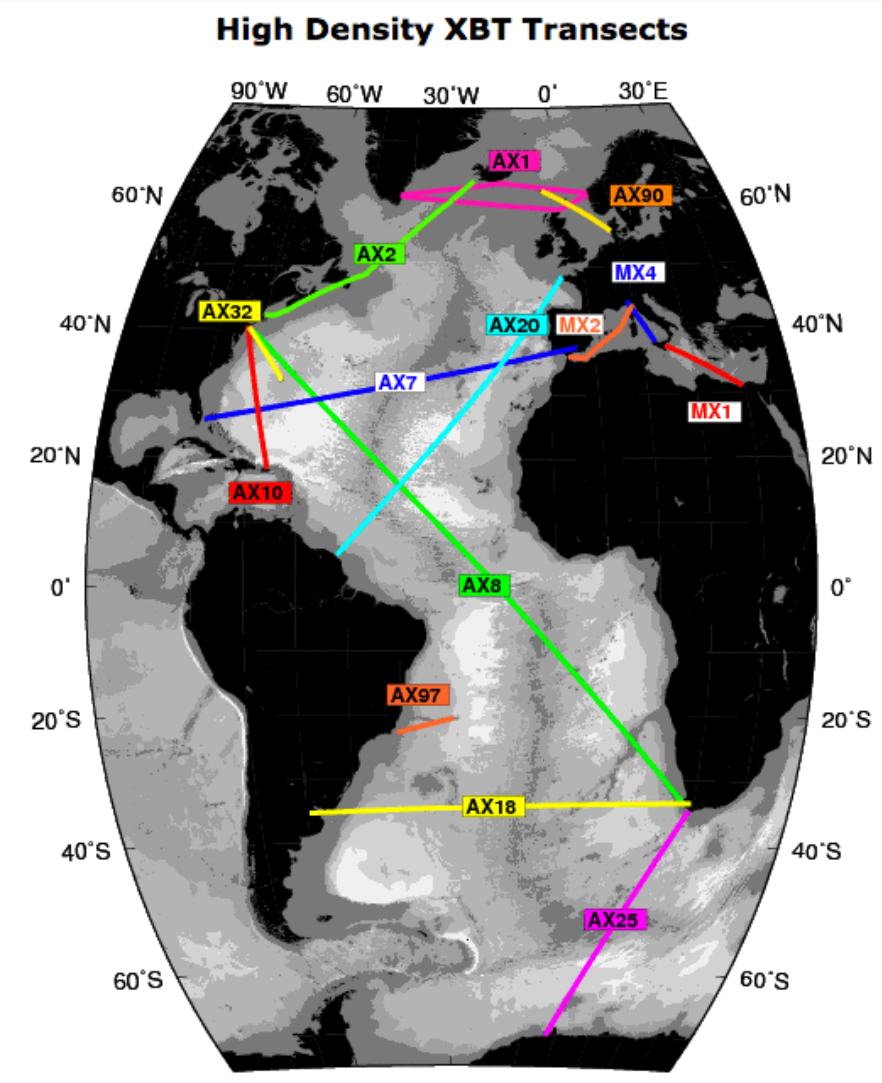
Notes from Argo comparisons

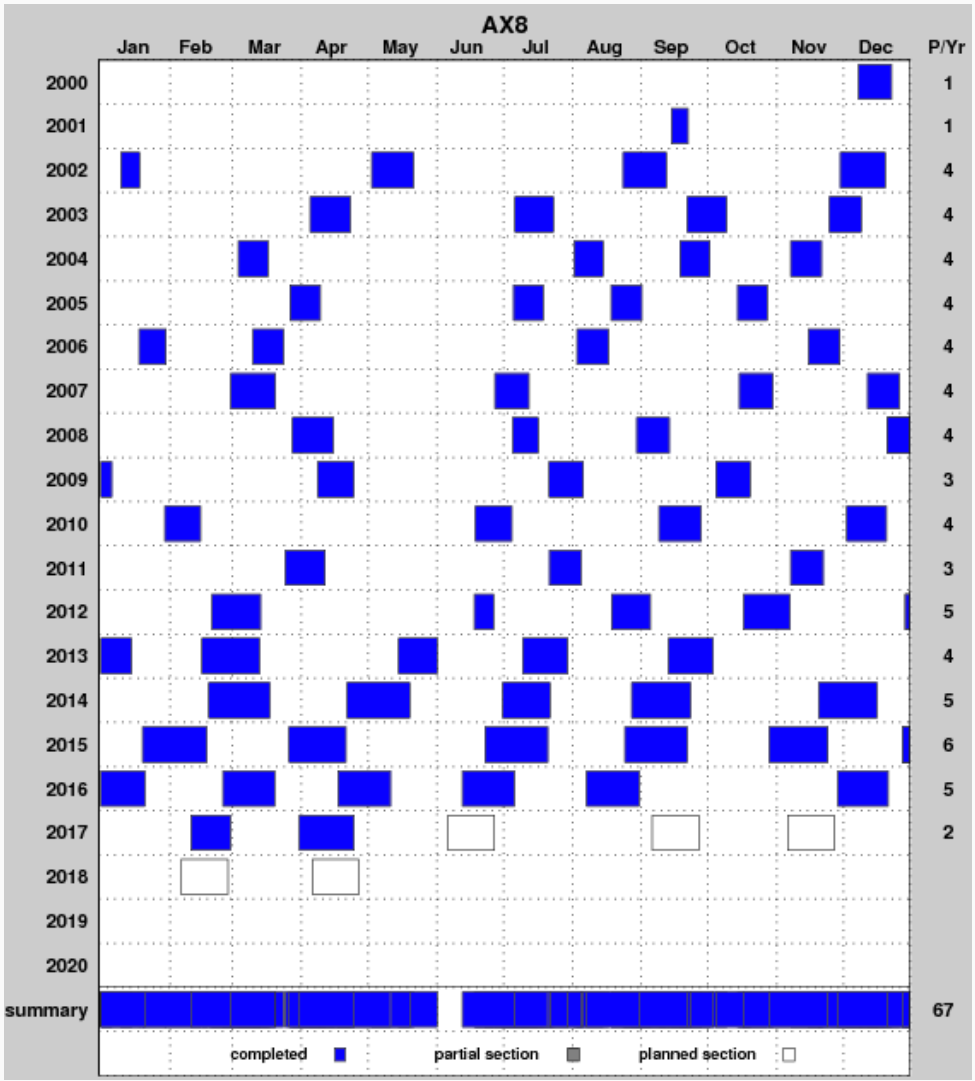
- Comparisons with non-SOLO-type floats obtained negative results. Why?

- The α coefficient (ratio of steric height relative to z_r versus steric height relative to the level of no motion) is surprisingly variable (computed from full-water-column WOCE profiles).

- There was no detectable time lag related to the finite duration of the profiling time. The explained variance is optimized at essentially zero lag.

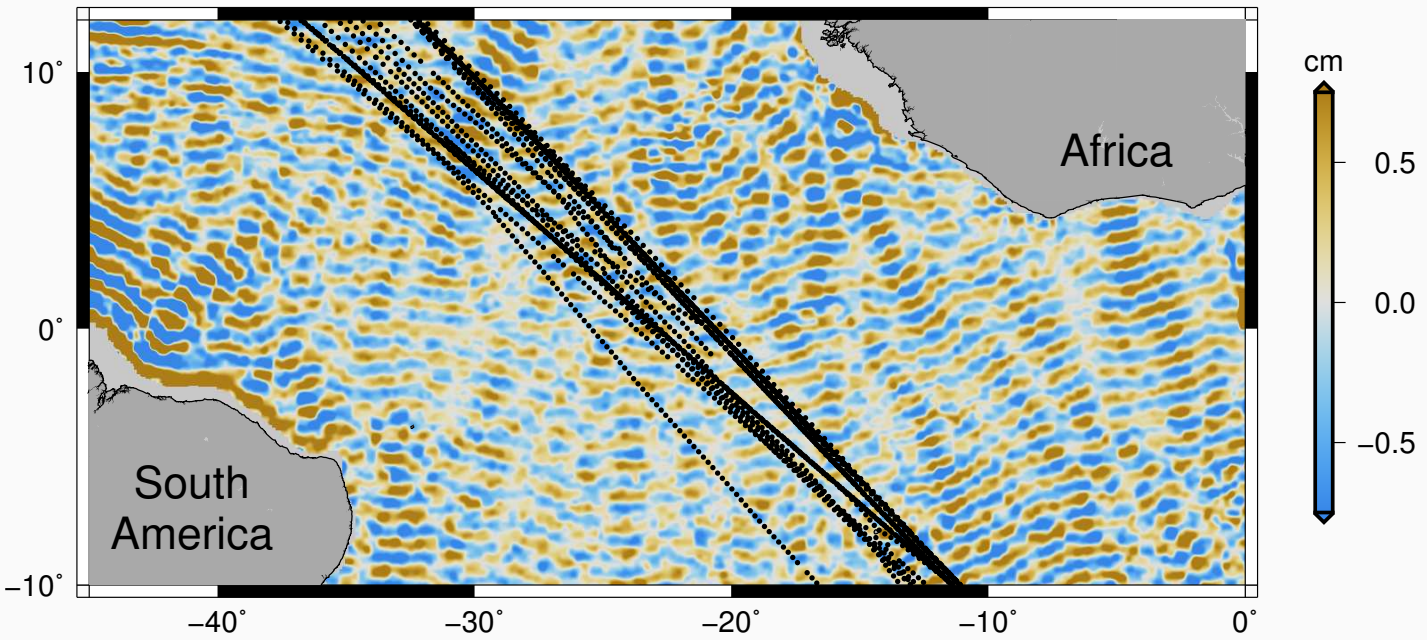
XBT comparisons: AX8 transect from Cape Town to Newark





Data help from Molly Baringer, NOAA/AOML.

AX8 Transect



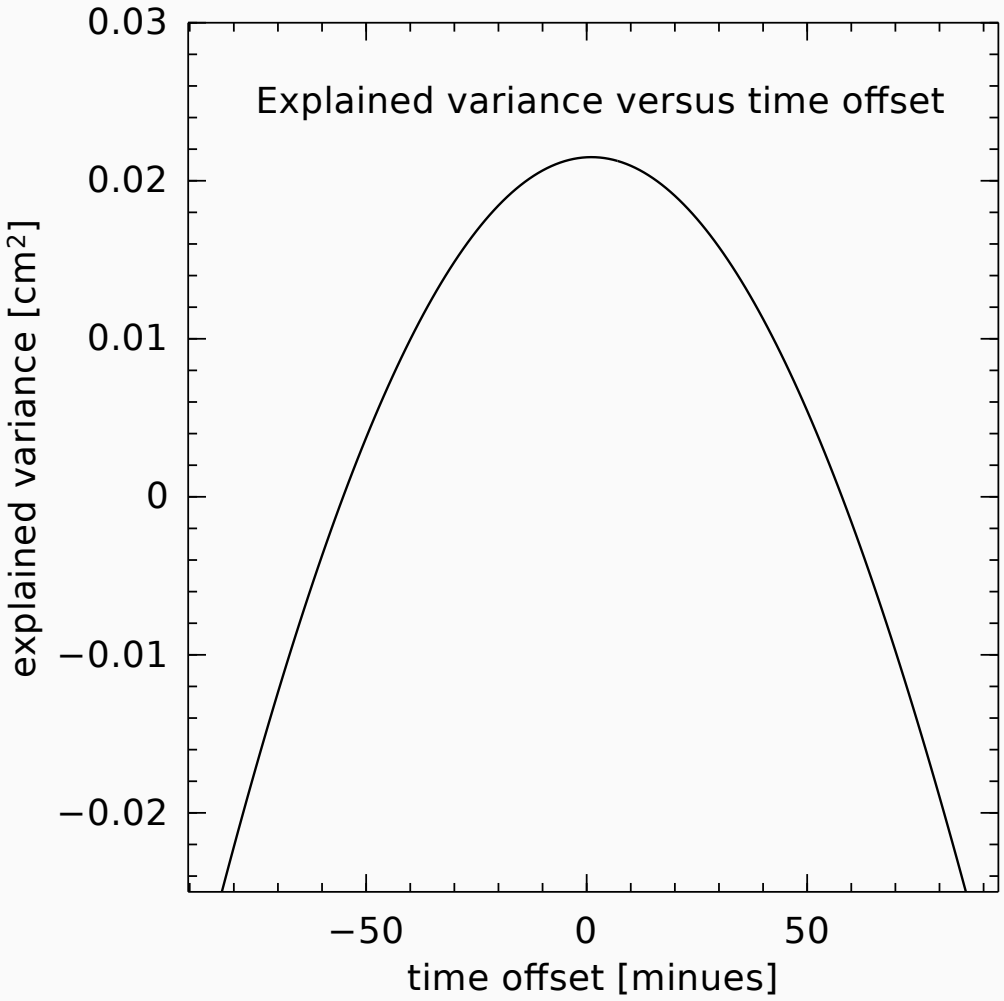
$N = 4518$

$\sigma^2_{\text{data}} = 22.3\text{cm}^2, \quad \sigma^2_{\text{model}} = 0.15\text{cm}^2, \quad \sigma^2_{\text{expl.}} = 0.02\text{cm}^2$

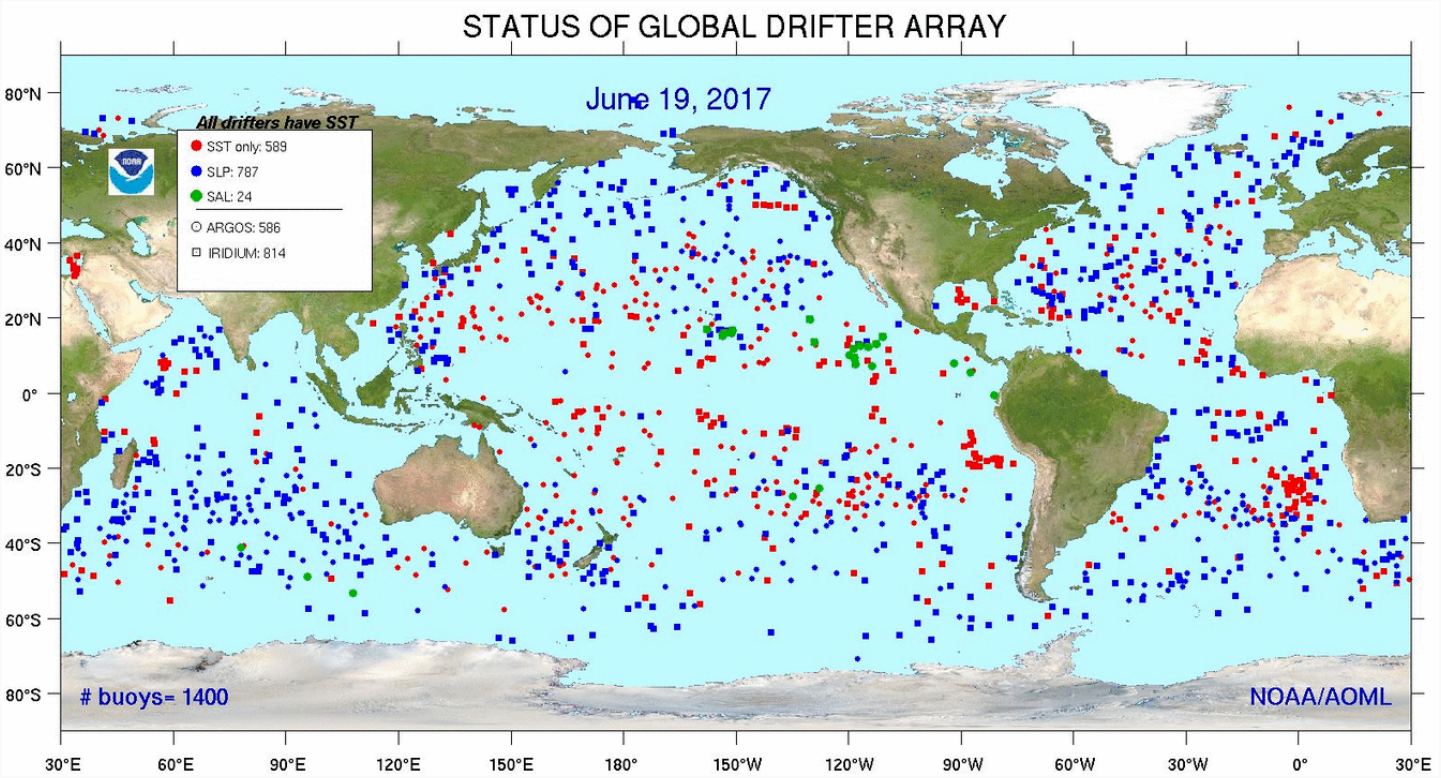
With $\alpha = 0.6$, obtain $\sigma^2_{\text{expl.}} = 0.05\text{cm}^2$ and $\sigma^2_{\text{expl.}}/\sigma^2_{\text{model}} = 0.9$.

AX8 time lag

Assess “significance” by introducing an artificial time lag between model and observation.

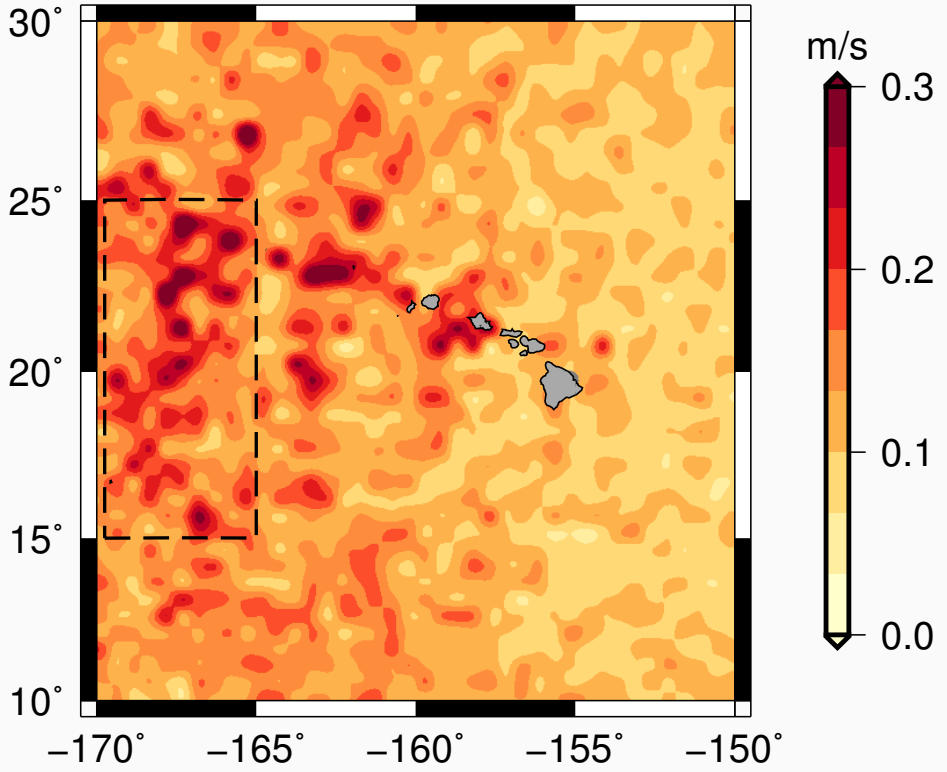


NOAA/PhOD Global Drifter Program (GDP)



Data from 2005–2015 were provided by Mayra Pazos, GDP DAC. Trajectories were interpolated to 1-hr. location and velocity (version 1.00 of the Elipot et al, 2016, data set). The dataset consisted exclusively of Argos-tracked drifters. I did not investigate the differences between Argos- and GPS-tracked products.

GDP Tidal Currents



$$u_t + f \times u = -g\nabla\eta - \lambda u$$

No improvement for $\lambda \neq 0$.

$$N = 6.8 \times 10^4$$

$$\sigma^2_{\text{data}} = (483, 367)(\text{cm/s})^2, \quad \sigma^2_{\text{model}} = (8.9, 18.2)(\text{cm/s})^2$$

$$\sigma^2_{\text{expl.}} = (-2.5, 14.5)(\text{cm/s})^2$$

Bad zonal component (u)!

Summary

Take-home messages:

1. The internal tide model does explain steric height variance of in situ data sets.
2. Deficiencies with GDP velocity comparisons are consistent with known deficiencies in the tide model.

Next steps:

1. Attempt a tidal correction to geostrophic transport (depends on vertical modes).
2. Attempt a global or basin-scale intercomparison.

Extra Slide: Results Summary

Data Set	N	Variance Units	Variance Data	Variance Model	Variance Explained $\alpha = 1$	Variance Explained optimal α
Argo	1497	cm^2	107.0	0.58	0.35	0.37
GDP-u	6.8×10^4	$(cm/s)^2$	483.0	8.9	-2.5	n/a
GDP-v	6.8×10^4	$(cm/s)^2$	367.0	18.2	14.5	n/a
AX8	4518	cm^2	22.3	0.15	0.02	0.05

$\alpha = 0.8$ for Argo (Pacific range, $0.6 - 0.8$).

$\alpha = 0.6$ for AX8 (Atlantic range, $0.3 - 0.7$).