Precision Orbit Determination for Jason-2 with GPS

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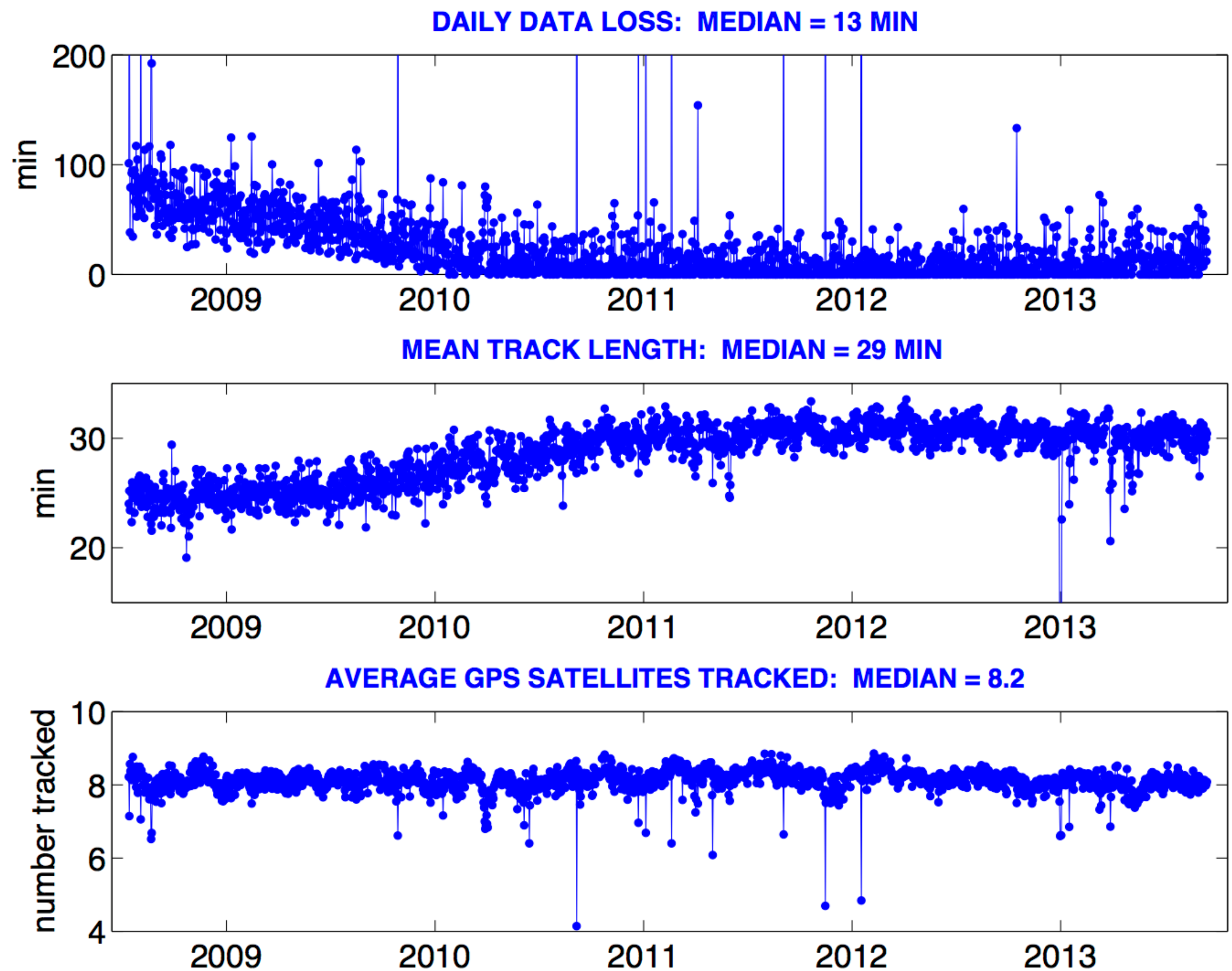
JASON-2 GPS Receiver Performance



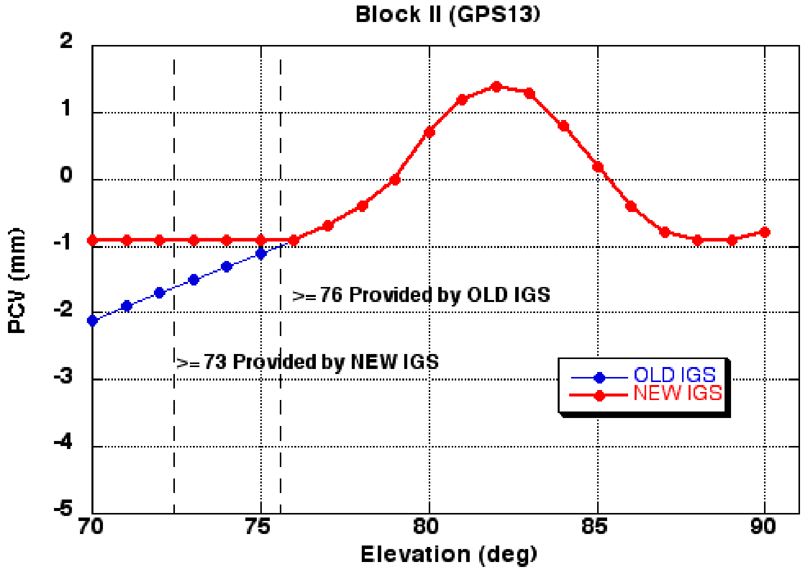
Focus

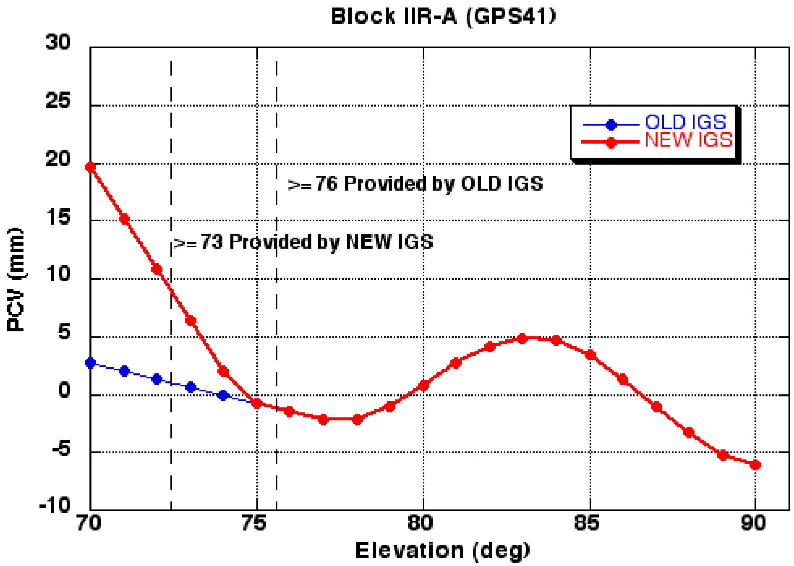
- POD with GPS
- Time Variable Gravity
  - EIGEN6S
  - JPLRL05M
  - Atmospheric/Ocean de-aliasing
    - GRACE RL05 (6-Hr Time Series)
    - 3-Hr ITRF2013 AOD (till Dec. 2012)
- GPS Antenna Calibrations
  - IGS has decided to change the standard for the GPS satellites
    - Only affects low Earth orbiters
    - Goal is to maintain consistency with IGS
  - Previous releases of JASON-2 antenna maps were consistent with the previous IGS Maps (with JPL extensions).
  - What are the effects of the change?

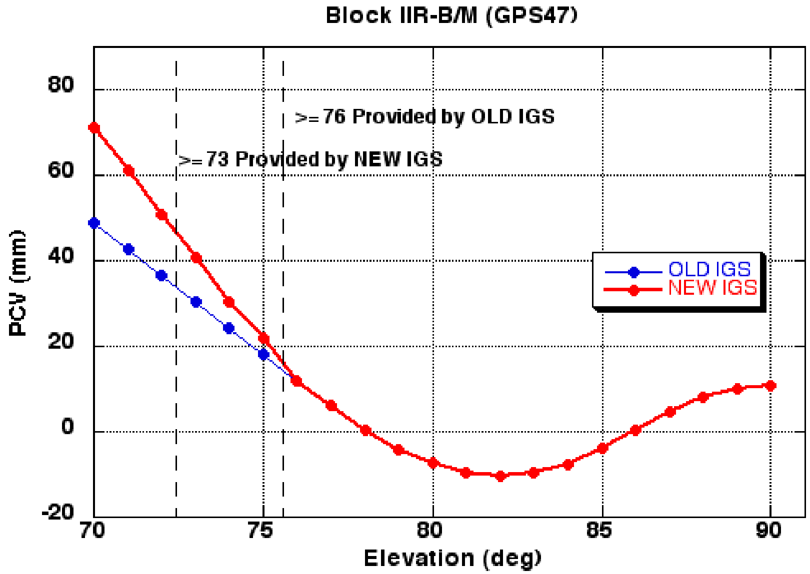
Antenna Calibrations

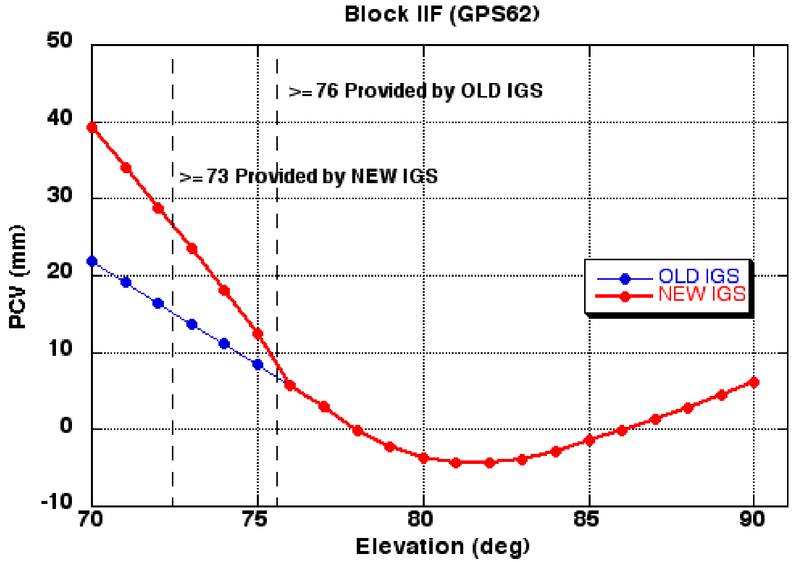
- IGS has released extensions to GPS transmitter antenna PCV calibrations for boresight angles of 15-17 degrees, as follows:
  - Block I: No change
  - Block II/IIA: Constant PCV using value at 14 degrees.
    - Becomes arbitrary reference for PCVs of other blocks.
  - Blocks IIR and IIF: Based on analysis of LEO data by CODE, using Block II/IIA constraint.
    - Used Jason-2, GRACE-A, GRACE-B, GOCE, MetOp-A.
- No change to PCV calibrations from 0-14 degrees
  - Previously JPL used linear extrapolation > 14 degrees

GPS Satellite PCV: New vs. Old

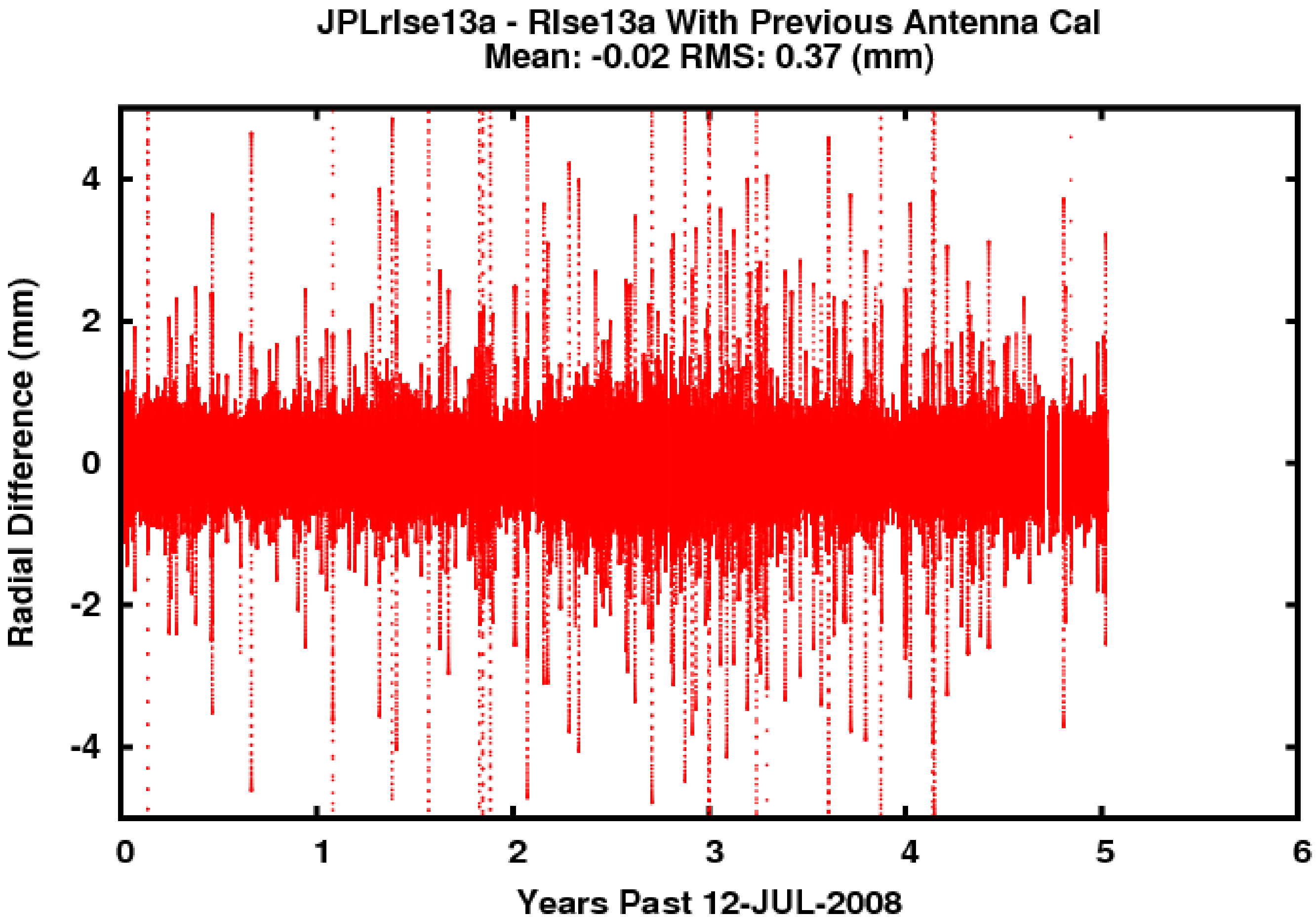






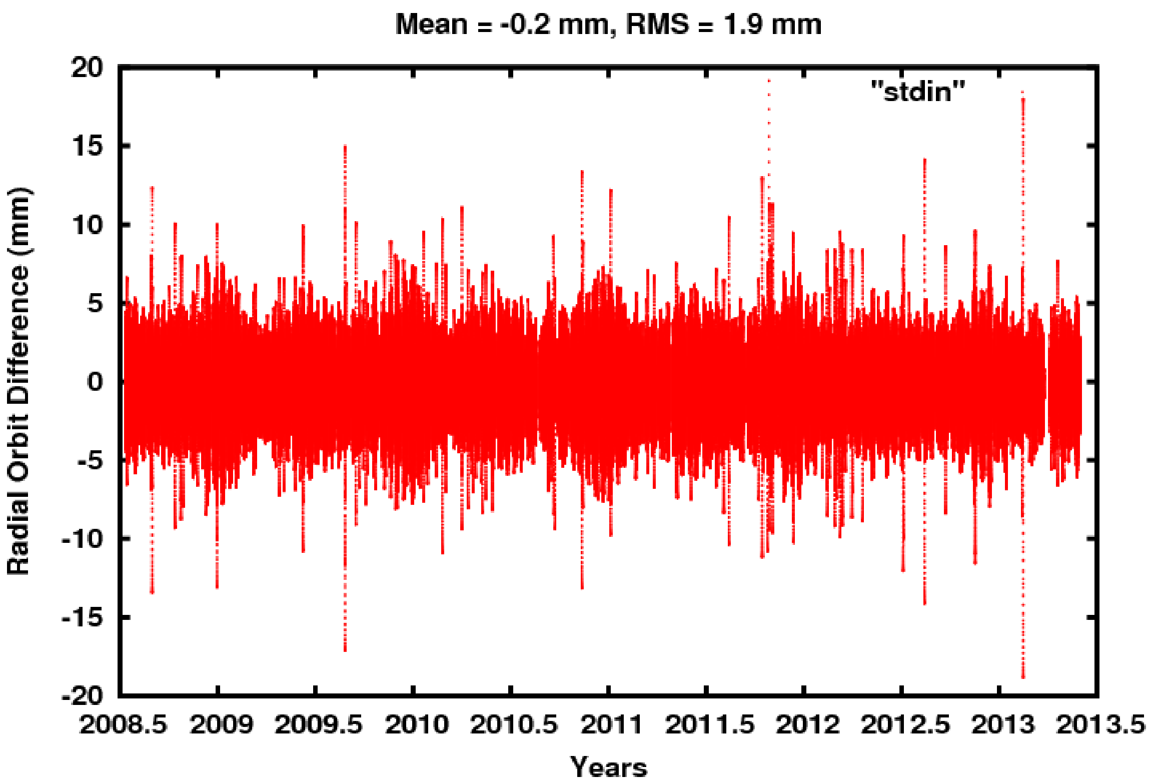


- Impact of new pairing (GPS satellite PCV + Jason-2 PCV) is small (0.4 mm RMS)
- Old pairing is fine, as long as consistency is maintained.



Impact of New Antenna Standards on Jason-2 POD: Worst Case

- Use new IGS GPS Calibrations, but:
- Fail to update prior release (i.e. RLSE11A) of Jason-2 calibrations



	Mean	RMS
Radial	–0.2	1.9
Cross Track	0.0	1.2
Along Track	0.0	4.2

Antenna Test Summary

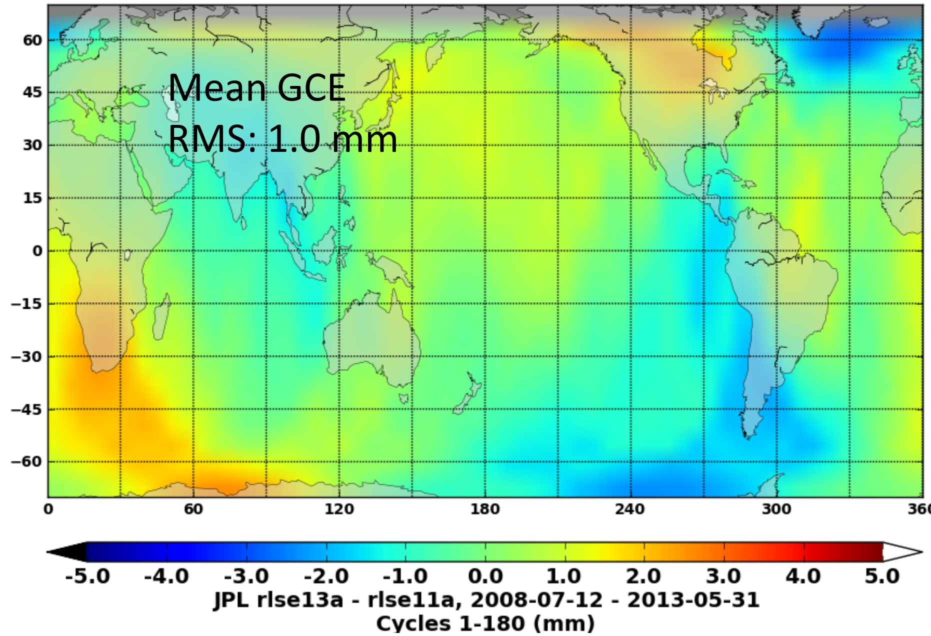
- Failure to change antenna calibrations on Jason-2 while using the new IGS antenna calibrations => errors ~2 mm RMS
- Update Jason-2 or, for now, stay consistent and use previous GPS antenna calibrations
  - Updating is simpler, if you want to use IGS Calibrations, given unknown future launches

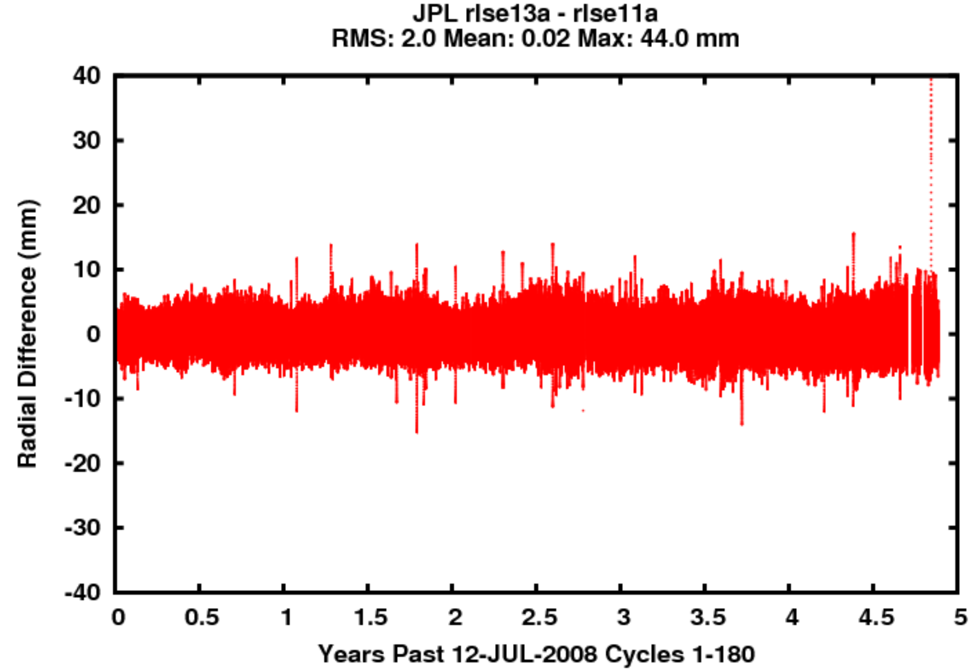
Time Variable Gravity, RLSE13a

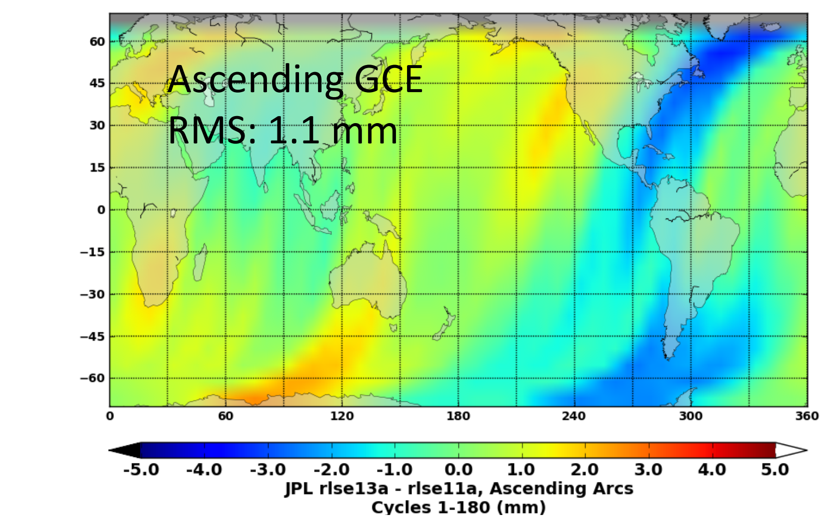
- RSLE13a = RLSE11a + TVG(JPL) + New Antenna Cals
  - Bias Fixed, reduced dynamic
- Time Variable Gravity
  - EIGEN6S
    - Lageos (6.5 years), GRACE Data 2003 – June 2009; GOCE data from first 6.7 months (until June 2010).
  - JPLRL05M
    - GRACE(2003-2012) fit to Surface Mass Concentrations
    - Fit Drift, Annual, Semi-annual to monthly mass concentrations + background GIF48 field
  - Atmospheric/Ocean de-aliasing
    - GRACE RL05 (6-Hr Time Series) – Jan. 2013 to Aug. 2013
    - 3-Hr ITRF2013 AOD – through Dec. 2012

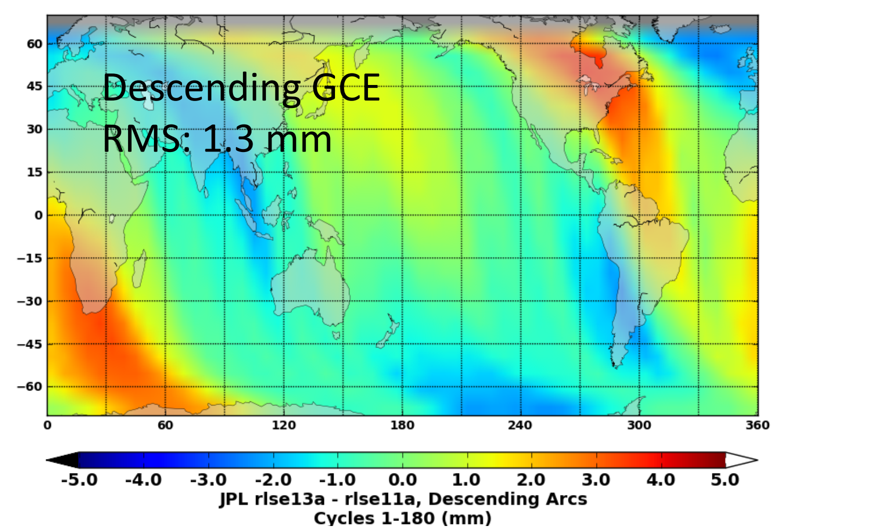
RLSE13a □ RLSE11a Radial Orbit Differences

(JPLRL05 time variable gravity vs. GGM02C static gravity)





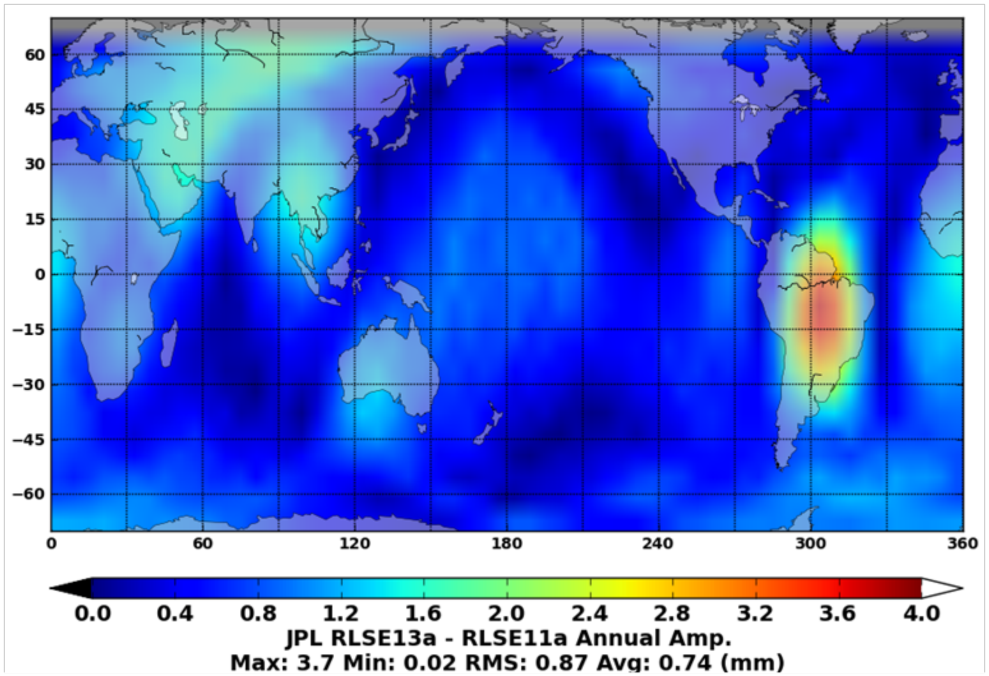




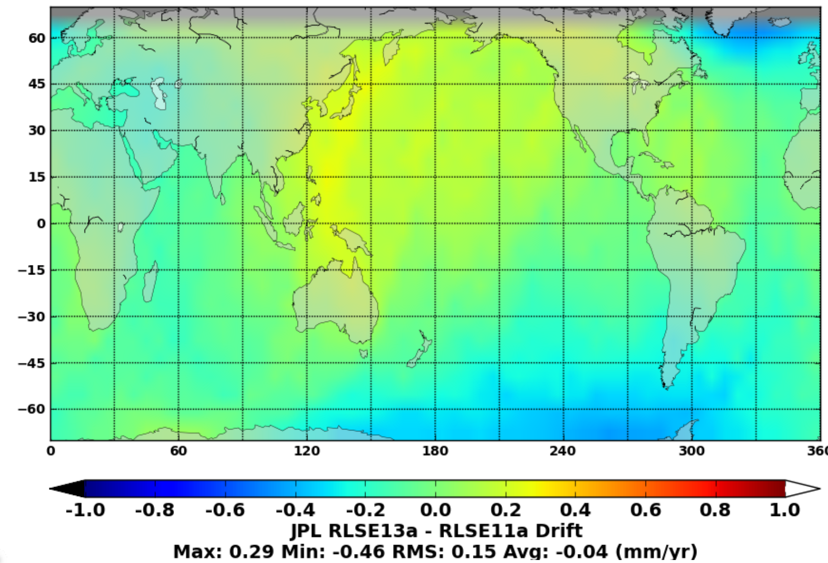
RLSE13a □ RLSE11a Radial Orbit Differences

(JPLRL05 time variable gravity vs. GGM02C static gravity)

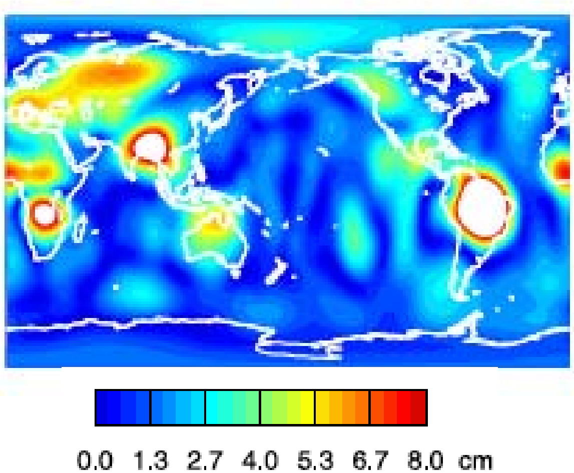
AMPLITUDE OF ANNUAL DIFFERENCES



RATE DIFFERENCES



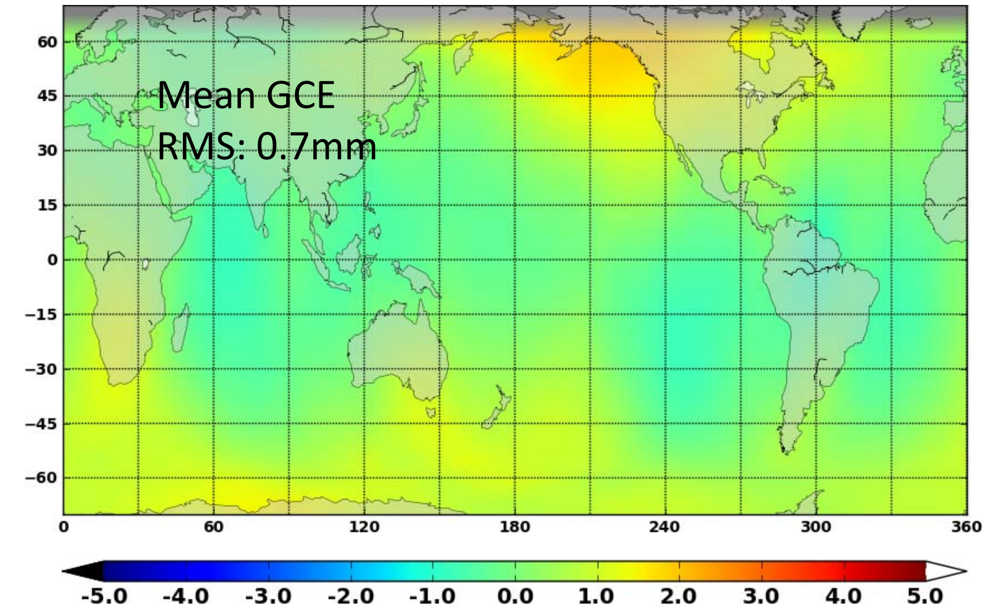
Amplitude of Annual Differences Highlights Amazon



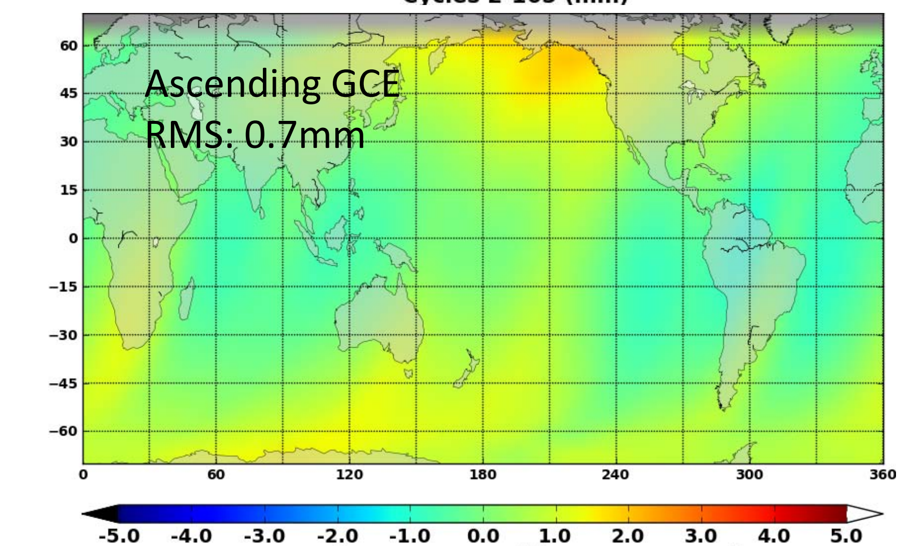
Annually varying surface mass from GRACE (Wahr et al., 2004)

Impact of Different TVG Models on GPS Reduced Dynamic Orbit
(JPLRL05 vs. EIGEN6S)

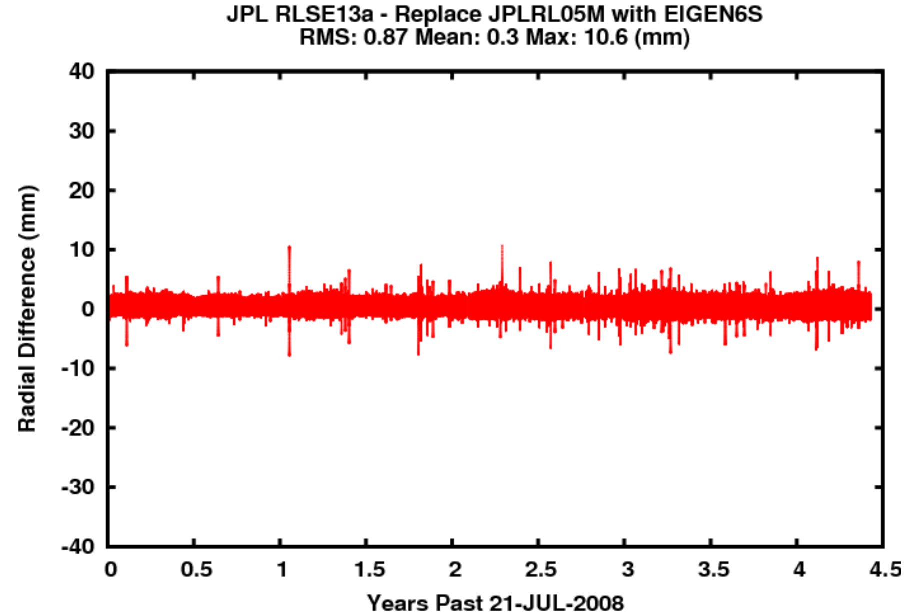
JPLRL05 chosen on basis of crossover performance (slight advantage) and improved dynamic POD

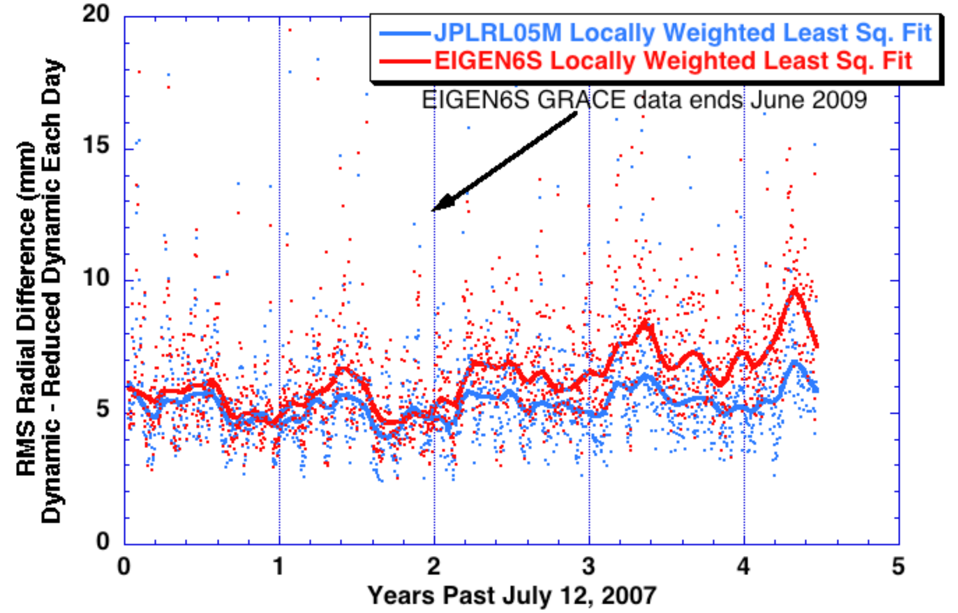


JPL RLSE13a - Replace JPLRL05M with EIGEN6S
Cycles 2-165 (mm)

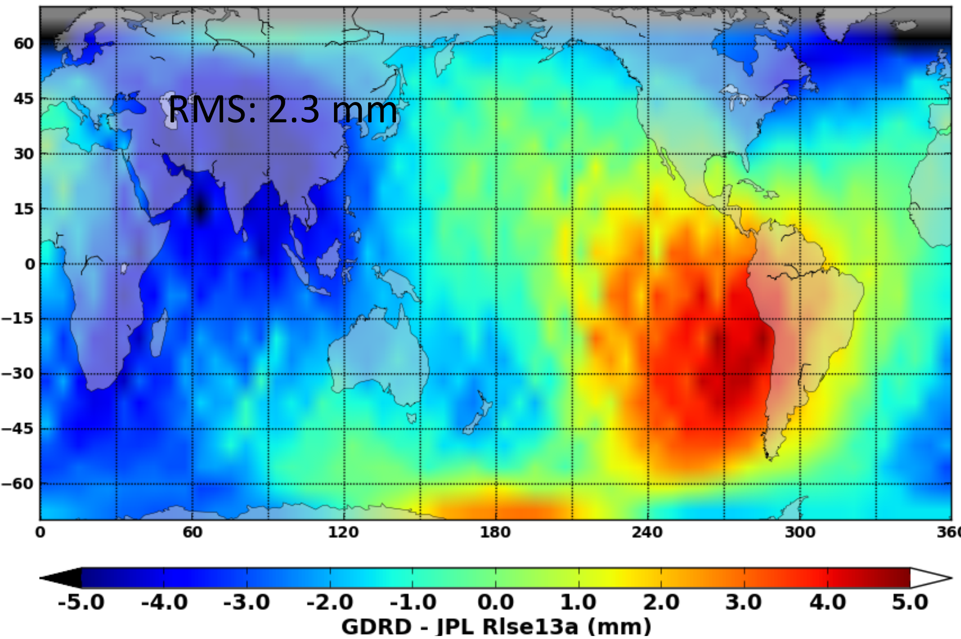


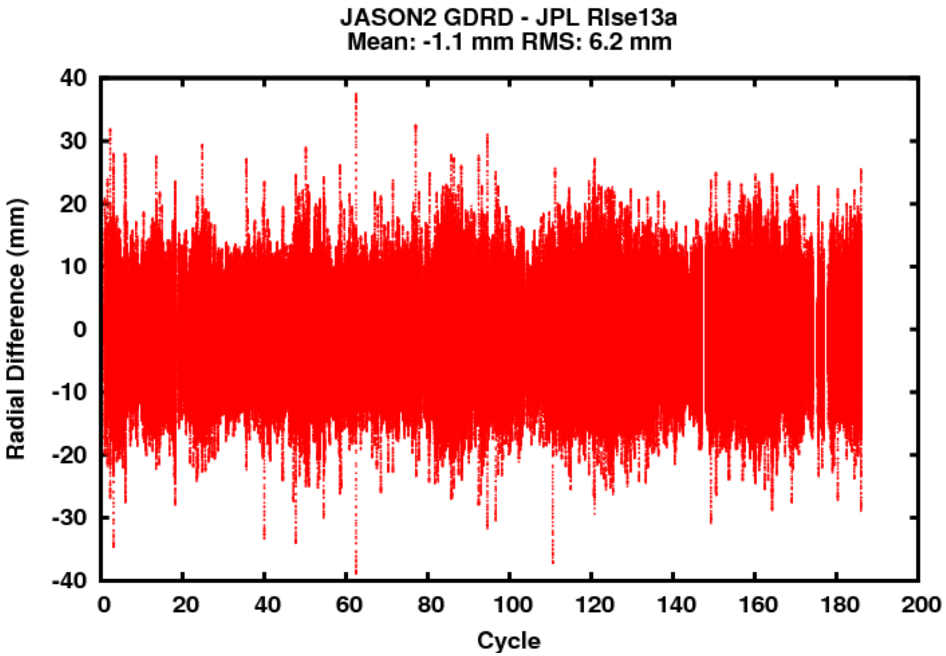
JPL RLSE13a - Replace JPLRL05M with EIGEN6S, Ascending Arcs
Cycles 2-165 (mm)

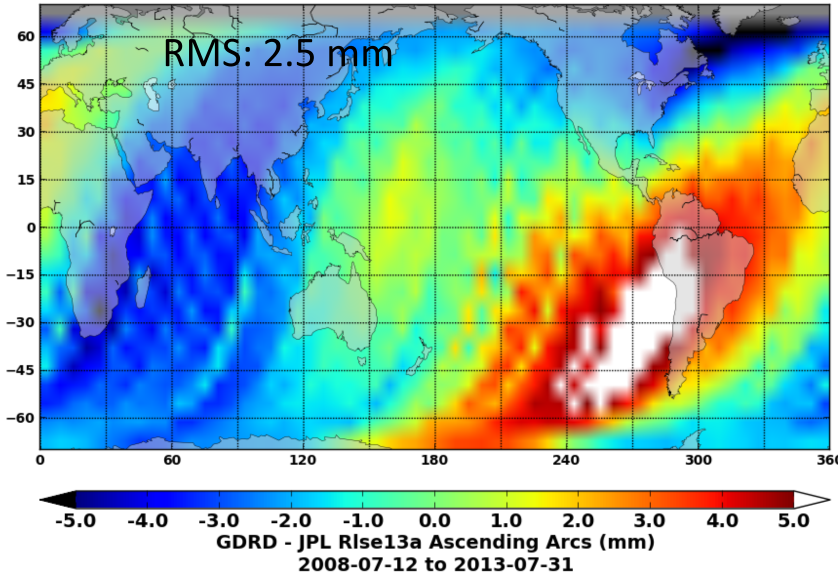


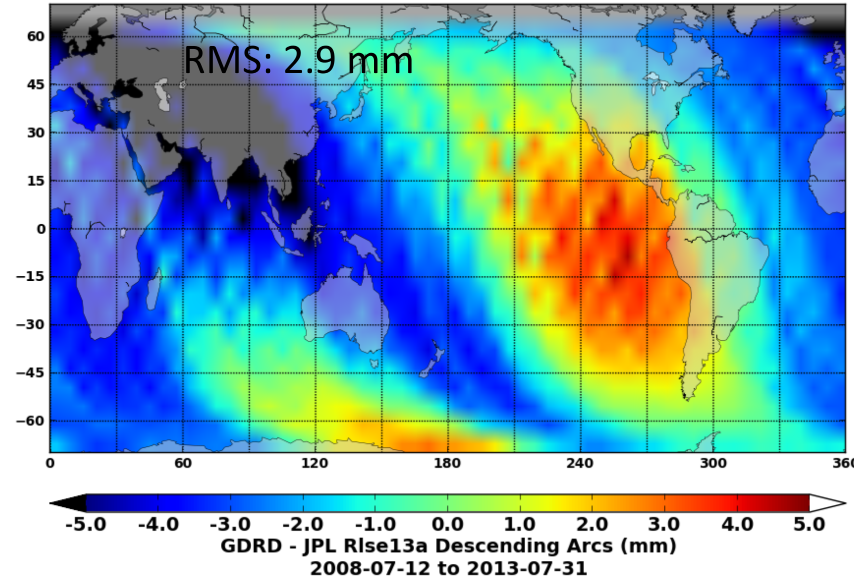


GDR-D POE – JPL RLSE13a Radial Orbit Differences

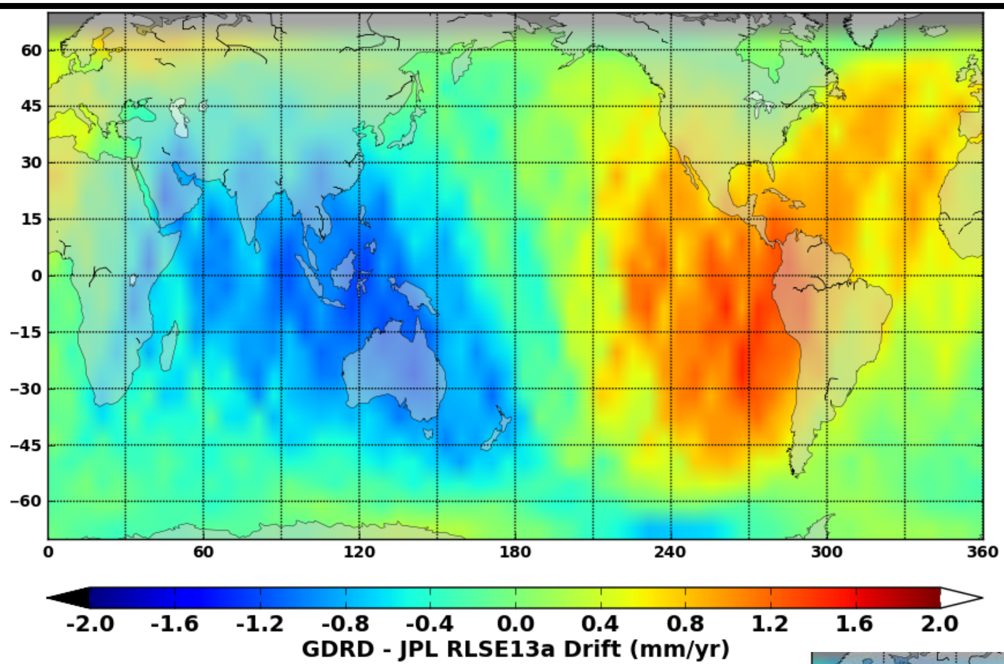


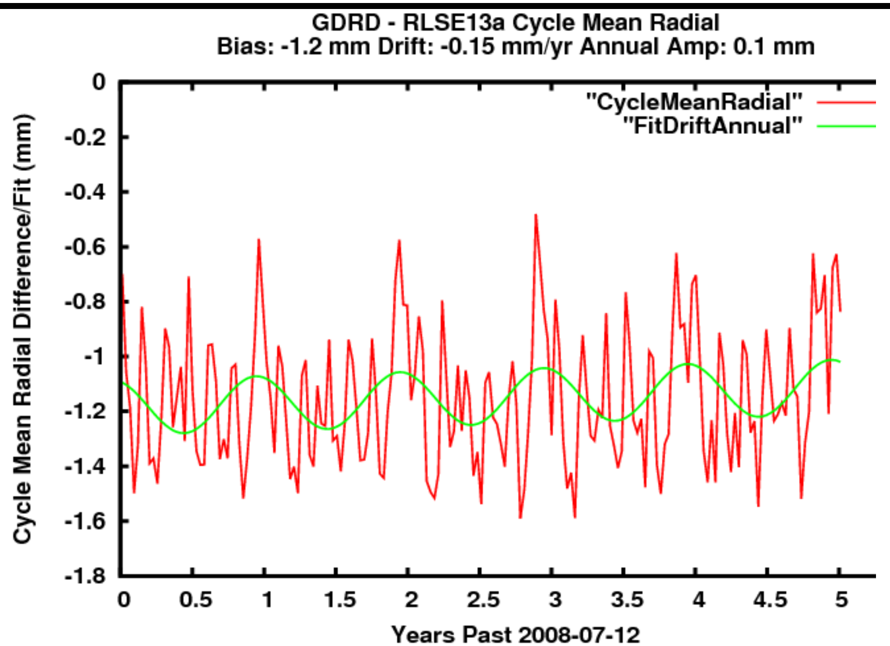


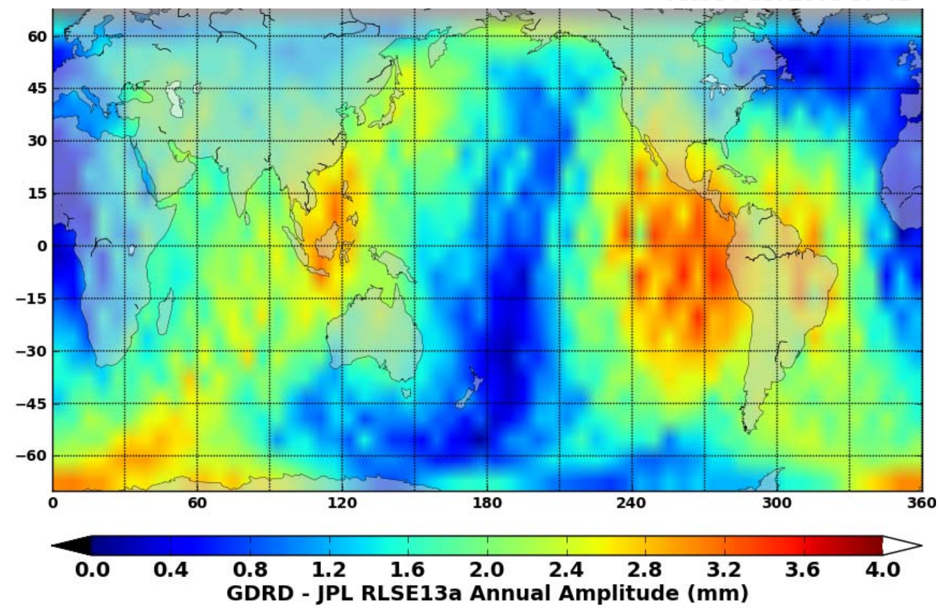




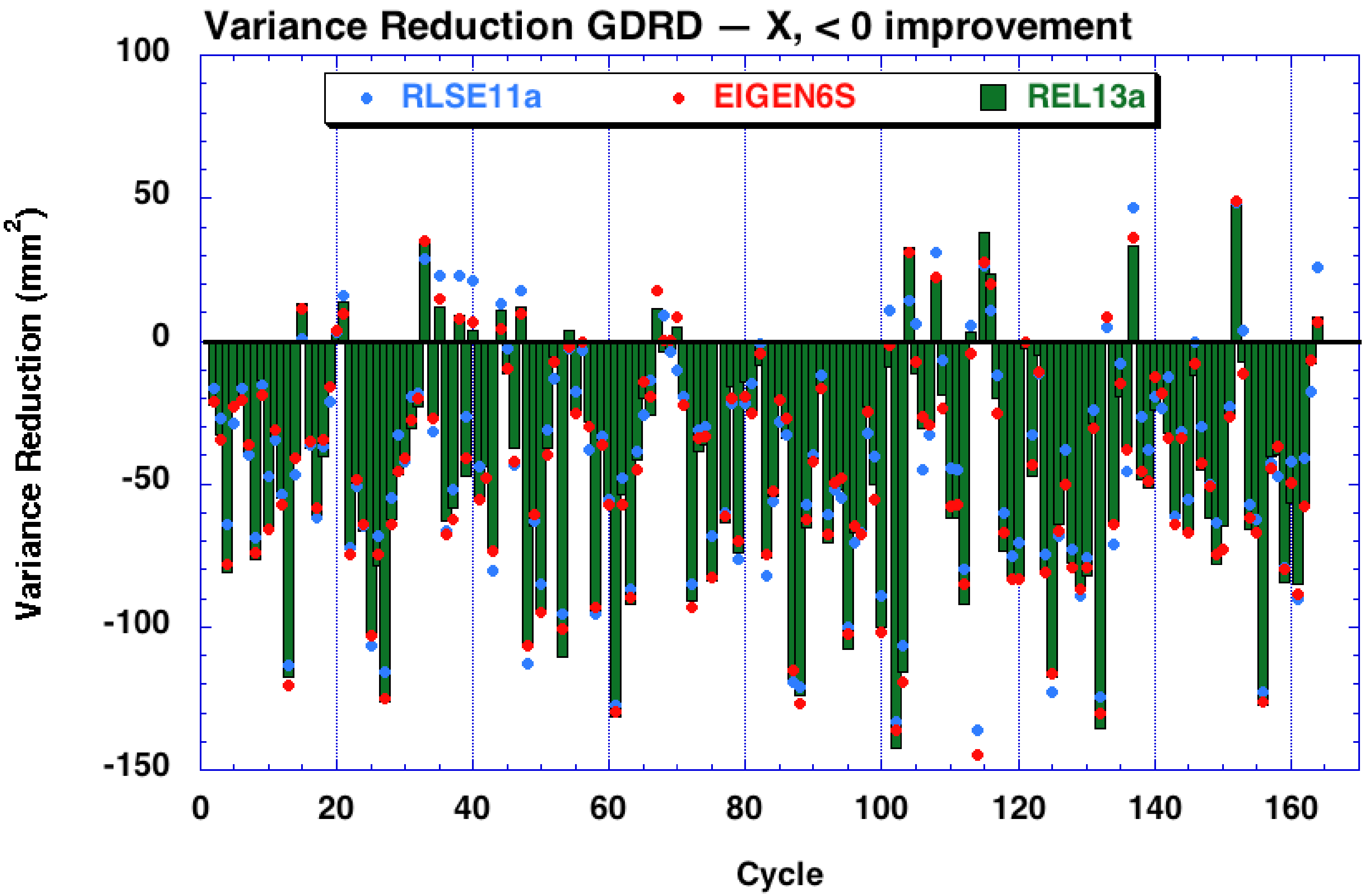
GDRD – JPL RLSE13a Radial Orbit Difference Time Variability



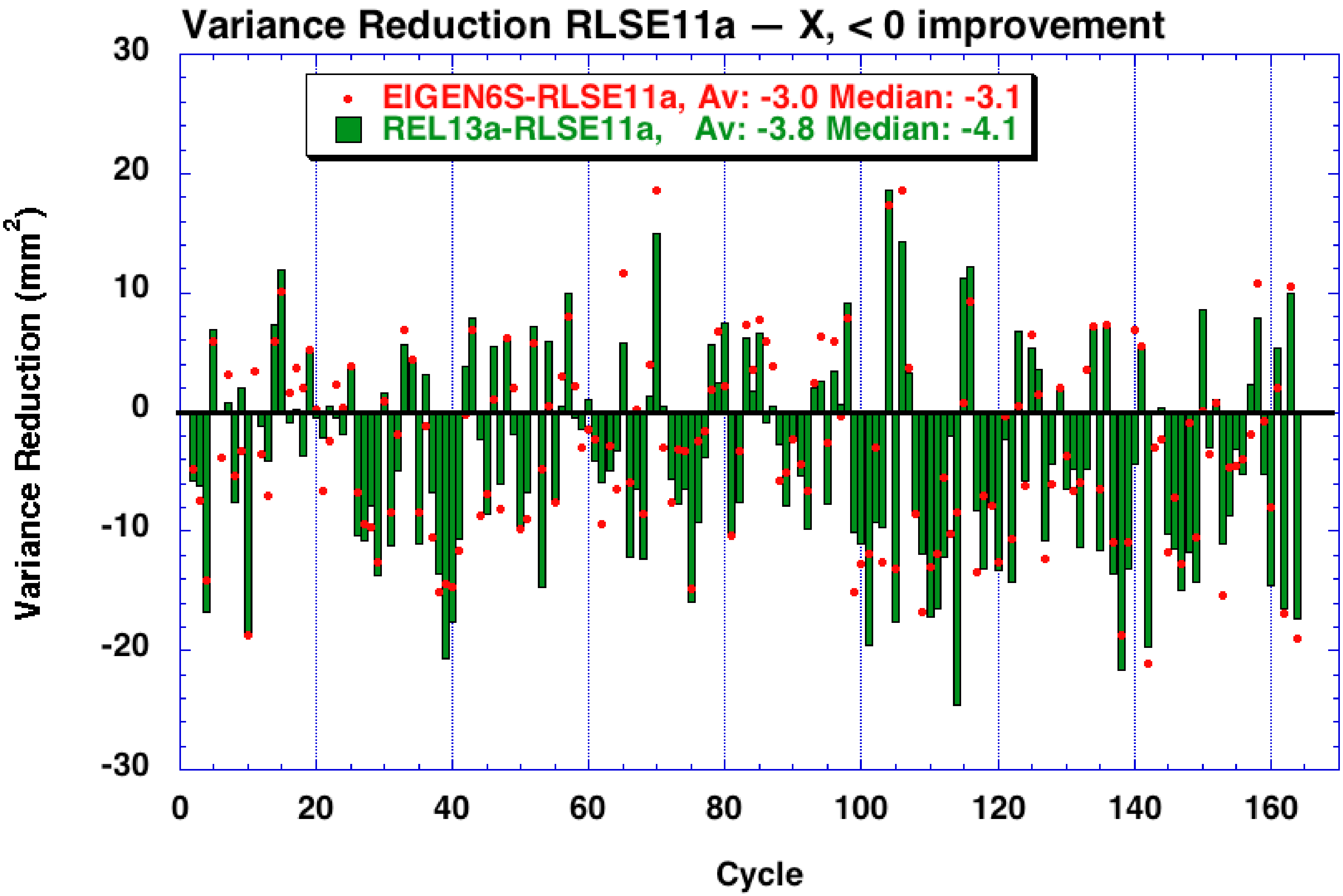




Crossover Variance Reduction
Relative to GDR-D POE



Crossover Variance Reduction, Relative to RLSE11a



Summary

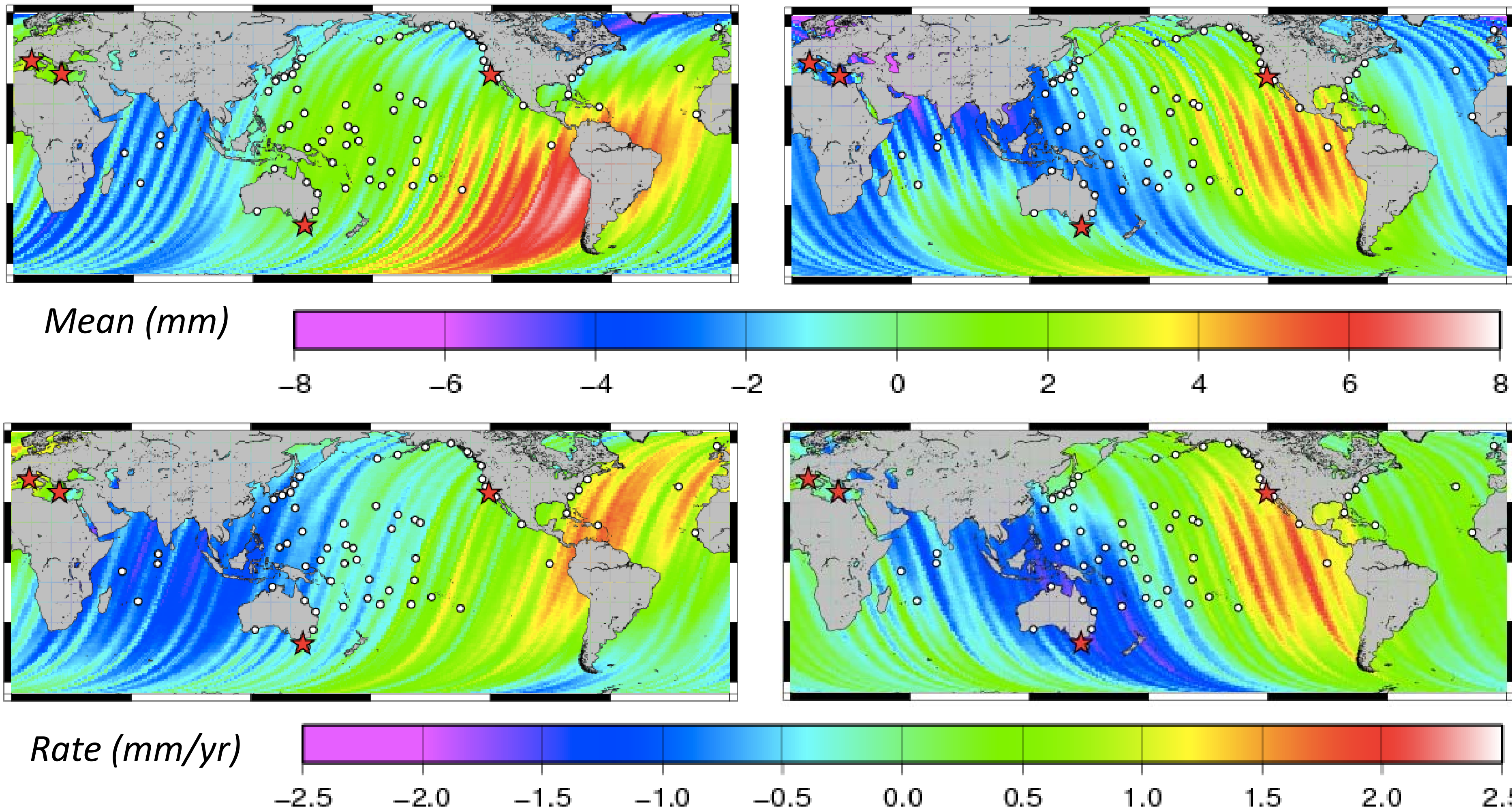
- Excellent GPS Receiver Performance – stable for last two years
- New IGS GPS transmit antenna calibrations do not have big impact.
  - Recommend Jason-2 update to be consistent
- Time Variable Gravity
  - ~ 2 mm (RMS) impact on reduced-dynamic GPS orbits (i.e., RLSE13a vs. RLSE11a)
  - Competing TVG models (EIGEN6S vs. JPLRL05M) yield similar reduced dynamic orbits
    - EIGEN6S dynamic performance poorer than JPLRL05M
  - Annual Amplitude JPLRL05M(tvg) – GGM02C(static) largest over the Amazon: 3.7 mm
- Differences of GDR-D POE and latest GPS-based (RLSE13a) orbit:
  - 6 mm RMS (1 min. sampling, cycles 1-185)
  - RMS ~2-3 mm when averaged over 6°x 6° bins
  - Global Drift over mission: -0.15 mm/yr.
  - Crossover variation reduction of ~45 mm^2 for RLSE13a.

BACKUPS

Jason-2 Radial Orbit Differences

GDR-D POE — JPL GPS

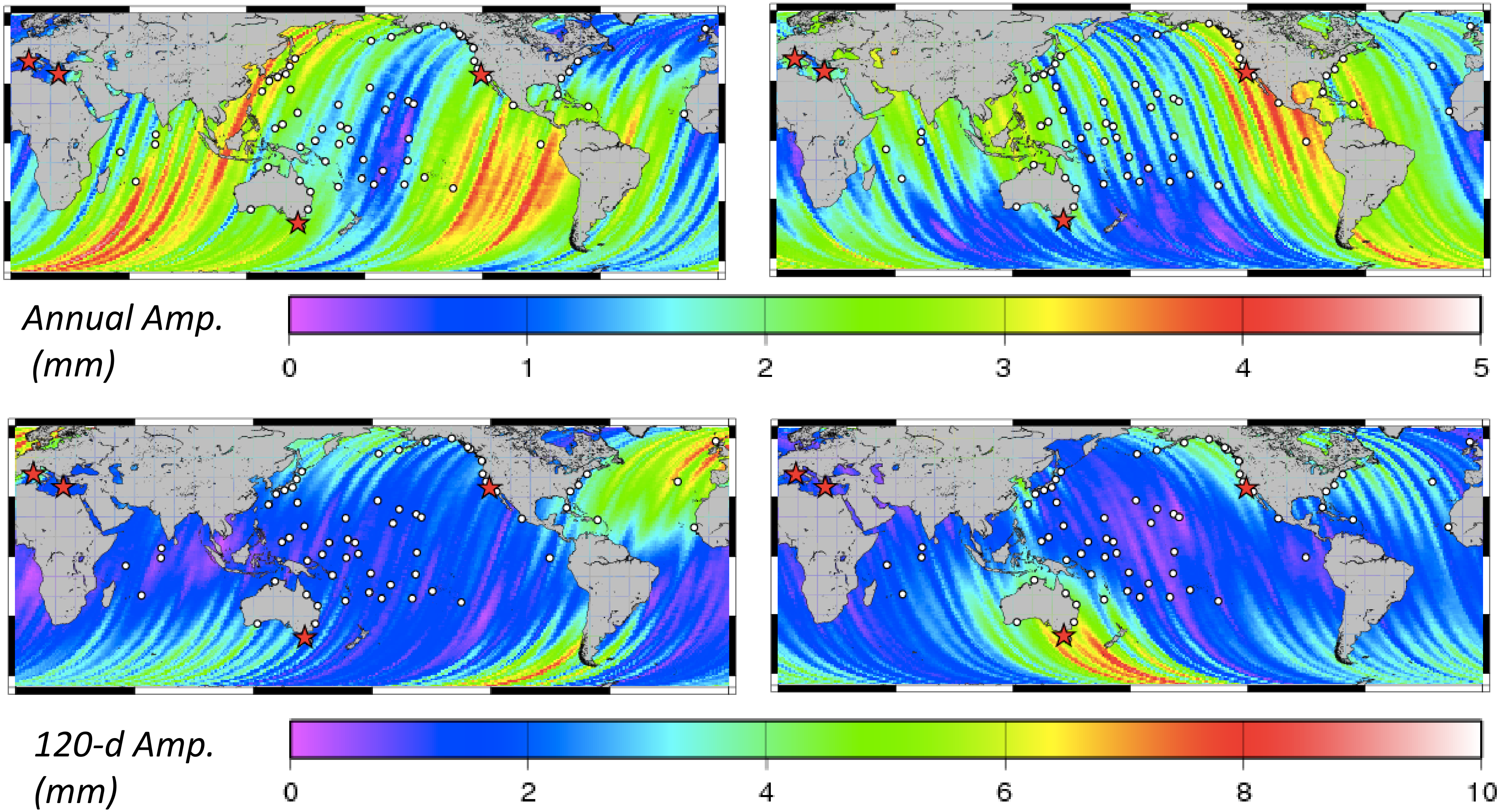
Ascending Passes | *Descending Passes*



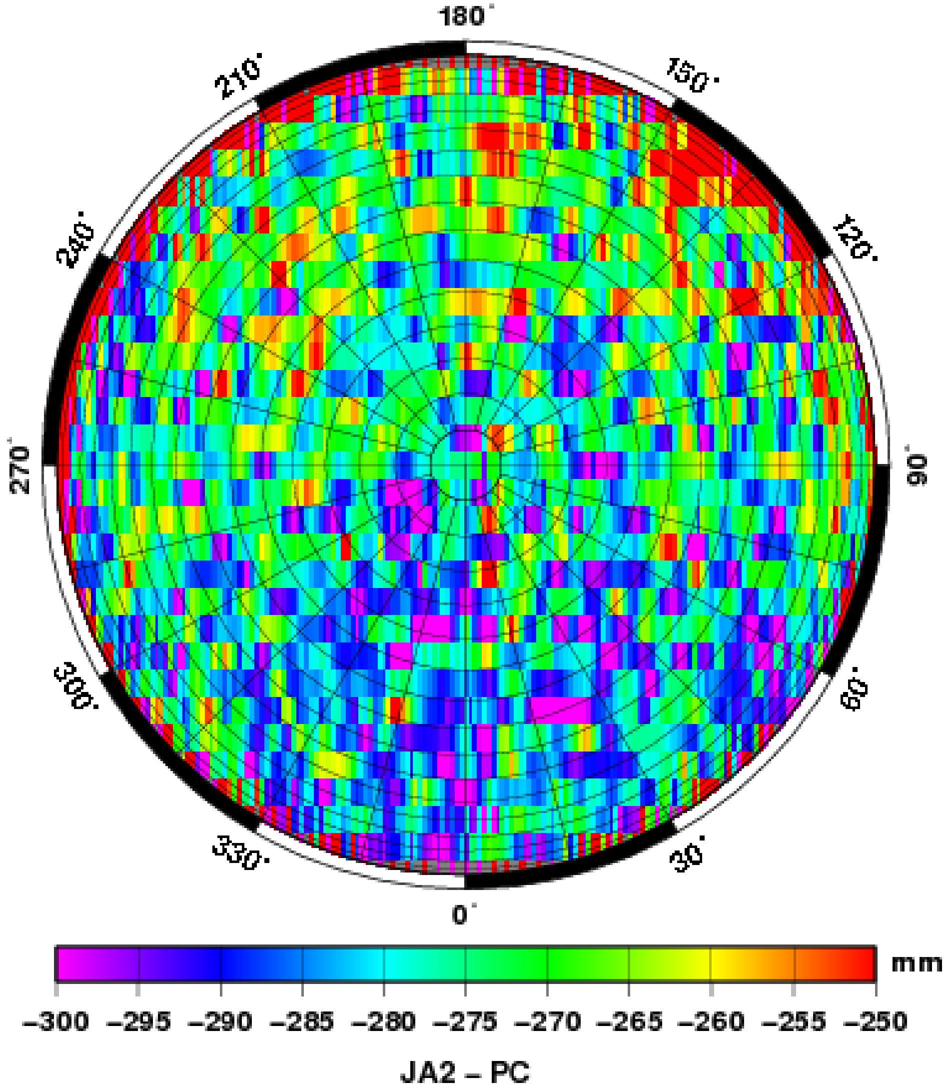
Jason-2 Radial Orbit Differences

GDR-D POE — JPL GPS

Ascending Passes | *Descending Passes*

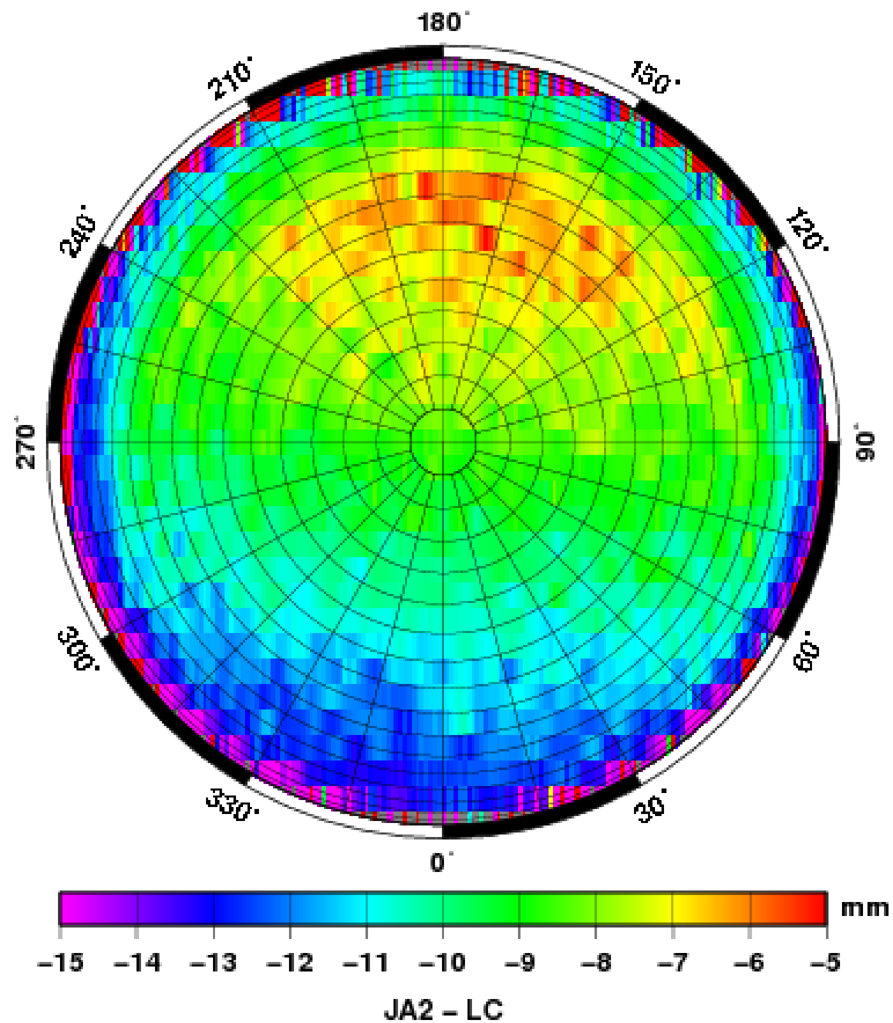


Recalibrated JASON2 GPS Code Center
New - Old



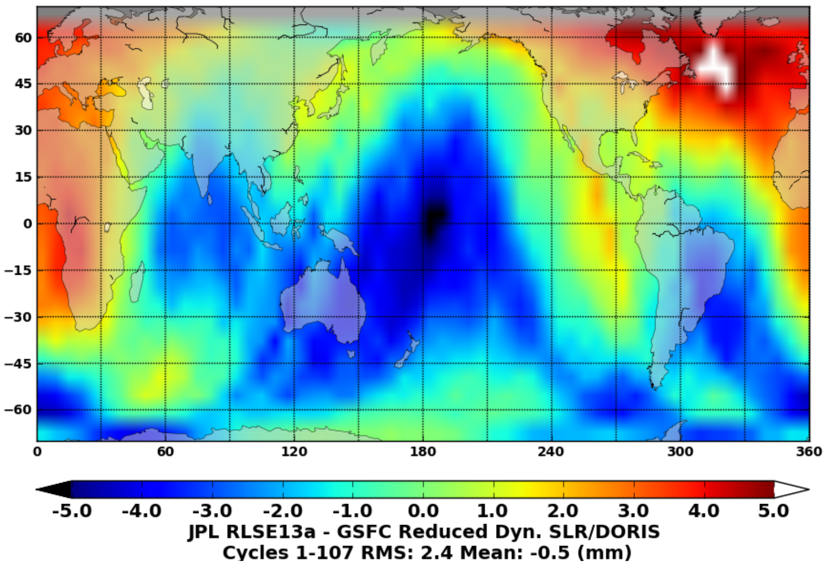
Dual-Freq. Code biased by -276 mm

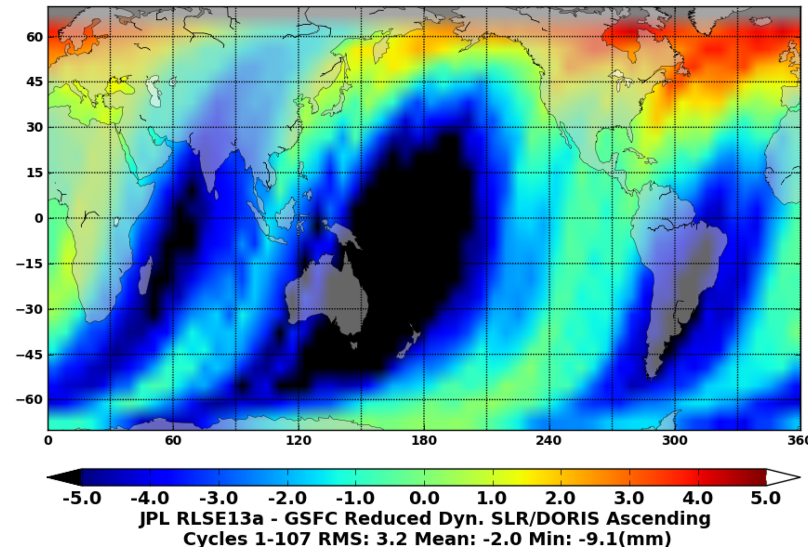
Re-calibrated Phase Center Map
New - Old

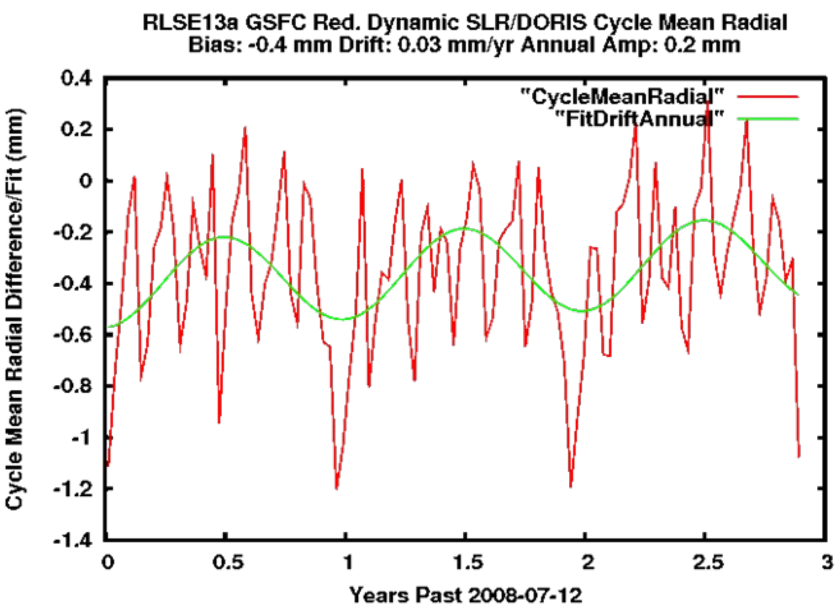


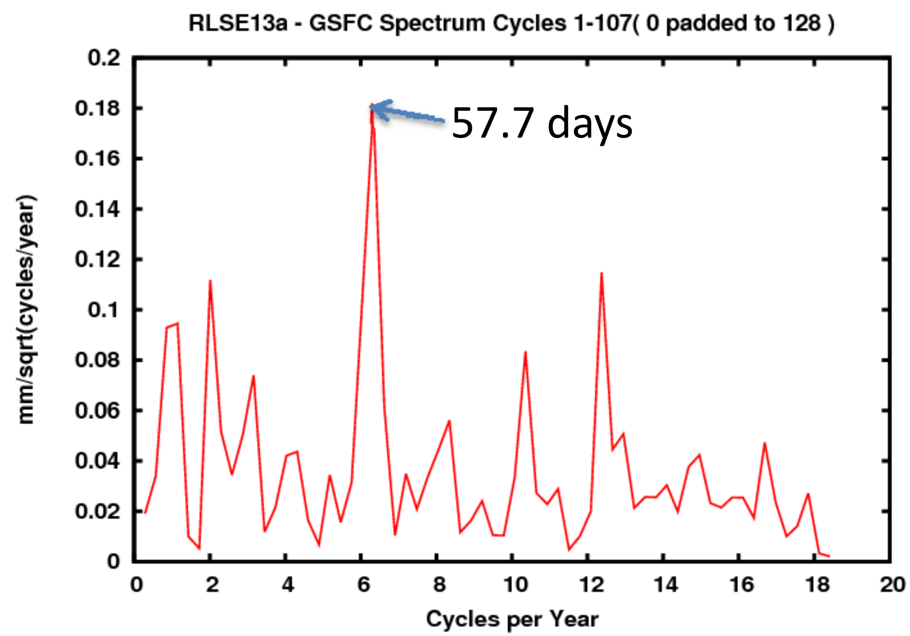
biased by -11 mm

Radial Diff. Comparison With Independent Data
GSFC Reduced Dynamic SLR/DORIS Cycles 1-107

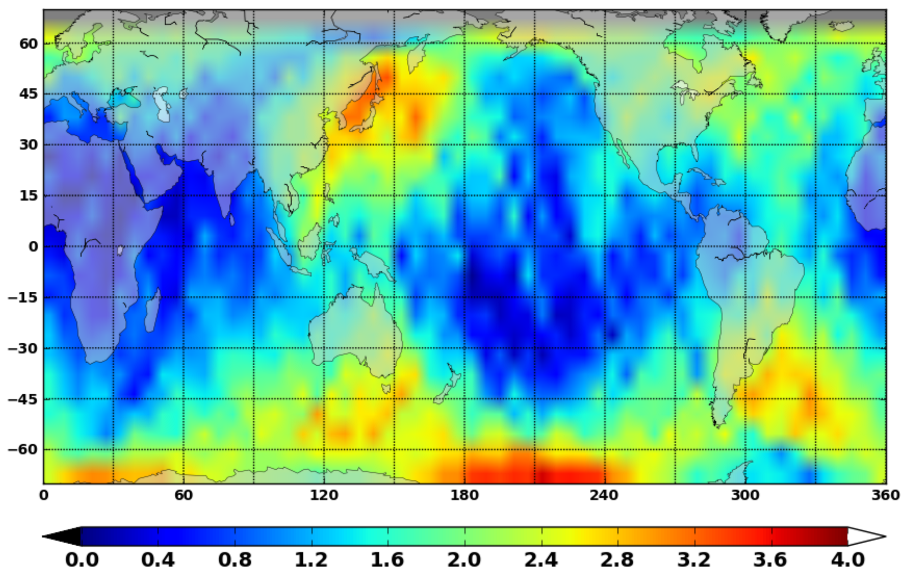




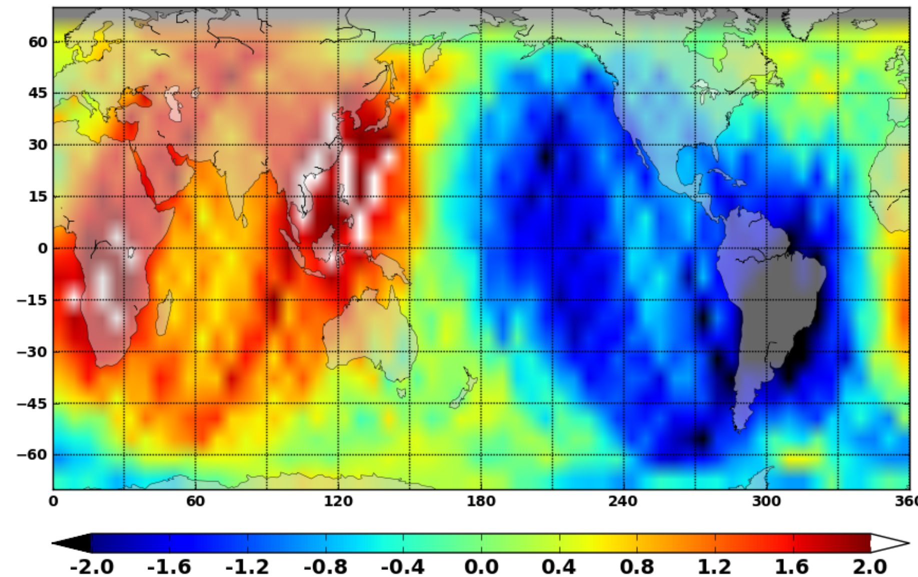




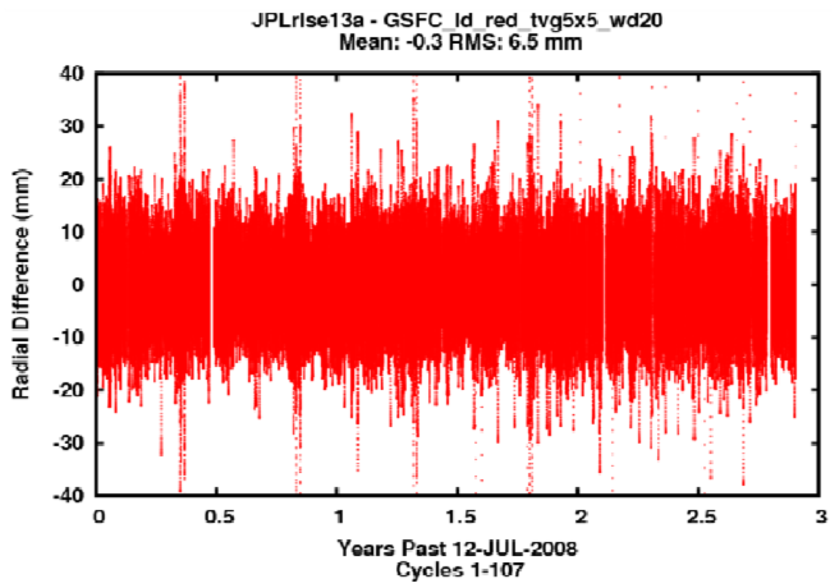
Comparison With Independent Data (Cont.)
GSFC Reduced Dynamic SLR/DORIS Cycles 1-107



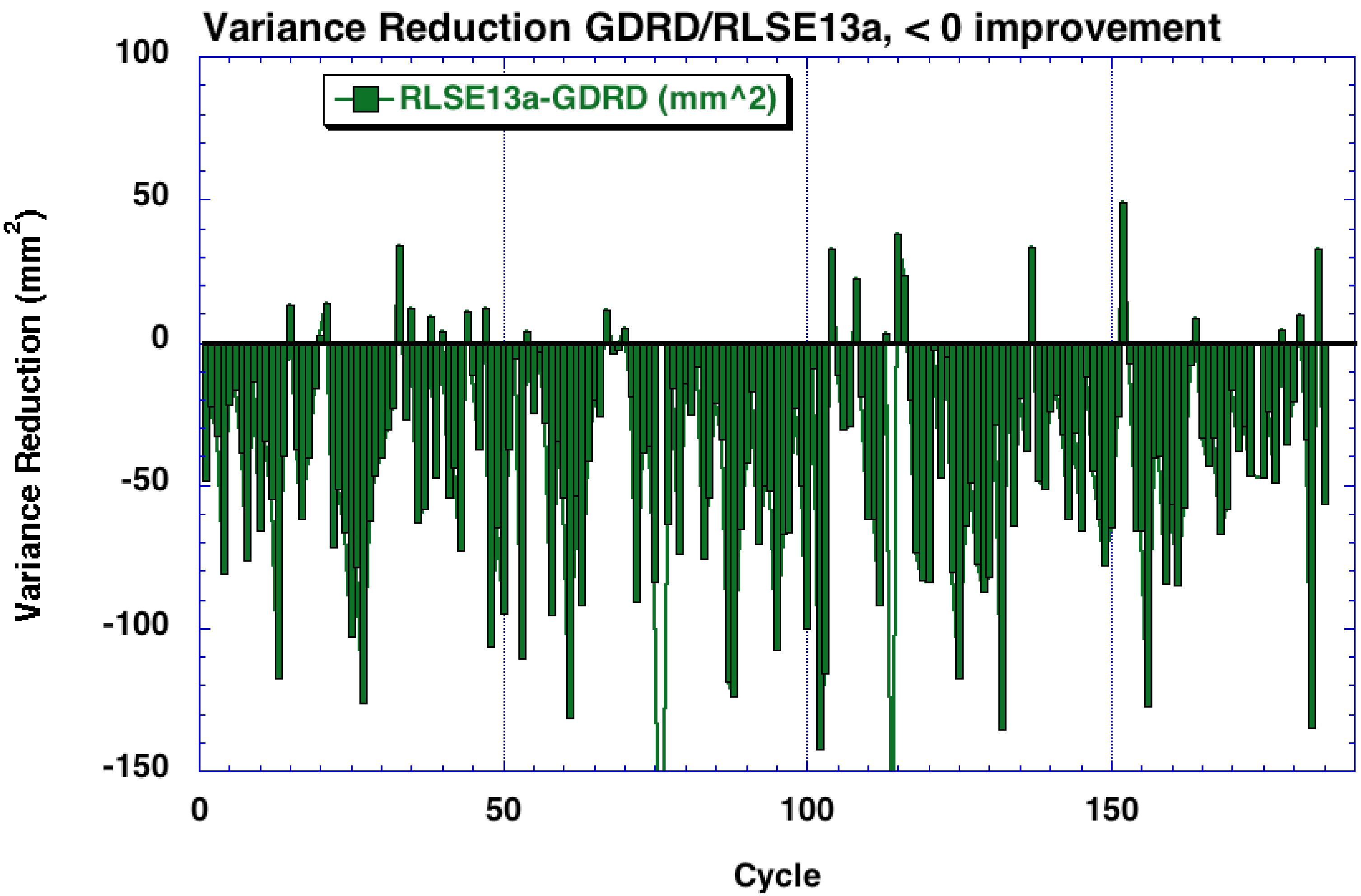
JPL RLSE13a - GSFC Red. Dyn. SLR/DORIS Annual Amp.
Max: 3.7 Min: 0.07 RMS: 1.7 Avg: 1.5 (mm)



JPL RLSE13a - GSFC Red. Dyn. SLR/DORIS Drift
Max: 2.4 Min: -2.6 RMS: 1.1 Avg: 0.02 (mm/yr)



Cross-Over Variance Reduction
Cycles 1-185; Mean: -45 Median: -41 mm^2

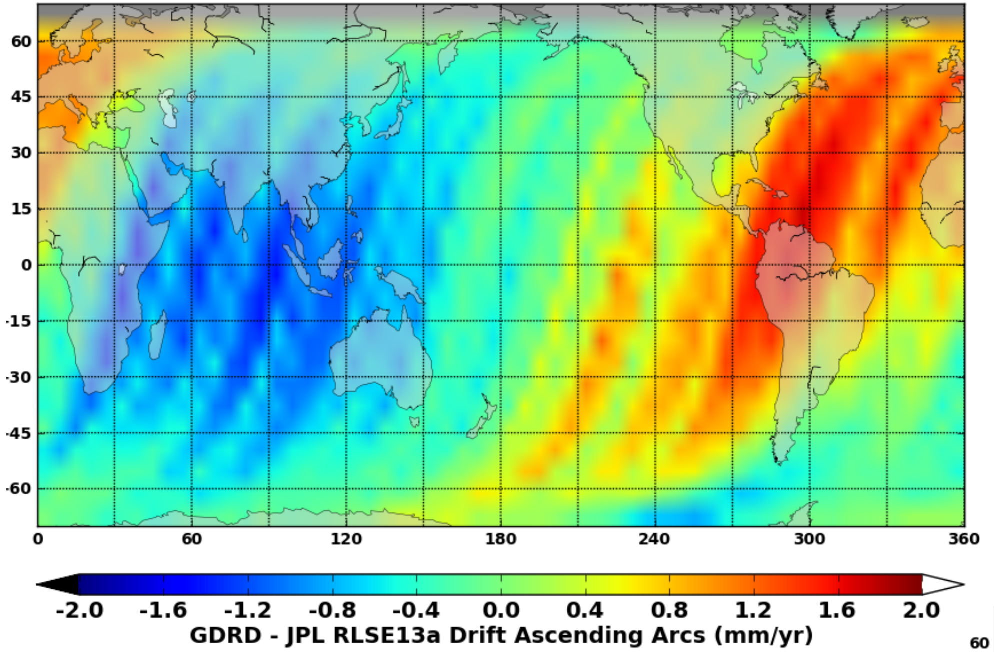


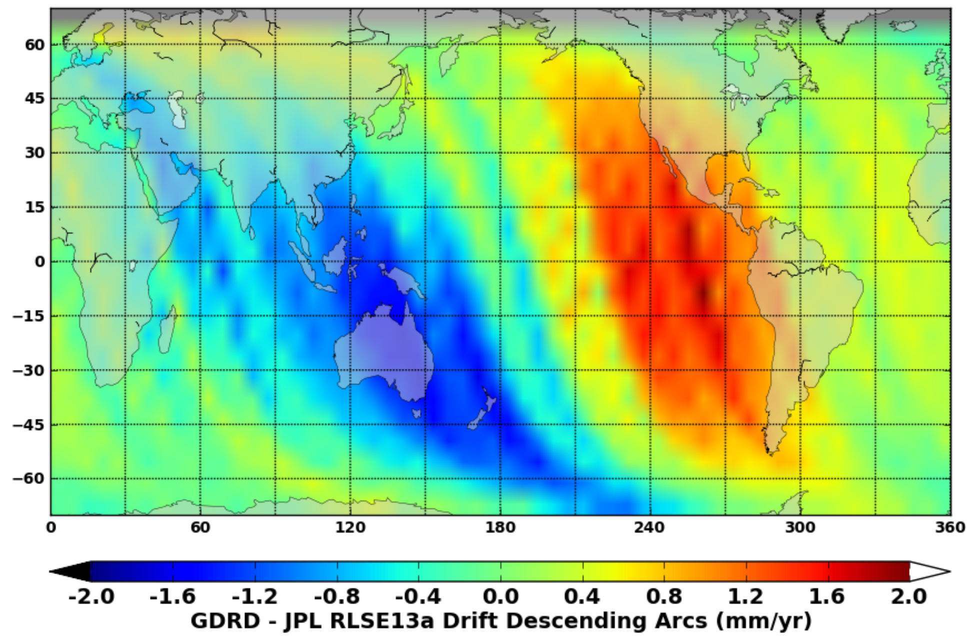
Cross-Over Means

GDRD: +1.6 ± 0.3 mm

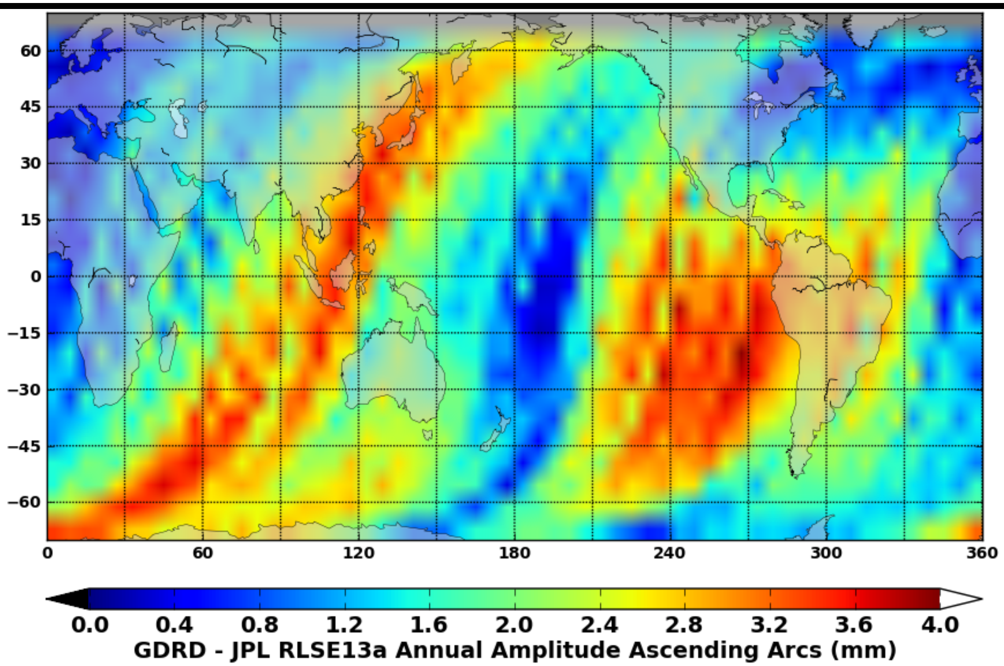
RLSE13a: +0.5 ± 0.3 mm

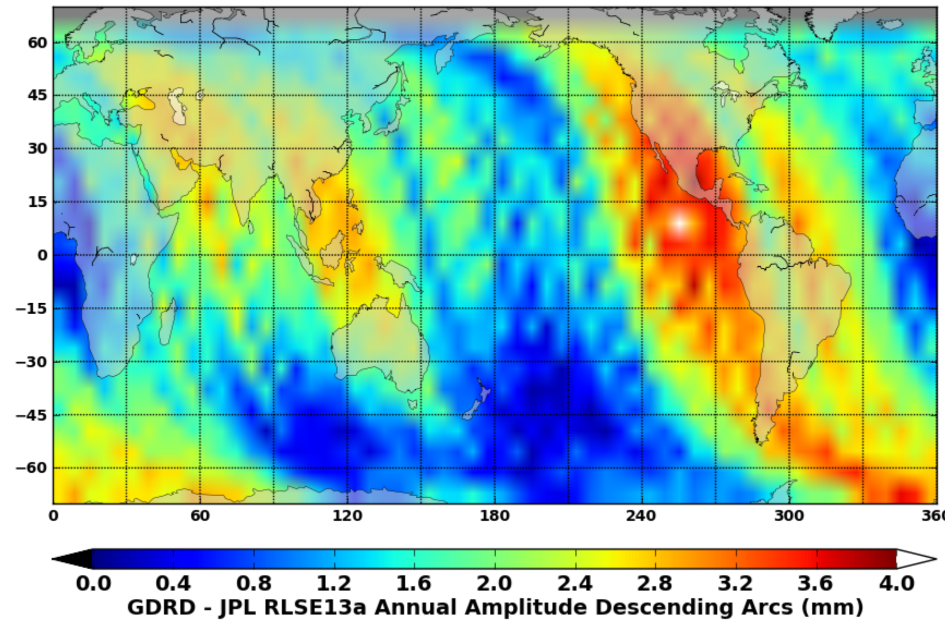
GDRD – JPL RLSE13a Ascending/Descending Drift (mm/yr)





GDRD – JPL RLSE13a Ascending/Descending Annual Amplitude (mm)





RLSE13a – GSFC Reduced Dynamic Laser/DORIS