

GRACE JPL Level 2 Processing Status

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October 10, 2017

GRACE Science Team Meeting

Austin, TX

Overview

GRACE / GRACE-FO



- RL05 Status
- Accelerometer Transplant
- Pitch Bias
- Mascon Error Calibration
- Mascon Analysis – Spectral Content/Leakage Error
- RL06 Status

Overview

GRACE / GRACE-FO



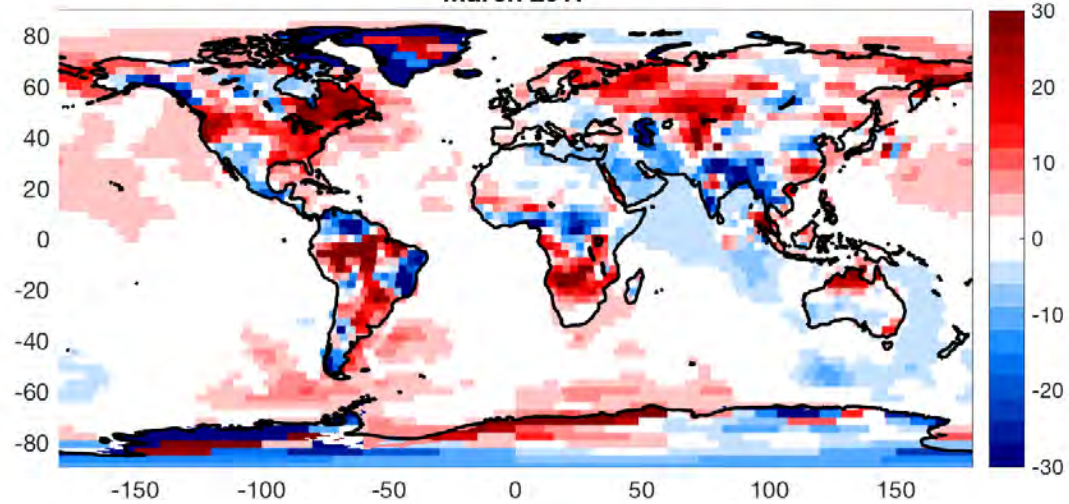
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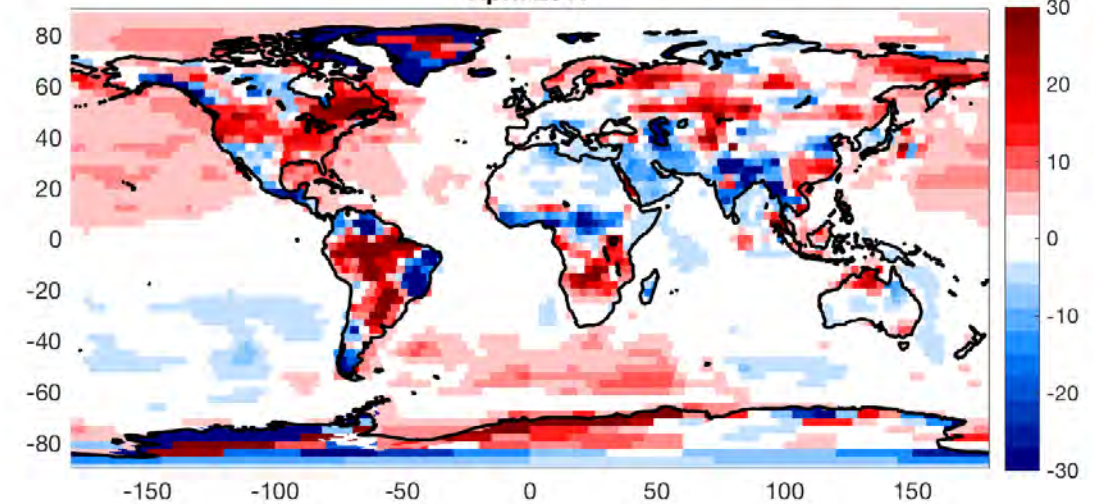
GRACE / GRACE-FO



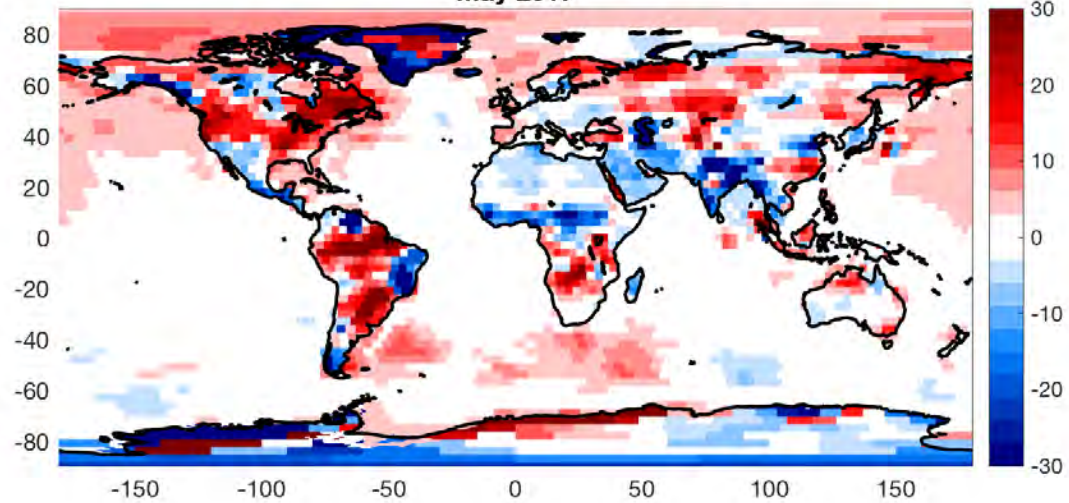
March 2017



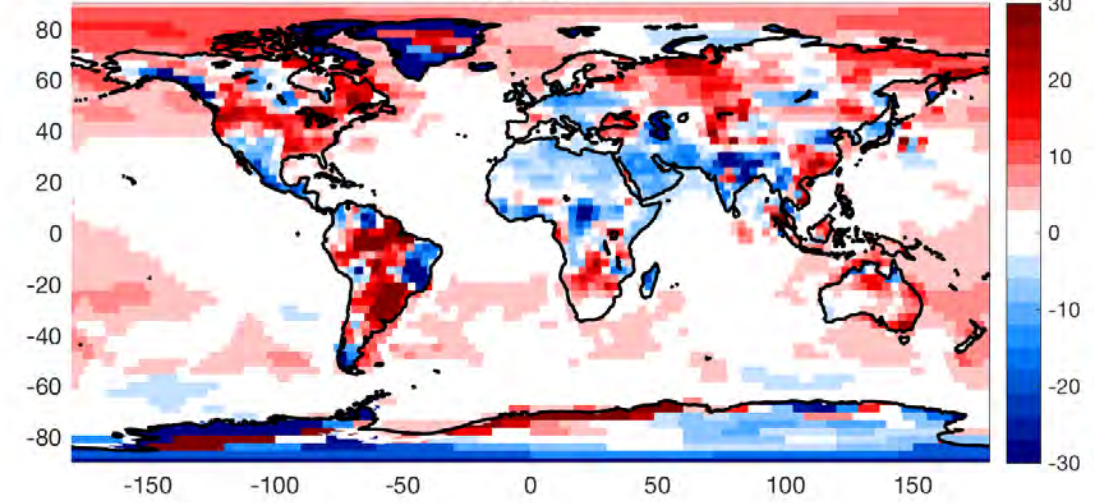
April 2017



May 2017



June 2017

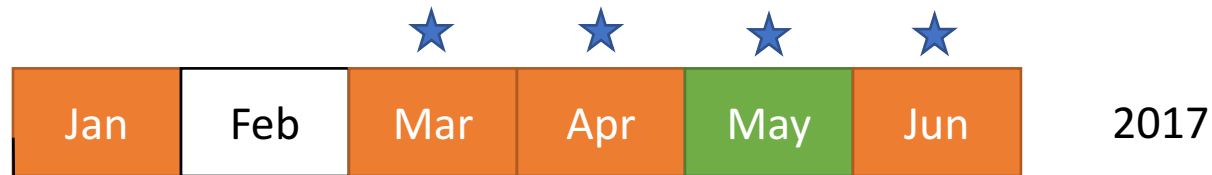
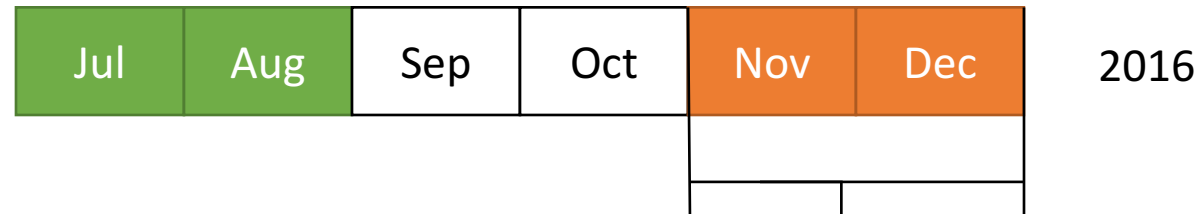


Updates since GSTM 2016

Two accelerometer Solution

Single accelerometer Solution

- ★ Pitch Bias introduced
Degrades zonal coefficients

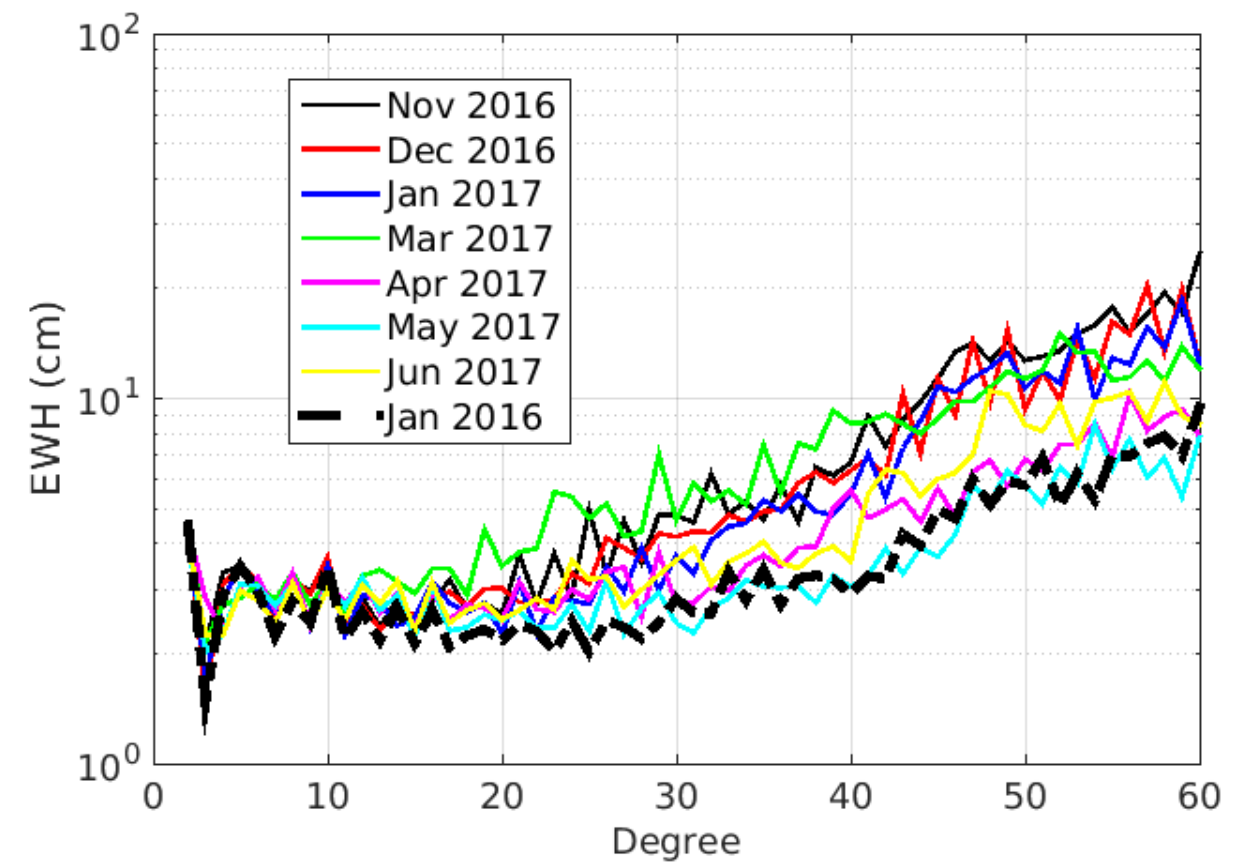
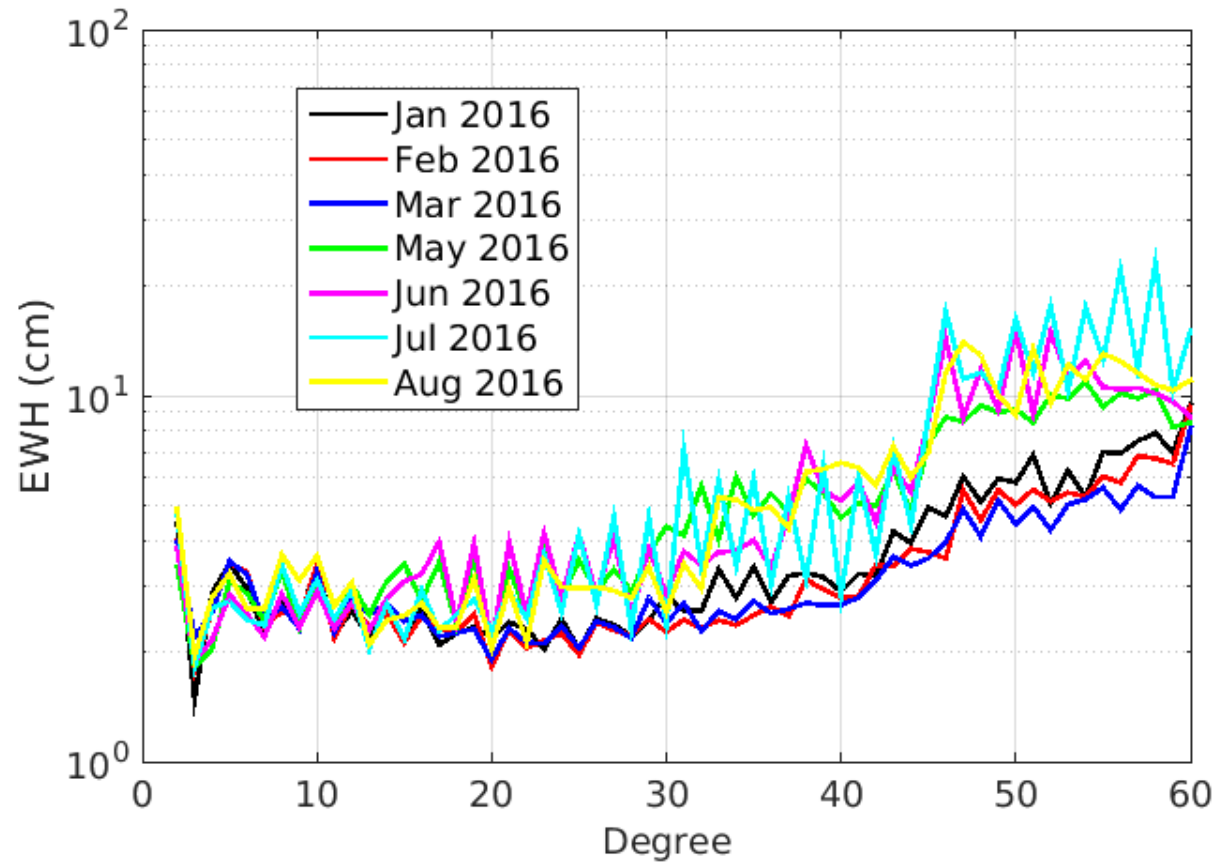


Estimate two sets of local parameters independently for KBRR and GPS measurements

“Single Accelerometer Parameterization”

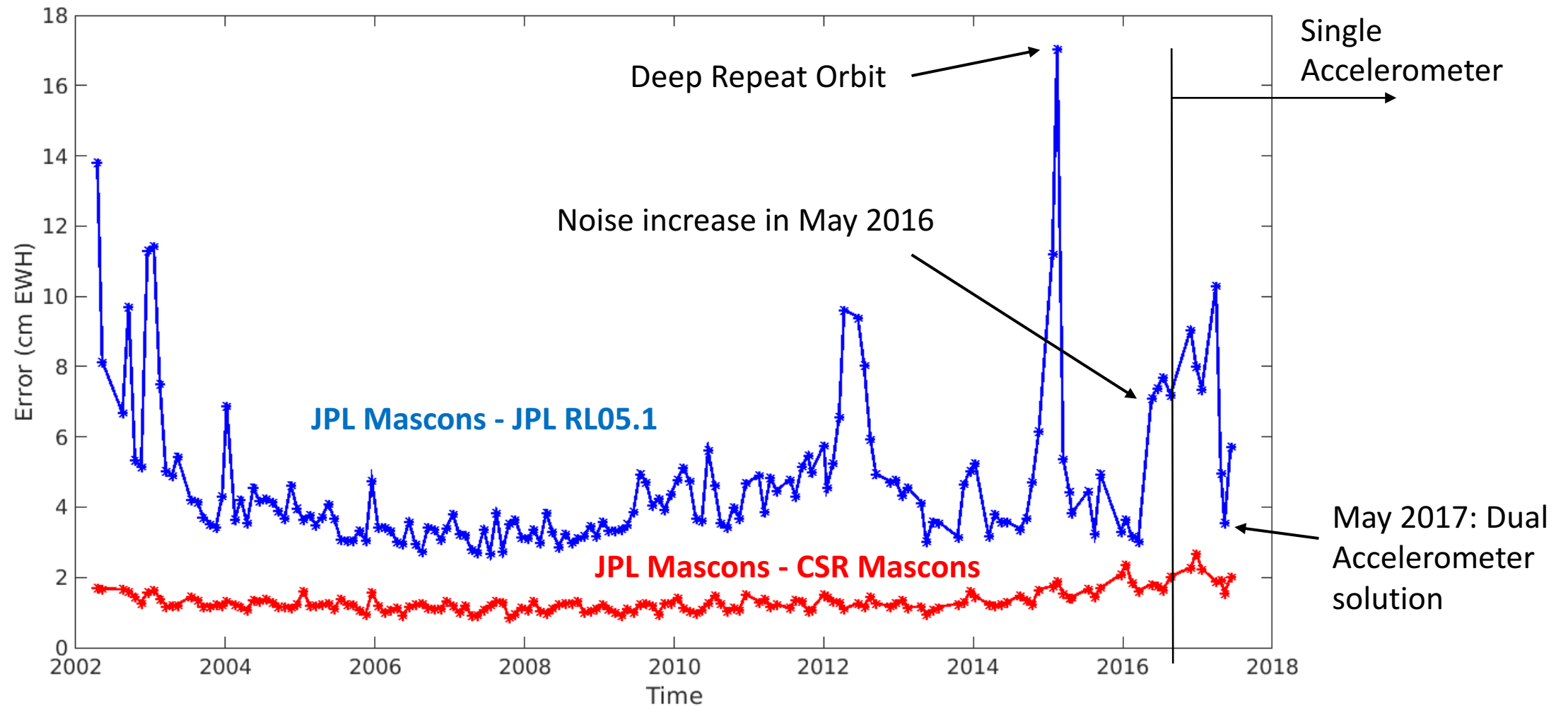
Estimate bias and 1 cycle/rev empirical accelerations in transverse and normal directions every 90 minutes on GRACE-B only

Degree variance analysis



Quality of monthly solutions

Global Spatial RMS of monthly differences between JPL Mascons: Smoothed at 300 km



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Impact of Accelerometer Transplant



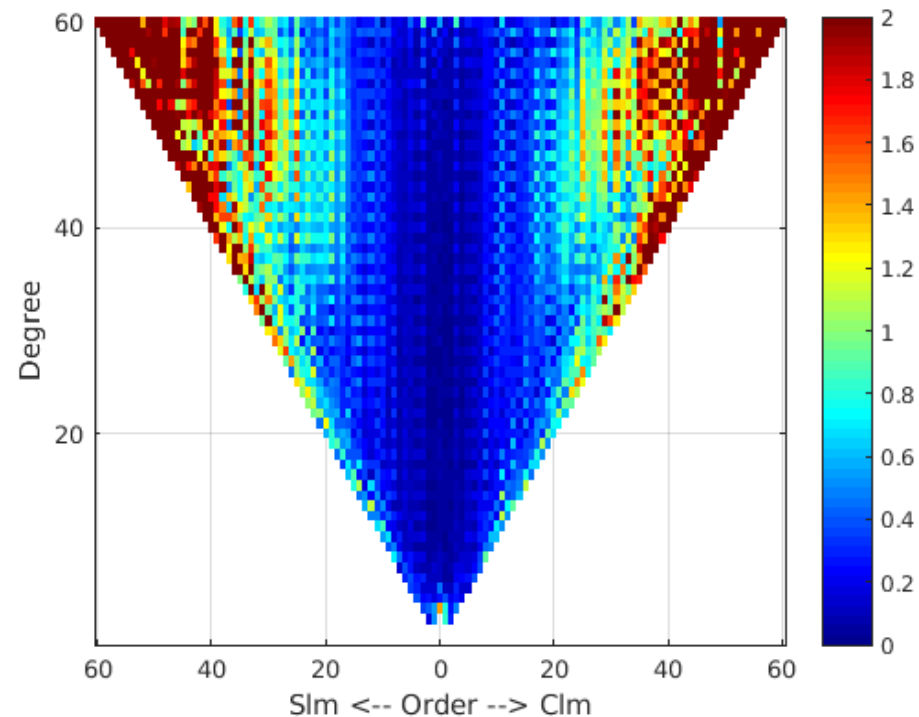
2016 Jan Feb Mar Apr May Jun Jul Aug **Two Accelerometers**

↓ Deliberate Degradation to Single ACC ↓

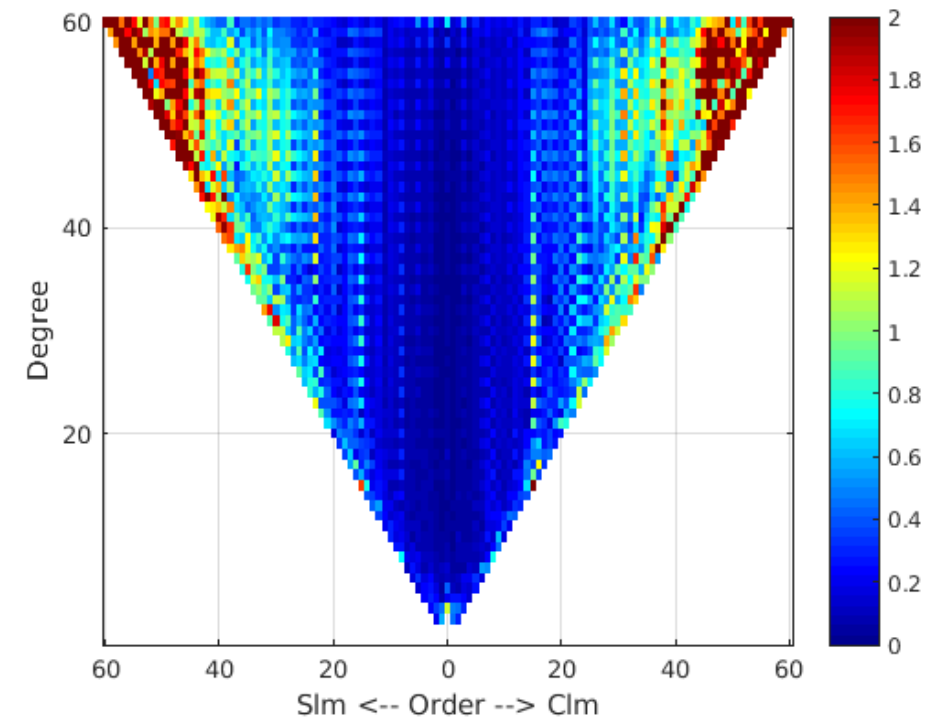
2016 Jan Feb Mar Apr May Jun Jul Aug **Single Accelerometer**

RMS of differences in
coefficients (cm water height)

Normal Parameterization



Single Accelerometer Parameterization



Impact of Accelerometer Transplant



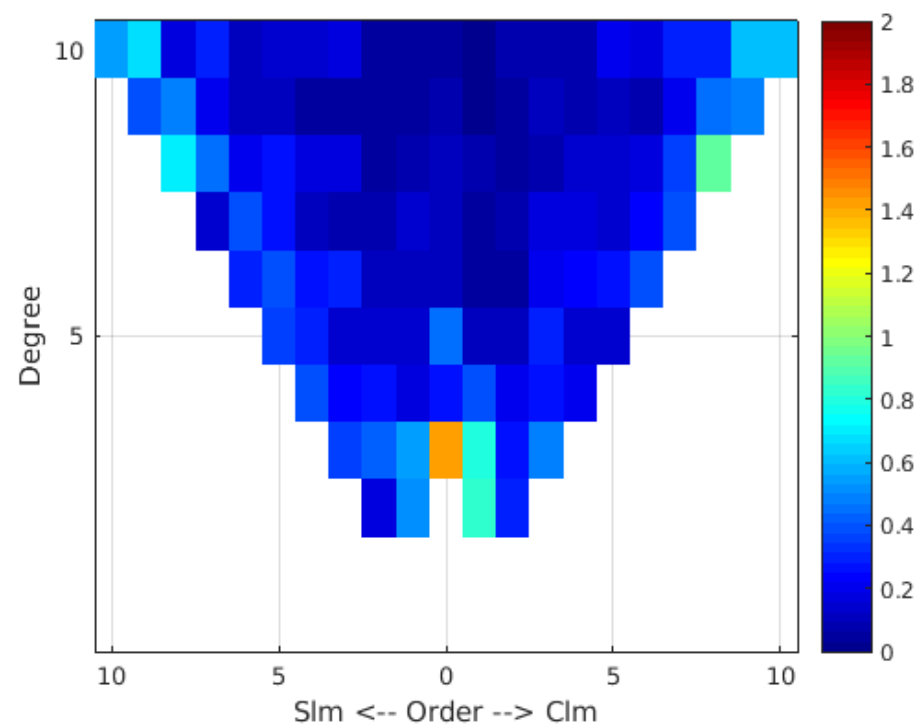
2016 Jan Feb Mar Apr May Jun Jul Aug **Two Accelerometers**

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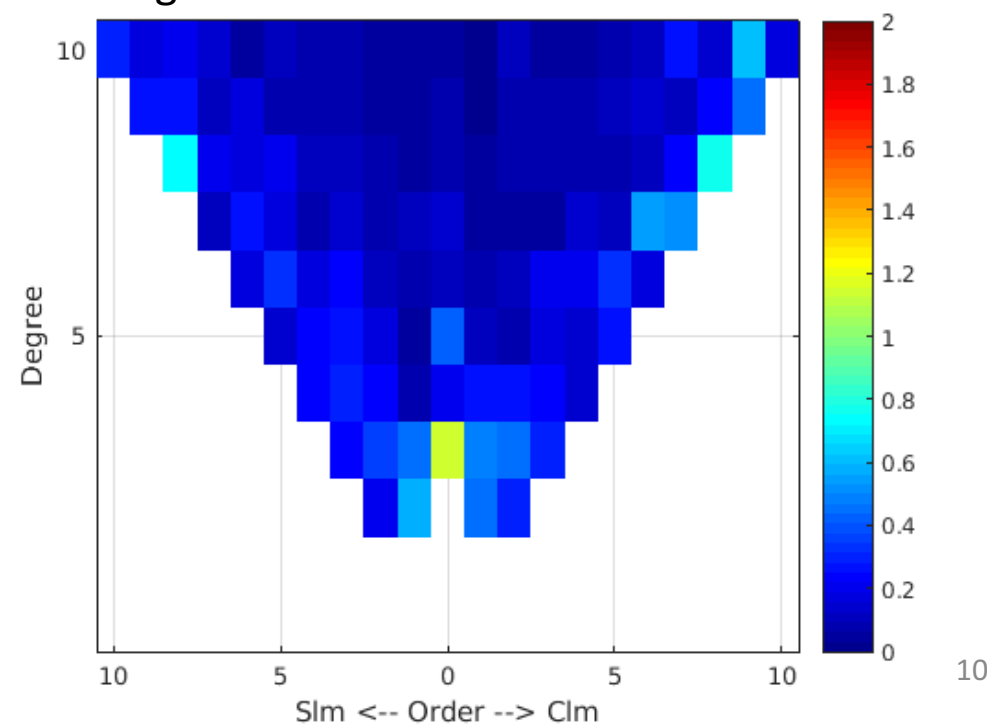
2016 Jan Feb Mar Apr May Jun Jul Aug **Single Accelerometer**

RMS of differences in
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Normal Parameterization

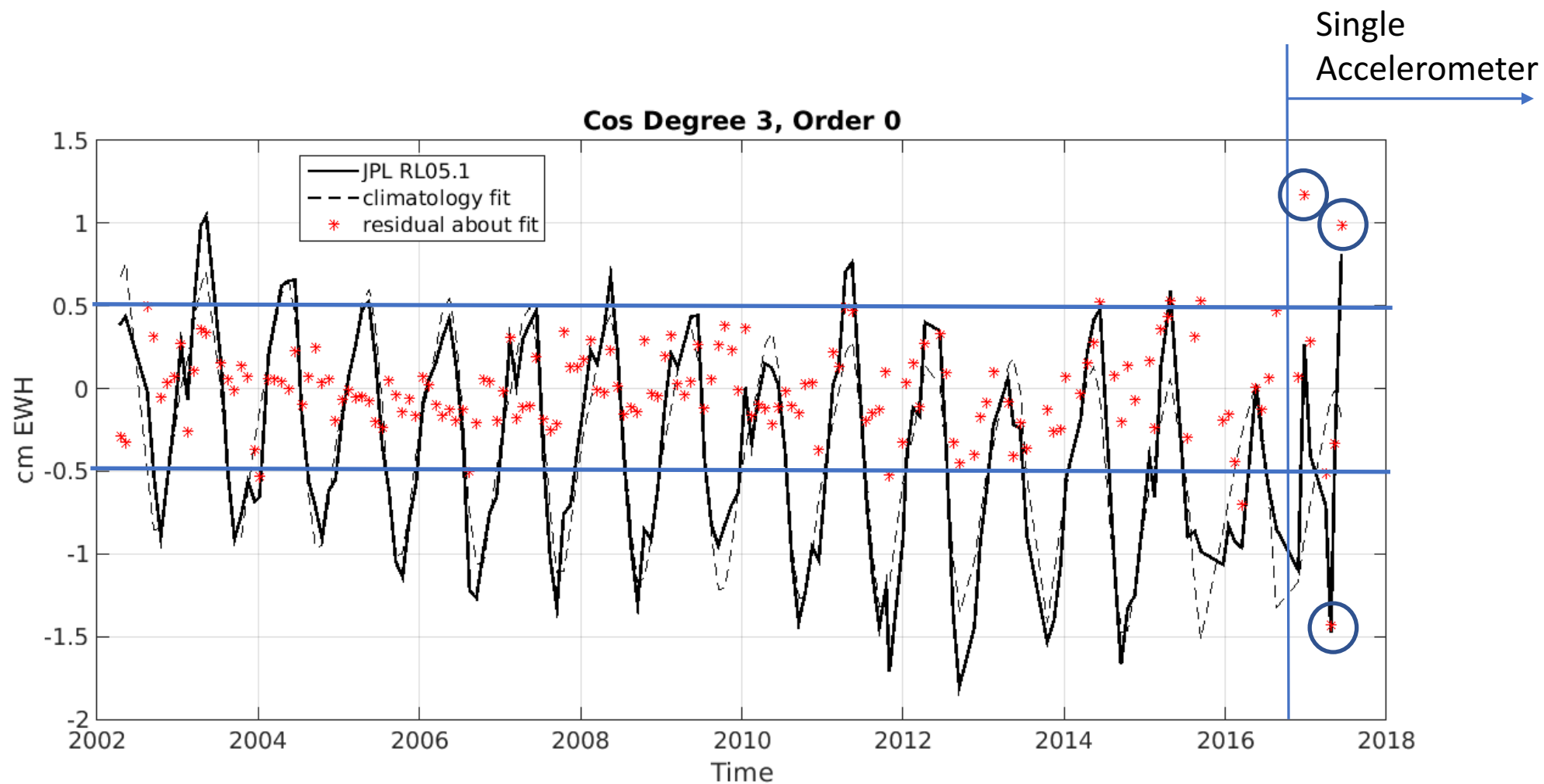


Single Accelerometer Parameterization



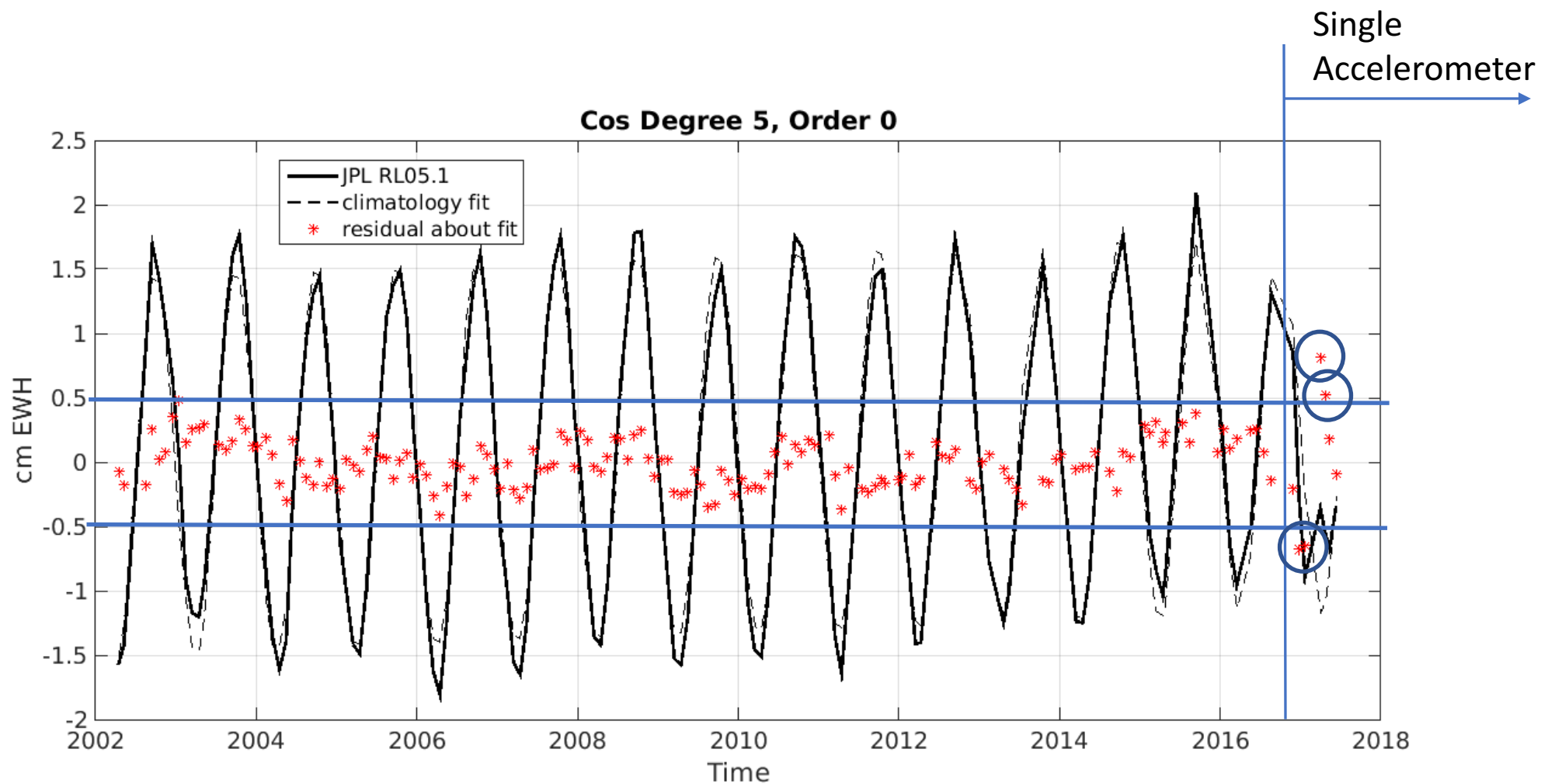
C(3,0)

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C(5,0)

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Overview

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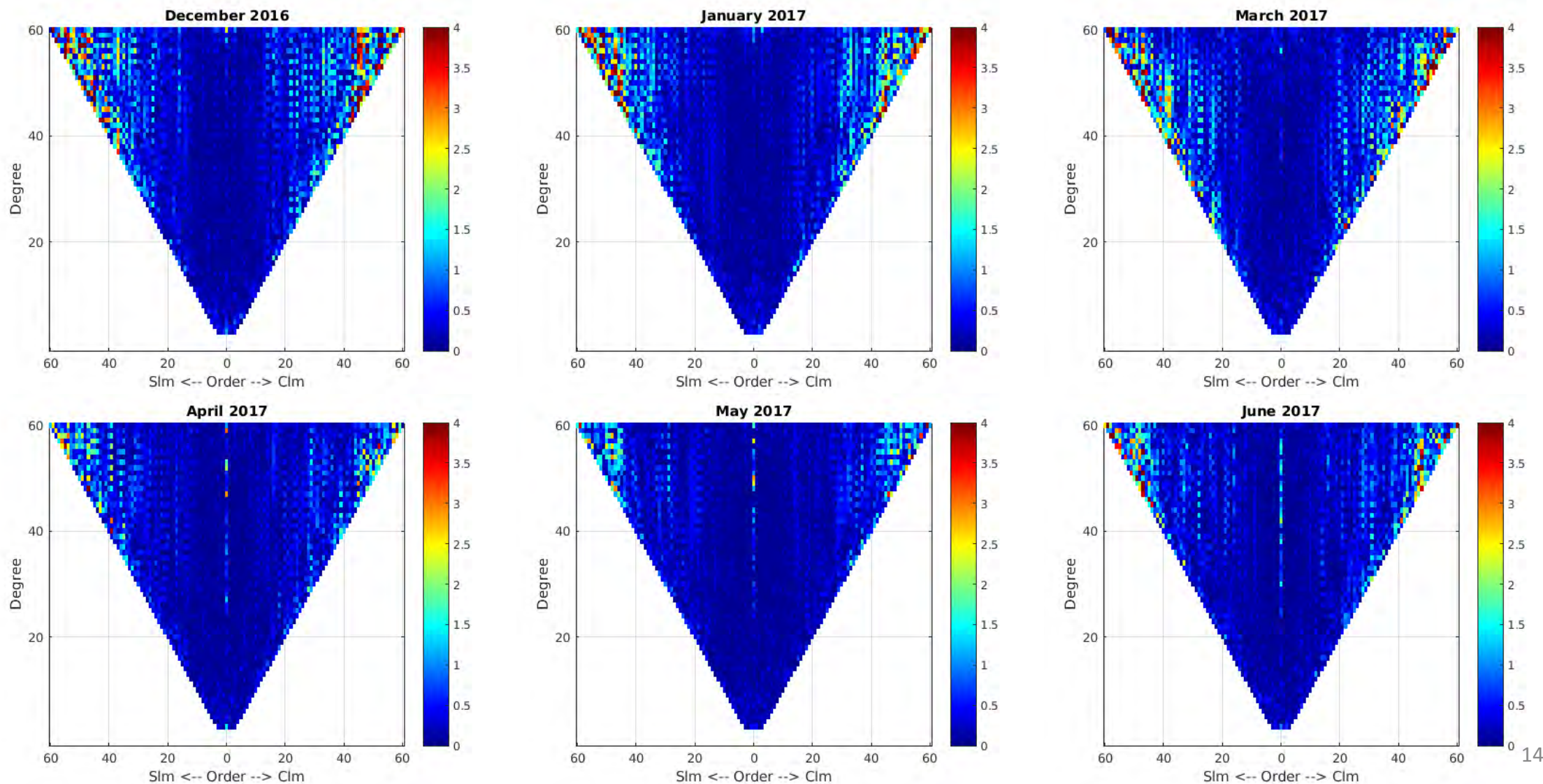
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Pitch Bias Effect on Gravity Solutions

GRACE / GRACE-FO

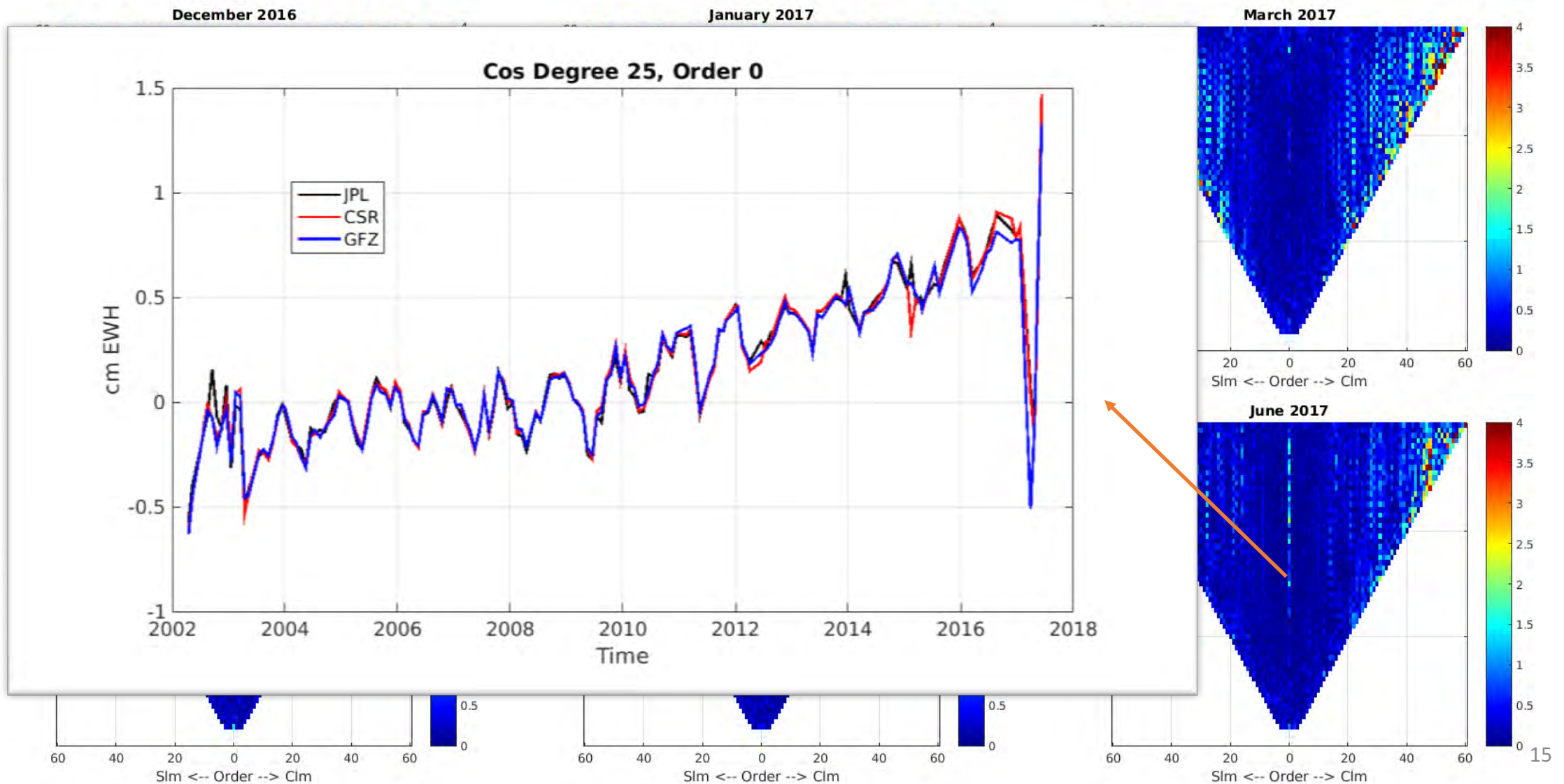


Residuals about a climatology fit to each spherical harmonic coefficient in cm equiv. water height



Pitch Bias Effect on Gravity Solutions

Residuals about a climatology fit to each spherical harmonic coefficient in cm equiv. water height



Pitch Bias Effect on Gravity Solutions

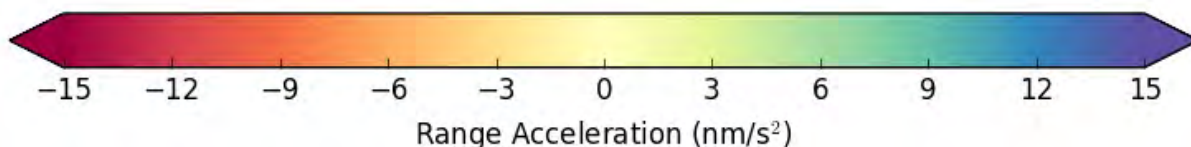
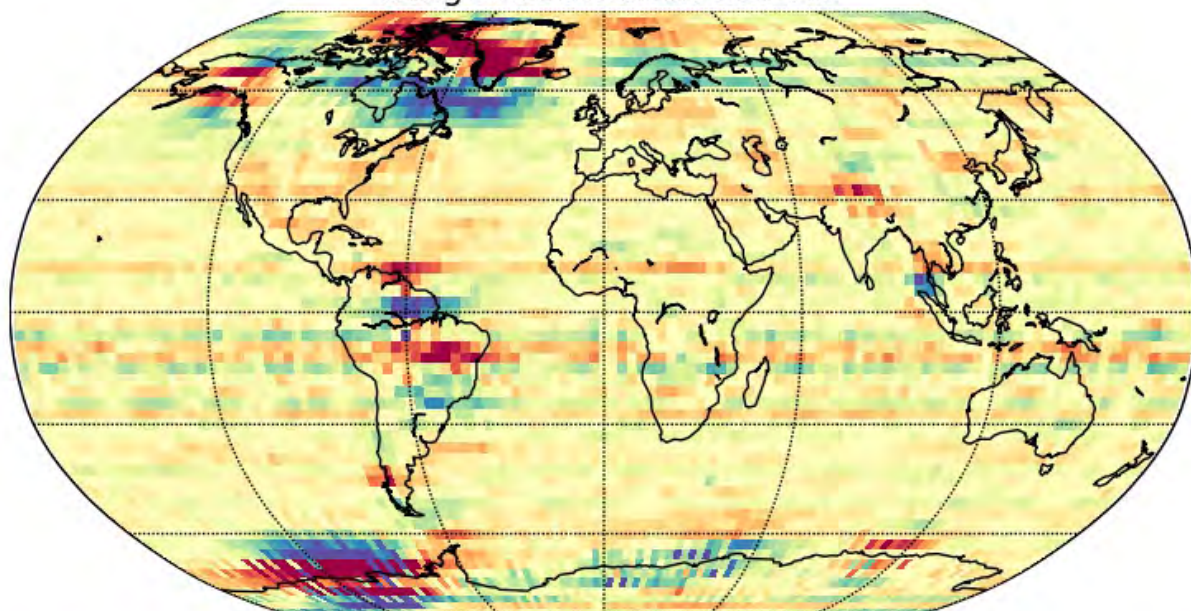
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June 2017 JPL gravity solutions mapped into range-acceleration space

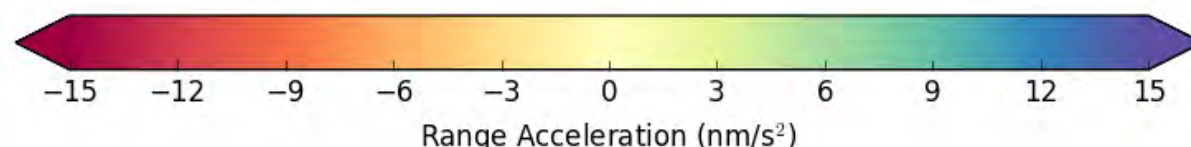
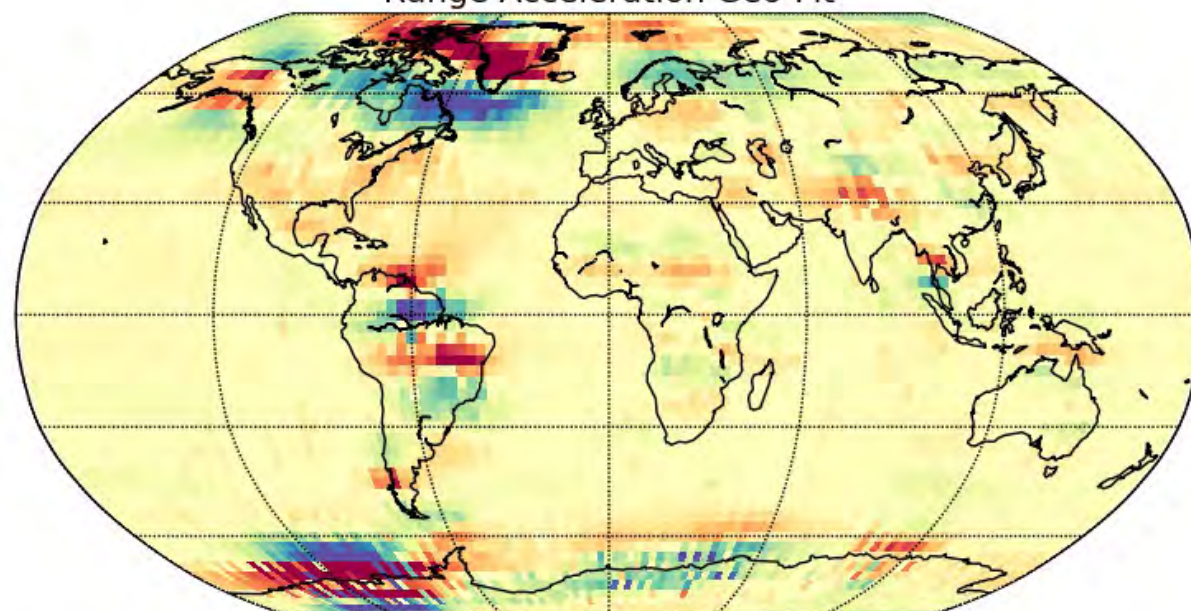
JPL Spherical Harmonics

Range Acceleration Geo-Fit



JPL Mascons

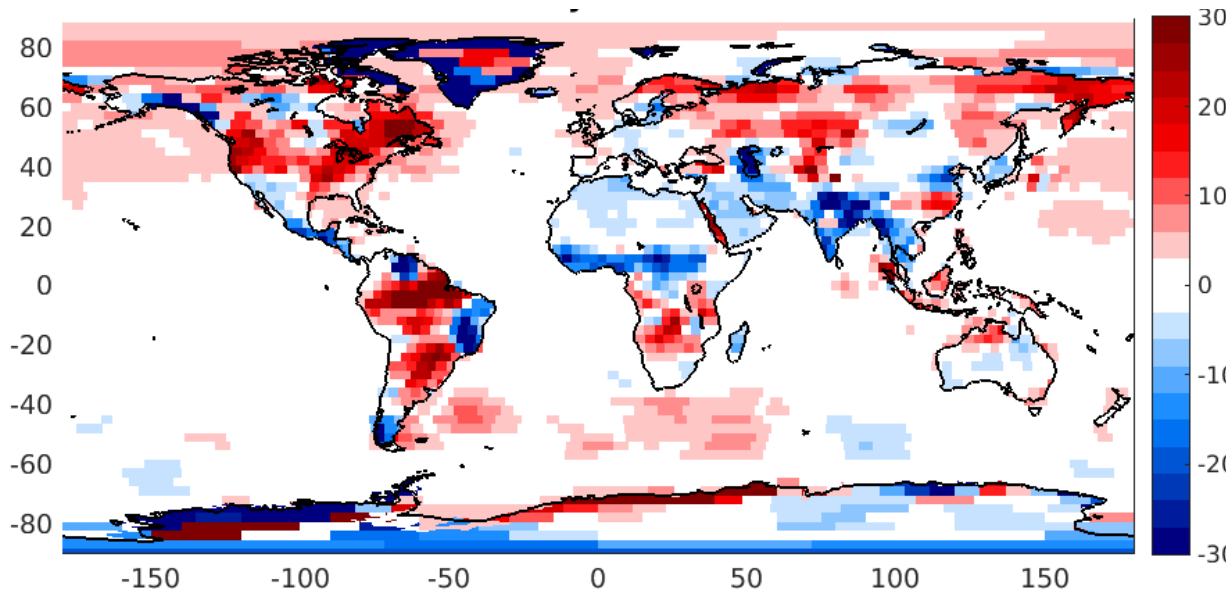
Range Acceleration Geo-Fit



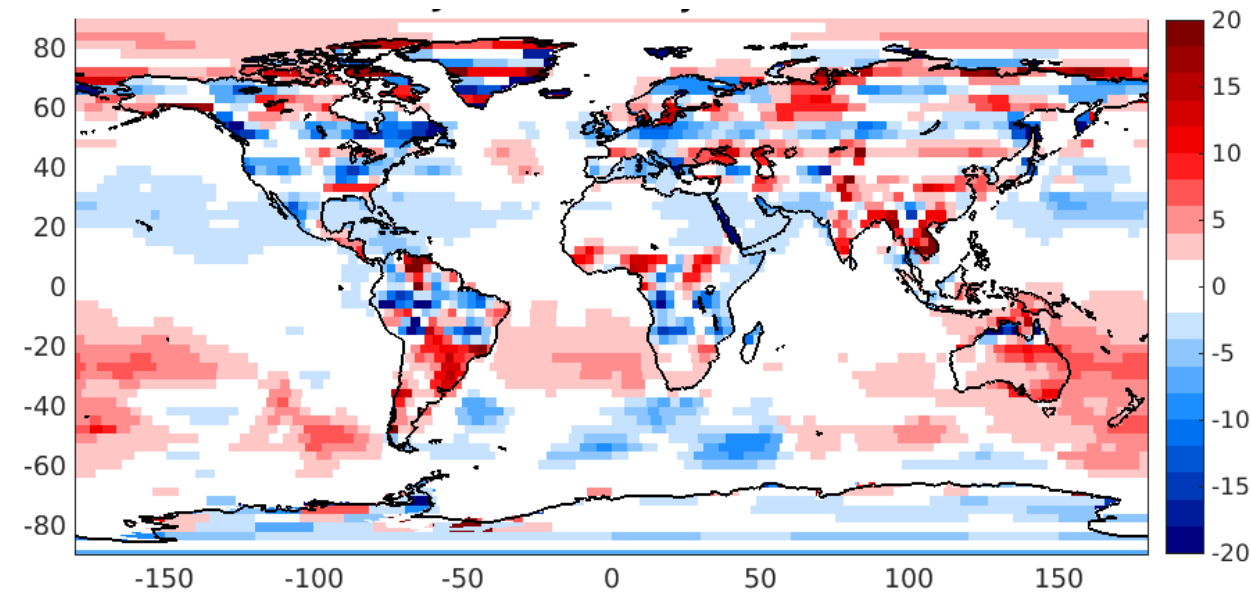
Pitch Bias Effect on JPL Mascons



May 2017 Solution



June 2017 – May 2017



Units: cm equiv. water height

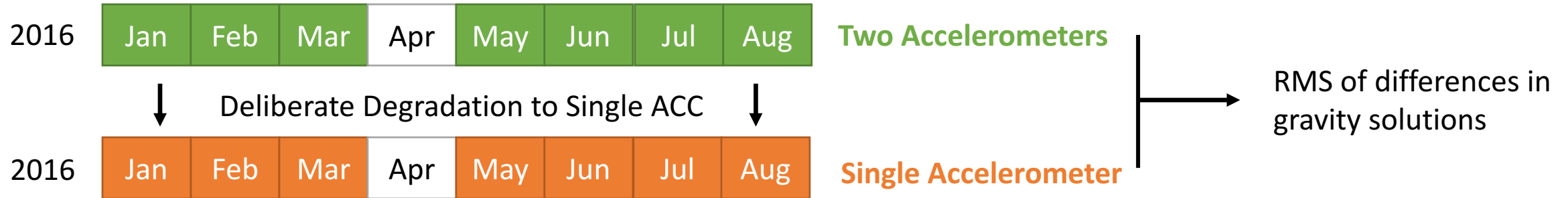
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GRACE / GRACE-FO

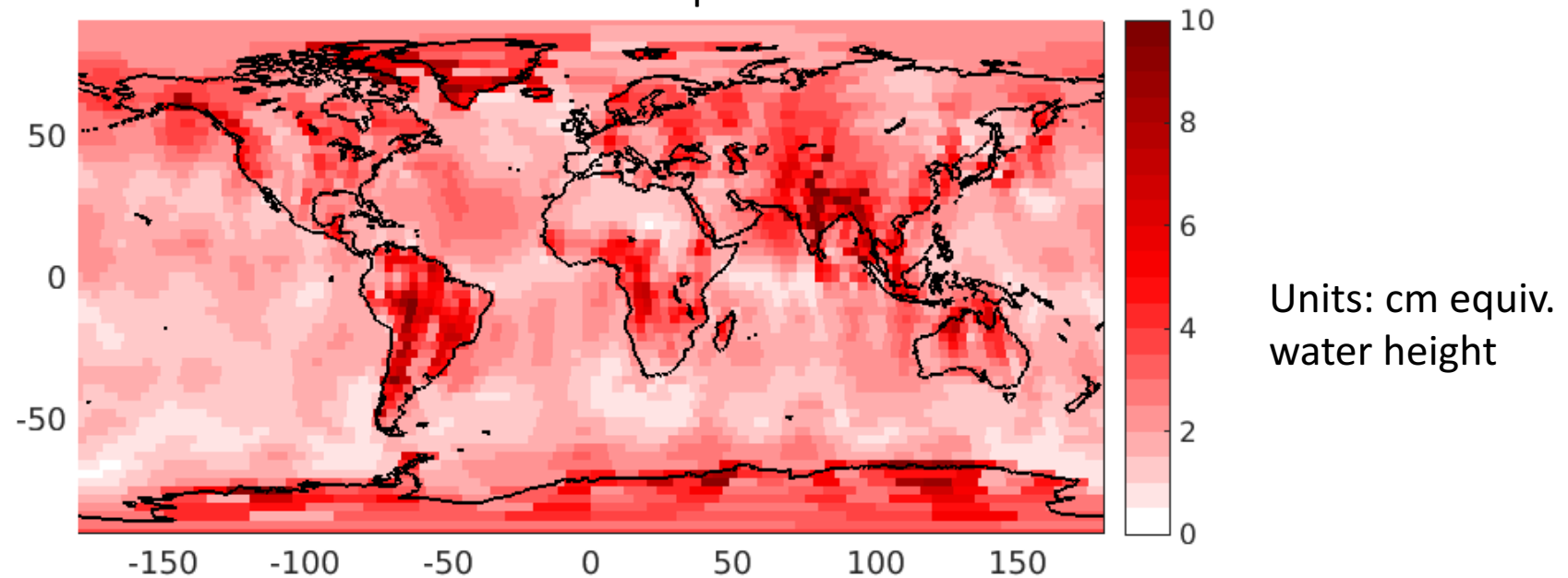


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JPL Mascon Error Calibration



“Accelerometer Transplant Error”



JPL Mascon Error Calibration

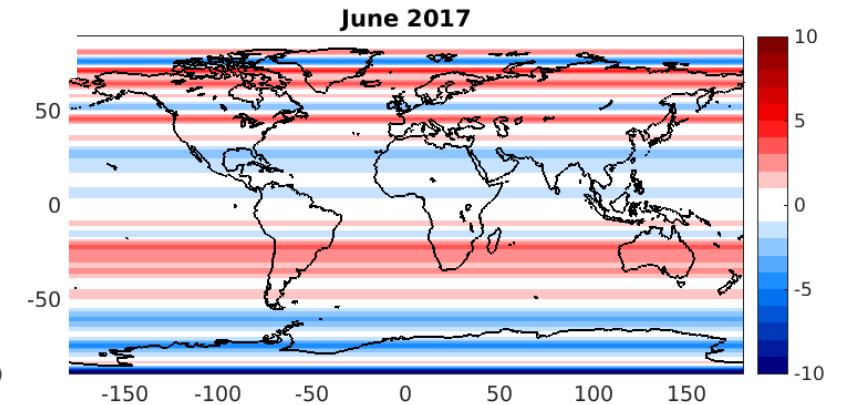
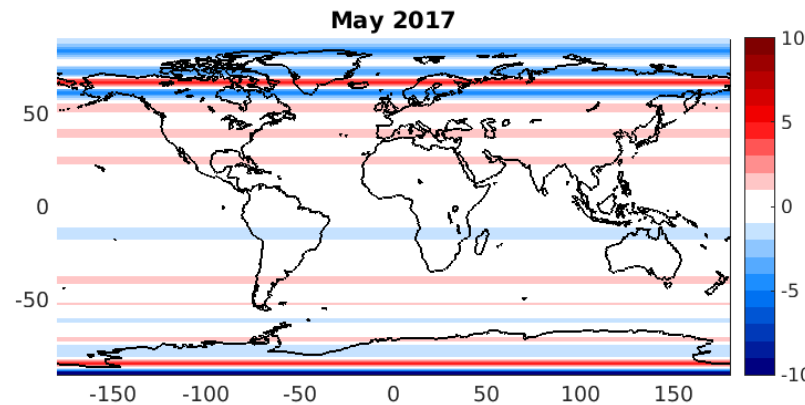
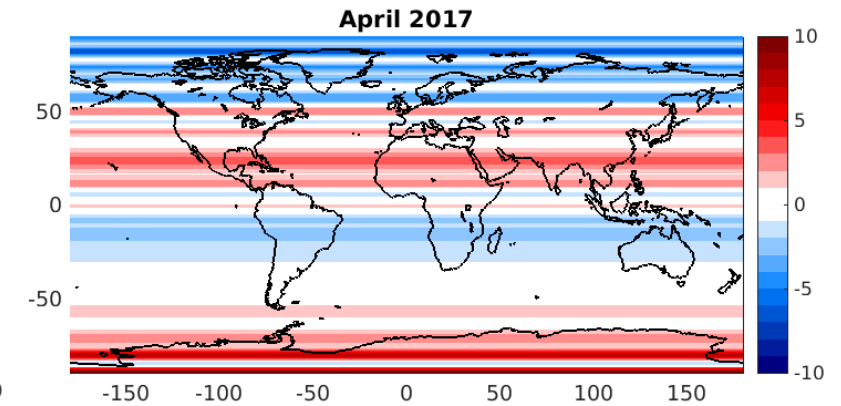
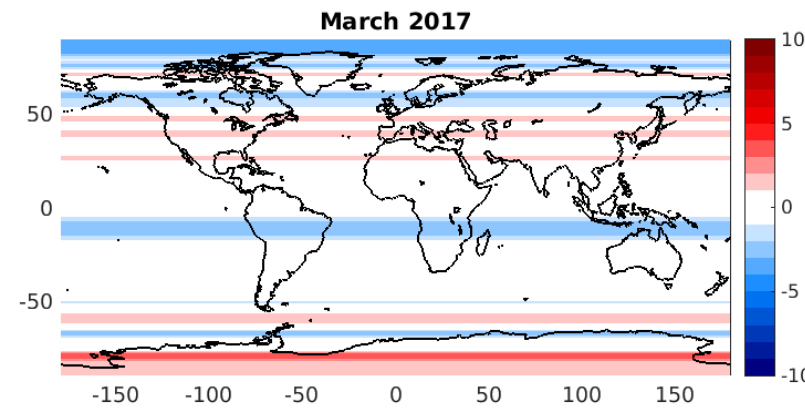
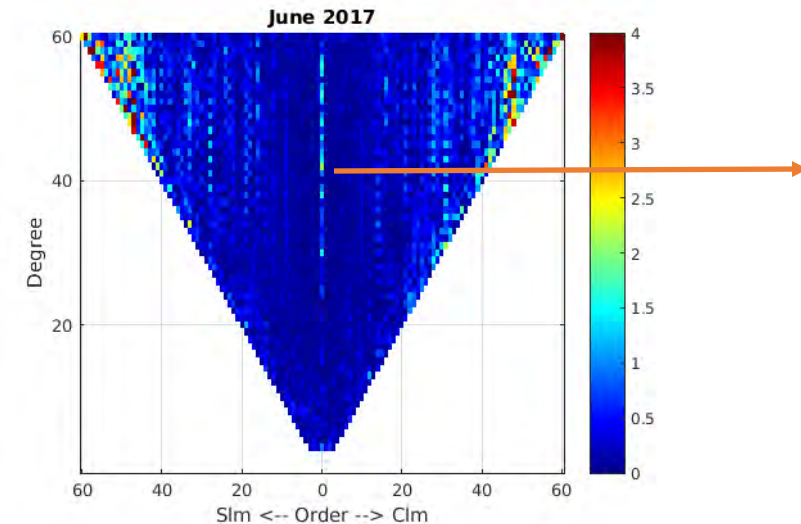
GRACE / GRACE-FO



Residuals about a climatology
fit to each zonal spherical
harmonic coefficient

Monthly “pitch bias error” maps are defined for March, April, May, June 2017

Units: cm equiv. water height



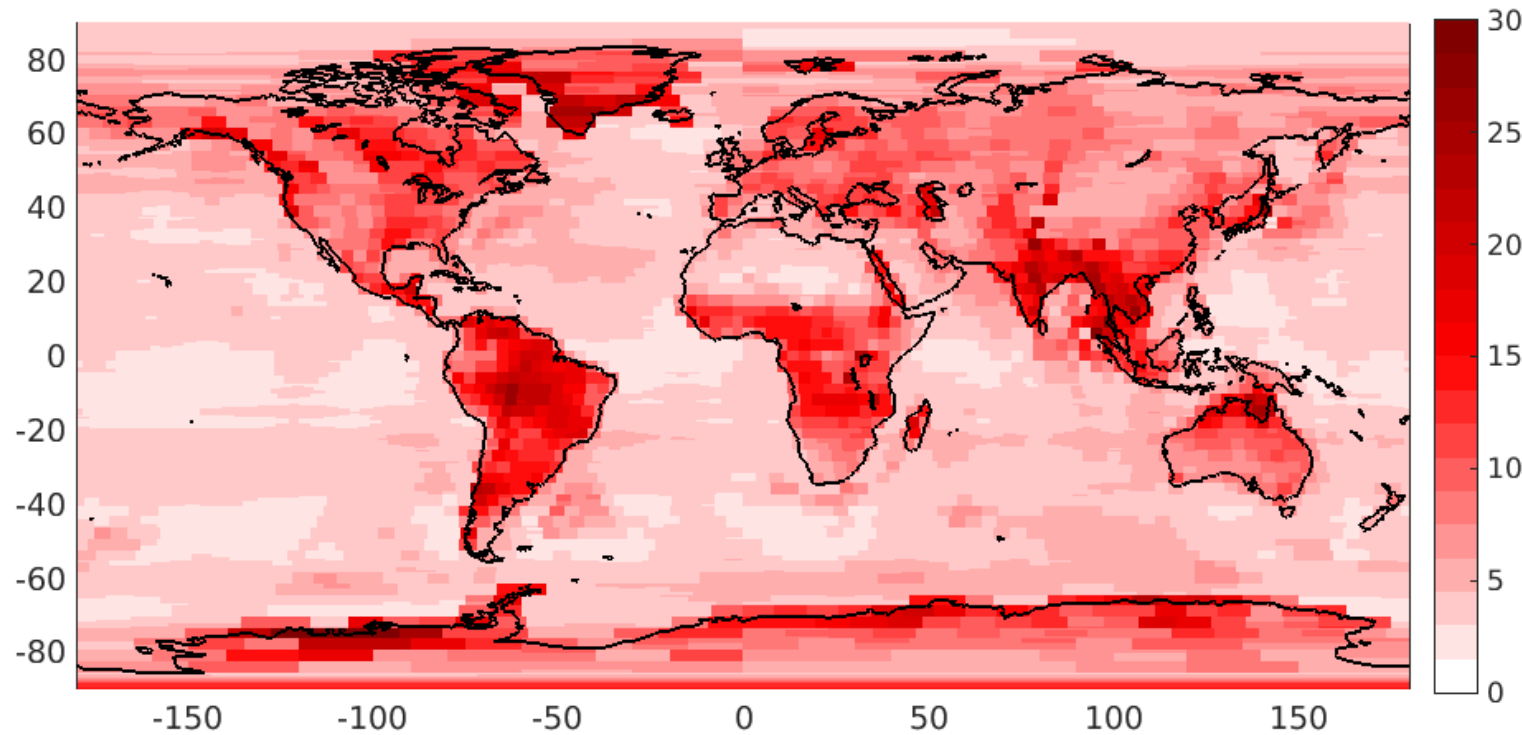
JPL Mascon Error Calibration

GRACE / GRACE-FO

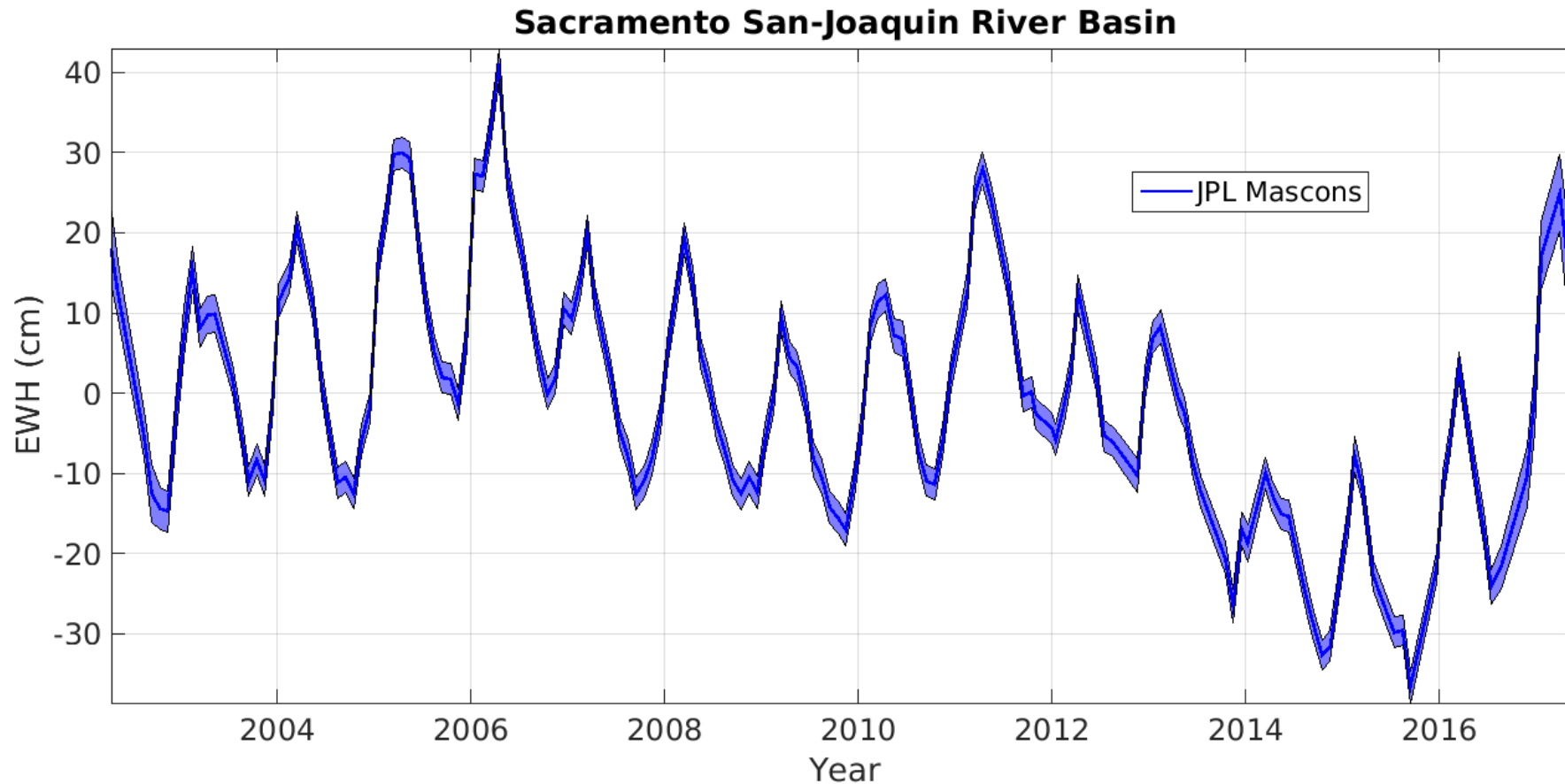


Total Error = Root sum of squares of [Measurement Error + Accelerometer Transplant Error + Pitch Bias Error]

JPL Mascon 1-sigma uncertainty for June 2017 in cm water height

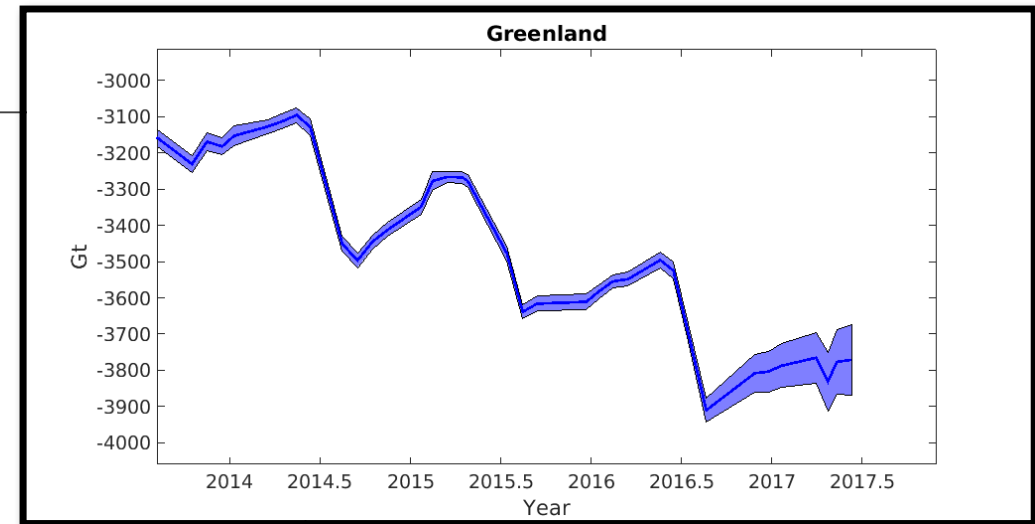
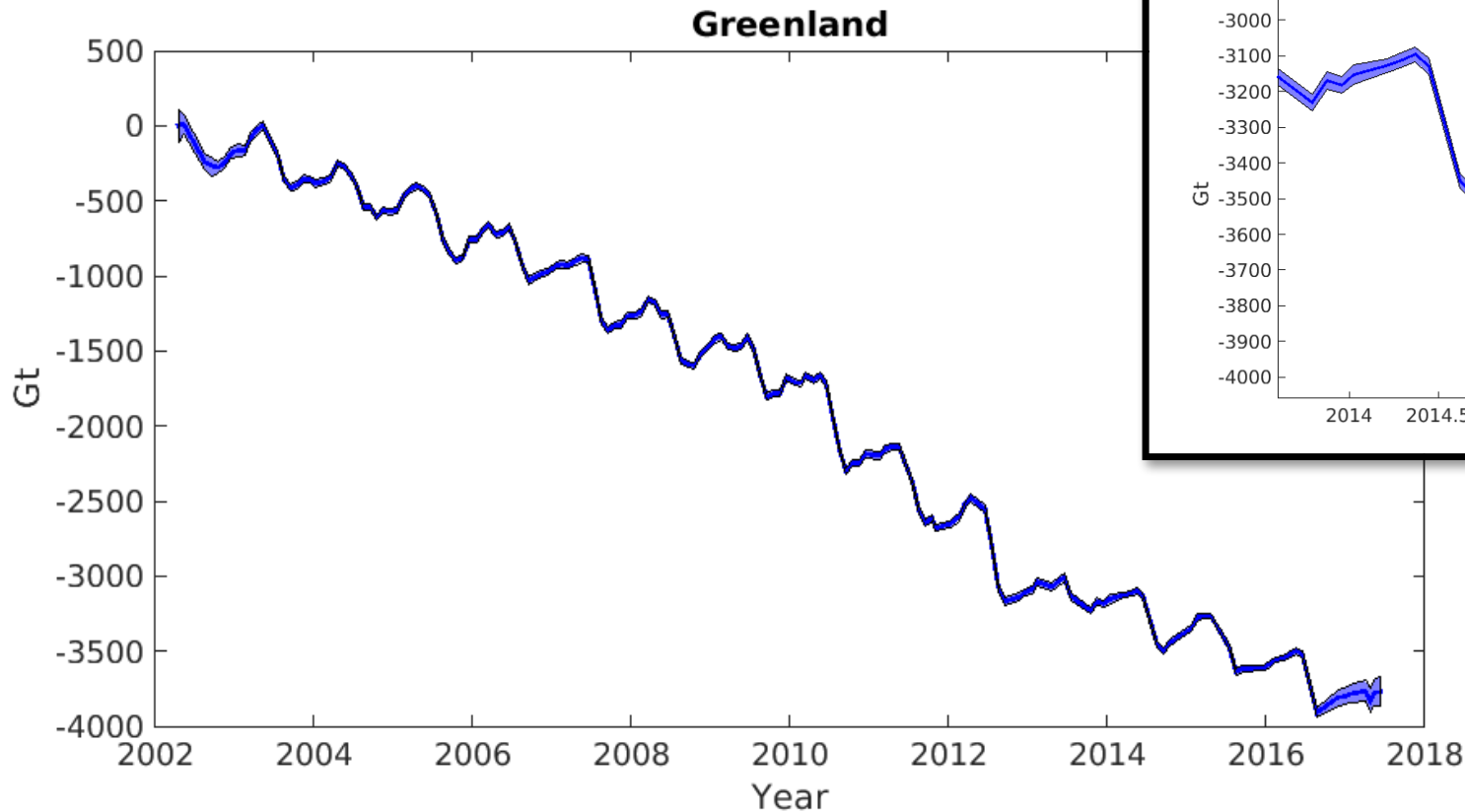


Practical Applications



Over California, the total error budget has increased by ~60% in the latest months; however, the interpretation of the “drought recovery” is still very much possible.

Practical Applications



Greenland still has a very clear annual signature; however errors on the last data point increase by ~50% relative to dual-accelerometer/no pitch bias operations.

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Mascon spectral content/leakage error

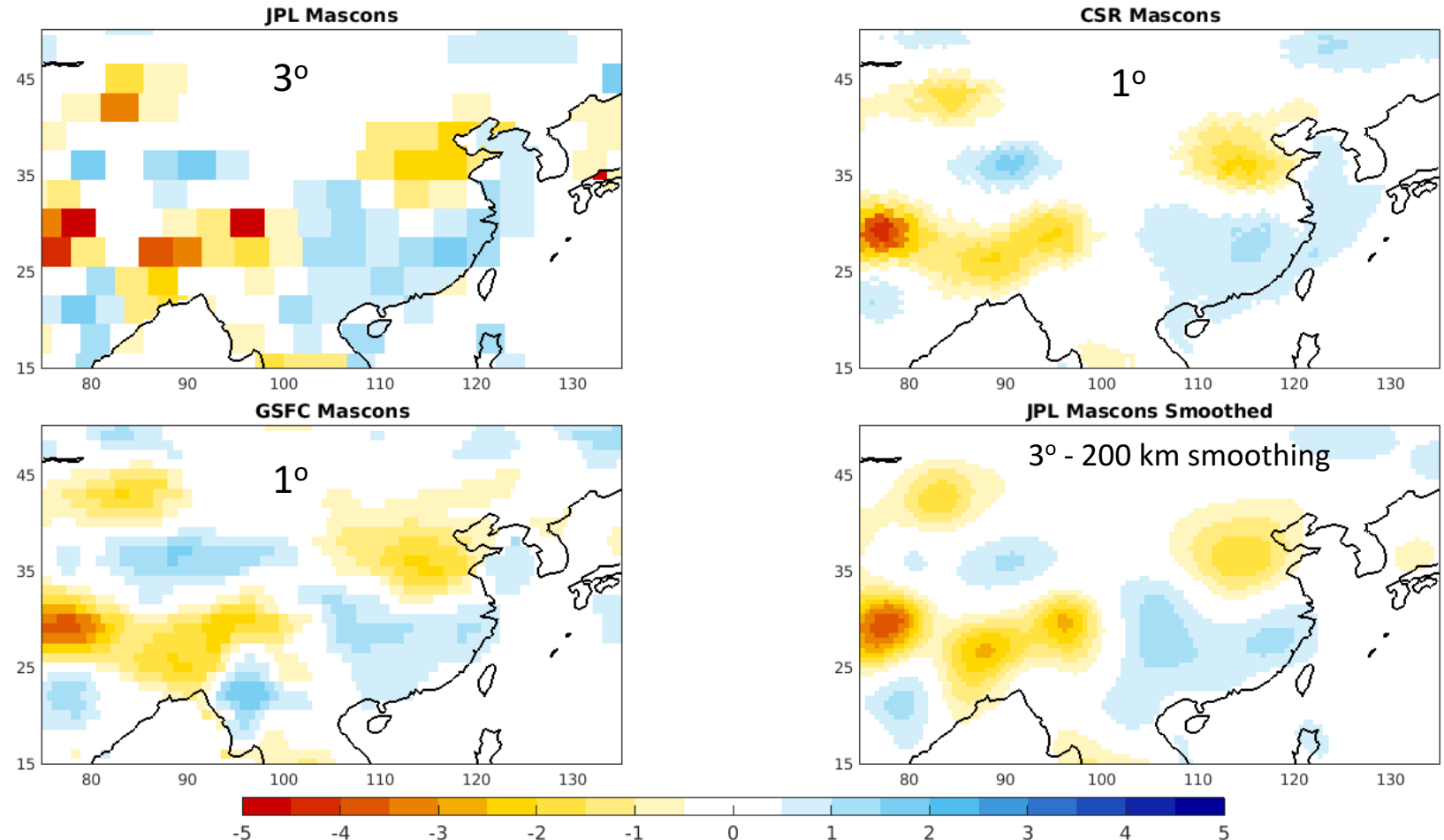


2003-2016 trends (cm/yr): A comparison between mascon products

Several studies have noted more pronounced signal amplitudes/trends in JPL Mascons relative to other products (Scanlon et al., 2016)

A possible explanation is a fundamental difference in spectral content and unique consideration of leakage errors between solutions

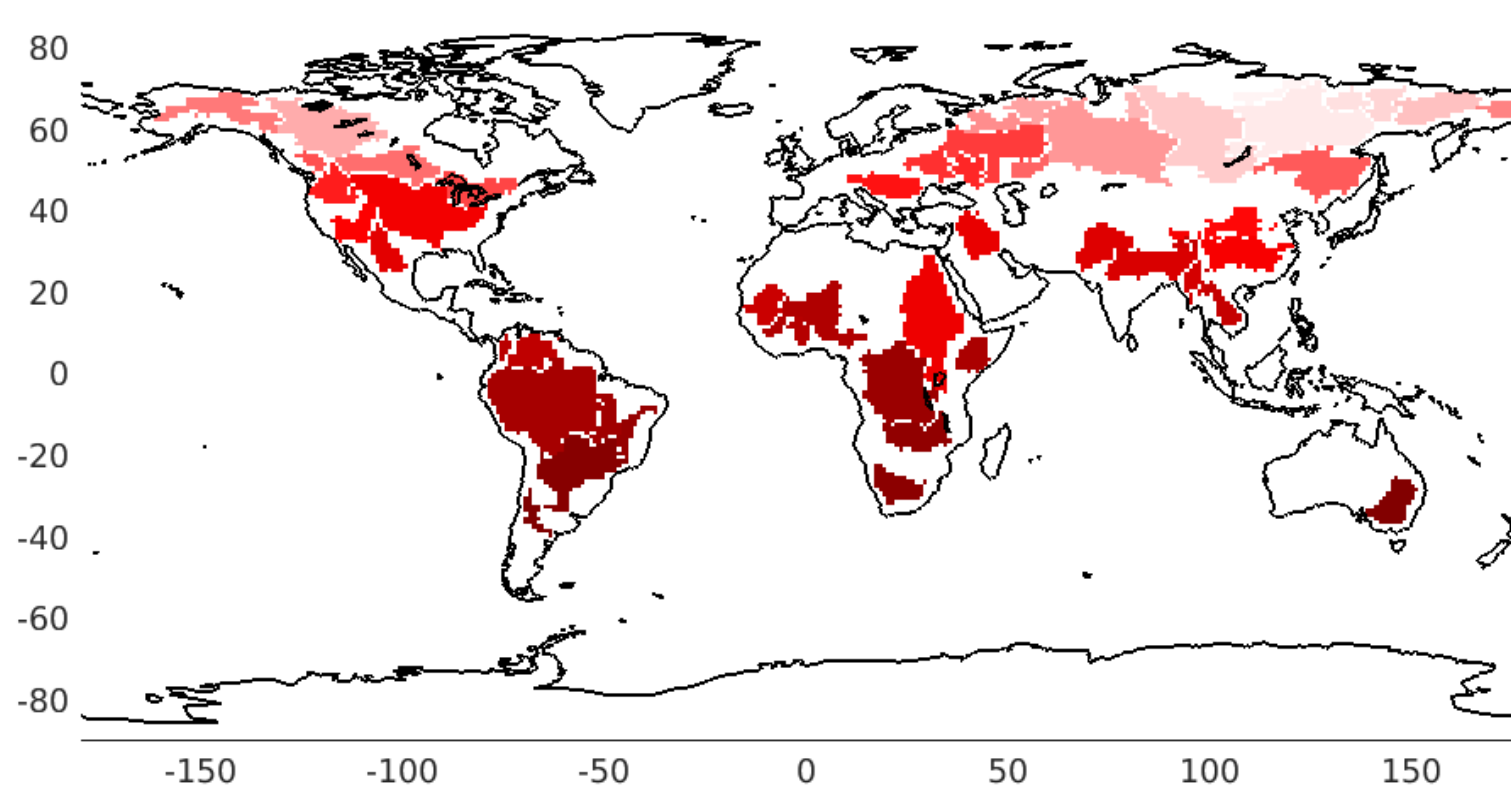
Smoothing JPL Mascons at 200 km provides a nice qualitative comparison with CSR and GSFC mascons



Mascon spectral content/leakage error

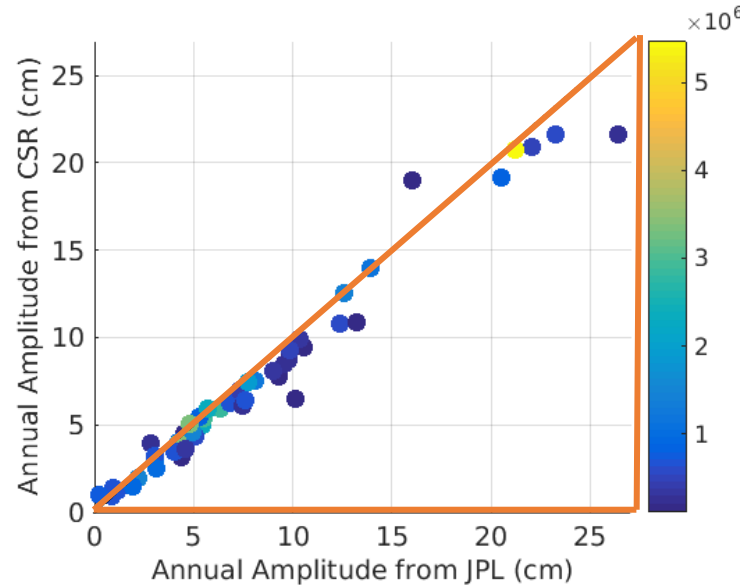
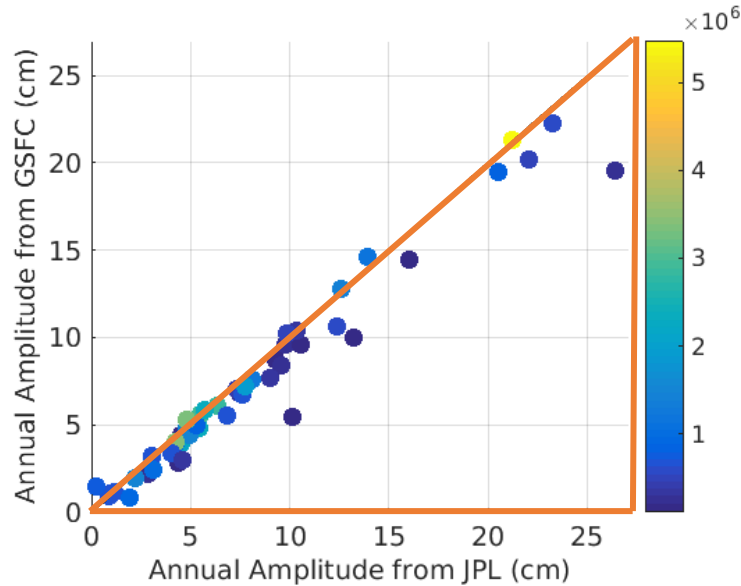


Map of exact basin boundaries



For a quantitative comparison, we extract timeseries from each mascon product using these exact basin boundaries

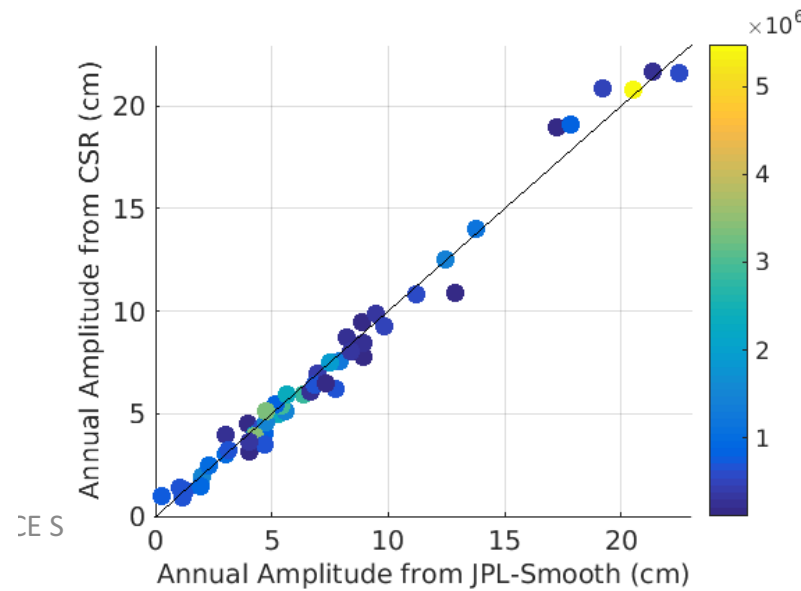
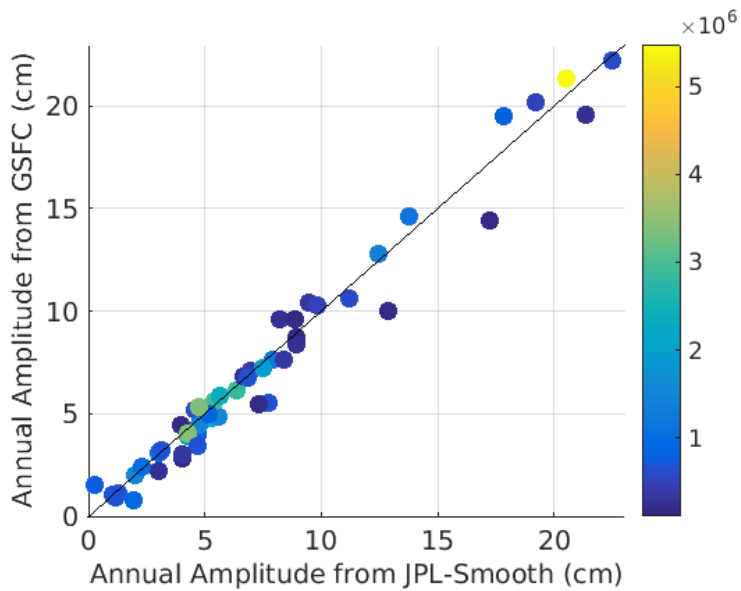
Annual Amplitude Comparison



2004-2016 Annual Amplitudes

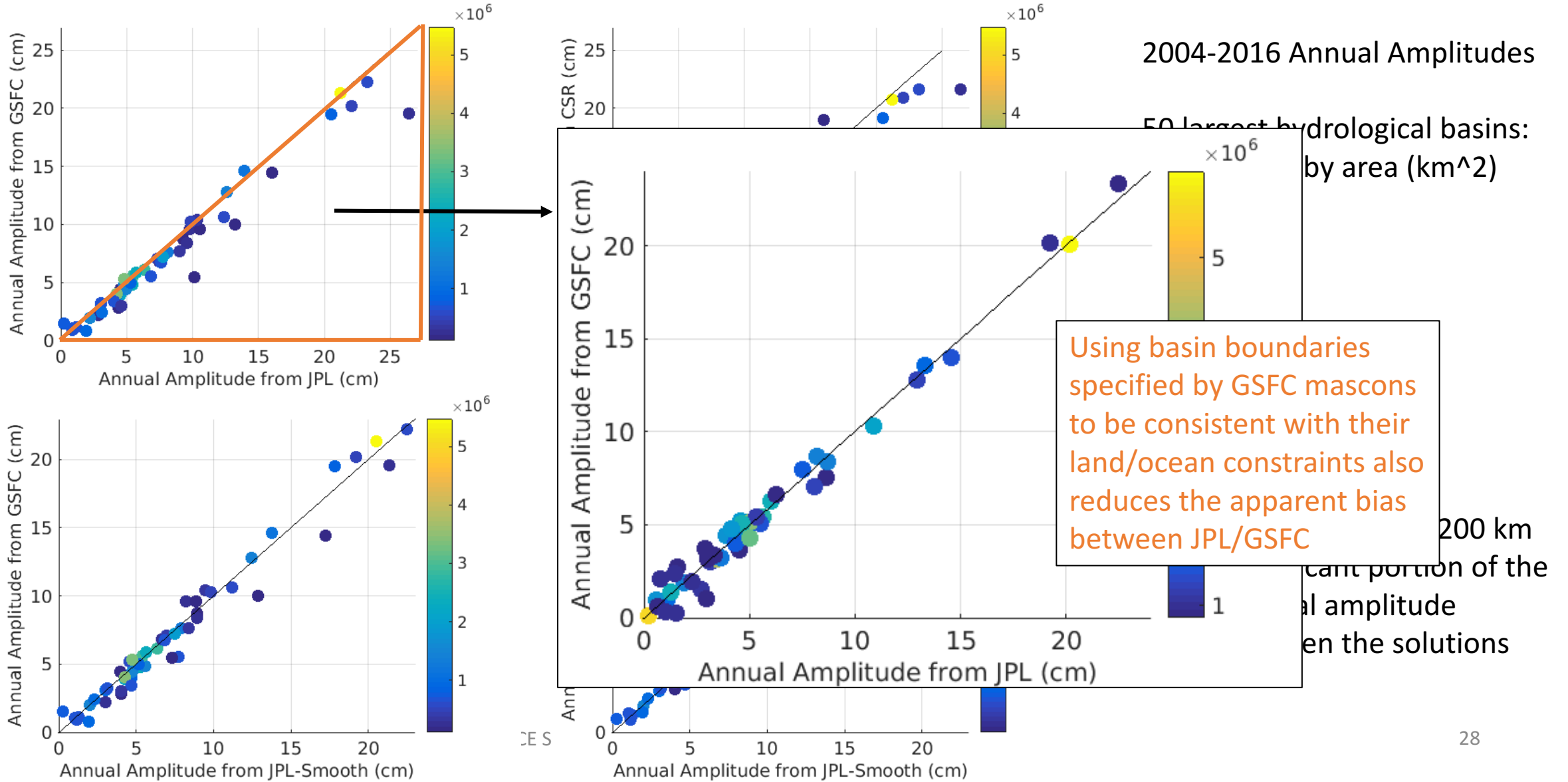
50 largest hydrological basins:
color-coded by area (km²)

JPL Mascons show larger annual amplitudes on average

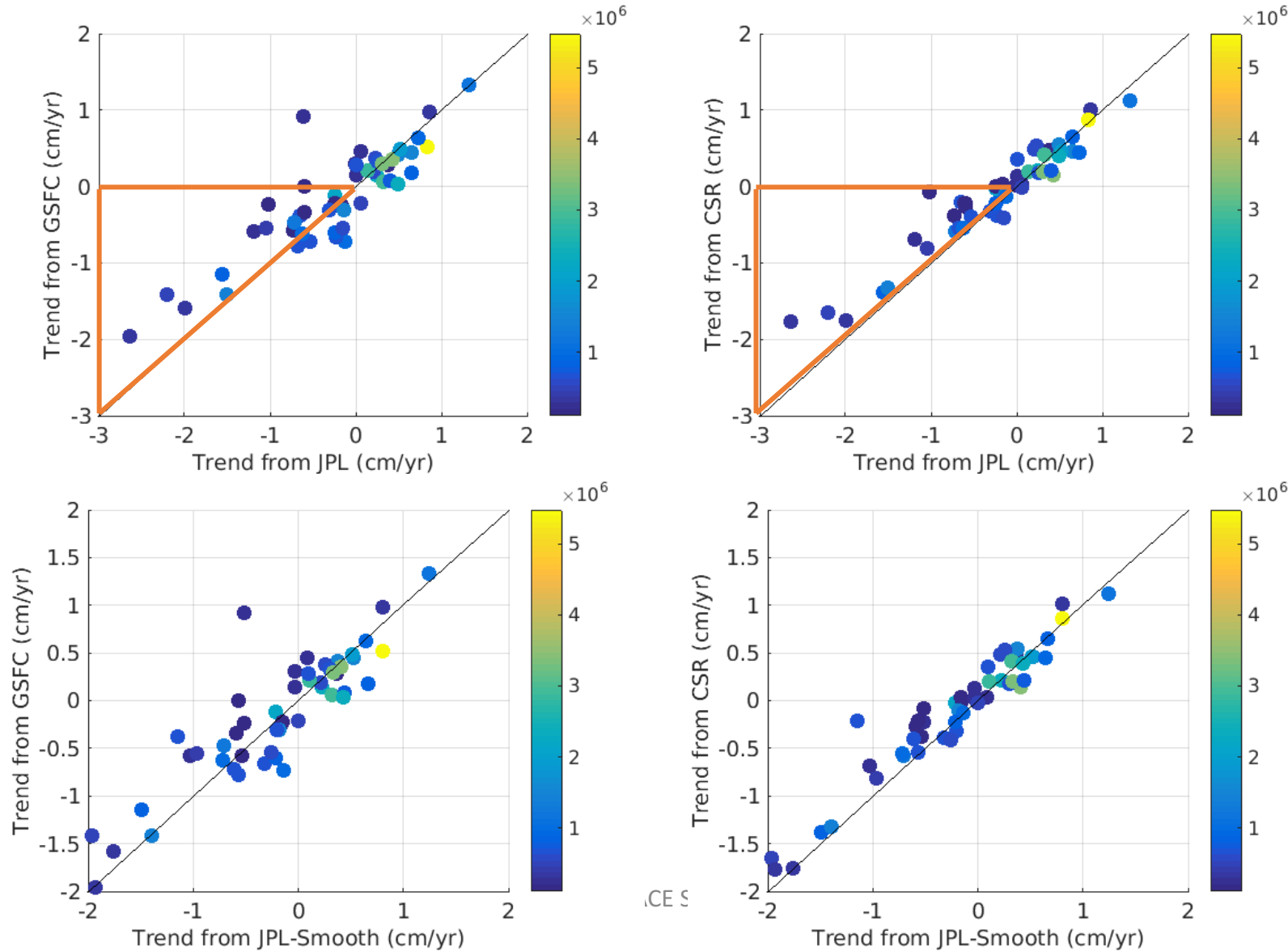


Smoothing JPL Mascons at 200 km removes a significant portion of the bias in the annual amplitude estimates between the solutions

Annual Amplitude Comparison



Trend Comparison



2004-2016 Trends

50 largest hydrological basins:
color-coded by area (km^2)

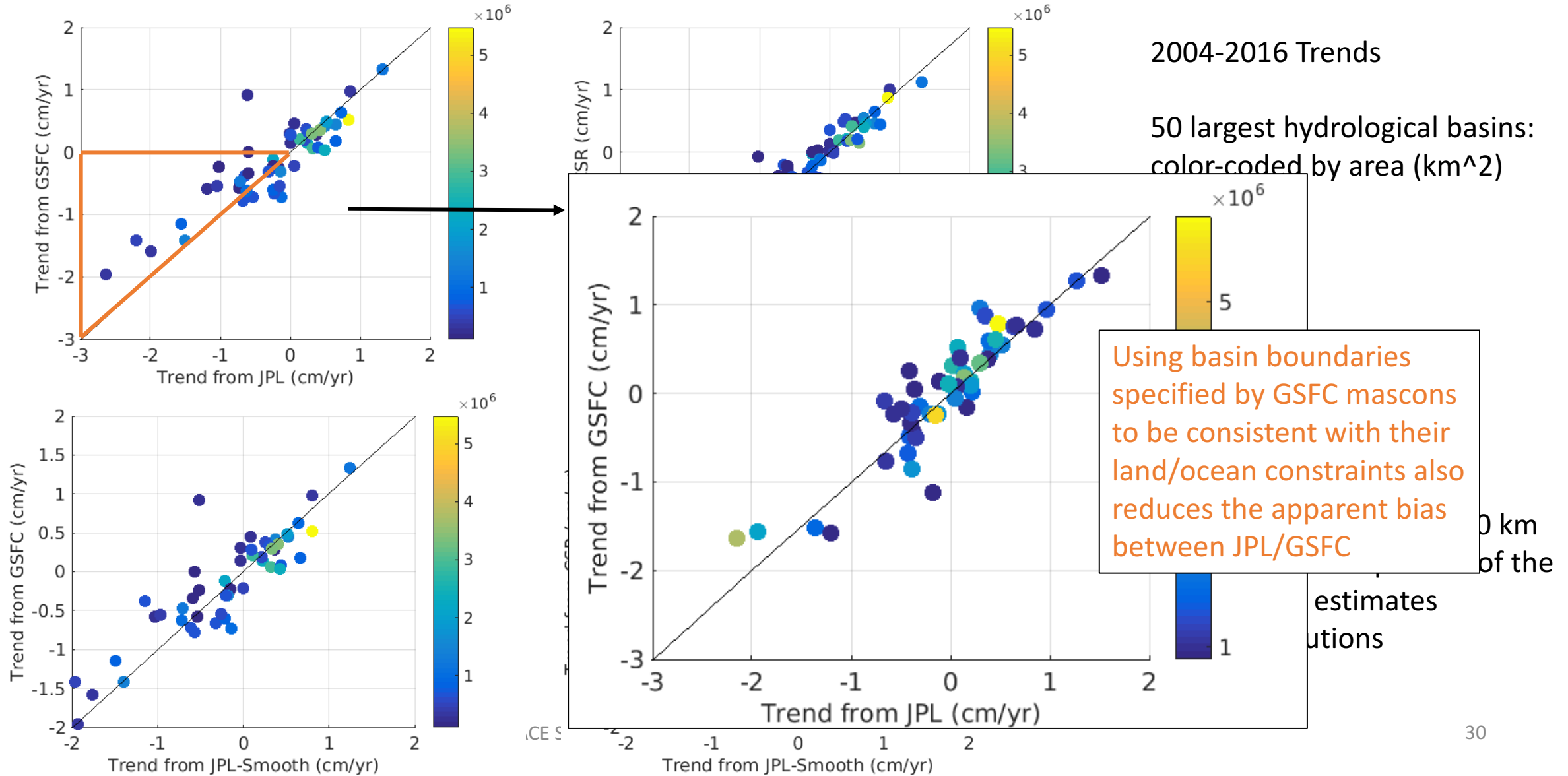
JPL Mascons tend to have more pronounced trends on average, particularly negative trends

Smoothing JPL Mascons at 200 km removes a significant portion of the bias in the trend estimates between the solutions

Trend Comparison

2004-2016 Trends

50 largest hydrological basins:
color-coded by area (km²)



Mascon spectral content/leakage error



- Overall, when interpreted correctly, there is fairly good agreement between the mascon products
- One should not expect to obtain exact matching timeseries when using the same basin mask on the three different mascon products
 - Care must be taken to consider unique land/ocean definitions of each product and leakage errors associated with each product
- For JPL Mascons, we advise using the CRI filtered product along with the provided land/ocean mask and scale factors to obtain mass estimates within user-defined basin boundaries
 - Exceptions are for ice-covered regions and inland seas (Caspian)

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RL06 Status



- RL06 processing is designed to harmonize the GRACE and GRACE-FO time series
- Experimentation and analysis currently ongoing
- Planning for release late 2017
- Comprised primarily of updates to level 1 data products, background models, parameterization strategies, and data editing

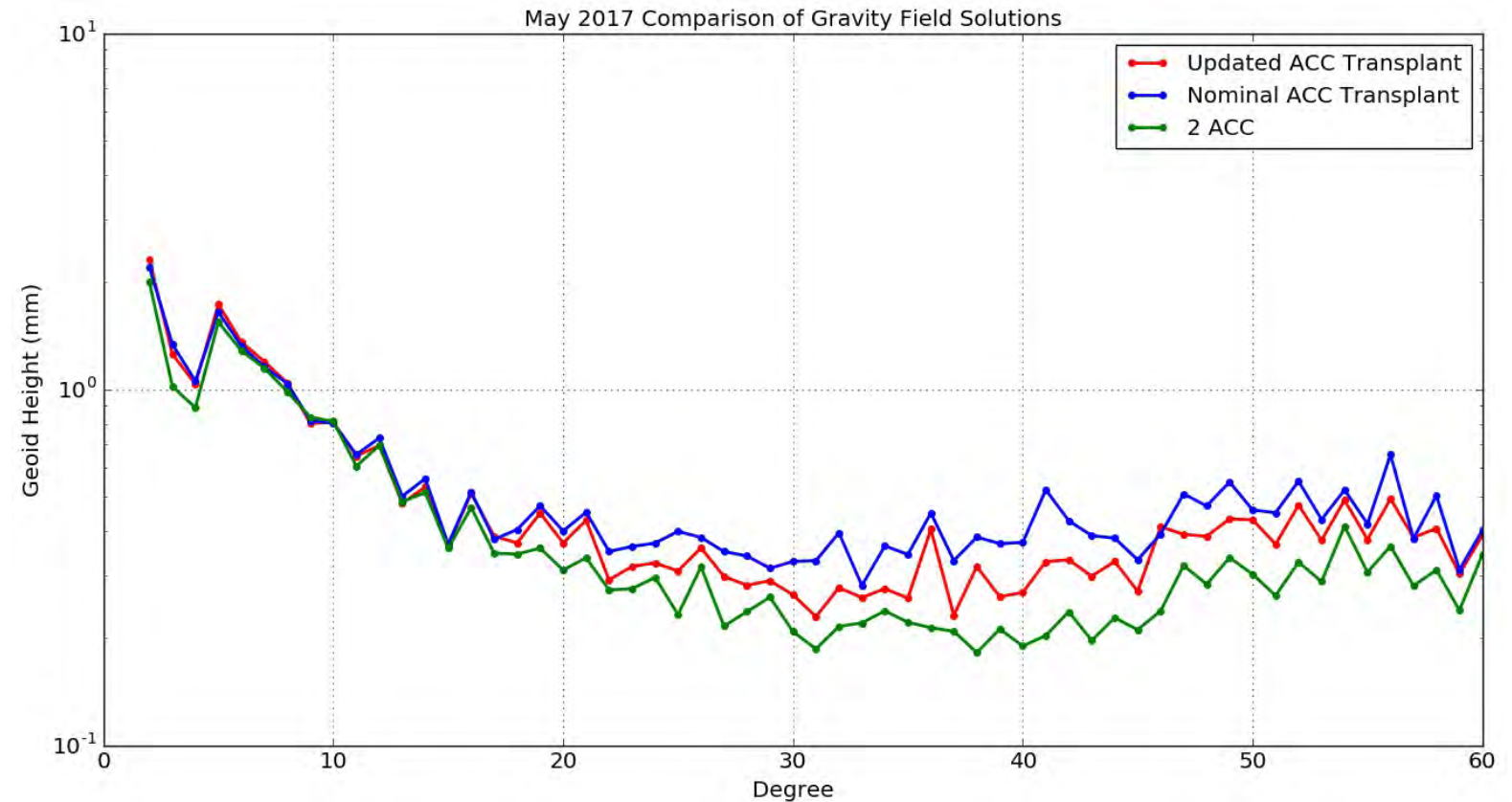
Overview of Updates/Changes

- Level 1 V03 Data – for details see Carly Sakumura Presentation
 - SCA1B
 - KBR1B
- Updated Accelerometer Transplant (Tentative) – for details see Tamara Bandikova Poster
- GPS data rate – 5 minutes to 30 seconds
- Parameterization
 - 1 ACC
 - 2 ACC
 - Experiments ongoing
- Updated Background Models
 - AOD RL06
 - Ocean Tides
 - Mean Field – GGM05C
 - Linear Mean Pole

Updated Accelerometer Transplant

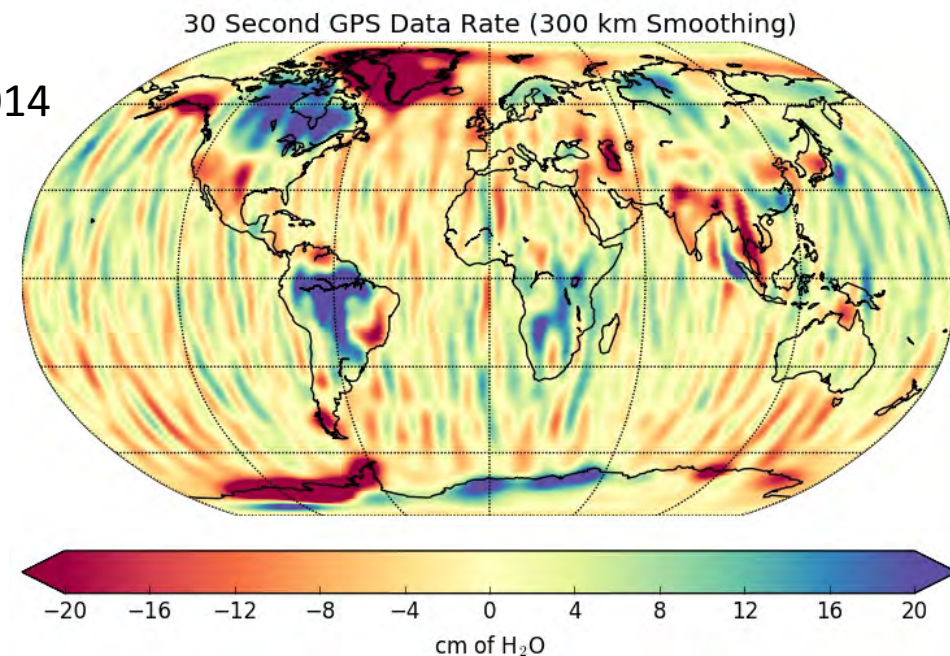
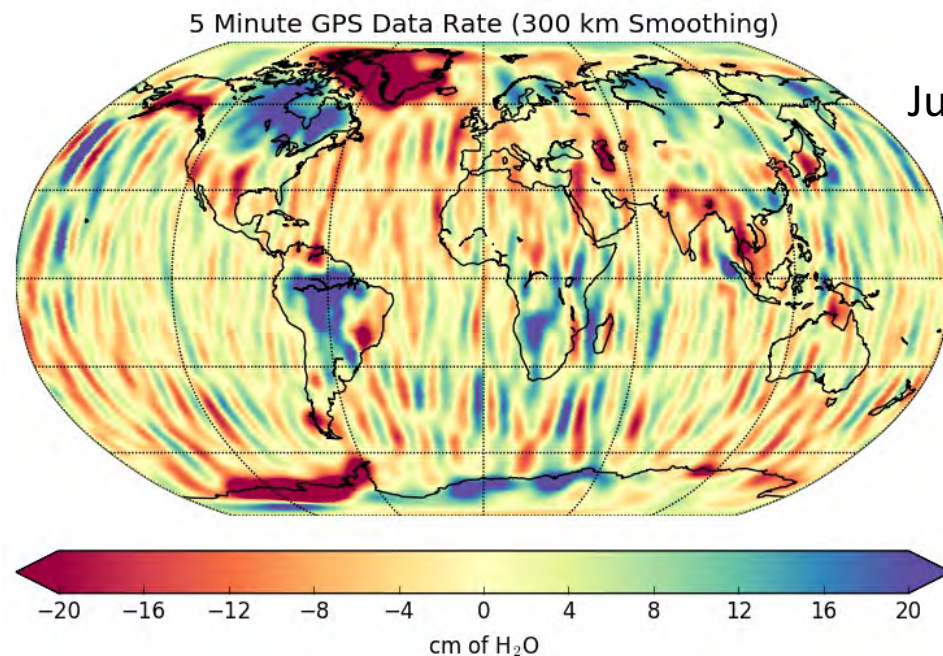


- Current transplant methodology translates and rotates accelerometer data between satellites (ignores attitude thruster firings)
- See poster by Tamara Bandikova for details on an updated transplant



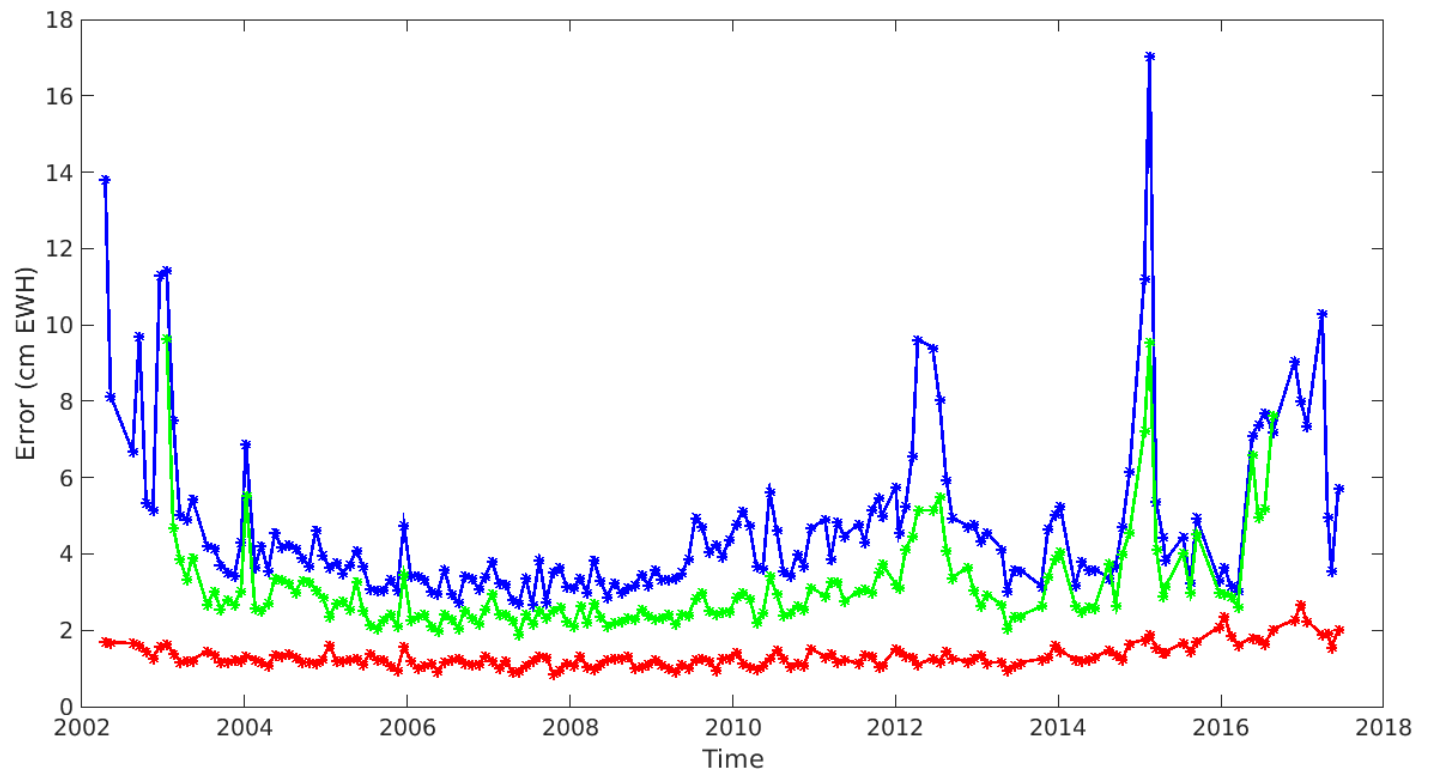
Parameterization/GPS Data Rate

- RL05 processed GPS data at 5 minute data rate
- RL06 will process GPS data at a 30 second data rate
- Difference most likely due to inconsistencies in the orbit solutions



Parameterization/GPS Data Rate

- Figure shows error – defined as difference with the JPL Mascon solution (300 km smoothing)
- Parameterization/data rate changes show significant improvements from RL05
- Difference between JPL/CSR Mascons is given as reference



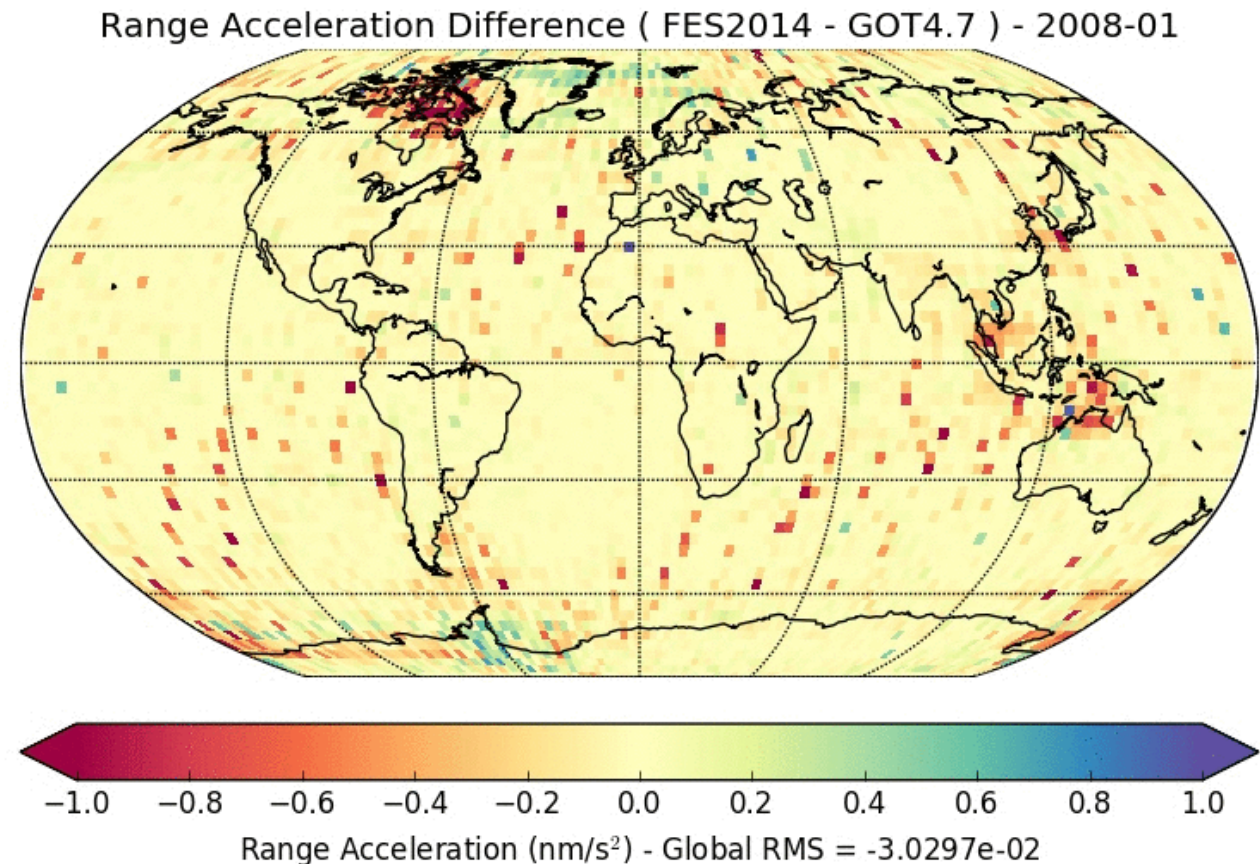
Ocean Tides – Variance Reduction



- Pre-fit inter-satellite range-rate residuals are computed, over a monthly time interval, for separate cases (differing only in the tide model – FES2014 or GOT4.7)
- Range-rate residuals are differentiated to range acceleration and the standard deviation is computed in each 3x3 degree geographic bin
- Smaller standard deviations indicate improved apriori modelling

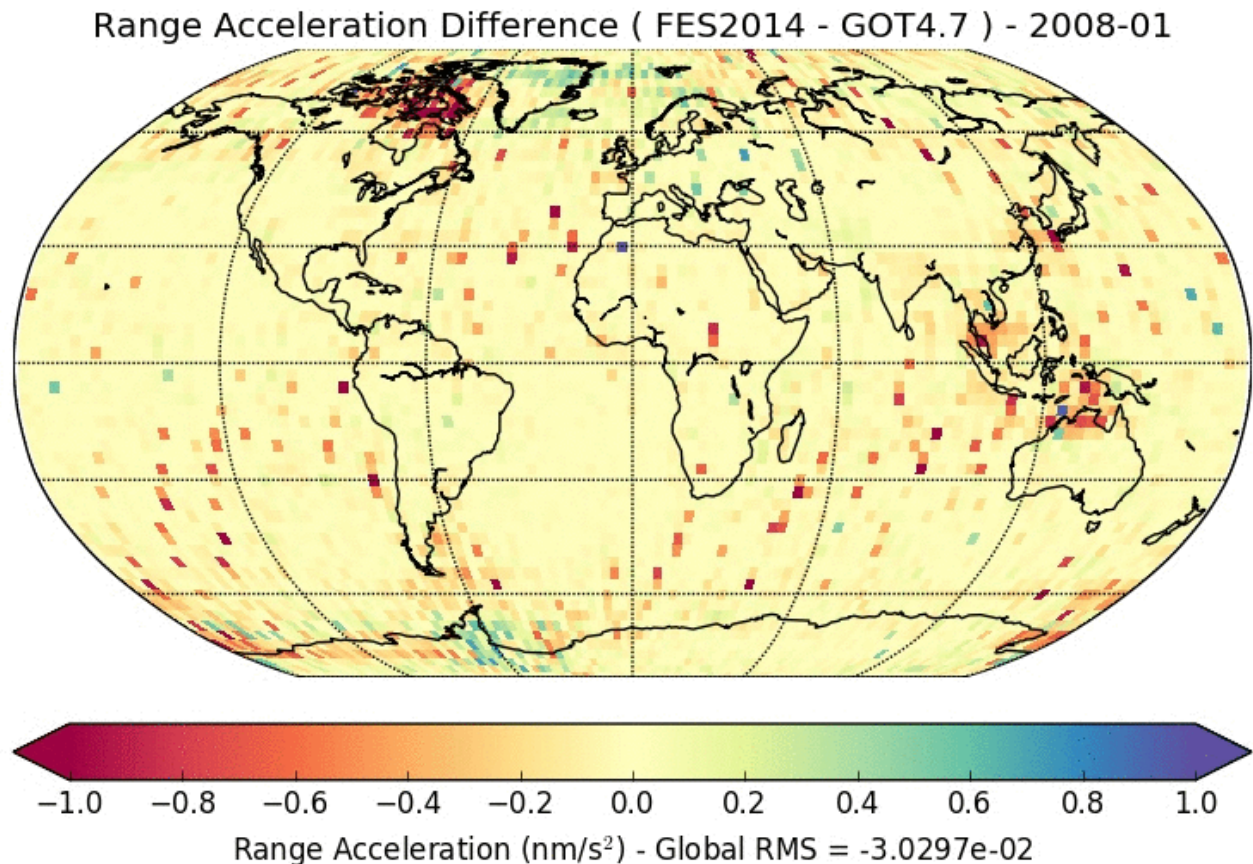
Ocean Tides – Comparisons

- Prime candidates are GGOT, GOT4.7, and FES2014
- Testing of GGOT (GOT4.7 corrected by GRACE) is still in progress
- 2008 pre-fit residual tests slightly favor FES2014
- Blue – GOT4.7 is “better”
- Red – FES2014 is “better”



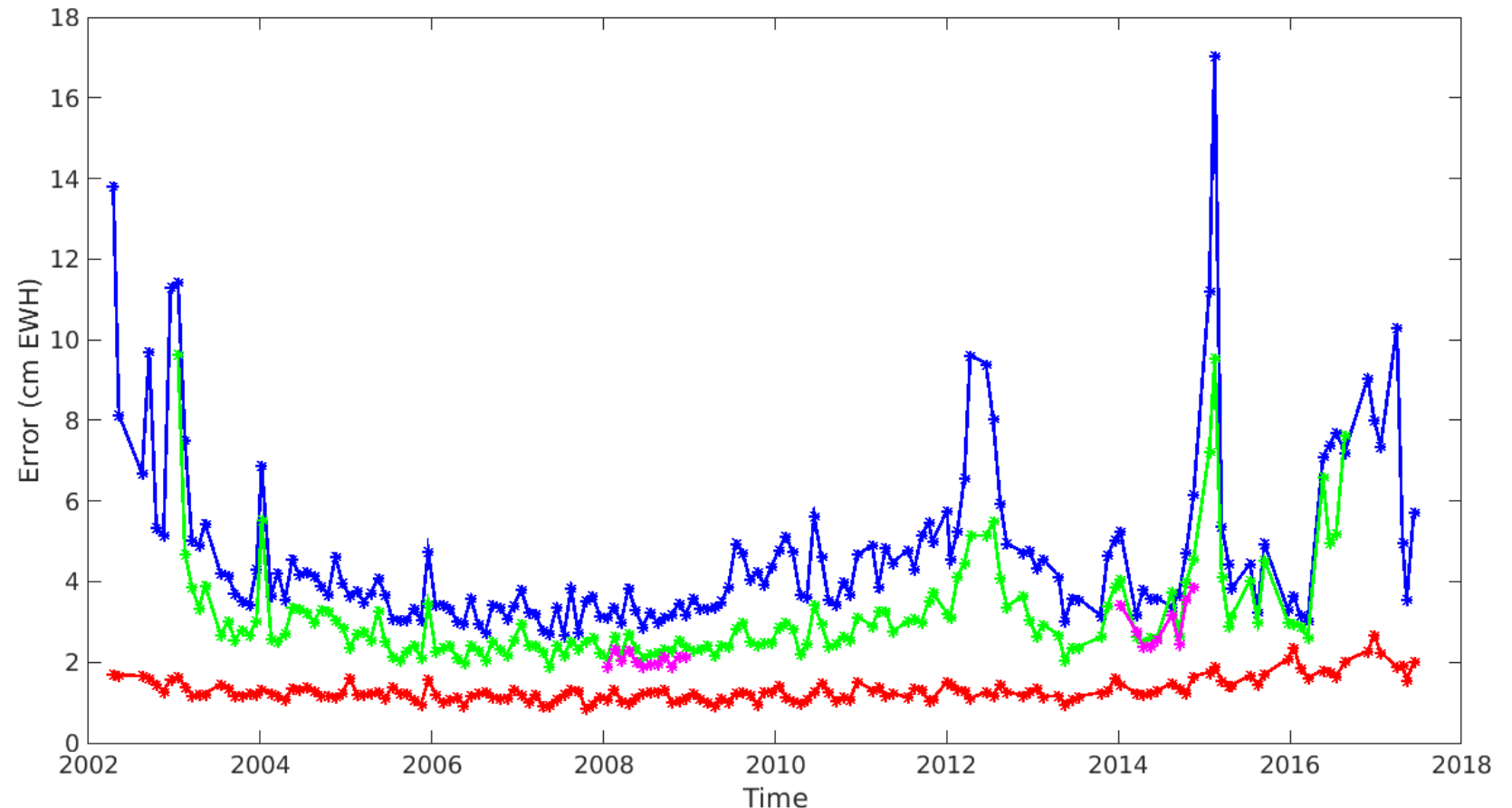
Ocean Tides – Comparisons

- **FES2014** is an improvement over **GOT4.7** in most regions
 - Gulf of Carpentaria
 - Enclosed seas in northern Nunavut
- Some ice-covered regions may perform slightly worse for **FES2014** than in **GOT4.7**
- Altimetry tracks are visible (originate from **GOT4.7**)



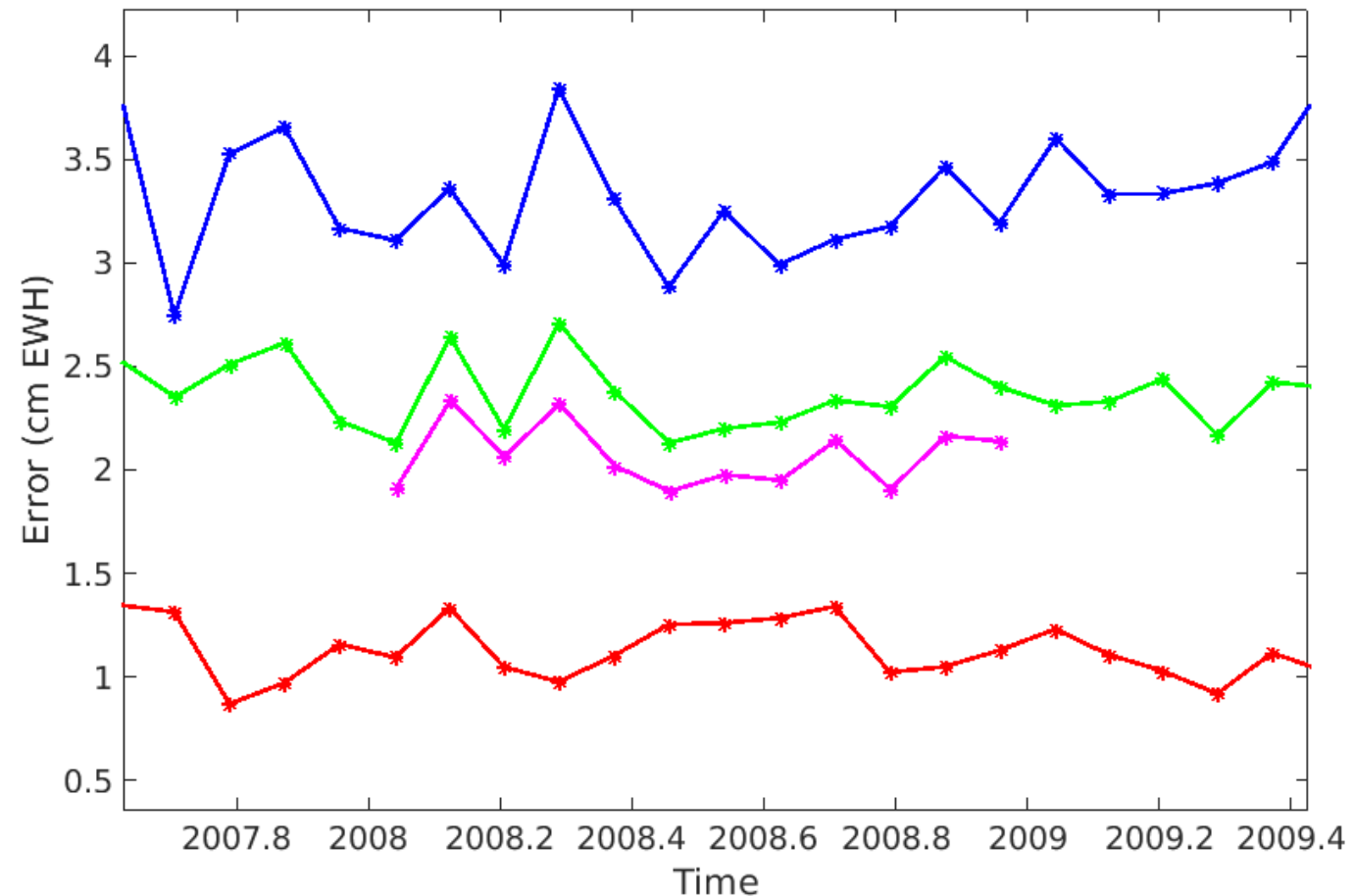
RL05/RL06 Comparison

- Error is defined as the difference with the JPL Mascon solution (300 km smoothing)
- Parameterization/
data rate changes,
RL05, and
difference
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Mascons are the
same as shown
previously
- RL06 candidate
solution shows
further
improvement



RL05/RL06 Comparison

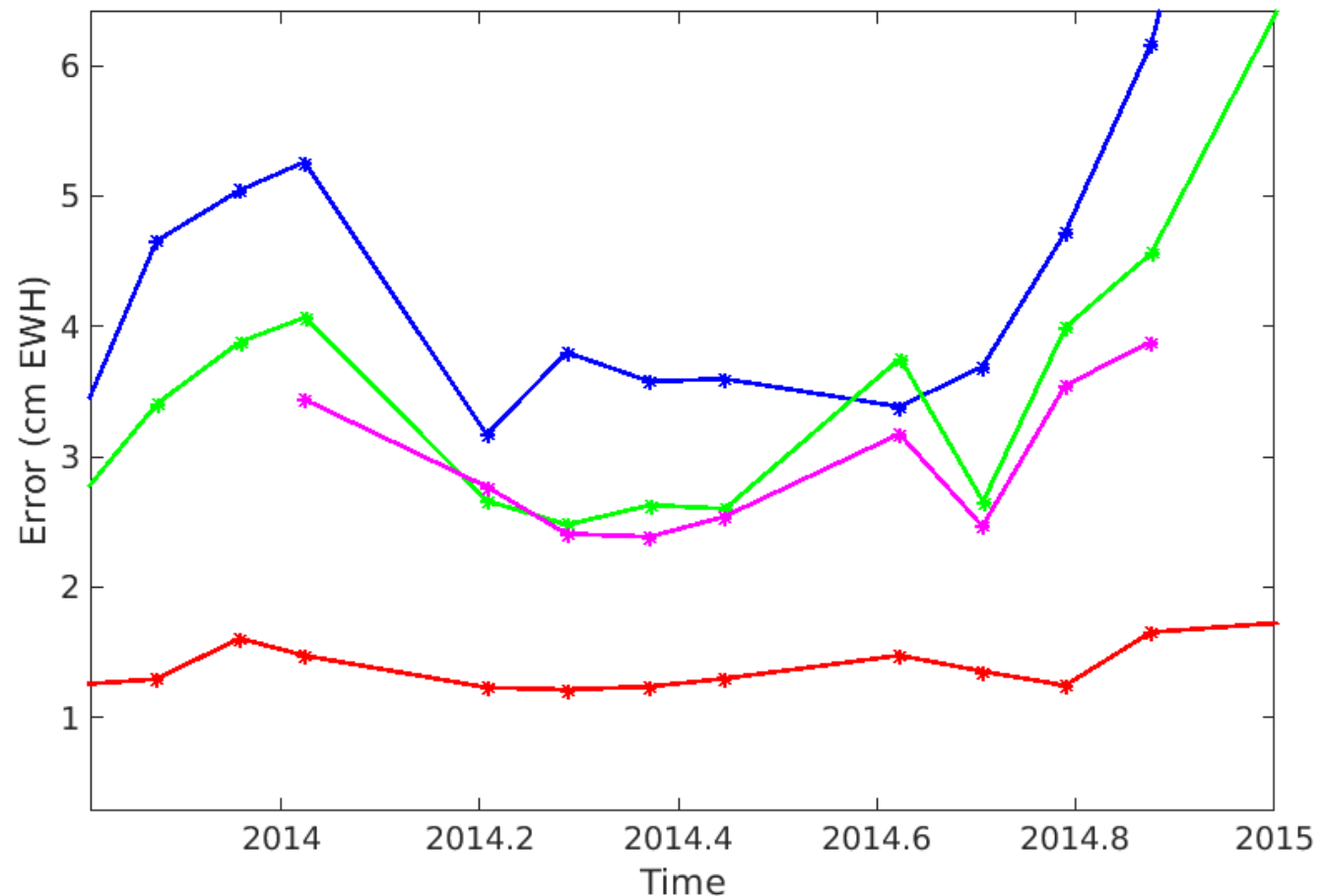
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JPL RL06 Mascons

GRACE / GRACE-FO



- All RL06 updates (data rate, background models, parameterization, etc.) will be included in the RL06 mascon solutions
- **Official release will be 3 degree mascon solutions**
- 1 degree mascon solutions are under development – when completed, available upon request

