Improving the DAC de-aliasing model by combining with sub-monthly GRACE gravity data

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GOAL: TO IMPROVE ALTIMETRY WITH THE HELP OF GRACE

- Jason altimetry uses an ocean de-aliasing model during processing.

  - Dynamic Atmospheric Correction ("DAC"): Mog2D ocean model + inverted barometer.

 - Errors in the model will alias into errors in sea surface height product.

> Can we use an experimental high-frequency GRACE series
> to improve the Jason "DAC" de-aliasing model?

- A continuation of work done with Don Chambers (GRL, 2011):

  - "Evaluation of high-frequency oceanographic signal in GRACE data: Implications for de-aliasing".

  - Used the Bonn group's ITG-2010 daily-resolution RL04-era GRACE series.

- Current paper in review in Ocean Sciences (Bonin and Save, 2019):

 - "Evaluation of Sub-Monthly Oceanographic Signal in GRACE Daily Swath Series Using Altimetry."

GRACE: CSR "Daily" Swath Series

- Mascon series (40000+ blocks; 120 km across).

  - Geoid anomalies estimated along varying groundtracks.

  - Polar grids observed every 1-2 days

  - Equatorial grids observed every 4-5 days.

  - Older local data and newer neighboring data fill gaps.

- Regularized using GRACE only (no models).

  - Reduces north/south striping.

  - Encourages no land/ocean correlation.

- Uses AOD RL05 (OMCT) as a background model

Example day: 1 Jan 2006
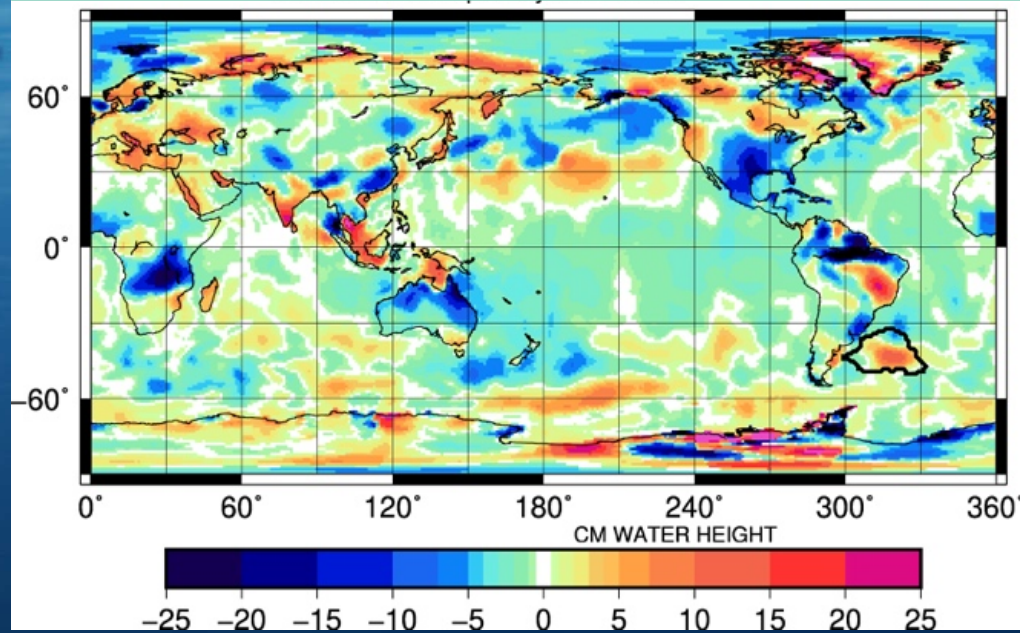
Time series over the Argentine ocean basin
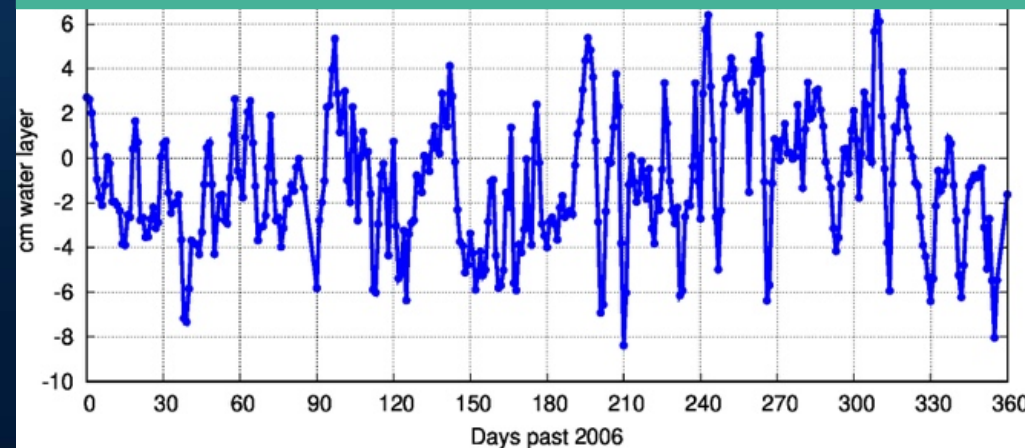
THEORY BEHIND COMPARISON

Ultimate Questions:

Can we supplement DAC with GRACE swath data to make a better altimetry de-aliasing model?

Over which areas, spatial wavelengths, and frequency bands can GRACE swath add value to DAC?

Technique to Answer Them:

Altimetry – GRACE residual will be non-zero:
- Non-pressure ocean signals & local effects.
- Non-ocean gravity signals.

If GRACE is detecting real ocean mass signal:

$$\text{var(Alt} - \text{GRACE)} < \text{var(Alt)}$$

If GRACE is more accurate than the model:

$$\text{var(Alt} - \text{GRACE)} < \text{var(Alt - model)}$$

TREATMENT OF DATA

- To better match Jason altimetry to GRACE's spatial/temporal scale:
  - Smooth each day's altimetry ground-tracks with a 300-km filter to remove short-wavelength features.
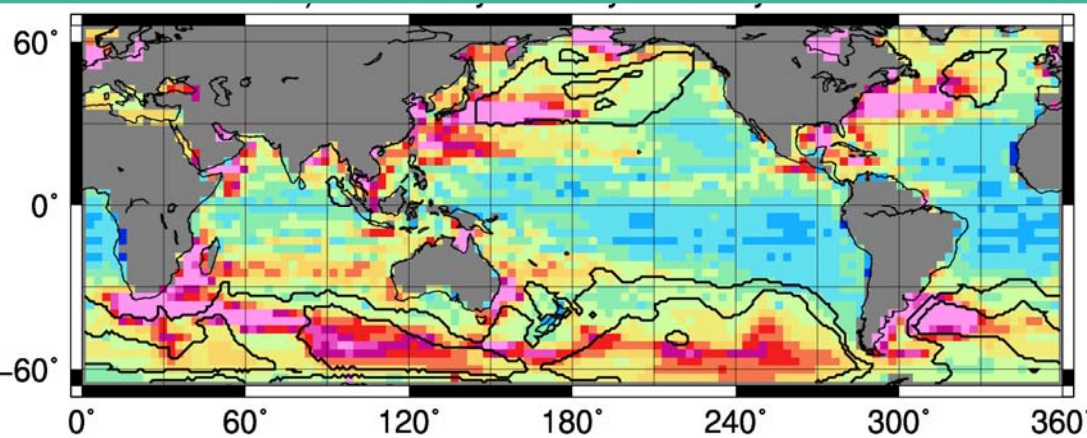 - Average the along-track sea level anomaly data into daily files at 3°x 3° gridded resolution.

Daily altimetry (unsmoothed)

Daily altimetry (300km-smoothed)
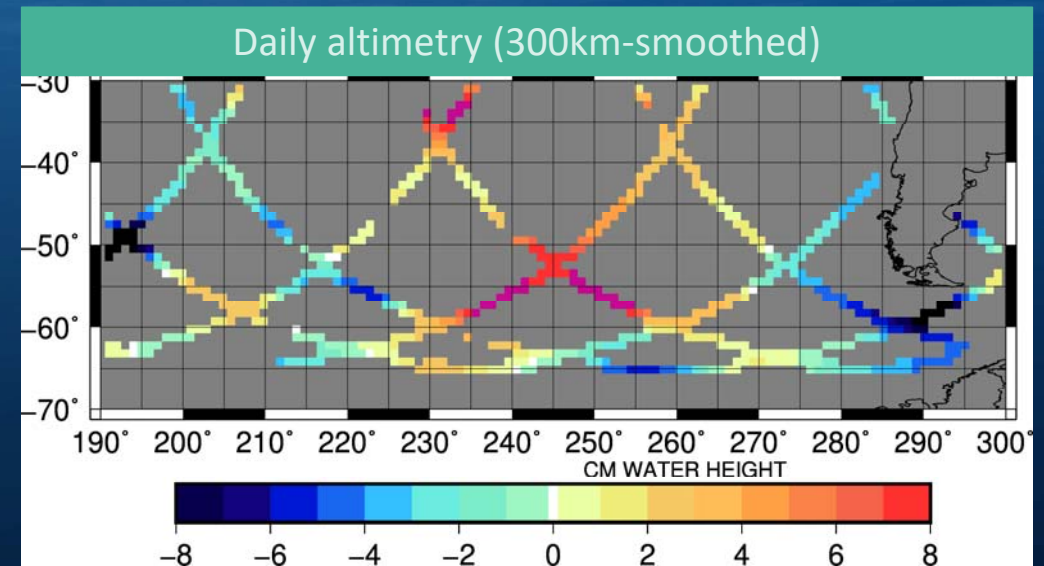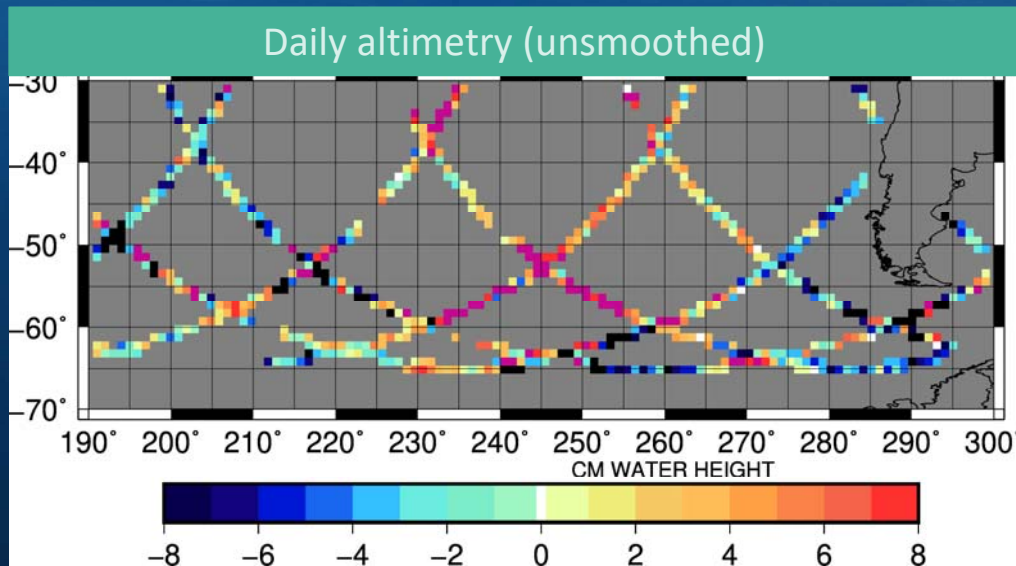
- GRACE and model data are masked to mimic the altimetry groundtracks.
- Difference altimetry with GRACE/models.
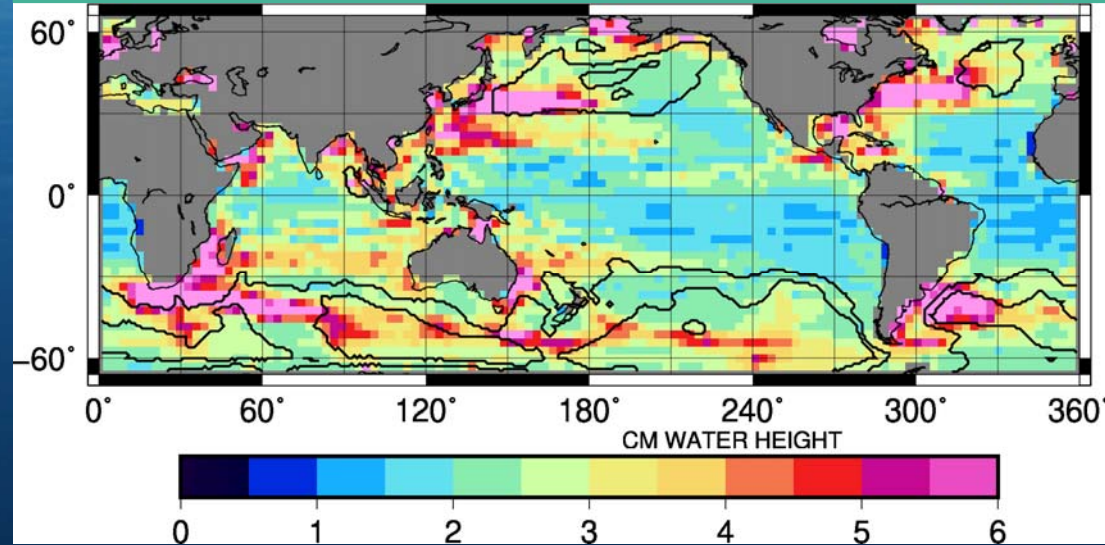- High-pass filters are applied to limit the frequency bands looked at.

GRACE Swath Sub-20day Variability

Altimetry-GRACE Sub-20day Variability
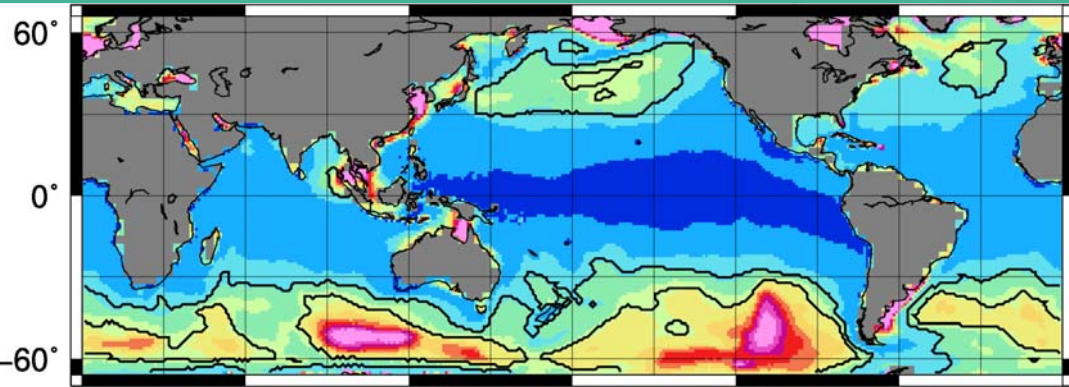
Altimetry Sub-20day Variability

CM WATER HEIGHT

Jason signal reduced in southern ocean, but ACC and western boundary currents are not seen by GRACE.

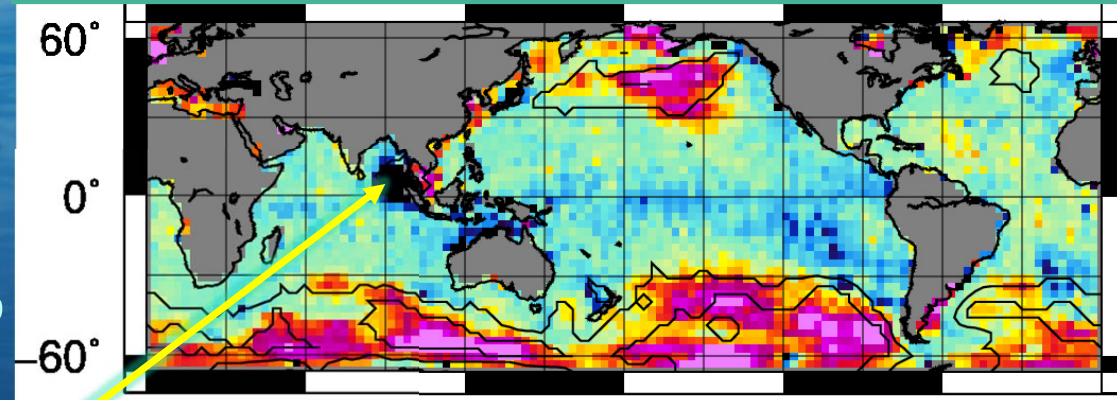# Percent of Altimetry's Variance Explained by Each Series (P.V.E.)

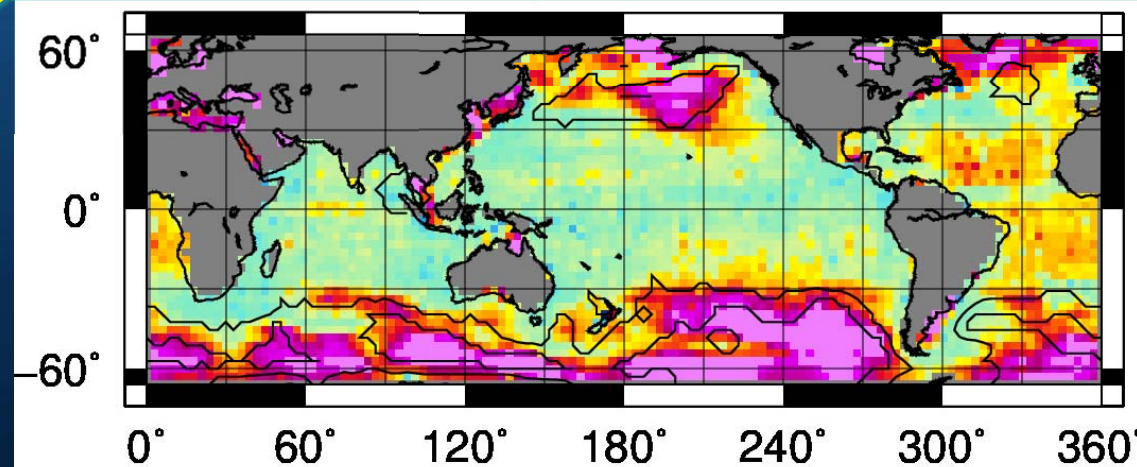$$P.V.E. = \left(1 - \frac{var(Alt - GRACE)}{var(Alt)}\right) * 100\%$$

Earthquake!

In areas with high amounts of signal, both the DAC model and GRACE are capable of explaining a large fraction of altimetry's signal in the sub-20day frequency band.

(Altimetry - GRACE) Sub-20day P.V.E.

(Altimetry − DAC) Sub-20day P.V.E.

PERCENTAGE OF ALTIMETRIC VARIANCE EXPLAINED
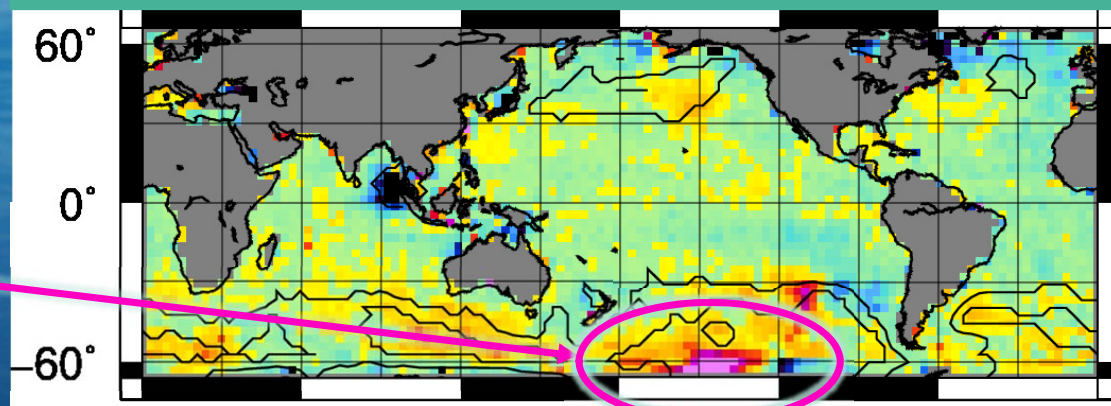
DAC Model Comparison Relative to GRACE swath series

Used this analysis to find a model limitation in GRACE's AOD RL06 model, which is being corrected.

But altimetry's DAC model fits the sub-20day altimetric signal slightly better than the GRACE swath series does.
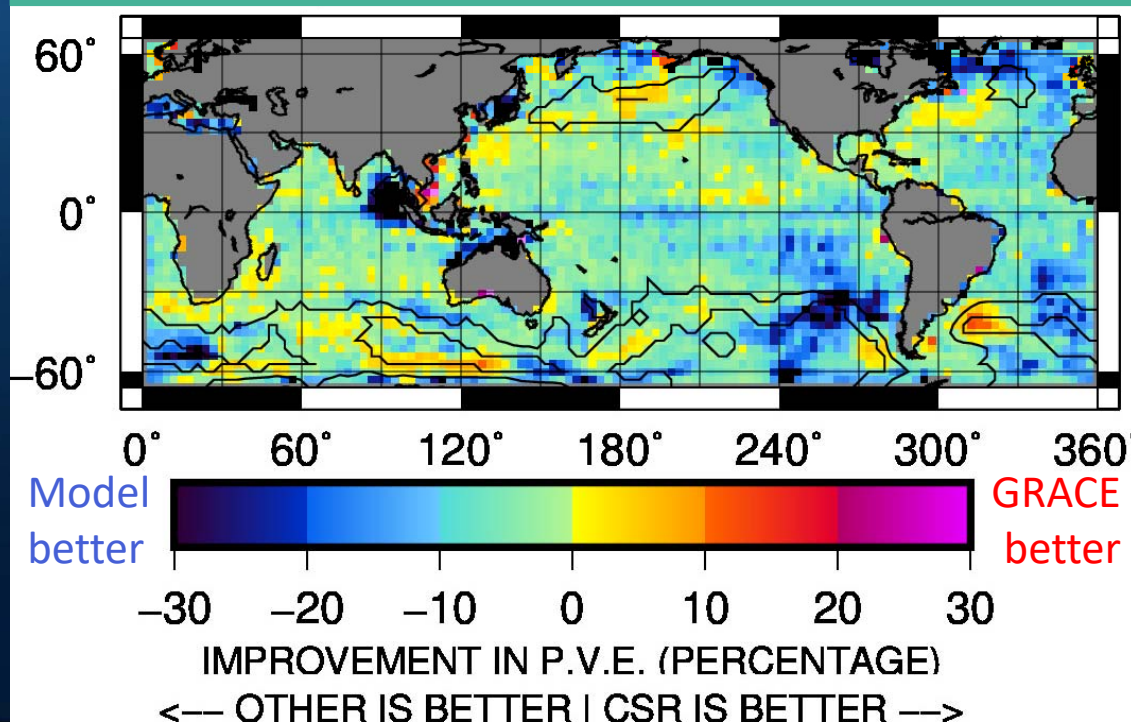
- DAC is better than CSRswath in 87% of bins (83% of bins with more than 2cm submonthly signal).

Based on this, can the GRACE swath series really be used to improve the altimetry de-aliasing model???



PVE(Alt-GRACE) – PVE(Alt-AOD06) Sub-20day

PVE(Alt-GRACE) – PVE(Alt-DAC) Sub-20day

Model better   GRACE better

IMPROVEMENT IN P.V.E. (PERCENTAGE)
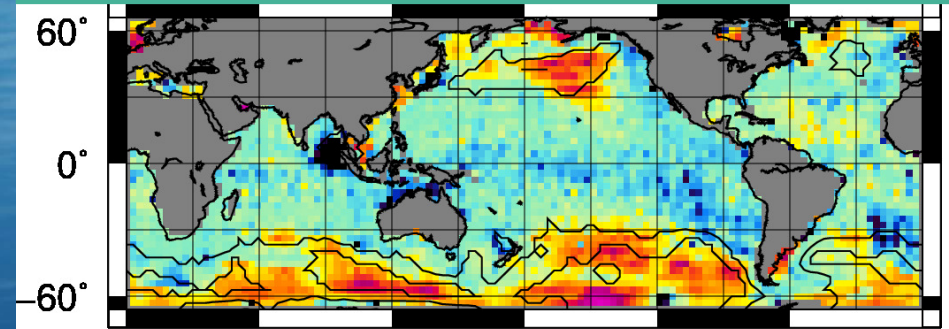
<–– OTHER IS BETTER | CSR IS BETTER ––>

PERCENT VARIANCE EXPLAINED BY GRACE AT EACH FREQUENCY BAND

For periods of 1-10 days, the GRACE swath series explains only a small amount of altimetry's signal.
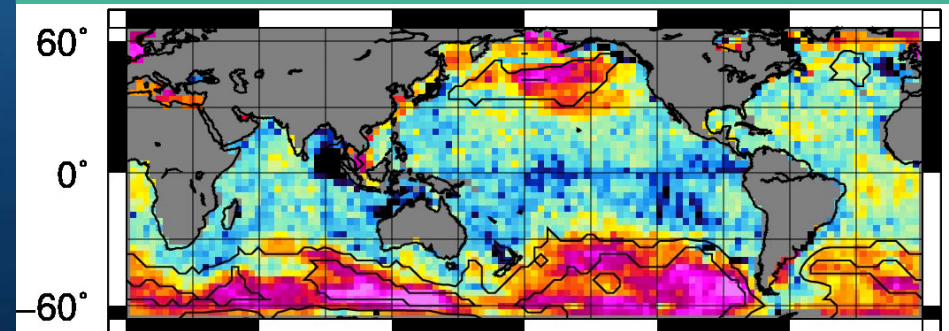
For periods of 10-20 days, the GRACE swath series explains 50% or more of the altimetry signal in most bins with more than 2cm submonthly signal.
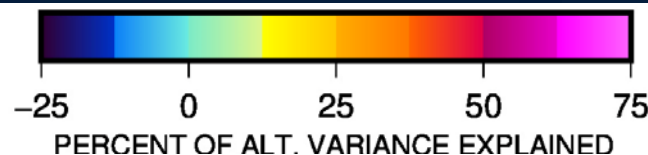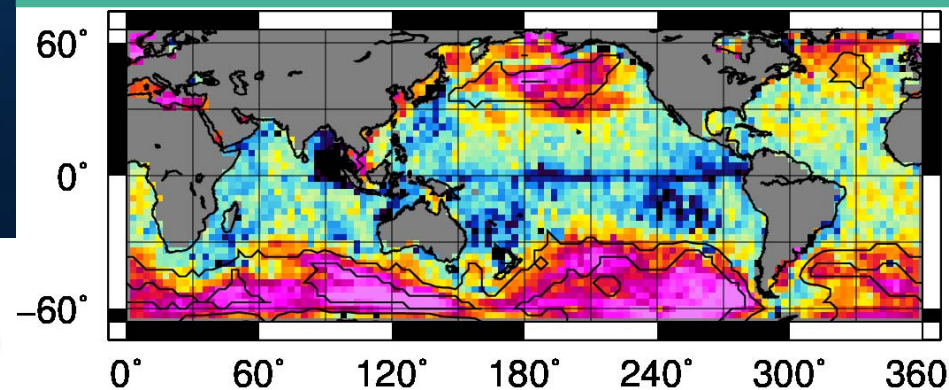

PVE(Altimetry-GRACE) 1-10 days

PVE(Altimetry-GRACE) 10-15 days

PVE(Altimetry-GRACE) 15-20 days

PERCENT OF ALT. VARIANCE EXPLAINED

# IMPROVEMENTS OF GRACE OVER DAC AT EACH FREQUENCY BAND

CSR swath fits Jason altimetry better than DAC does:
- For periods > 15 days.
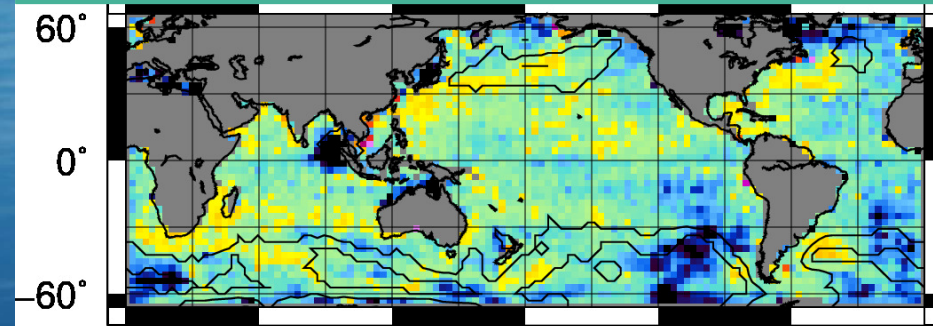- Across high-signal areas (the southern ocean).

Jason's current de-aliasing model is better:
- For periods < 10 days.
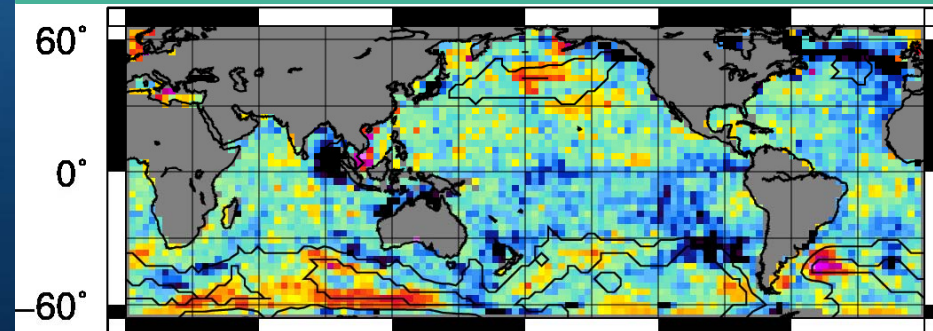- Across the equatorial regions and Altlantic.

The GRACE swath series *can* be used to improve the altimetry de-aliasing model!

Model is better   GRACE is better
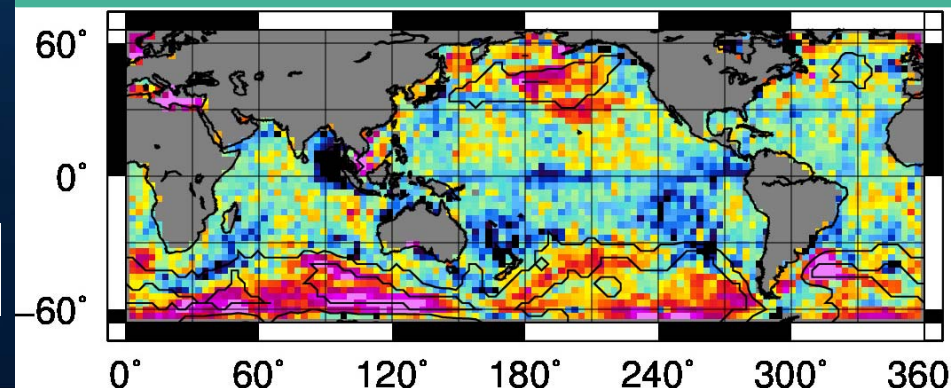
Improvement in PVE (percentage)
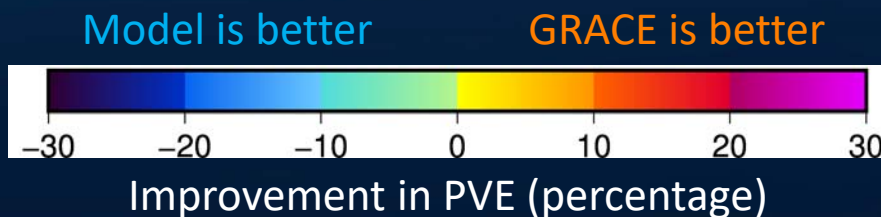
PVE(Alt-GRACE) − PVE(Alt-DAC) 1-10 days

PVE(Alt-GRACE) − PVE(Alt-DAC) 10-15 days

PVE(Alt-GRACE) − PVE(Alt-DAC) 15-20 days

PROOF OF CONCEPT: MIXING GRACE AND DAC

Regions/freqs where GRACE can add value to DAC?

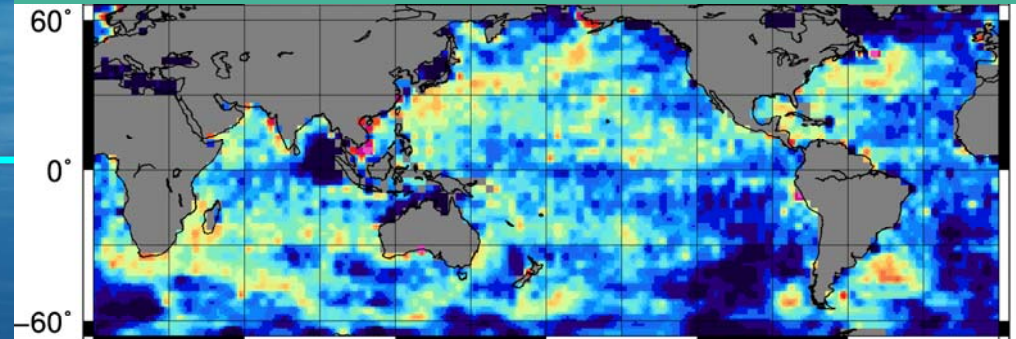- *Southern ocean, north Pacific.*

- *10-20 day periods.*

A "blended" de-aliasing model for altimetry:

- Current DAC model dominates at high frequencies and near equator.

- At longer periods and at higher latitudes, GRACE can add value.

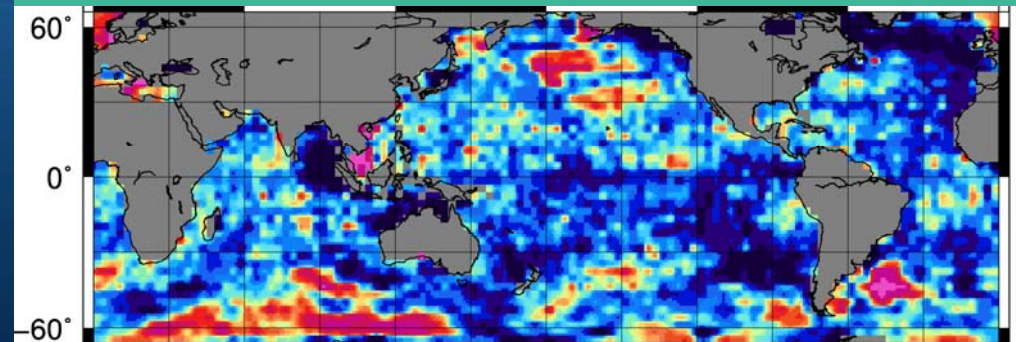- Make a combination of the two, weighted based on the above information.

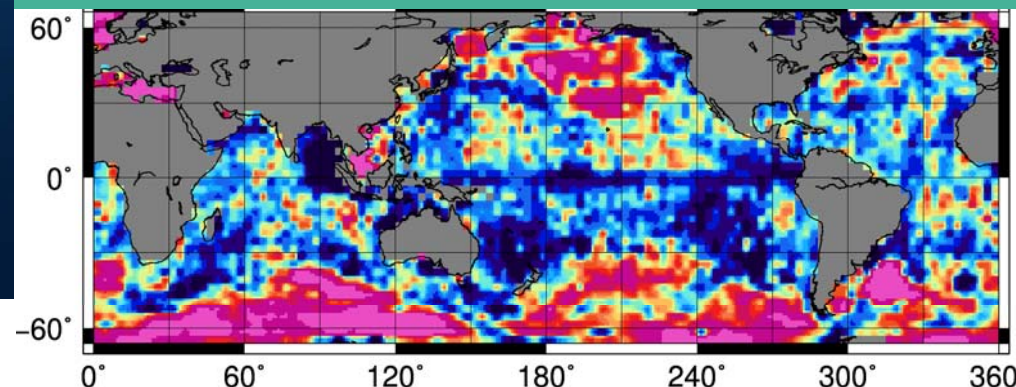Portion of signal to come from GRACE

THANKS MUCH!

Bonin and Save. "Evaluation of Sub-Monthly Oceanographic Signal in GRACE Daily Swath Series Using Altimetry." Ocean Science Discussions. 2019. https://www.ocean-sci-discuss.net/os-2019-68/