Quality of GRACE Orbits Using the Reprocessed IGS Products

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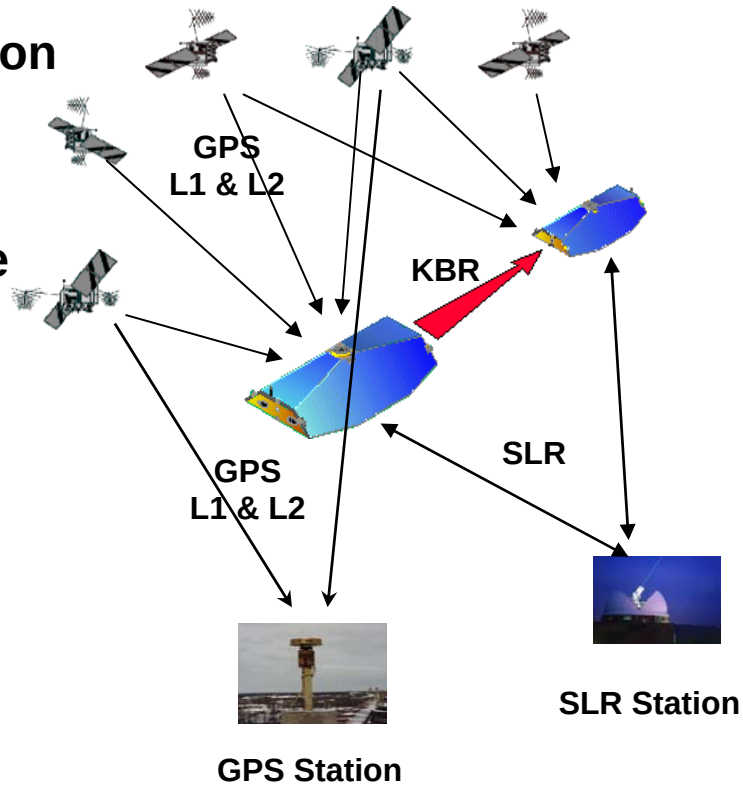
CSR

GRACE Precise Orbit Determination (POD)

- **Modeled observable:** double differences, ionosphere-free combination
- **Method:** dynamic orbit determination with estimation of many empirical parameters
- **GPS orbits:** the orbits from IGS are fixed
- **GRACE orbit evaluation:**
  1. Orbit fits (GPS DD RMS): internal accuracy
  2. SLR (Satellite Laser Ranging) Residuals: external accuracy
  3. KBR (K-Band Ranging) range Residuals: relative accuracy
  4. External orbit comparisons

GRACE POD System



Motivations and Objectives for GRACE Data Reprocessing

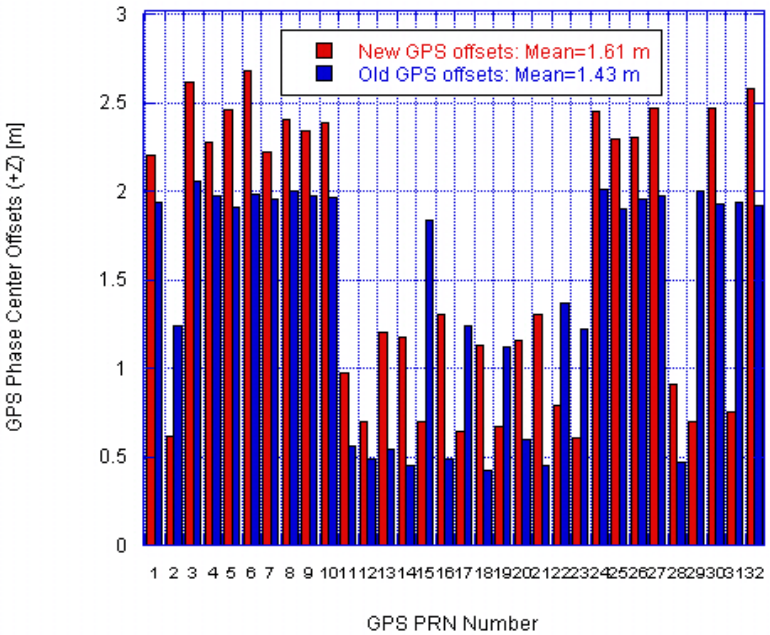
Motivations:

- **Reference frame change (IGS00 to IGS05)**
- **Absolute GPS satellite antenna corrections (IGS)**
  1. **Phase Center Offset (PCO) and**
  2. **Phase Center Variation (PCV)**
- **GPS receiver antenna corrections**
  1. **ground GPS receiver PCV (IGS) and**
  2. **LEO GPS receiver antenna PCV (JPL)**

Objectives:

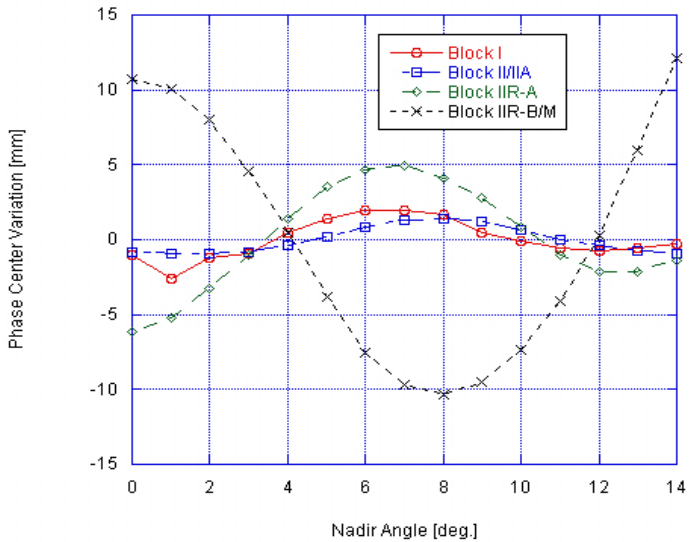
- Study the effects of various improvements on GRACE POD
- Investigate the impacts of different IGS GPS orbits on GRACE POD

GPS Satellite Antenna PCO & PCV



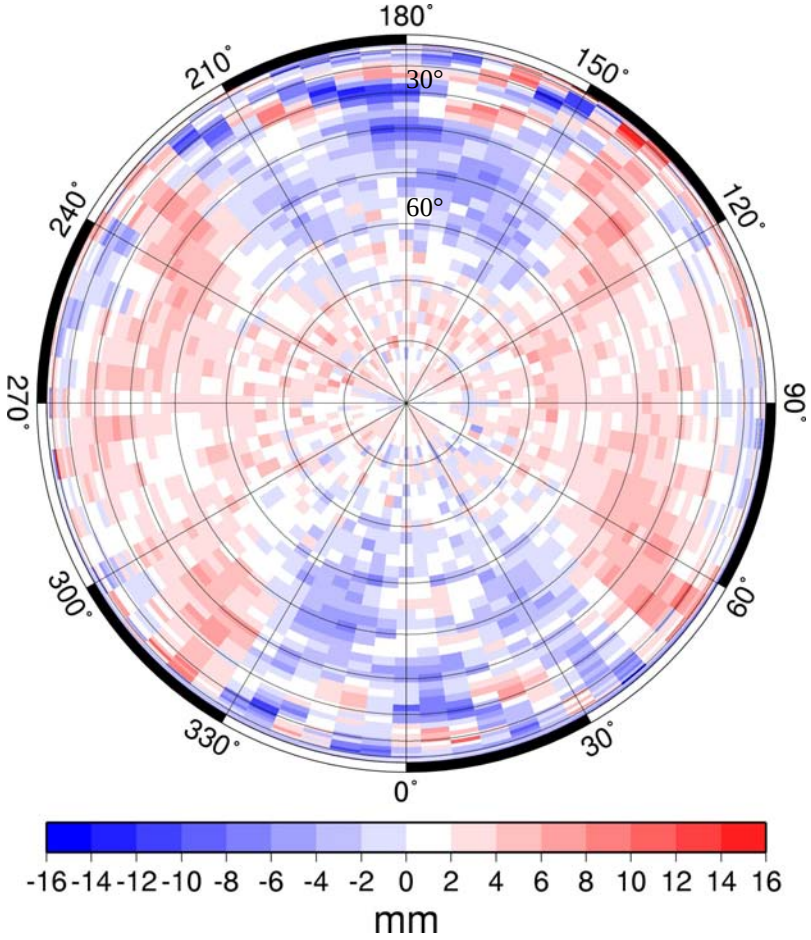
The new phase center offsets (PCO) are from IGS, and the old offsets from JPL. The mean difference between old and new offsets is about 20cm. The new offsets for GPS block IIA are greater than that for old offsets; but for GPS block IIR, the new offsets are greater than the old for some GPS satellites, and smaller than old for some GPS satellites.

The GPS satellite phase center variation (PCV) maps are generated based on the ground GPS data and restricted to nadir angles of **14 degrees**. But the nadir angels up to **17 degrees** are encountered in processing of LEO GPS data. The linear extrapolation is used in our GRACE POD.

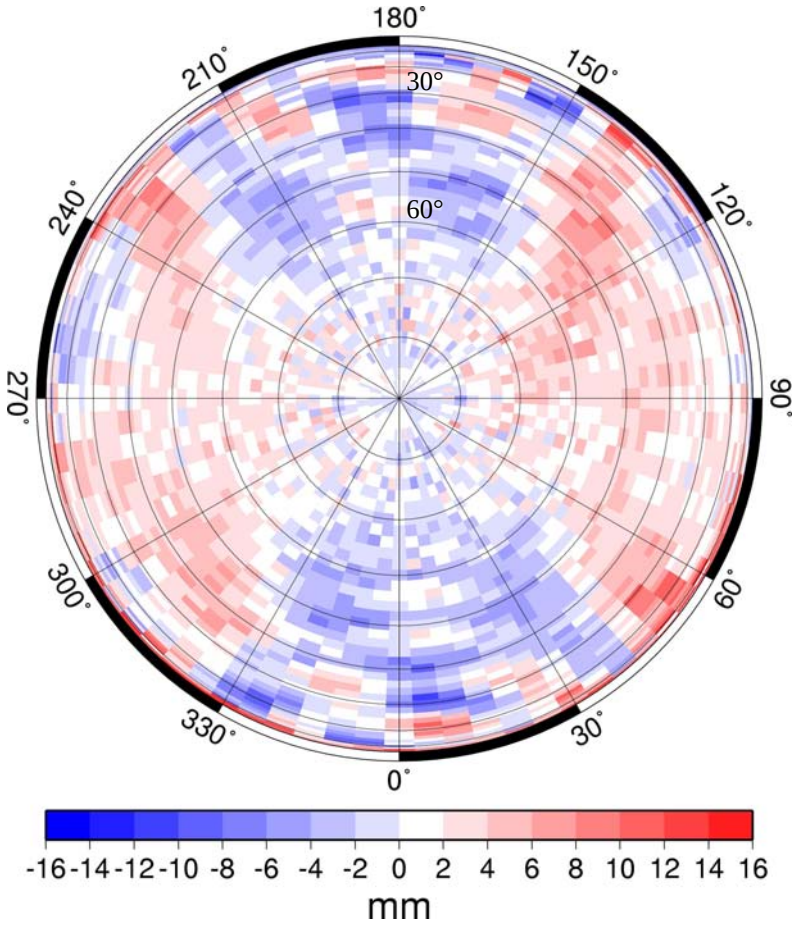


GRACE GPS Receiver Antenna Phase Center Variations

GRACE-A

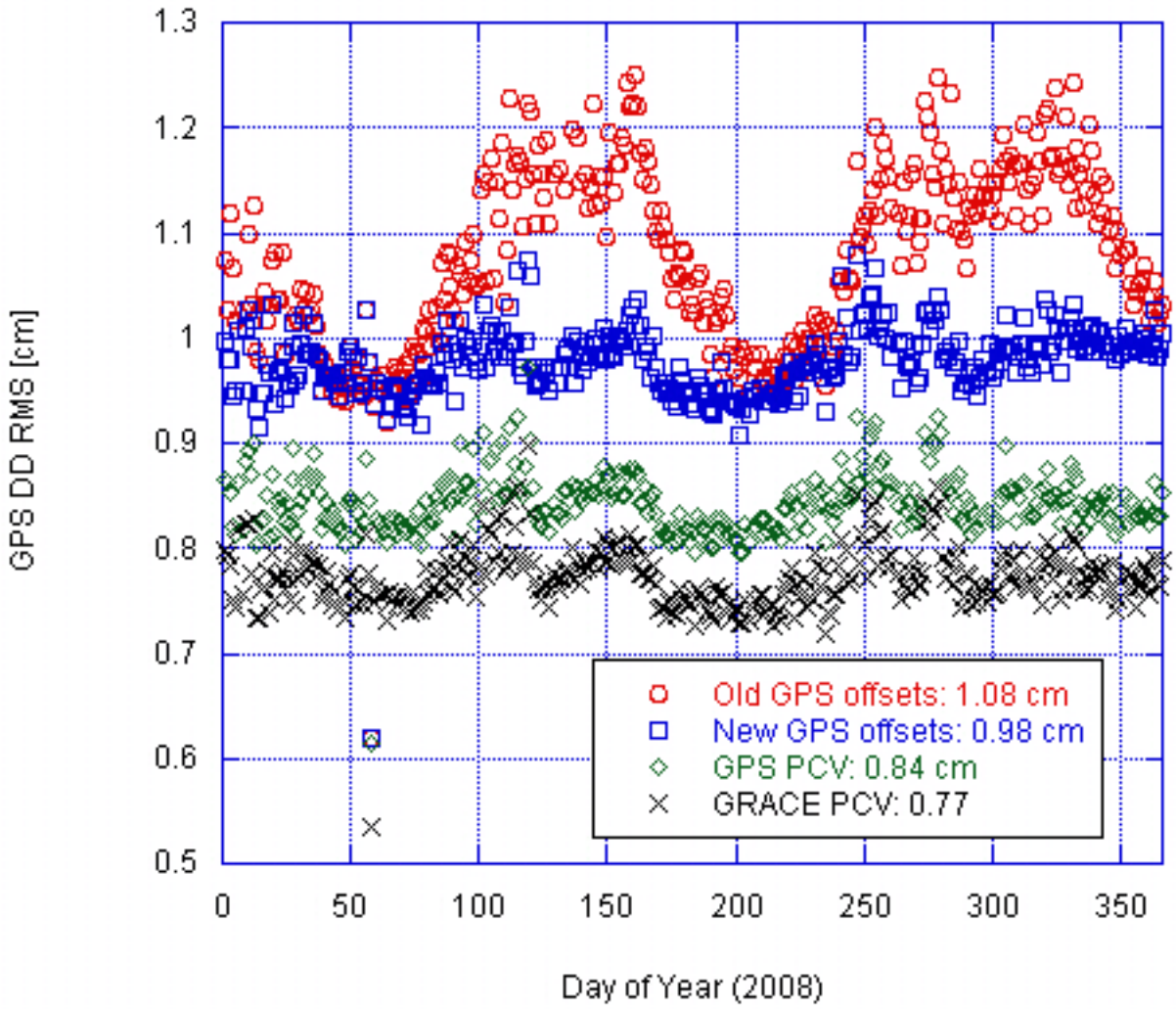


GRACE-B



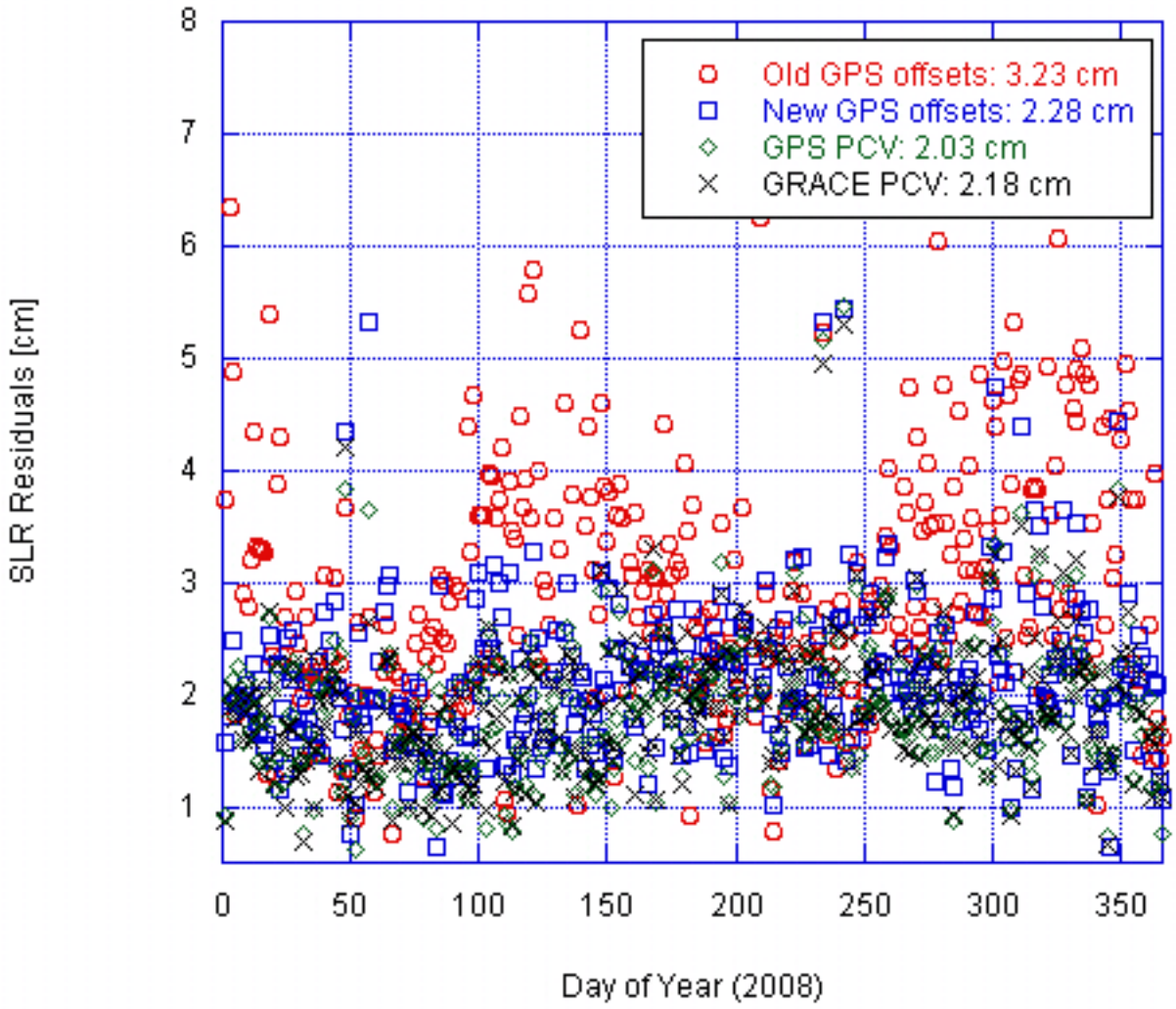
Elevation- and Azimuth-dependent Phase Center Variations

GRACE-A GPS DD RMS for different Tests



Using the new GPS antenna offsets, the GRACE-A GPS DD RMS is stable. Adding GPS PVC and GRACE PCV maps, the RMS's are consistently improved. The gain is **9, 14 and 8 %** for GPS PCO, GPS PCV and GRACE PCV, respectively.

GRACE-A SLR Residuals for different Tests



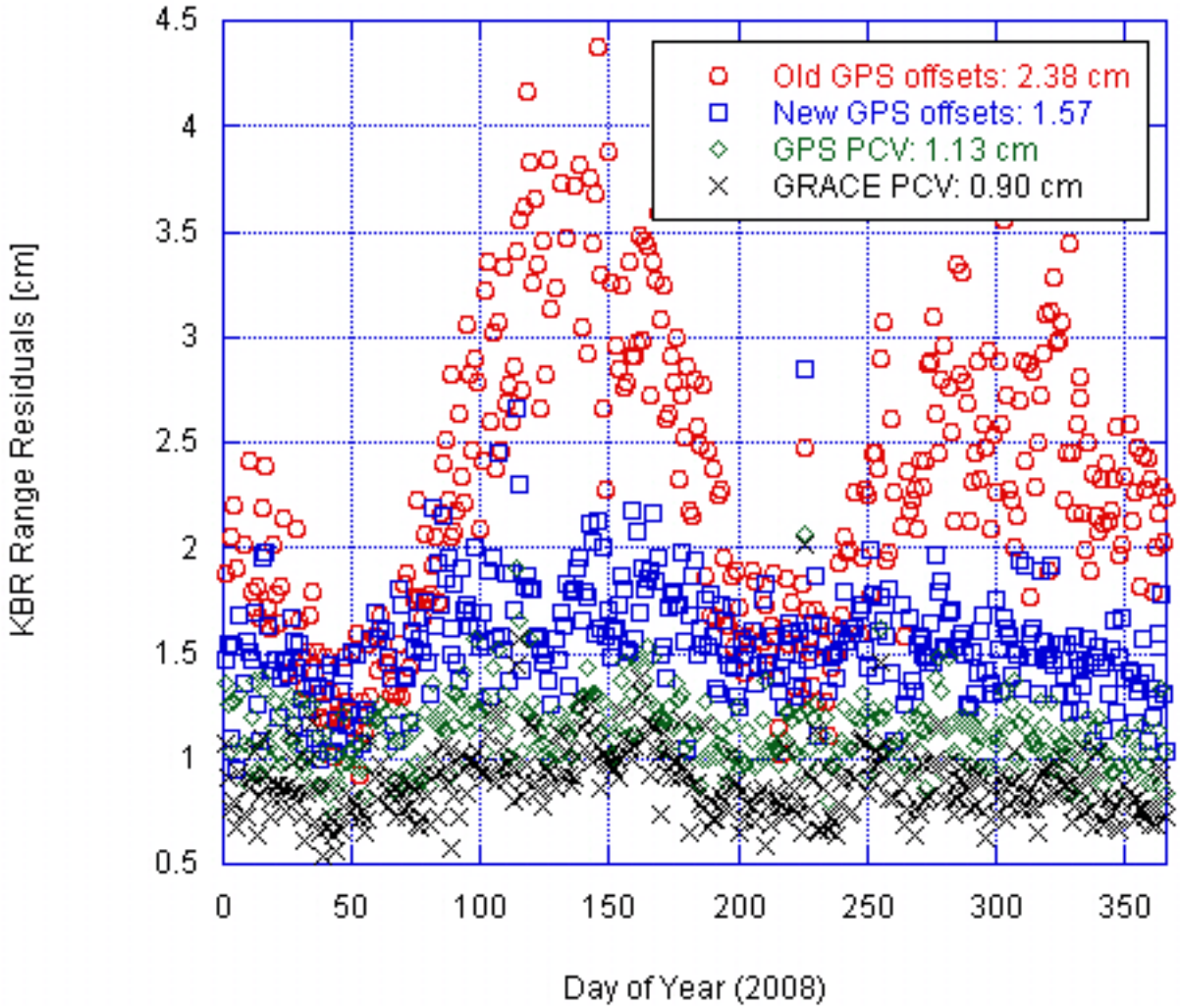
The SLR residuals computed using GRACE orbits and SLR ground station positions provide an independent assessment of the orbit accuracy. Therefore the residuals are effected by the orbits accuracy, station accuracy and attitude quality.

SLR (total): 2.18 cm

SLR (radial): 0.90 cm

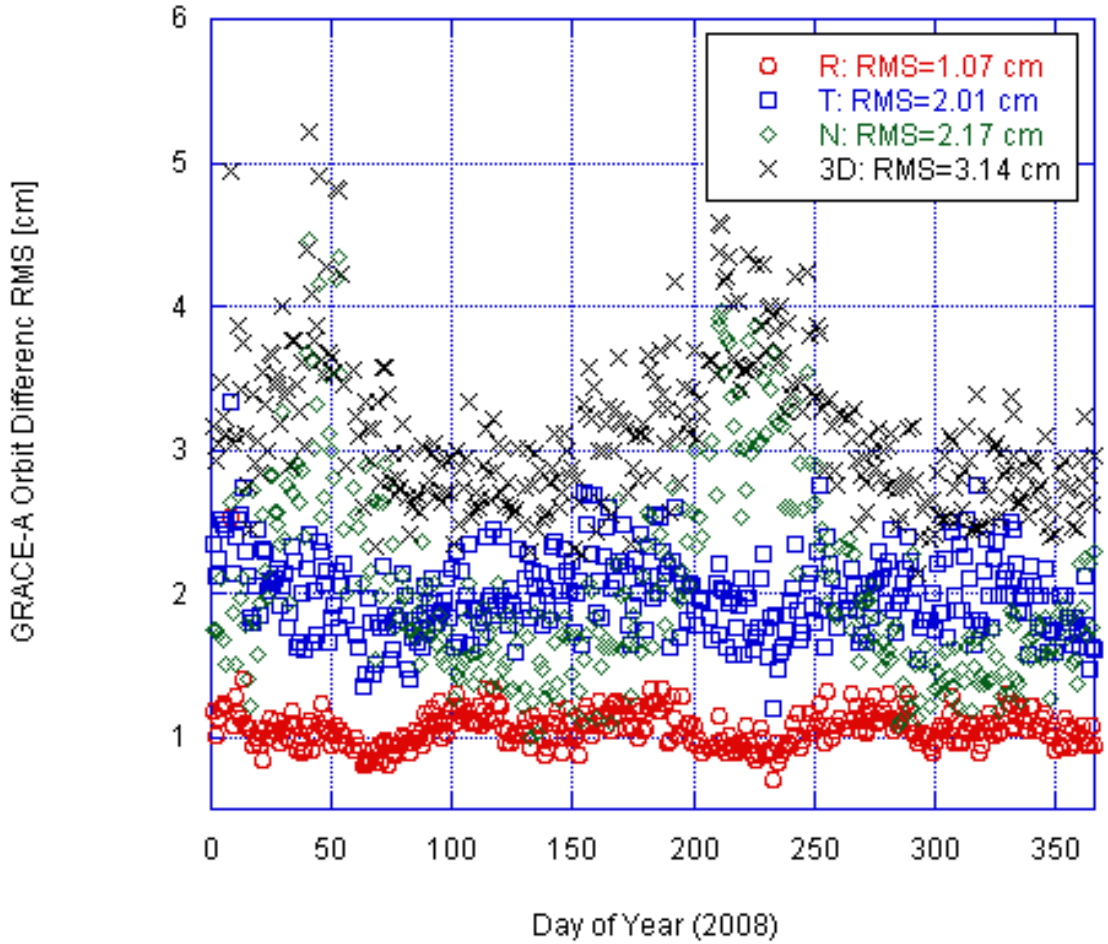
SLR (along-track): 2.10 cm

GRACE KBR Range Residuals for different Tests

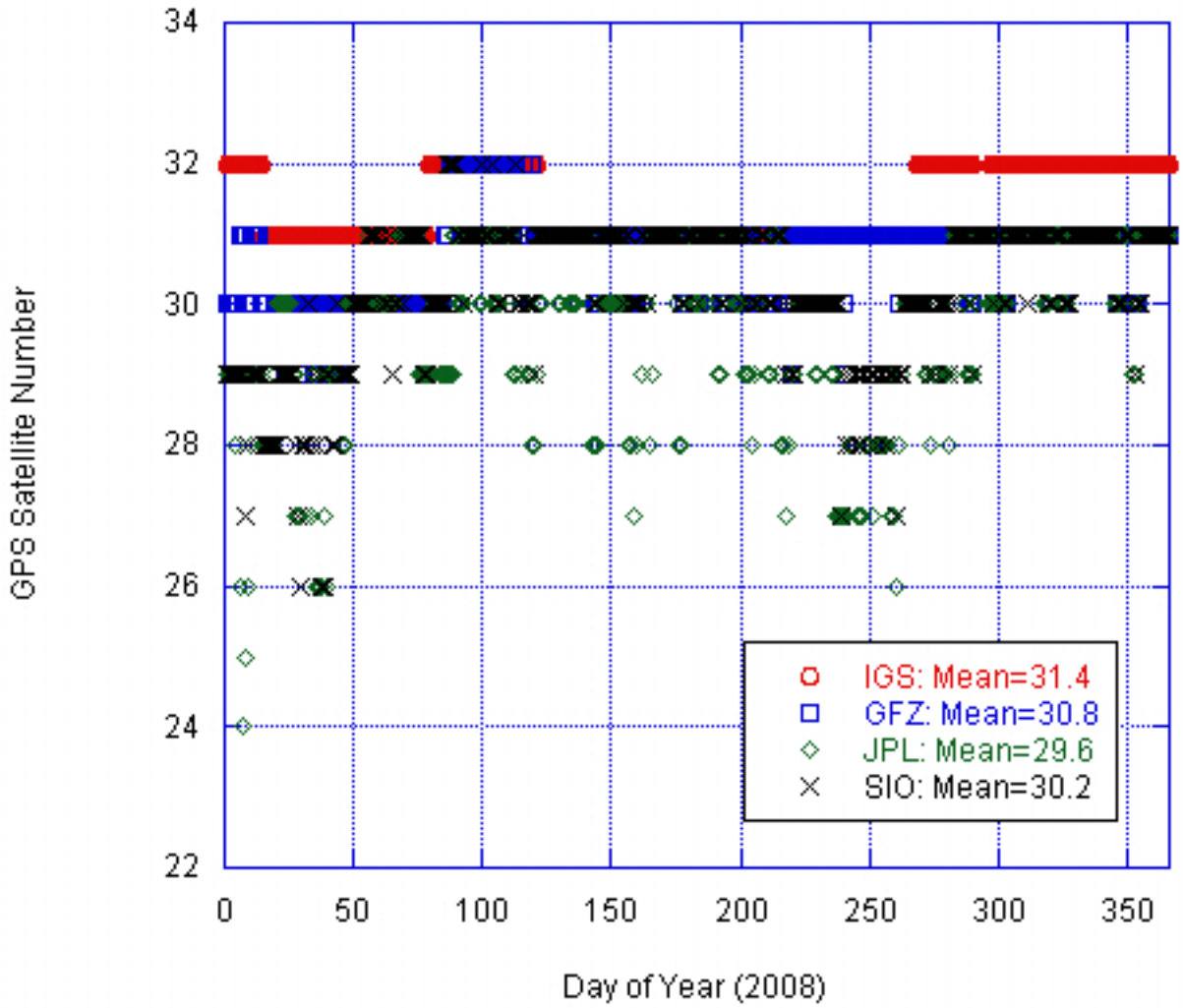


The KBR system measures the one-way range between the twin GRACE satellite with a precision of about 10 μm. The KBR residuals computed by fixing GRACE orbits can be used for evaluating the relative orbits accuracy.

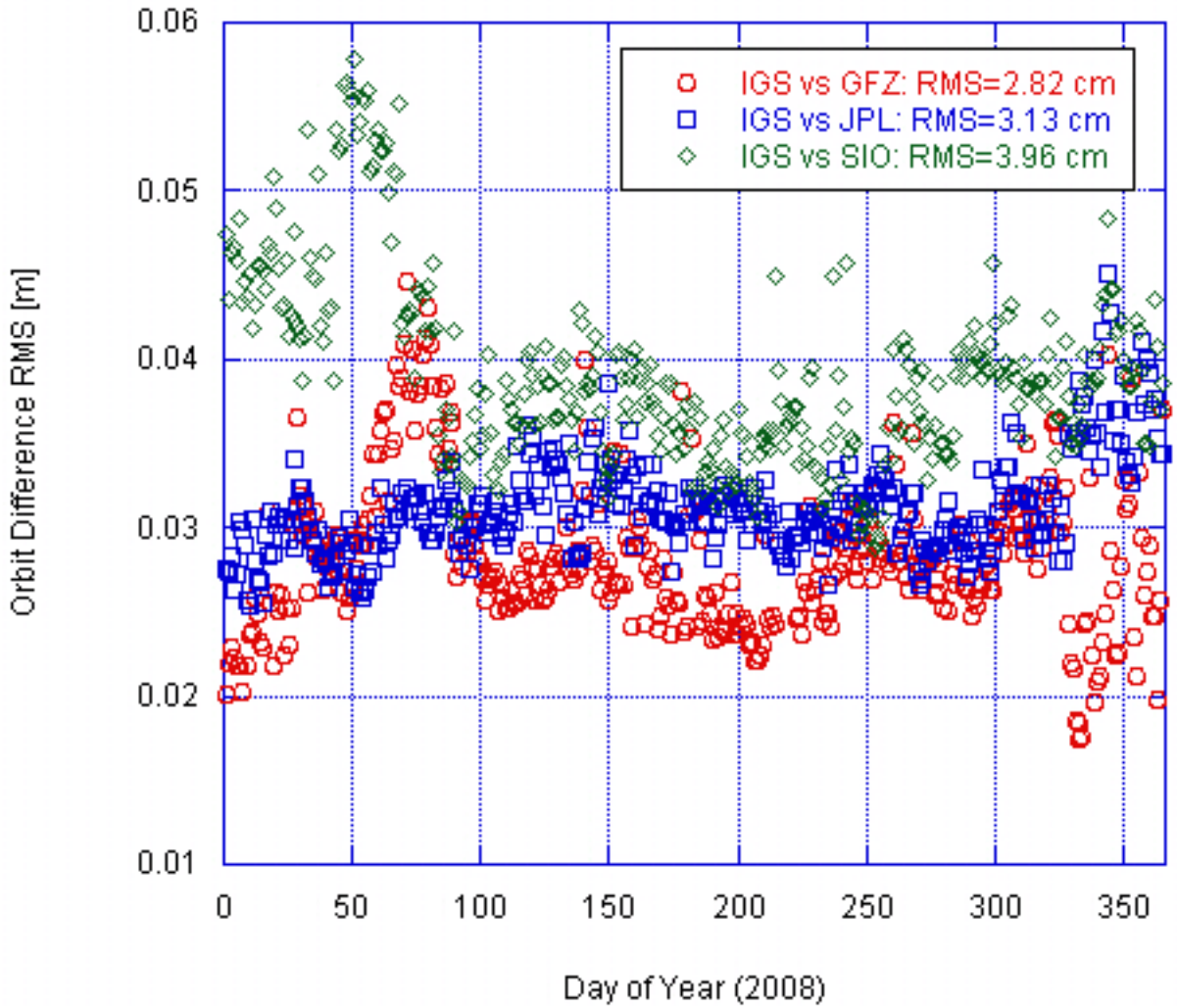
GRACE-A Orbit Comparison (CSR vs JPL)



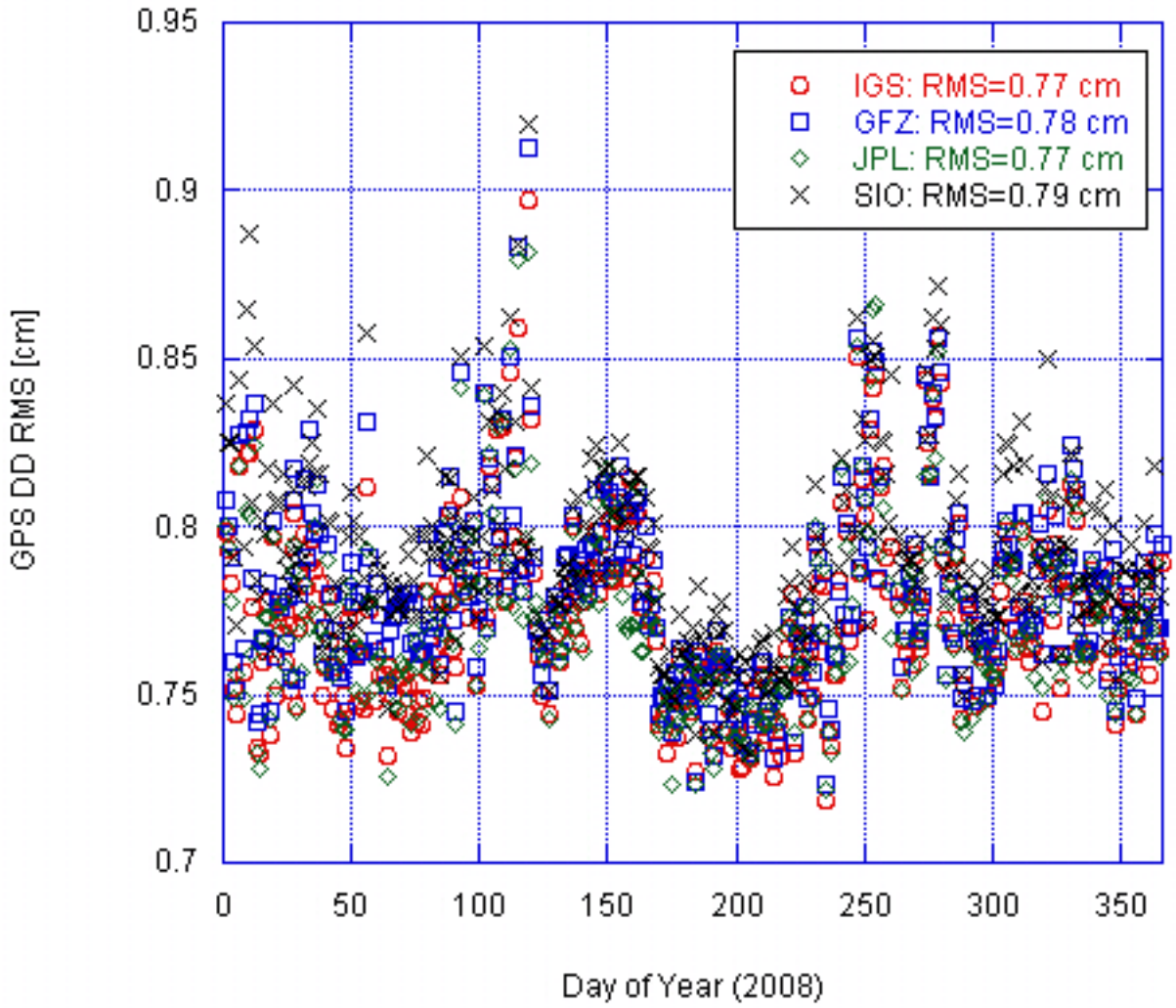
GPS Satellite Number from different Centers



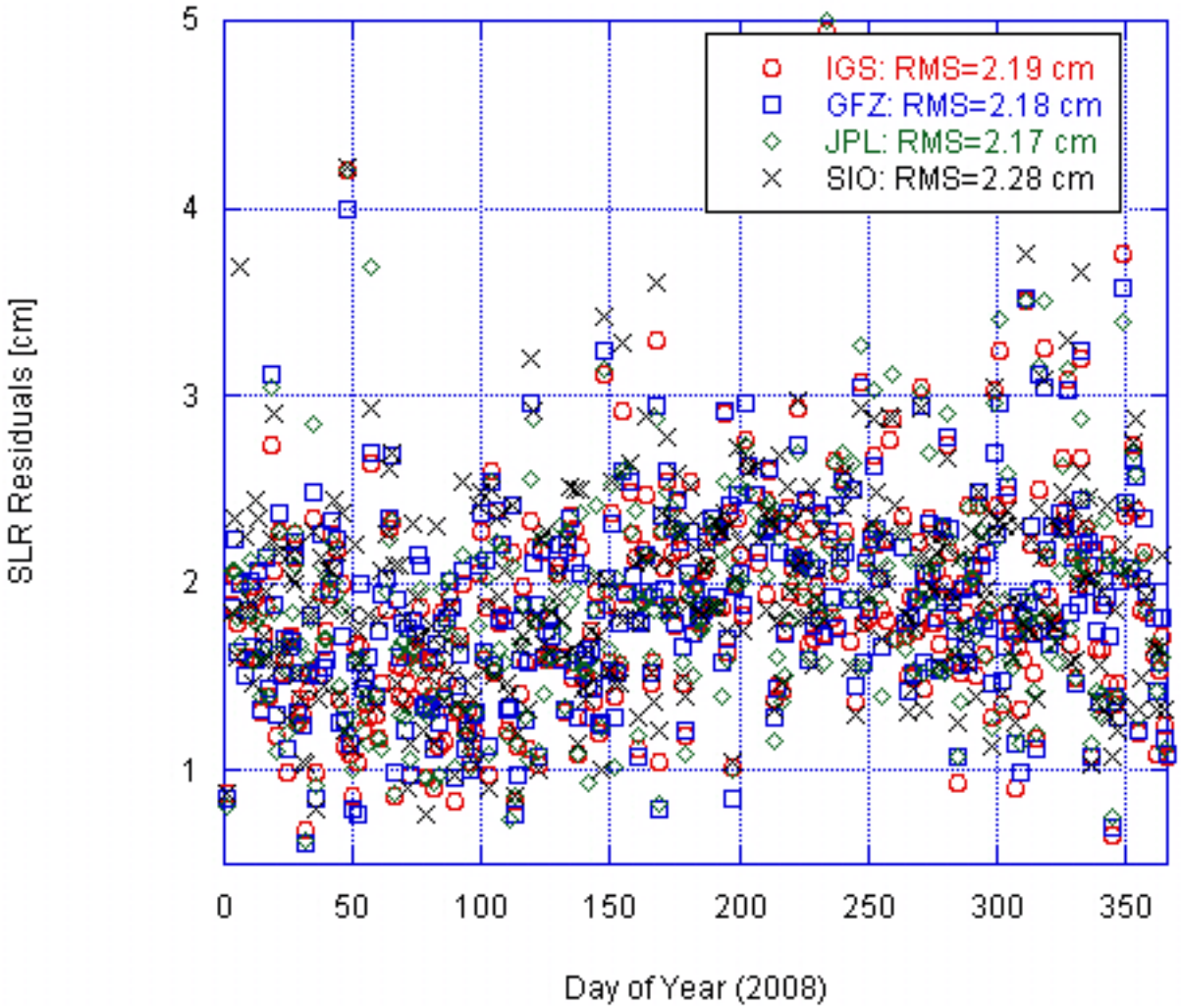
GPS Satellite Orbit Difference (3D) RMS



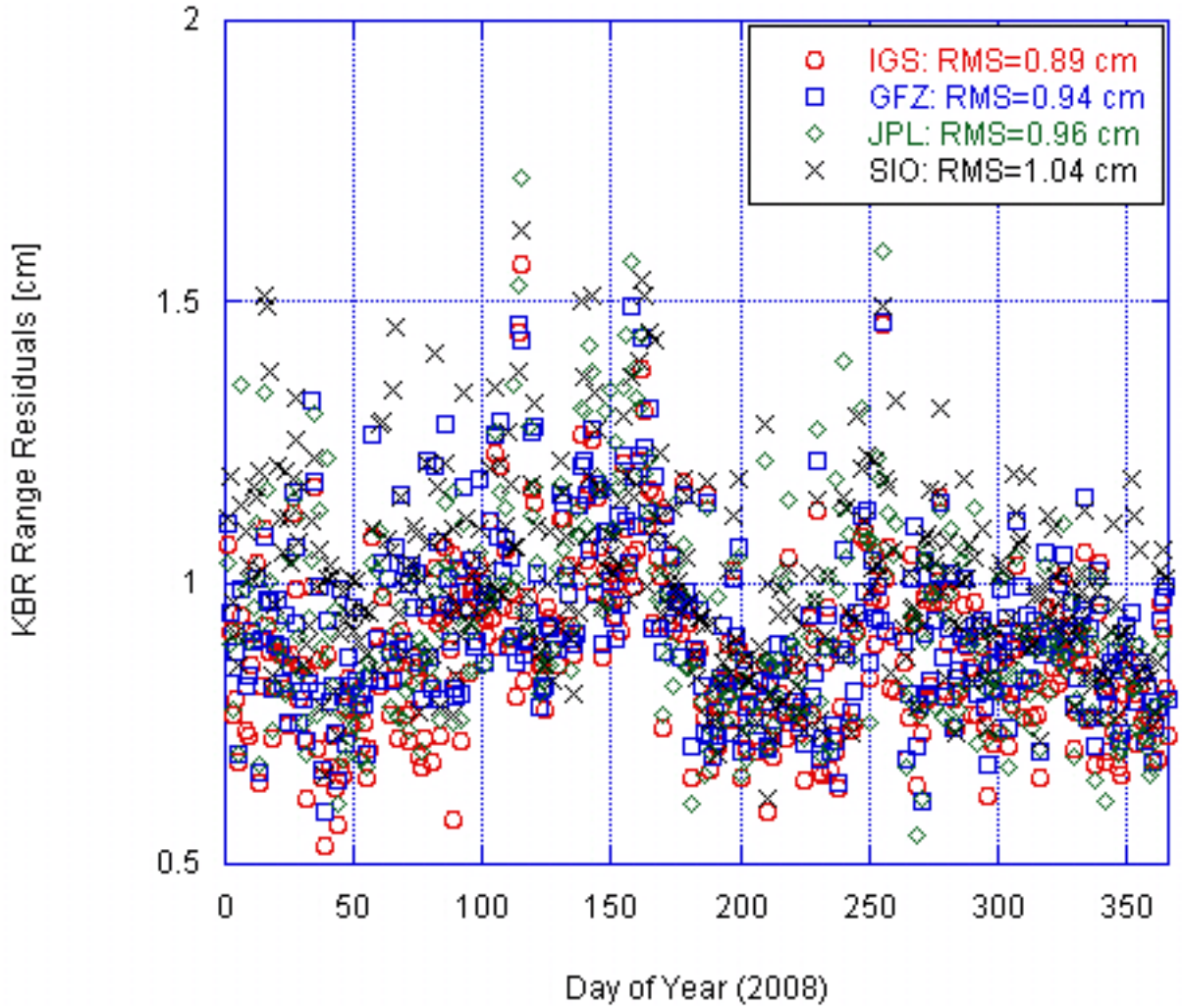
GRACE-A GPS DD RMS for different GPS Orbits



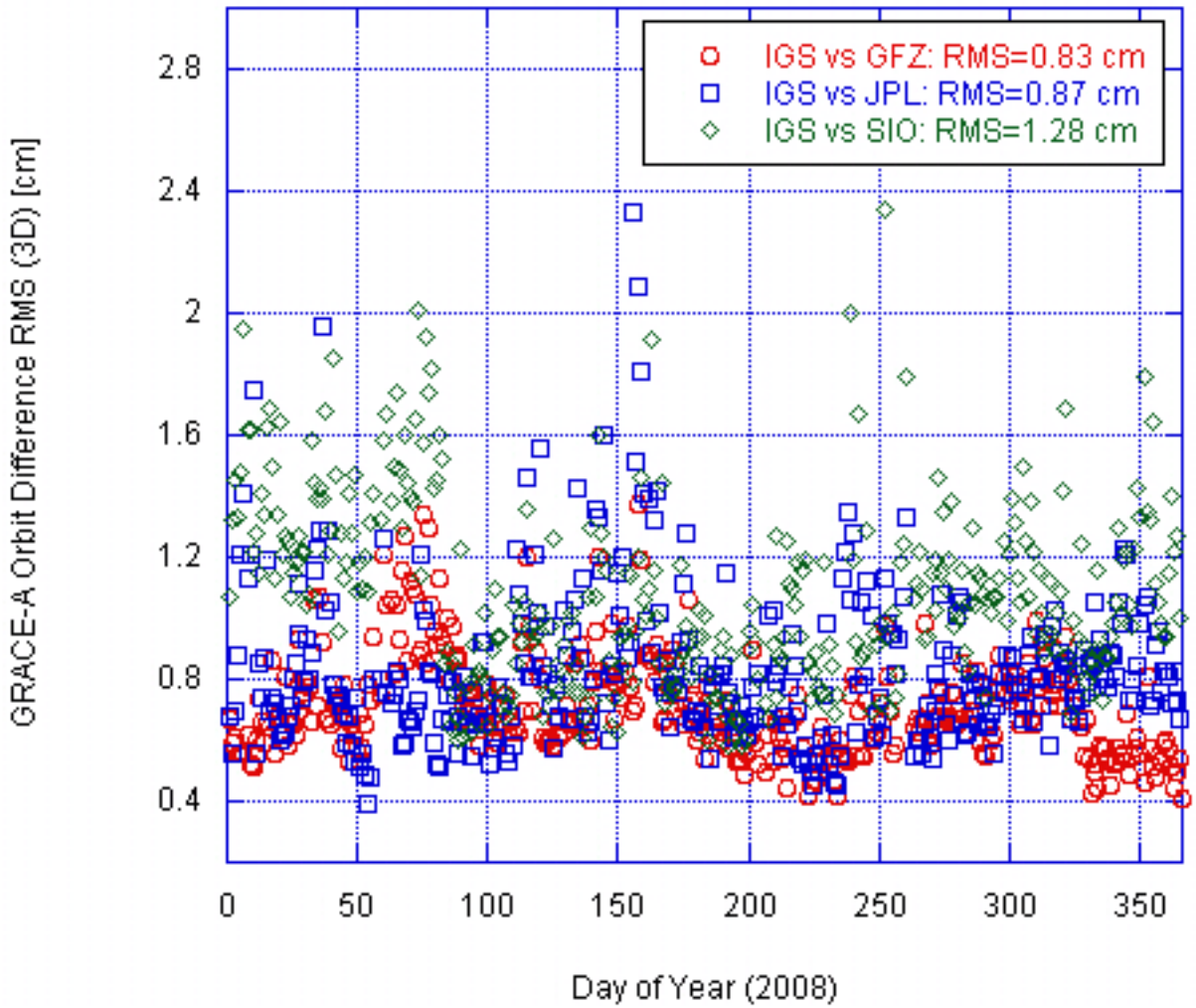
GRACE-A SLR Residuals for different GPS Orbits



GRACE KBR Range Residuals for different GPS Orbits



GRACE-A Orbit Comparisons for using different GPS Orbits



Summary

Several tests for reprocessing GRACE GPS data have been made.

Significant improvements due to using GPS satellite antenna phase center offsets (PCO) and phase center variations (PCV) from IGS as well as GRACE GPS receiver antenna PCV from JPL have been implemented.

Based on various orbit accuracy assessments, an accuracy of about 1 cm in the radial direction and about 2 cm in along-track and cross-track has been proved through internal tests and external comparisons. The relative accuracy between the two GRACE satellites is better than 1 cm in position.

There are no big effects of IGS GPS orbits on the GRACE data processing, when the orbit accuracy is better than about 3 cm. But the combined IGS GPS orbits can provide smaller KBR range residuals comparing with other GPS orbits.