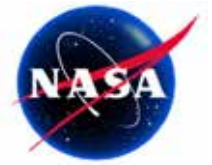


# GPS-Based Precision Orbit Determination for the Jason-2 and Jason-3 Missions

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# Introduction

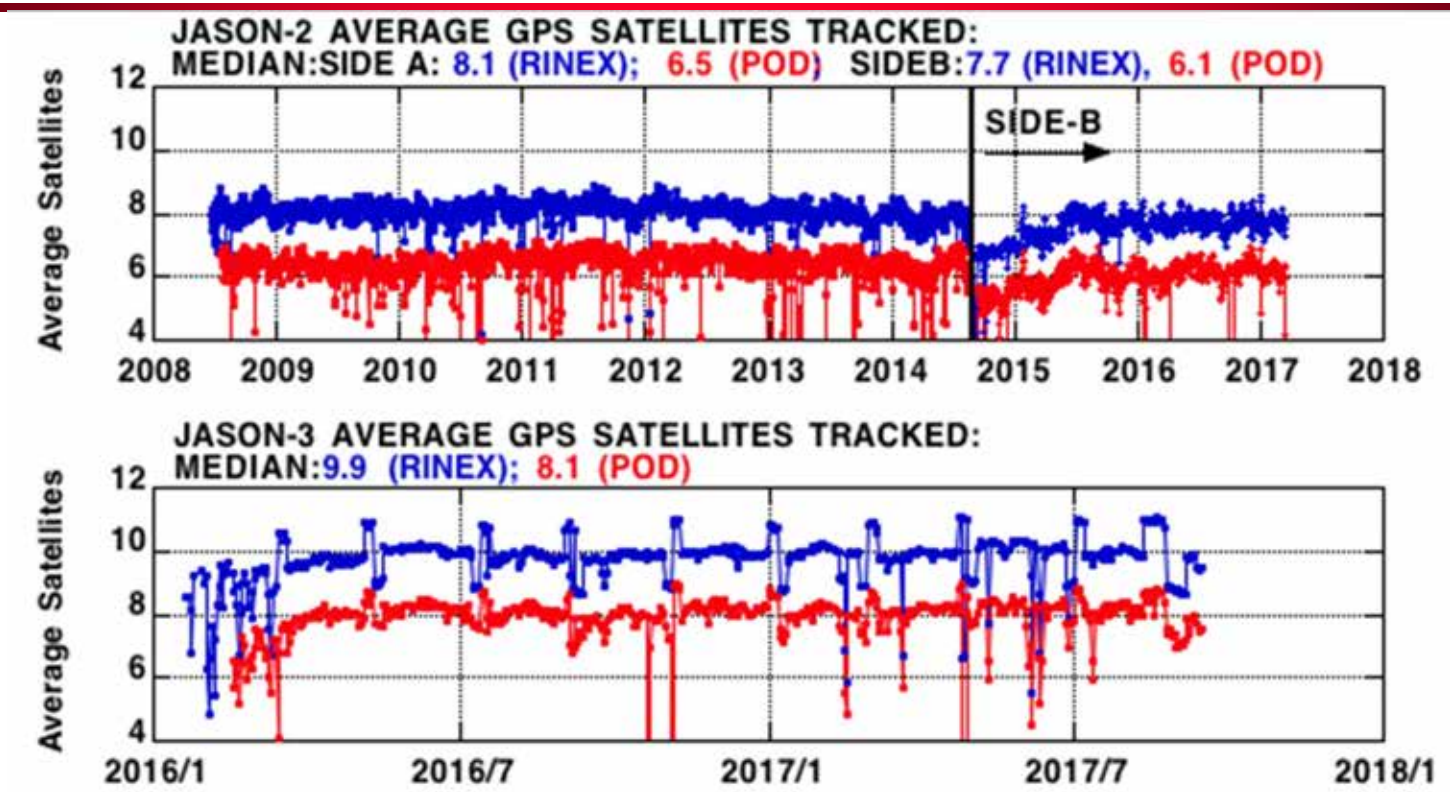
- Evaluate relative performance of reprocessed (rlse 2017a) GPS-based POD solutions for Jason-2 side A and B, Jason-3.
- Evaluate impact of in-flight calibration of antennas.
- Compare to CNES GDR-E and GDR-F, GSFC (ITRF14) solutions.
  - Independent SSH crossover variance metrics
  - SLR residuals.

- JPL's release 2017a GPS-based POD solutions:
  - Jason-2: Cycles 1-327
    - Side A: Cycles 1-228
    - Side B: Cycles 228-327
  - Jason-3: Cycles 1-59.
  - JPL's GIPSY/OASIS Software.

# JPL Release 2017a POD Processing Approach

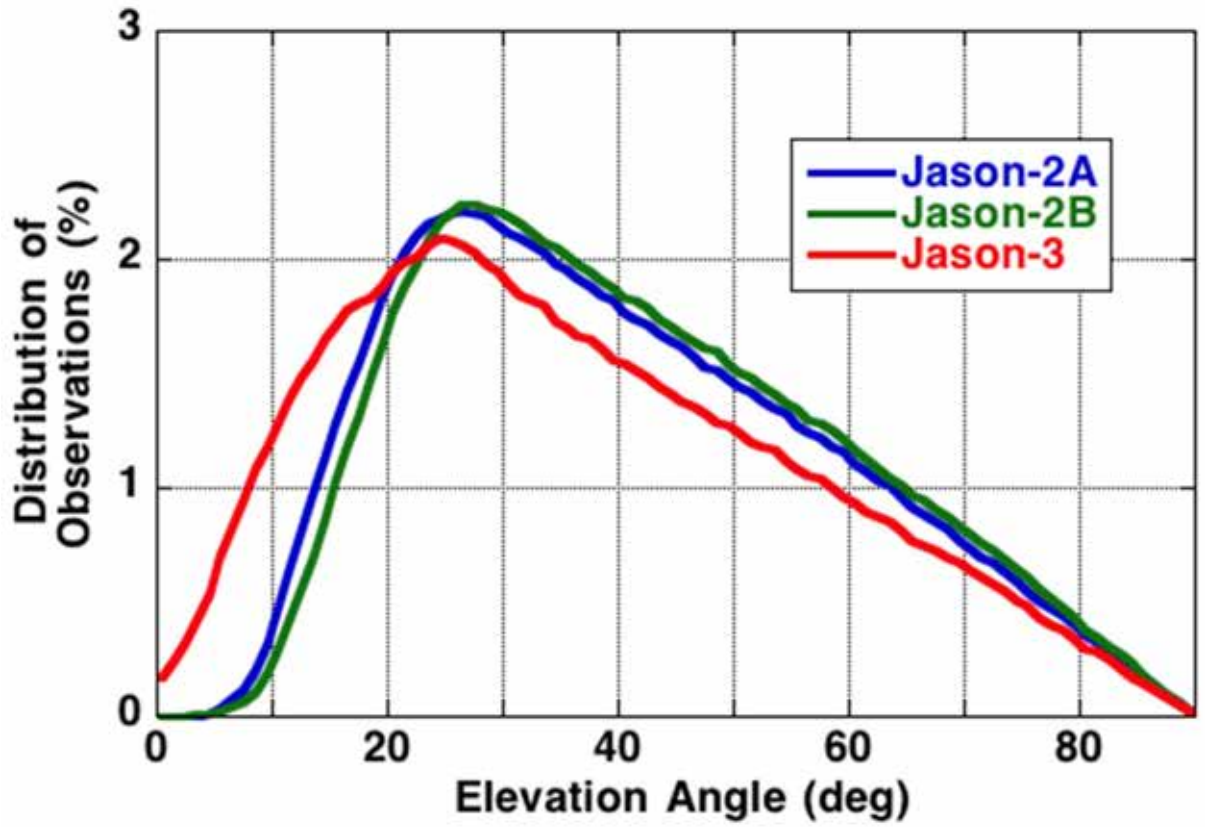
| Parameter | Value |
|---|---|
| Orbit Arc | 30-hours (daily) |
| Gravity Field | EIGEN-6S4.v2 |
| AOD | Release 6 |
| Tide Model | GOT4.8ac |
| Pole Tide Model | IERS 2010 |
| Attitude | Quaternions |
| Solar Panel Orientation | Reported Values |
| GPS Orbits/Clocks | JPL Finals IGS08 |
| Data Weights | 1 cm LC, 100 cm PC |
| Elevation Angle Cutoff | 0 degrees |
| Minimum Track Length | 10 minutes |
| Antenna Calibration | Pre-Launch and In-Flight |

# Number of Satellites in POD Processing (after data and track length editing)



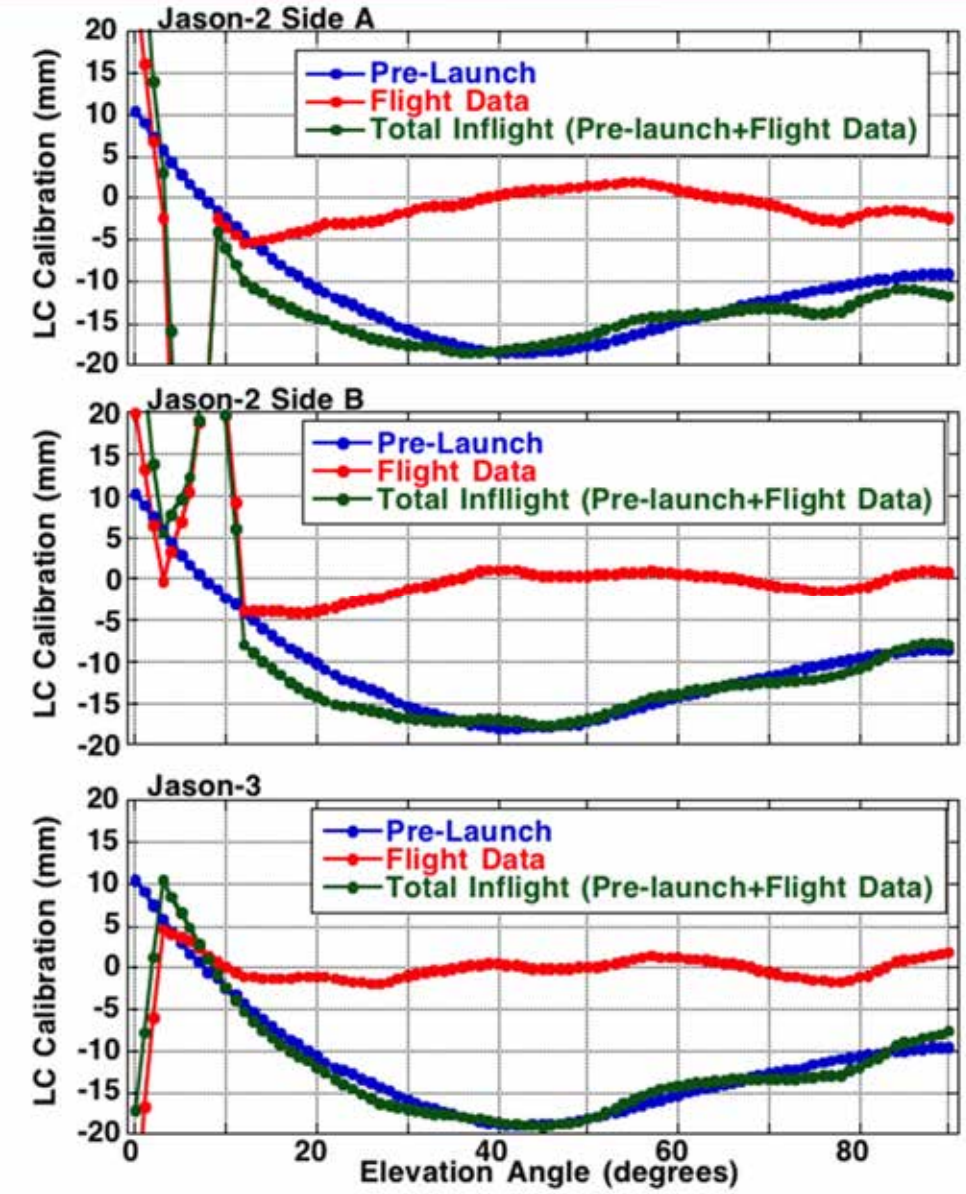

- Jason-3 tracks (and provides to POD) ~ 2 more satellites than Jason-2.
- 1-2 fewer satellites in POD solution than available in raw tracking data (RINEX).
  - Jason-2: Lower by 1.6; Jason-3 lower by 1.8.
- Jason-3 impacted by yaw-state.
  - Tracks fewer satellites when flying “forward” (heading = 0).
    - Impacted by longer fixed yaw periods.

# Distribution of Tracking Data used in POD



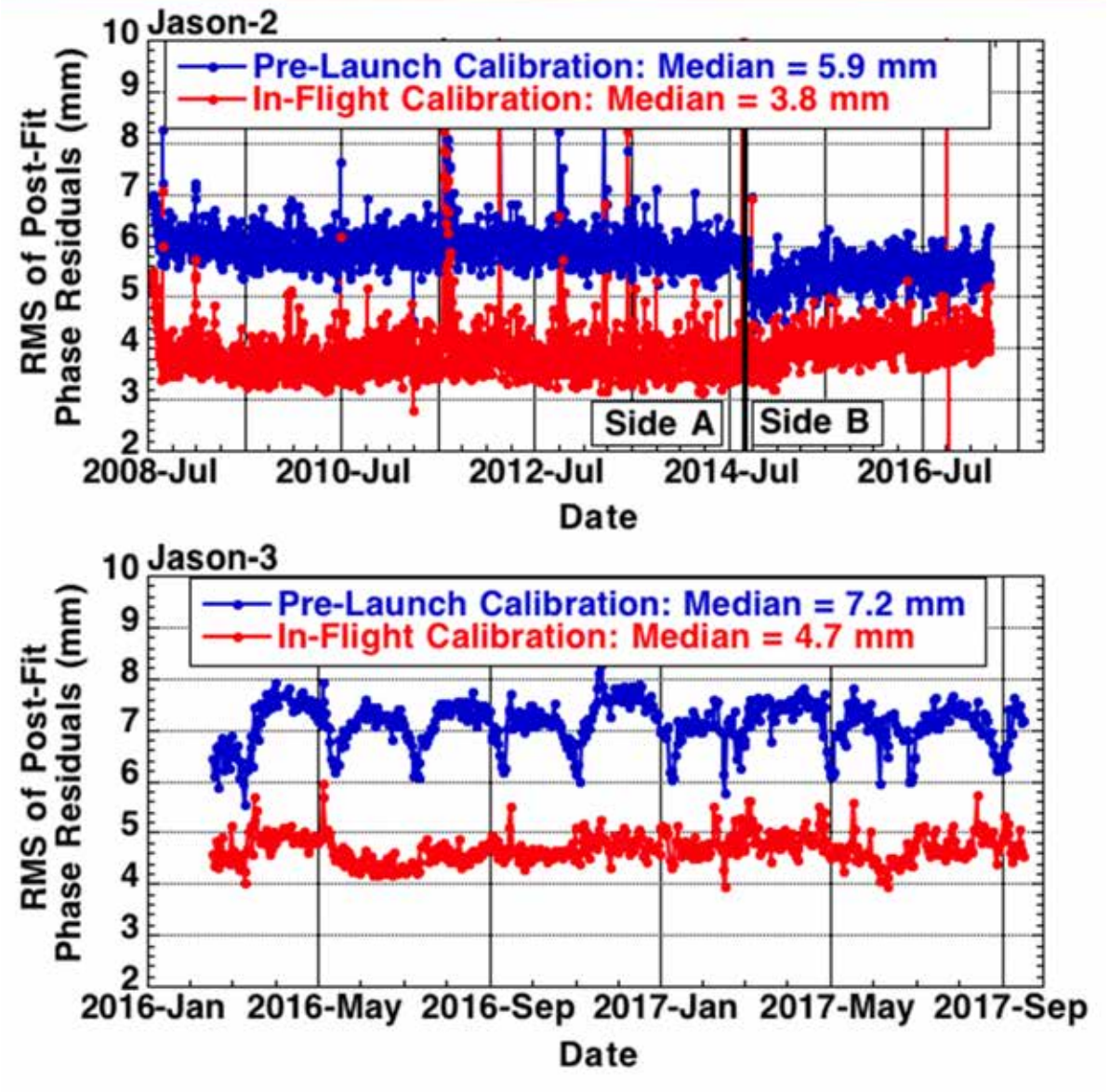

- Jason-2 Side A tracks to lower elevations than Side B.
- Jason-3 has significantly more data at lower elevations.
  - Jason-3 has more data and coverage than Jason-2.

# Dual-Frequency Phase (LC) Antenna Calibration



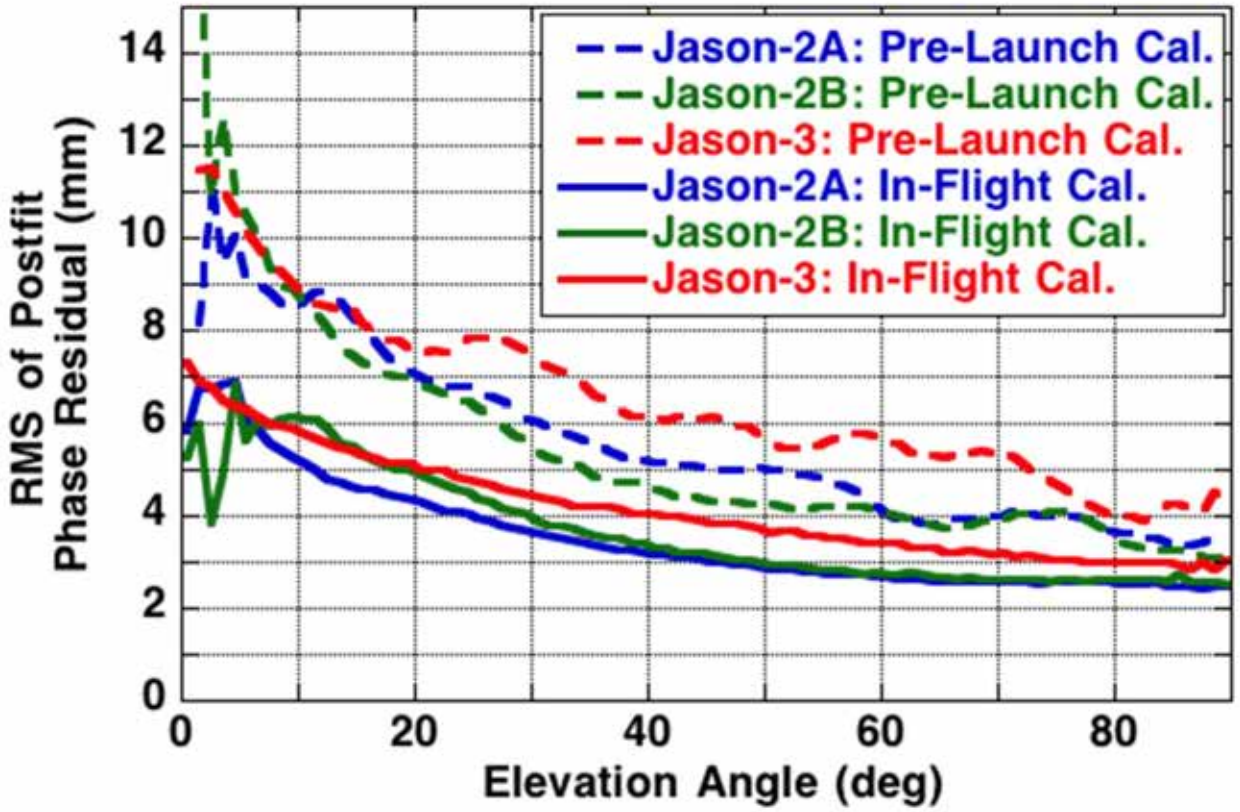

- Pre-launch calibration captures long-wavelength structure.
- In-flight data provides +/- 5 mm short wavelength "corrections".
  - Smaller "corrections" for Jason-3 antenna.
- Poor sampling at low elevations = high scatter of in-flight calibration.
  - Jason-2(A) < 9 degrees.
  - Jason-2(B) < 12 degrees.
  - Jason-3 < 3 degrees.

# Temporal Dependence of Post-fit Phase (LC) Residuals




- Stable long-term performance for JA2 and JA3.
- Jason-3 has higher postfit residuals than Jason-2 (4.7 vs. 3.8 mm)
- In-flight calibration eliminates strong yaw-state dependence of Jason-3 residuals.

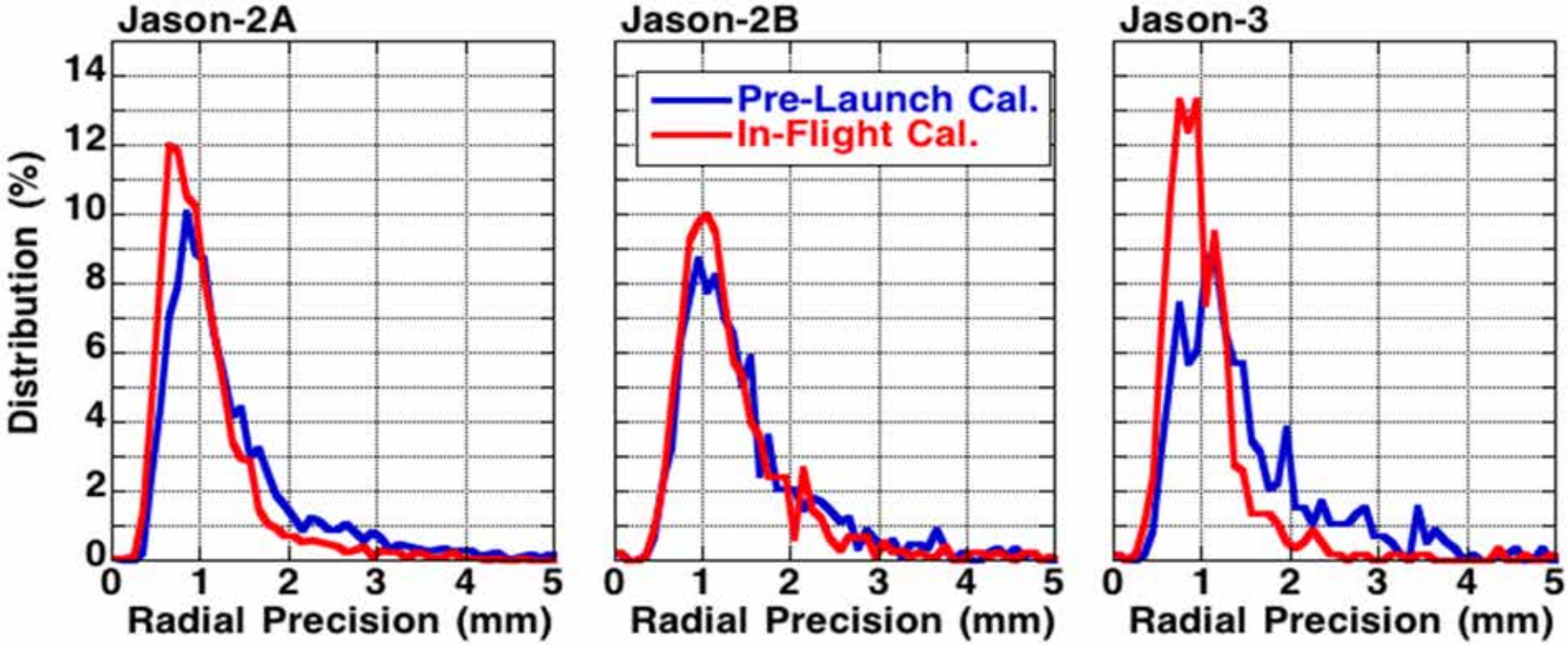
# Elevation-Dependence of Post-Fit Phase Residuals




- In-flight calibration eliminates short wavelength dependencies in post-fit residuals.
- Larger post-fit residual for Jason-3 consistent with larger volume of data at low elevations.
  - Low elevation data have higher data noise (lower SNR)

# Radial Orbit Precision

(Using overlapping differences between daily 30-hour solutions)

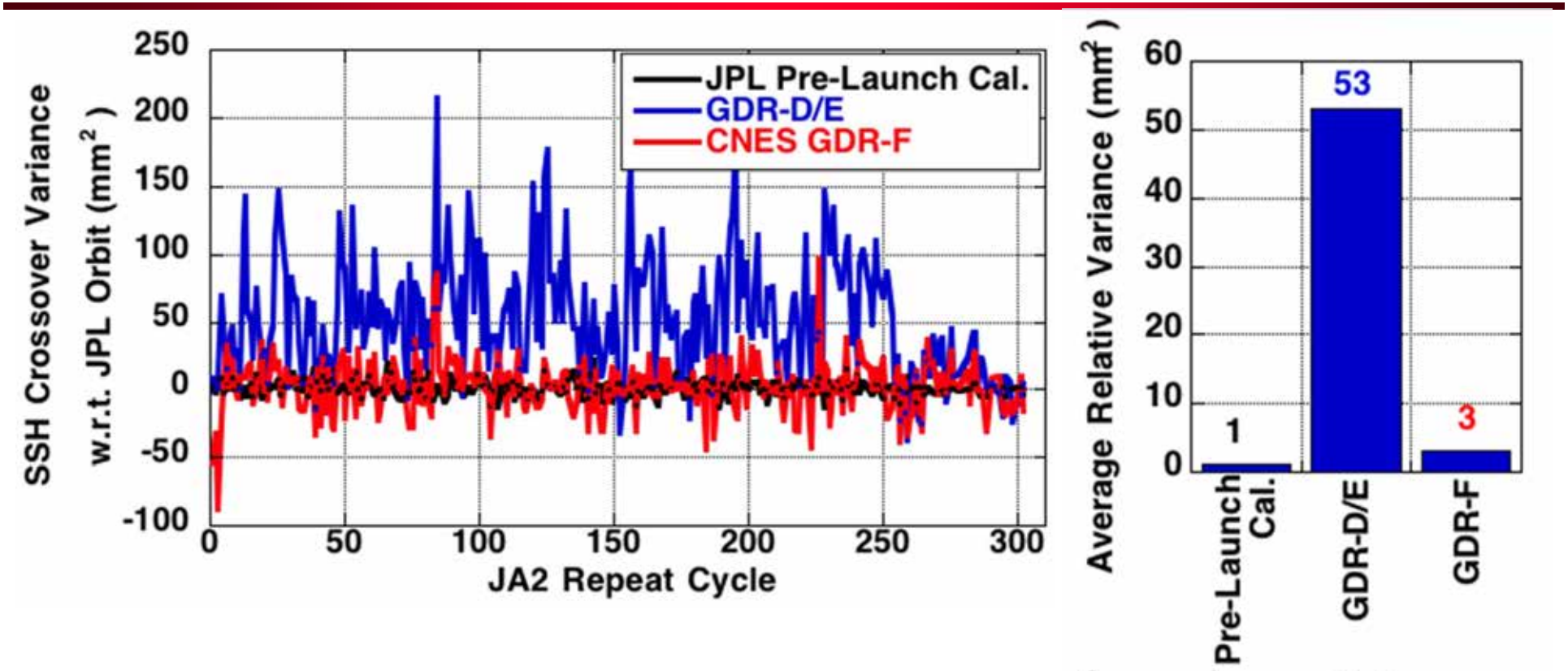



- Improved consistency with in-flight calibration.
- **Sub-mm radial precision for JA2-A and JA3.**

**Median of Radial Precision (mm)**

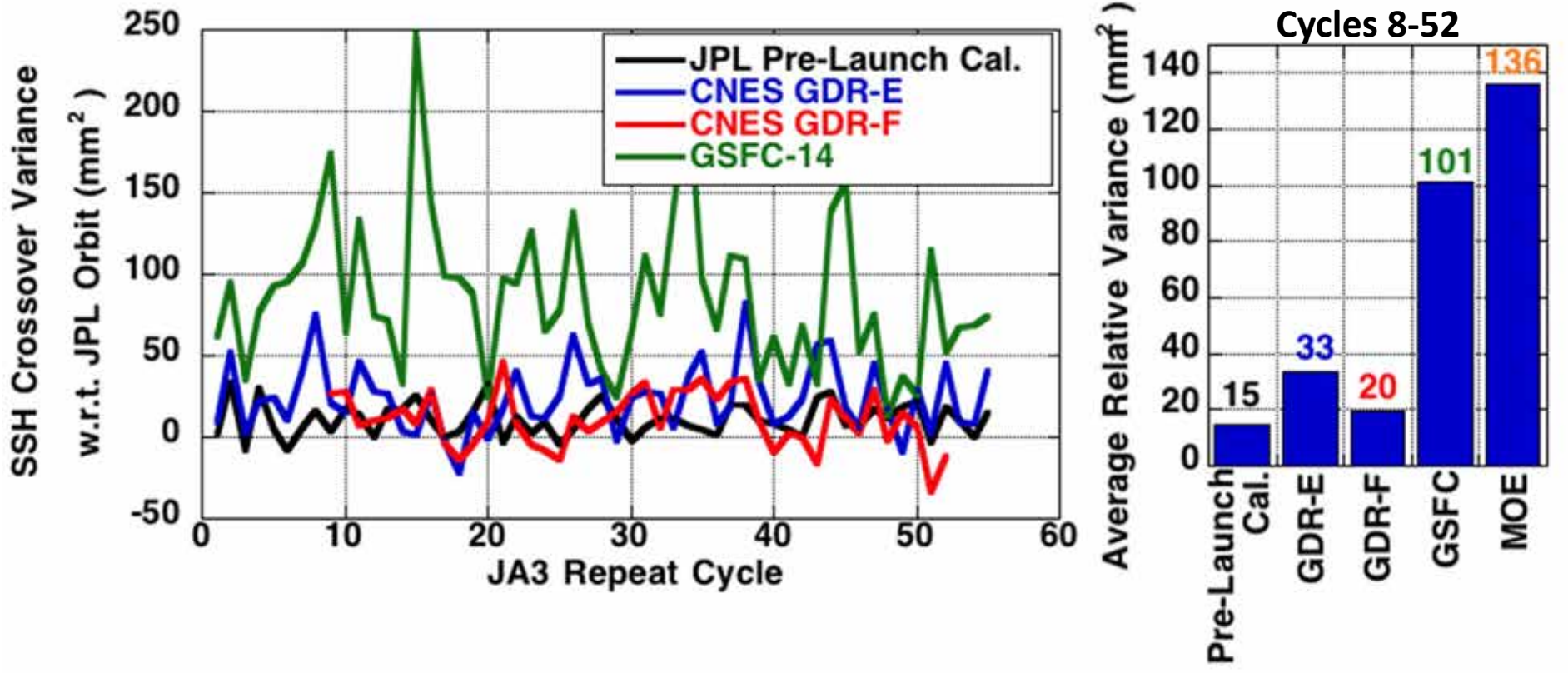
| | JA2-A | JA2-B | JA3 |
|---|---|---|---|
| Pre-Launch Cal. | 1.1 | 1.3 | 1.2 |
| In-Flight Cal. | 0.9 | 1.2 | 0.9 |

# JA2 SSH Crossover Variance Tests
# (Relative to JPL with In-Flight Antenna Calibration)



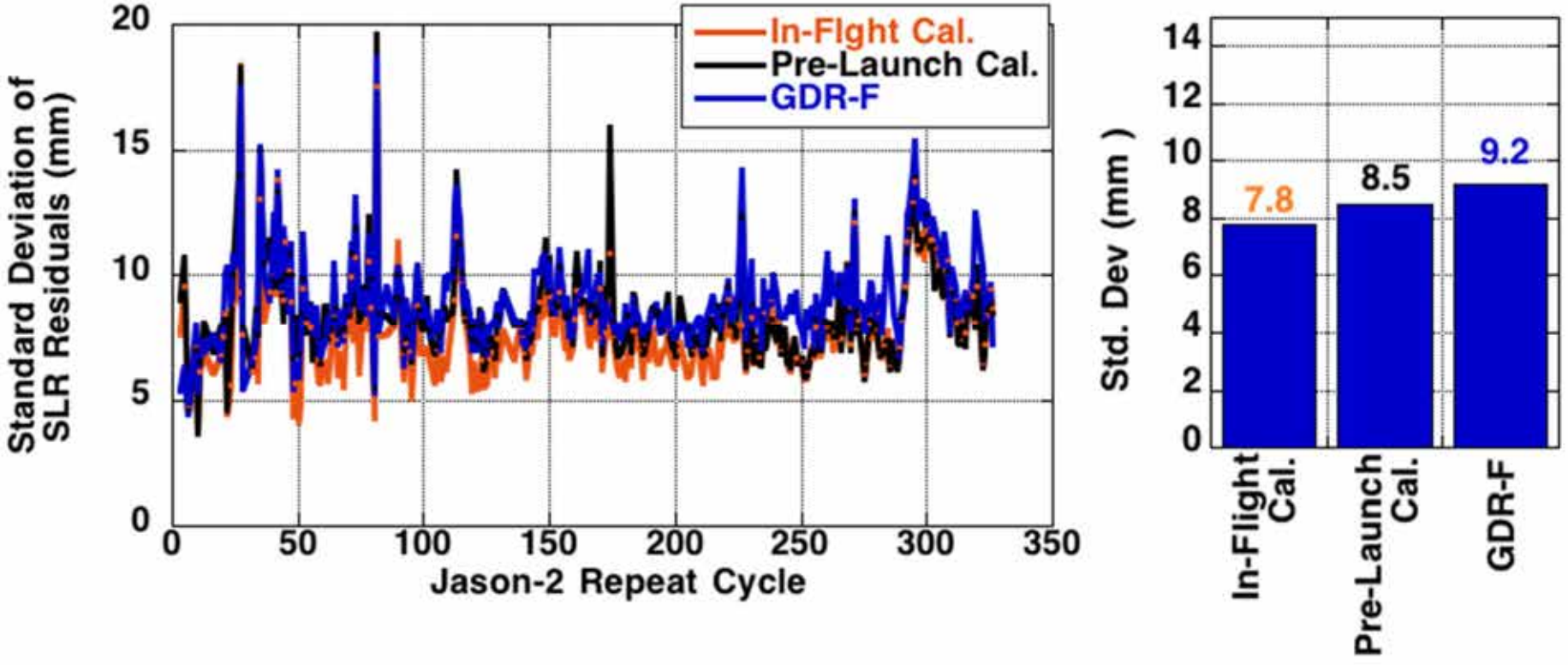

- Version D GDR products include ”GDR-D” orbits for cycles <= 253 and “GDR-E” orbits for cycles >= 254.
- In-flight antenna calibration has small impact on crossover variance.
- GDR-F has very similar performance to JPL orbit solutions.

# JA3 SSH Crossover Variance Tests
# (Relative to JPL with In-Flight Antenna Calibration)



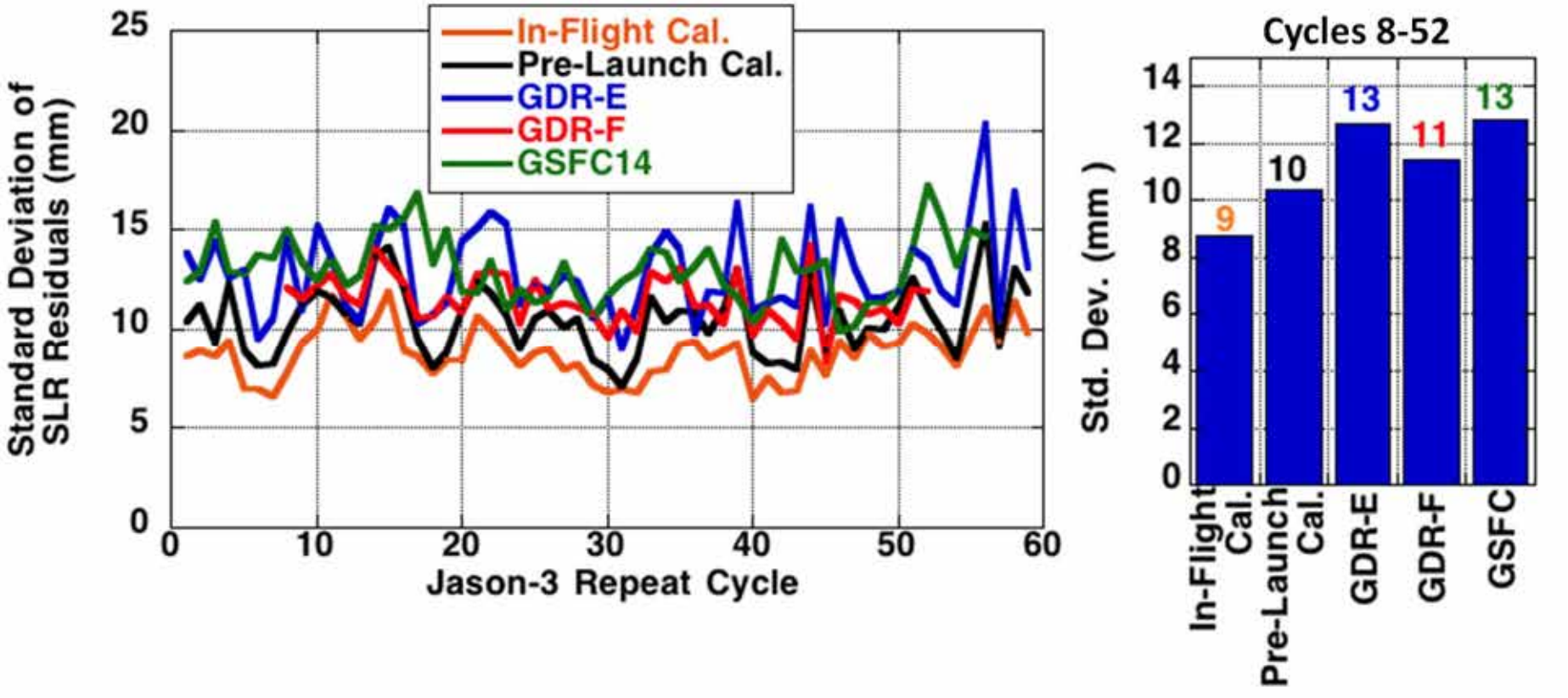

- In-flight calibration provides detectible benefits to crossover metrics.
- CNES GDR-F shows improvement over GDR-E.

# Jason-2 SLR Residuals (All Elevations)



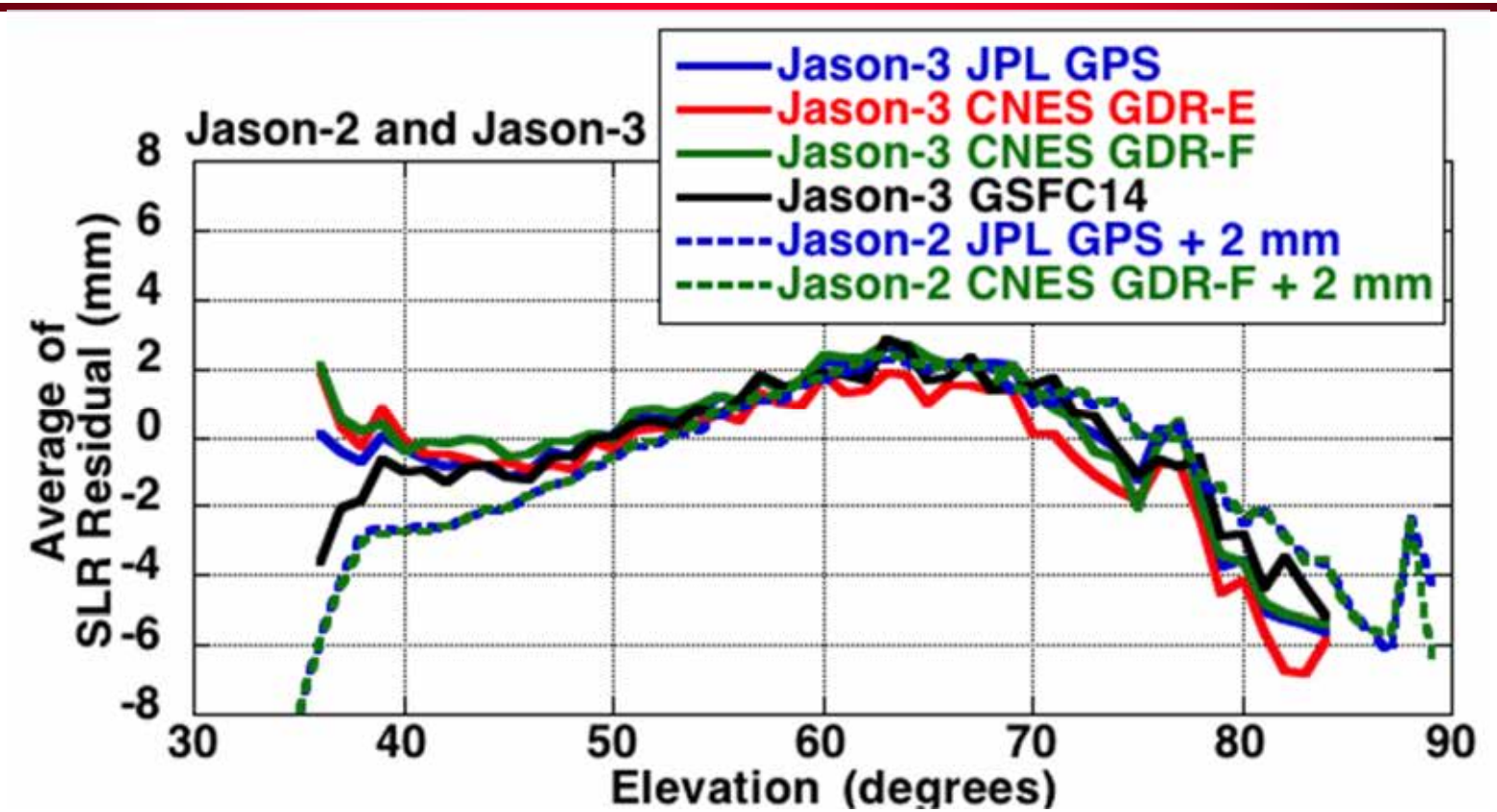

- In-flight calibration provides noticeable improvement for side A, but not for side B.
- JPL solutions have lowest SLR residuals.

# Jason-3 SLR Residuals
# (All Elevations)



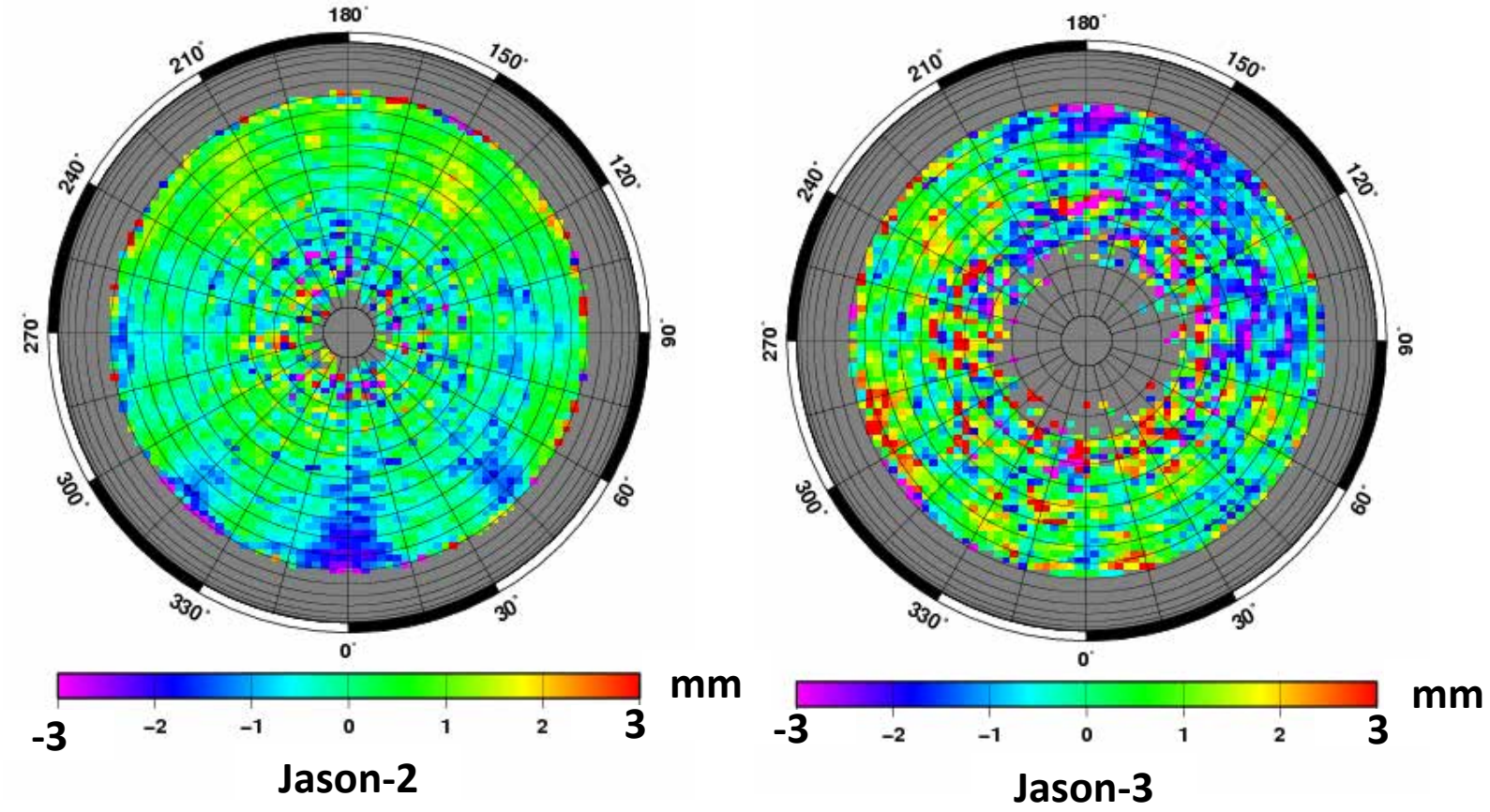

- Detectible improvement from in-flight calibration.
- GDR-F better than GDR-E.
- JPL solutions have lowest SLR residuals.

# Elevation-Dependence of SLR Residuals




- **Very similar systematic elevation-dependence between Jason-2 and Jason-3.**
  - As might be expected from “build-to-print” Jason-2 and Jason-3 LRAs.
  - Especially between 45-80 degrees.
  - Jason-2 biased lower by ~ 2mm
- Similar dependence from different orbit solutions.

# Azimuth-Dependence of SLR Residuals



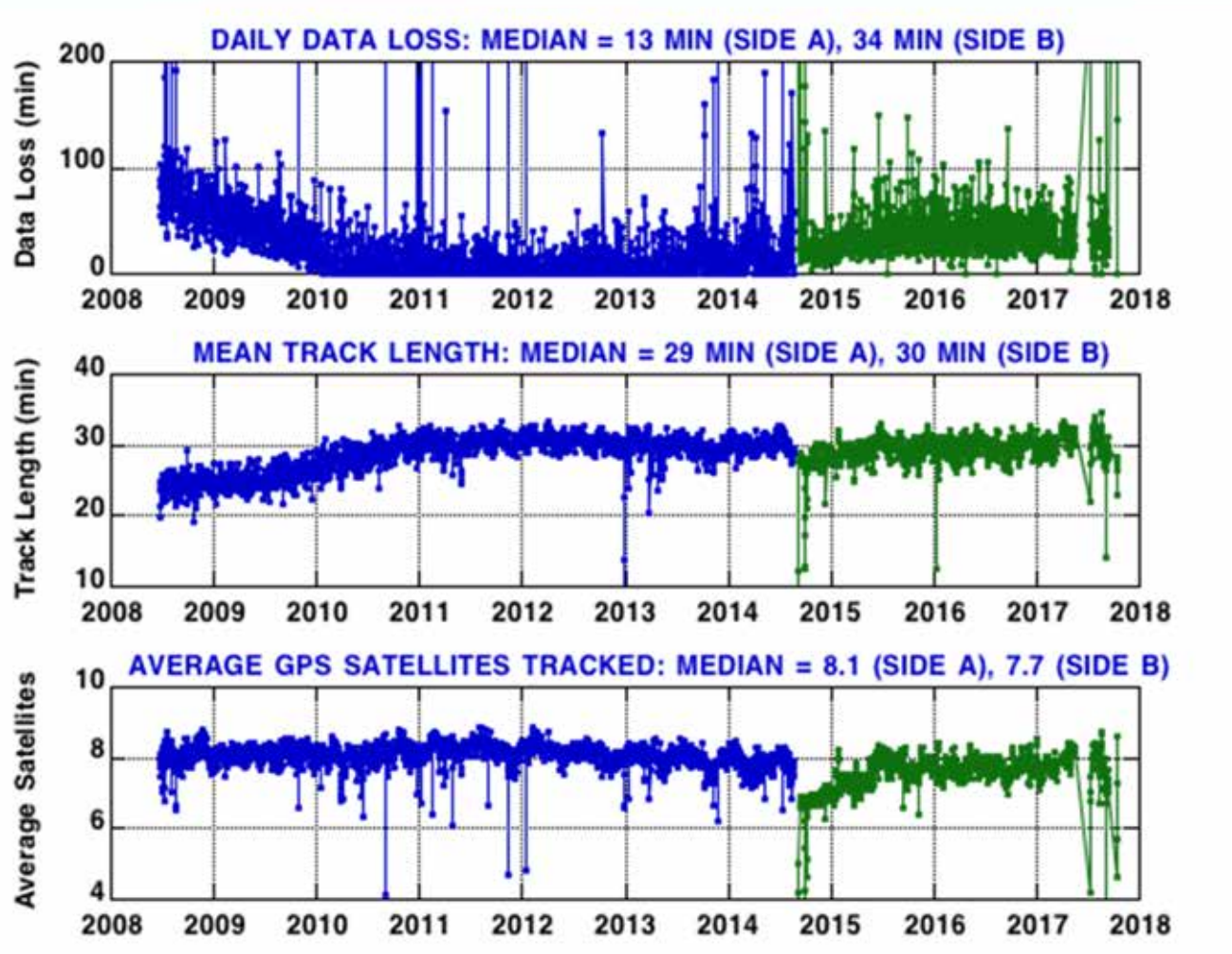

- Residual azimuth dependence of SLR residuals (after removing elevation dependence) < 3 mm.
- No apparent correlation between Jason-2 and Jason-3.

# Summary

- Jason-3 GPS receiver has larger data volume than Jason-2.
  - More data, especially at low elevations.
- Pre-launch GPS antenna calibrations for Jason-2 and Jason-3 provide good representation of long-wavelength structure.
- In-flight calibration of antennas provides noticeable improvements to POD precision and accuracy.
  - Supported by independent SSH crossover variance, and SLR residuals.
  - Seems to be important when there are more low elevation data (e.g., Jason-2 side A, and Jason-3).
- Jason-3 CNES GDR-F solutions have better crossover and SLR metrics than GDR-E.

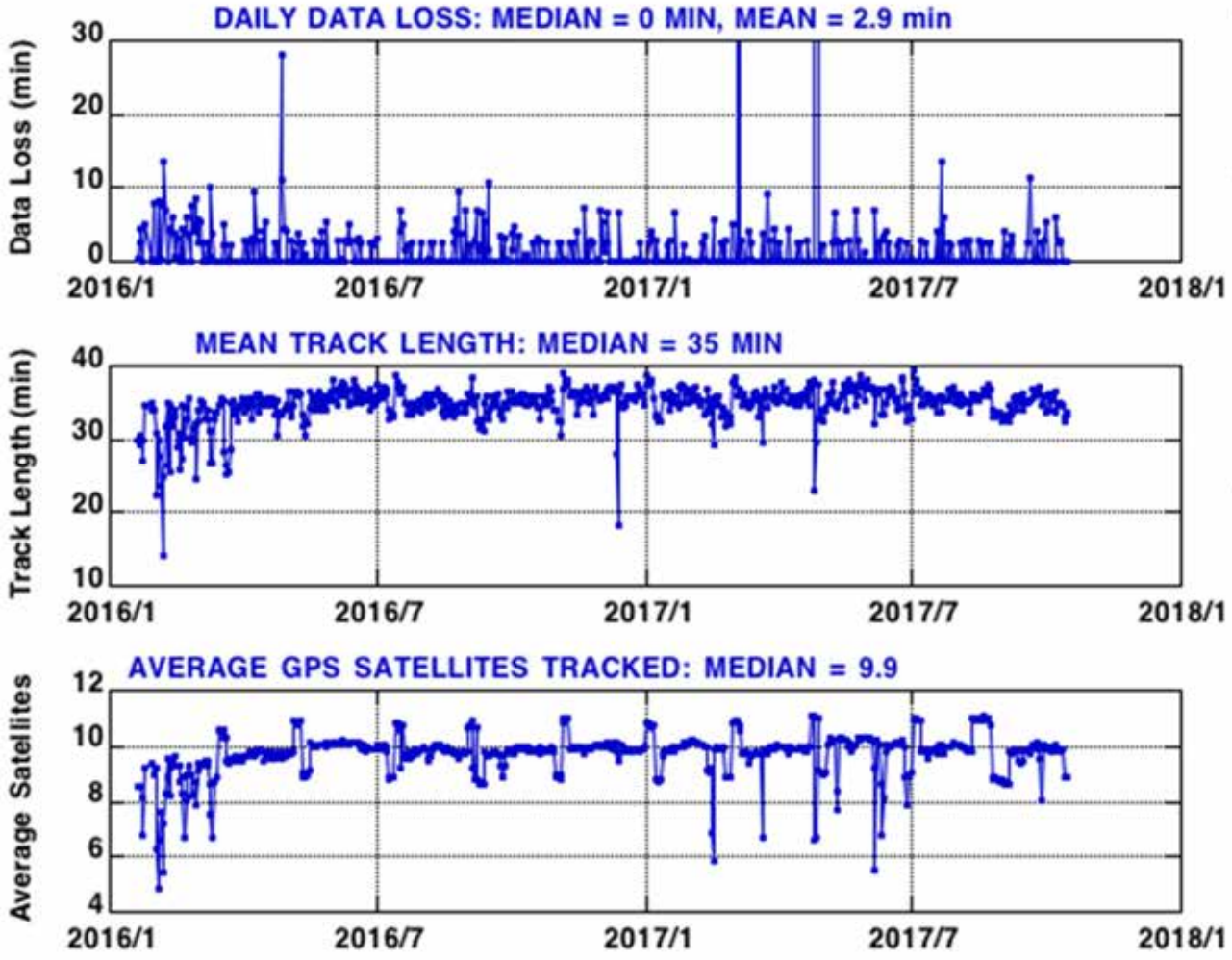
# Backup

# Jason-2 GPS Receiver Performance



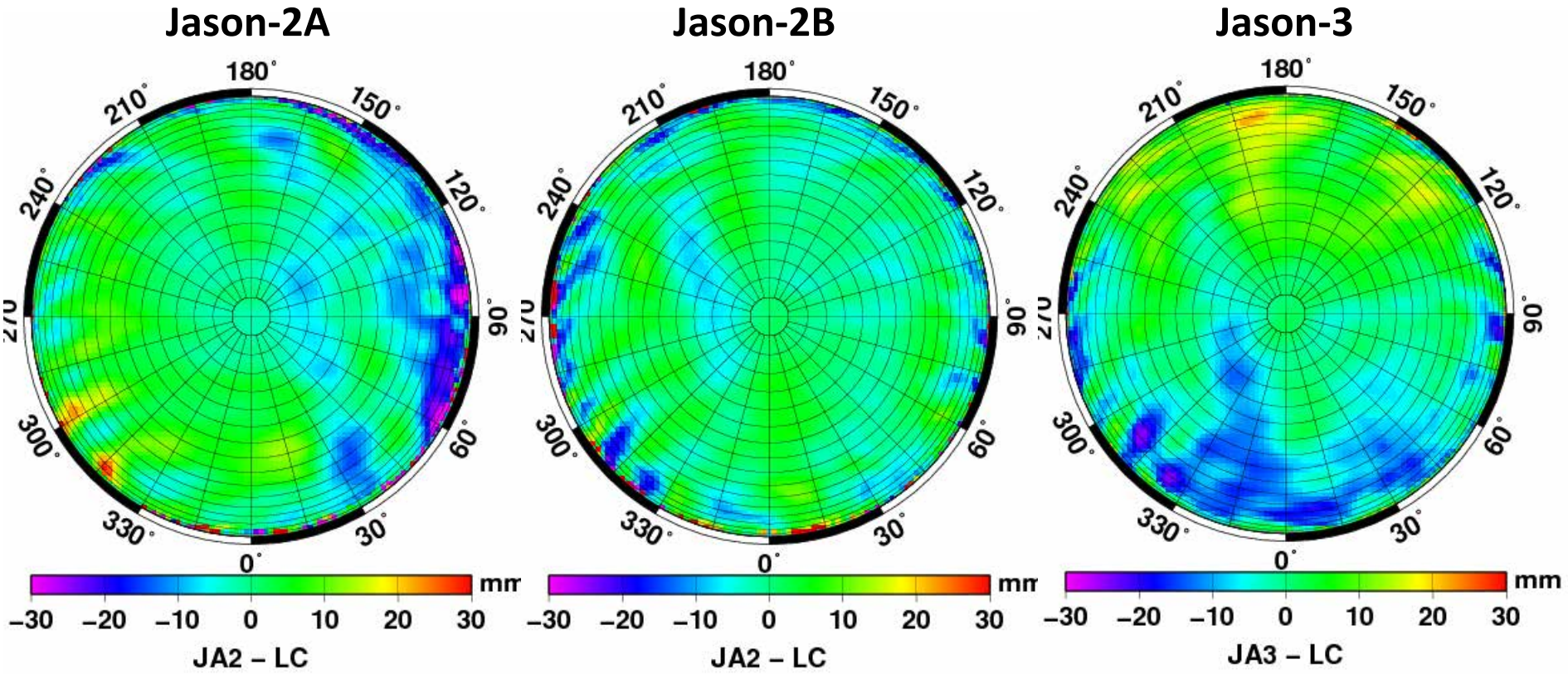

- Side-B turned on 2014-09-08.
  - Max Sats = 8.
- Max Sats modified:
  - 10: 2015-01-20
  - 12: 2015-03-04
- Jason-2 Safehold:
  - 2017-05-17 to 2017-07-02.

# Jason-3 GPS Performance

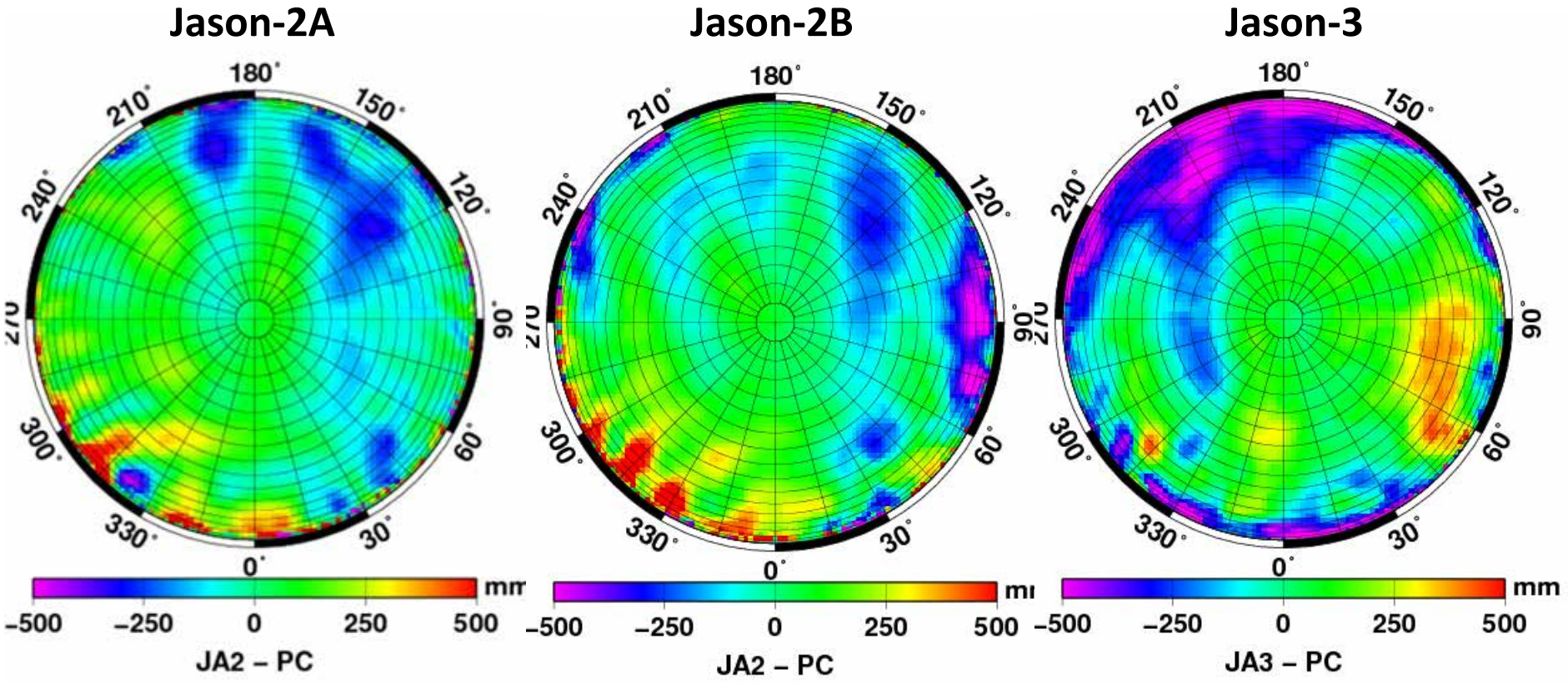



- Scrubbing enabled: 2016-02-29
- Higher data return than Jason-2.
  - More satellites.
  - Fewer data gaps.
- Fixed yaw periods evident in tracking coverage.
  - Reduced tracking when flying "forward" (heading of 0 degrees).

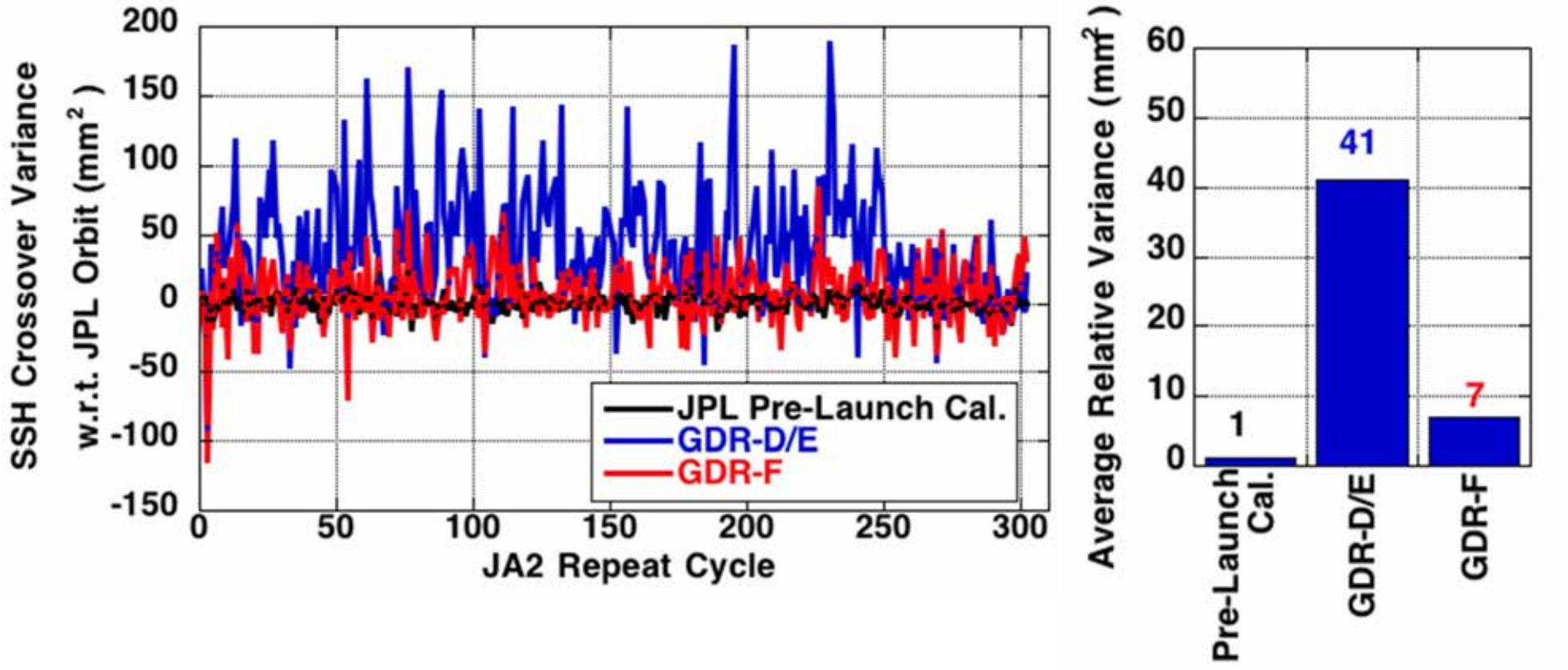
# In-Flight Phase (LC) Antenna Calibration Corrections



# In-Flight Range (PC) Antenna Calibration Corrections

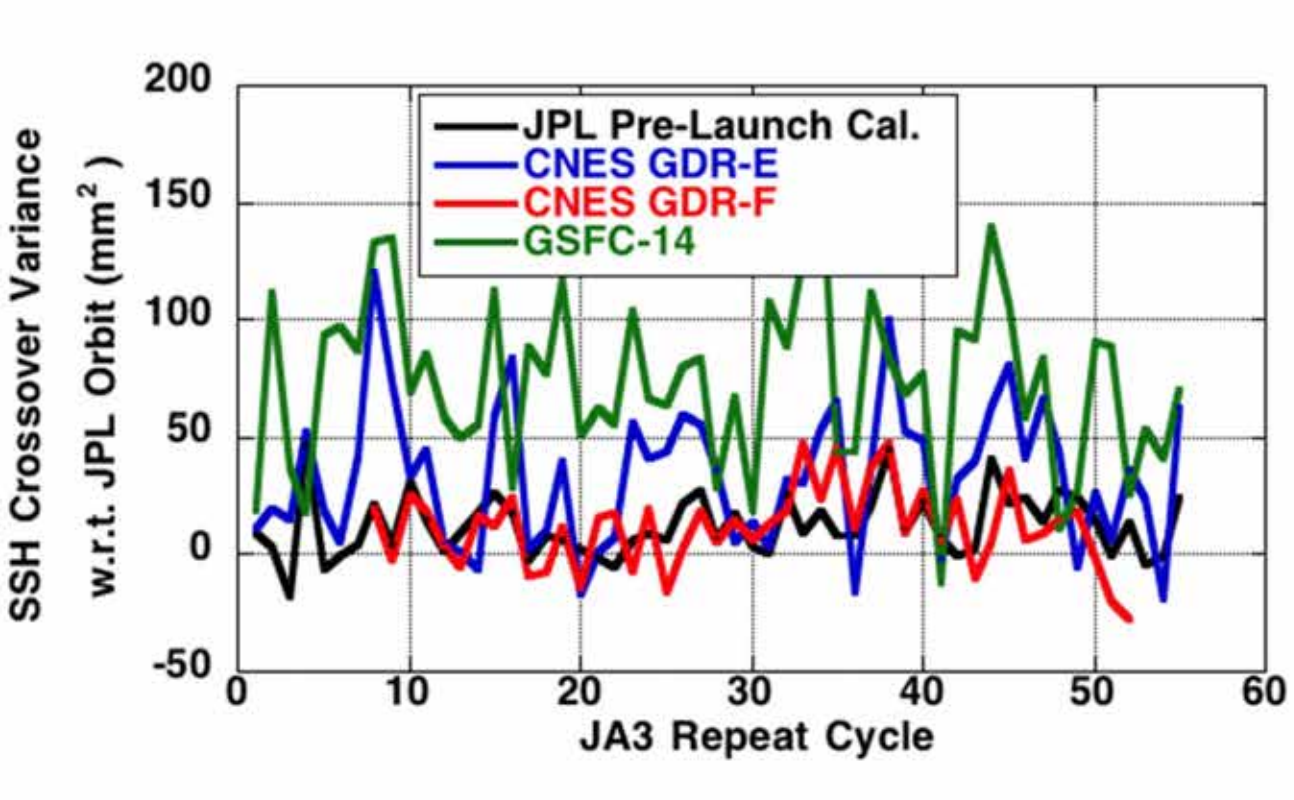


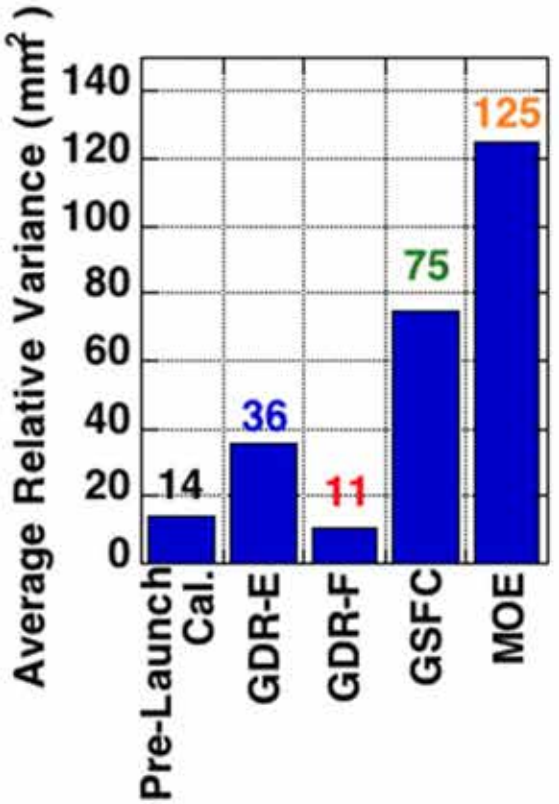
# JA2 Super-Edited Crossovers




- GDR-F provides improved consistency across mission, compared to GDR D/E.

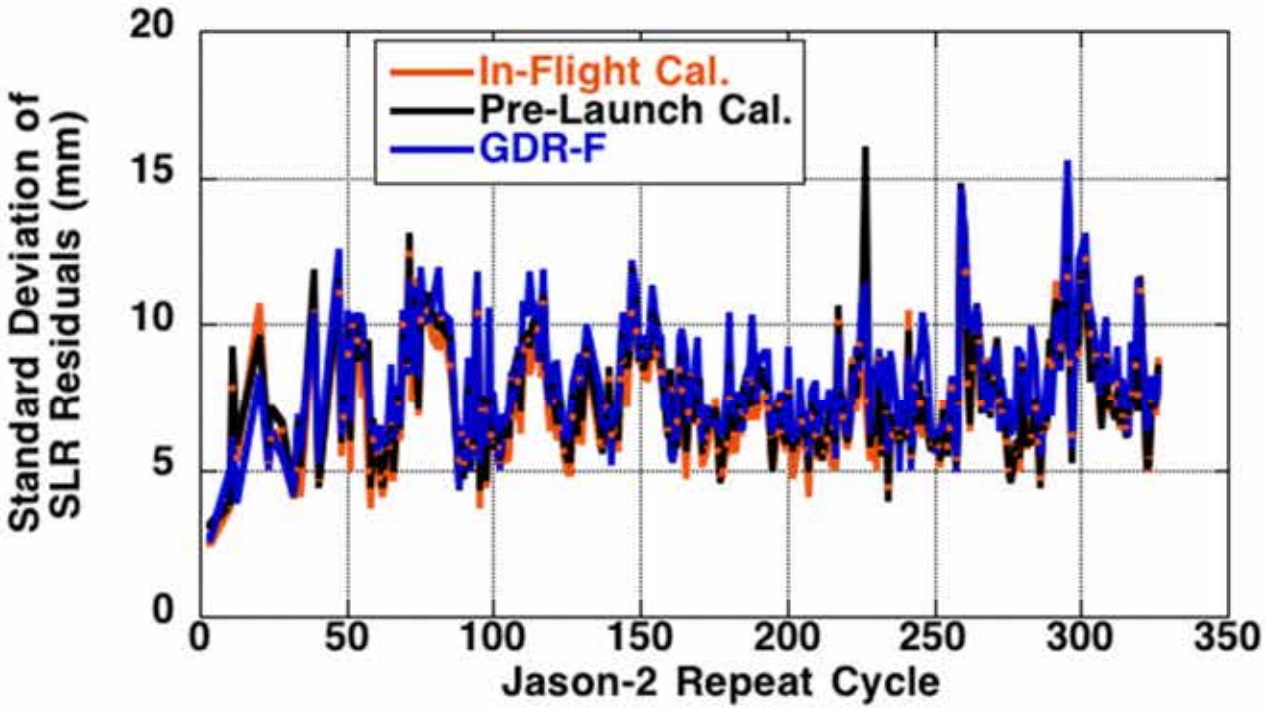
# JA3 Super-Edited Crossovers

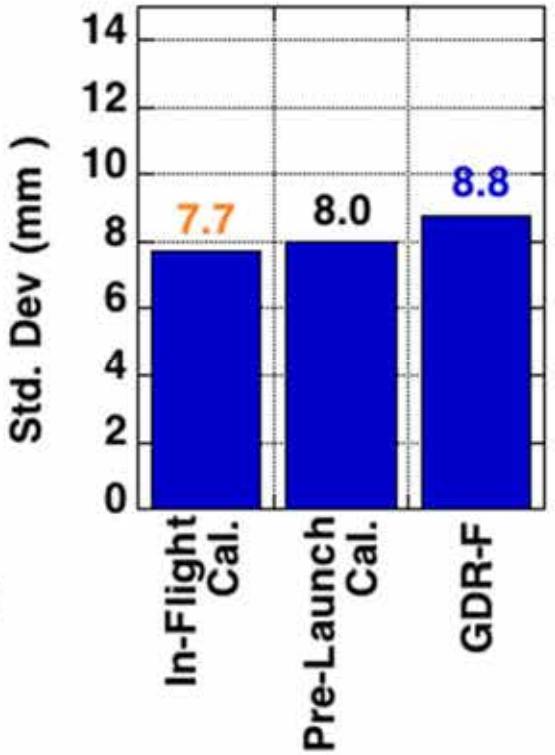



- GDR-F is improvement over GDR-E.
- JPL solutions with in-flight calibration have lowest overall crossover variance.

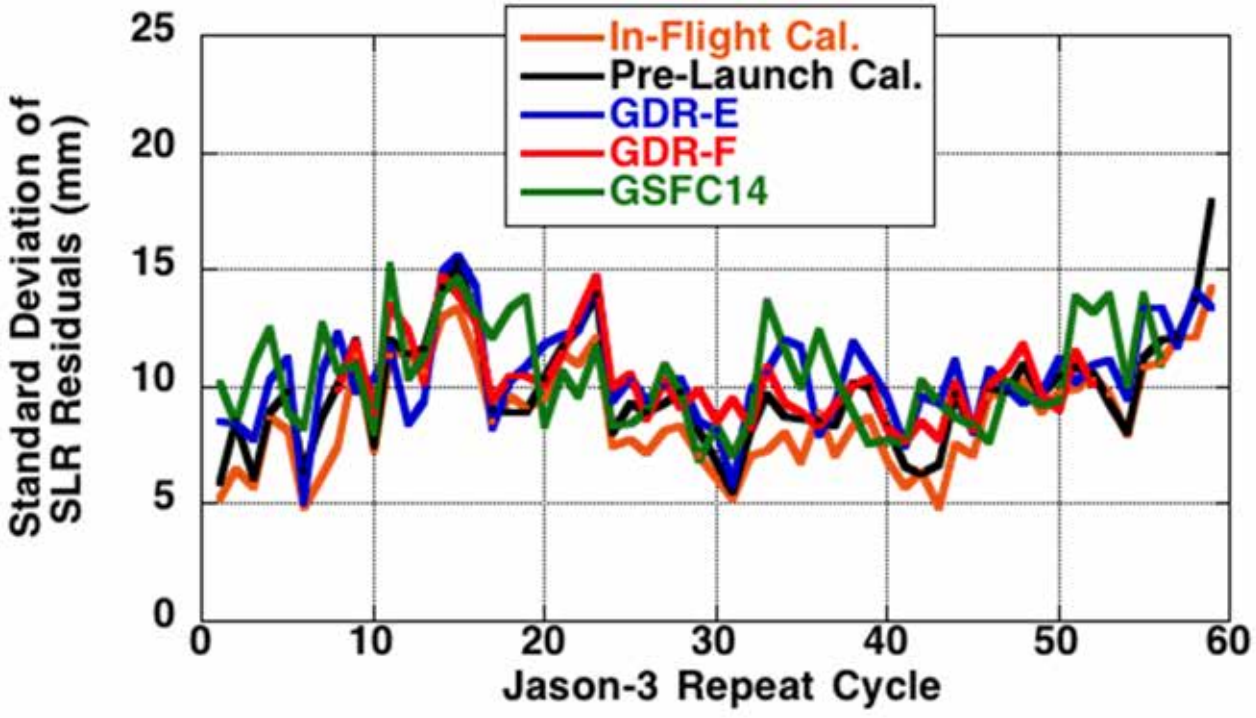
# Jason-2 SLR Residuals
# (High Elevation (> 60 degrees) Only)

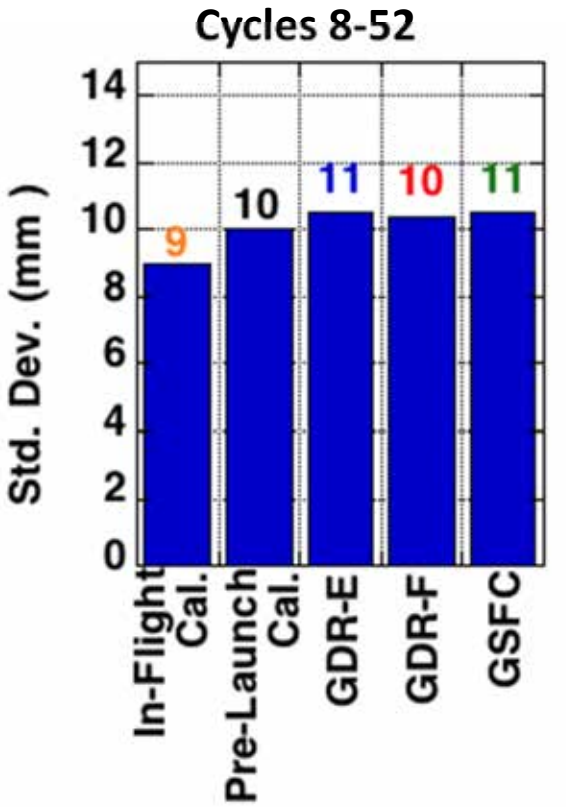



- JPL solutions slightly lower SLR residuals for side-A.
  - GDR-F similar to JPL solutions for side-B.

# Jason-3 SLR Residuals
# (High Elevation (>60 degrees) Only)




- JPL solutions with in-flight calibration have lowest SLR residuals.
- All other solutions have very similar performance.
  - GDR-F slightly better than GDR-E.