

LEO-based SLR Station Coordinate Determination using GNSS and SLR Data

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Background and Motivations

- ❖ A precise determination of SLR station coordinates is very important for realizing **ITRF**.
 - ❖ Currently, the coordinates are determined mainly by processing SLR data from spherical geodetic SLR satellites (such as **LAGEOS**).
 - ❖ Generally, SLR data from LEO satellites are mainly used for **evaluating LEO POD**.
 - ❖ Actually, SLR data from LEO satellites with other data (such as GNSS) can be also used for **determining SLR station coordinates**.
 - ❖ In the future, a combination and co-location of **SLR, GNSS, DORIS and VLBI** on LEO satellite platform (such as GENESIS) will be used for precisely realizing ITRF with a goal of 1 mm accuracy and 0.1 mm/year long-term stability.
- How well** can the SLR station coordinates using current SLR and other data from LEO be determined?
- What are the **main impacts** on LEO-based SLR station coordinate determination?

Objectives

- To investigate the **approaches** of LEO-based SLR station coordinate determination using SLR and GNSS data
- To study the **different effects** (such as SLR observation number, station range bias) on the coordinate determination
- To assess the solutions through **internal and external** comparisons

Approaches

Direct Approach for determining SLR station coordinates:

- Determine the LEO orbits using GNSS or GNSS + SLR data in **one-day span**
- Concatenate multi-LEO daily orbits into one orbit products based on the **arc lengths** (such as a week or four weeks) of LEO SLR data to be processed
- **Directly estimate** the SLR station coordinates by using SLR data and fixing LEO orbits by iteration

Indirect Approach for determining SLR station coordinates:

- Determine the LEO orbits using GNSS or GNSS + SLR in **one-day span**
- Generate **daily normal equations** by using SLR data and fixing LEO orbits
- Estimate the SLR station coordinates by using **multi-normal equations**

Test Data and Test Cases

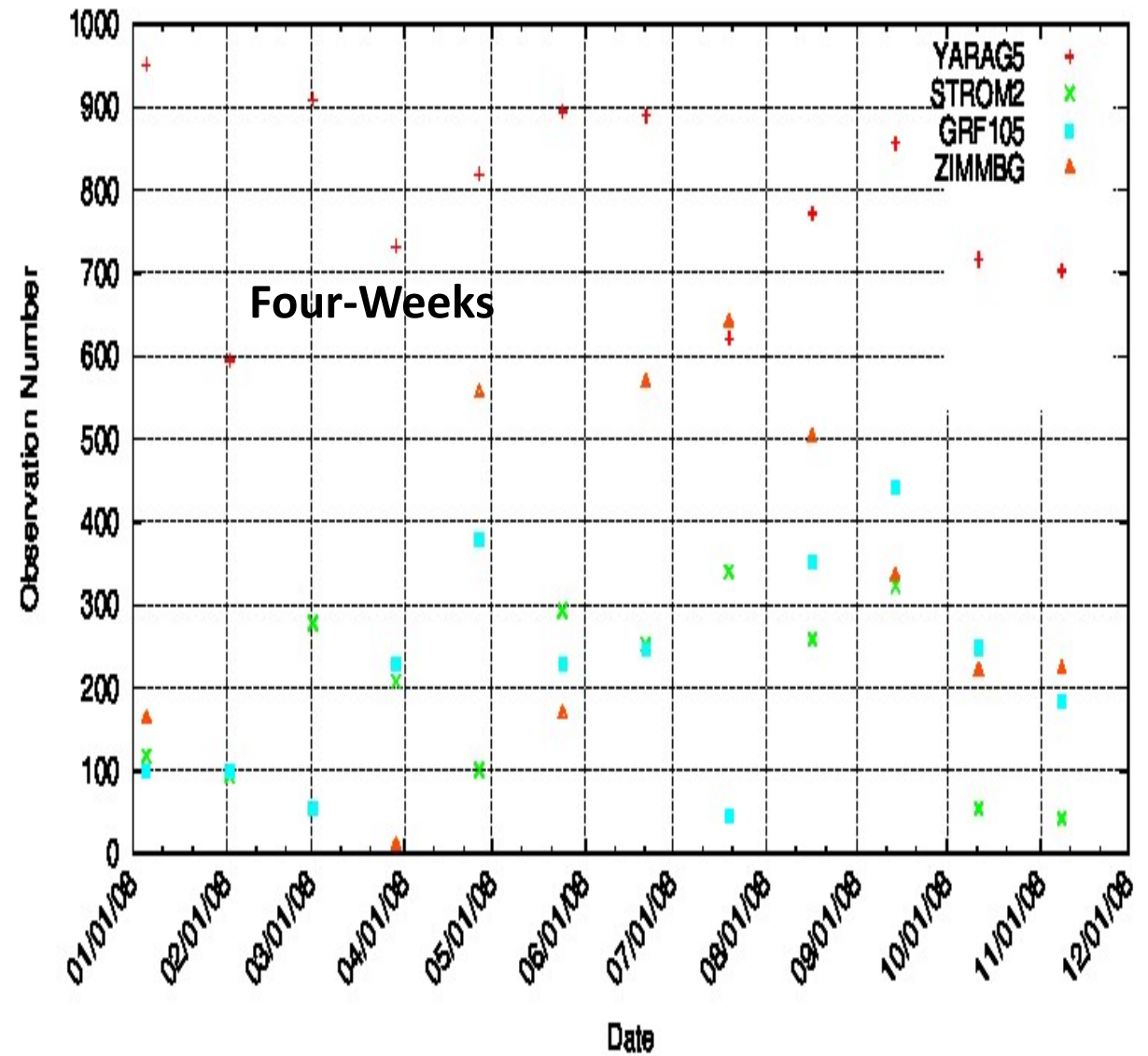
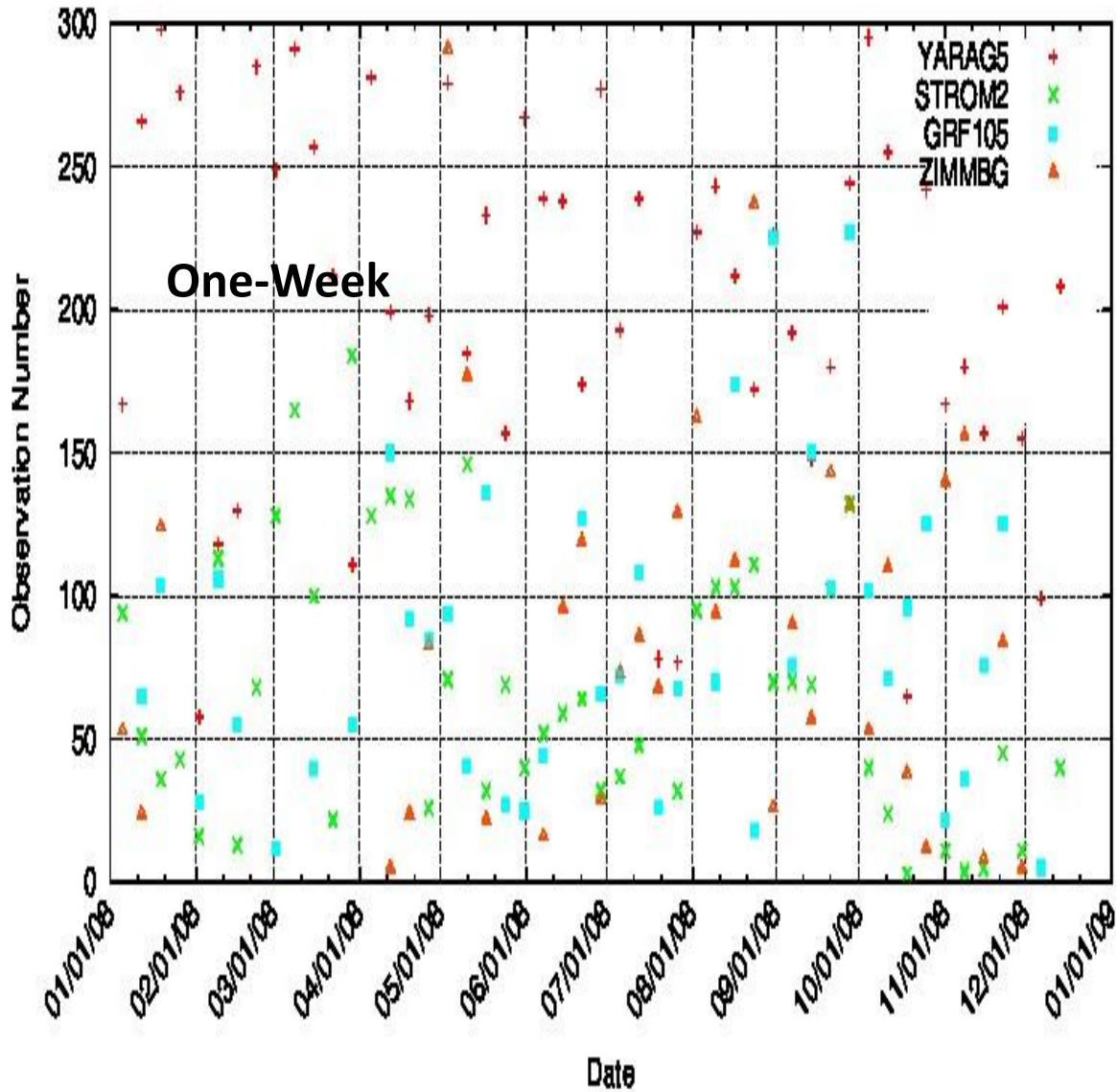
Test Data (2008):

- GRACE-A GPS and SLR Observations
- GRACE-B GPS and SLR Observations

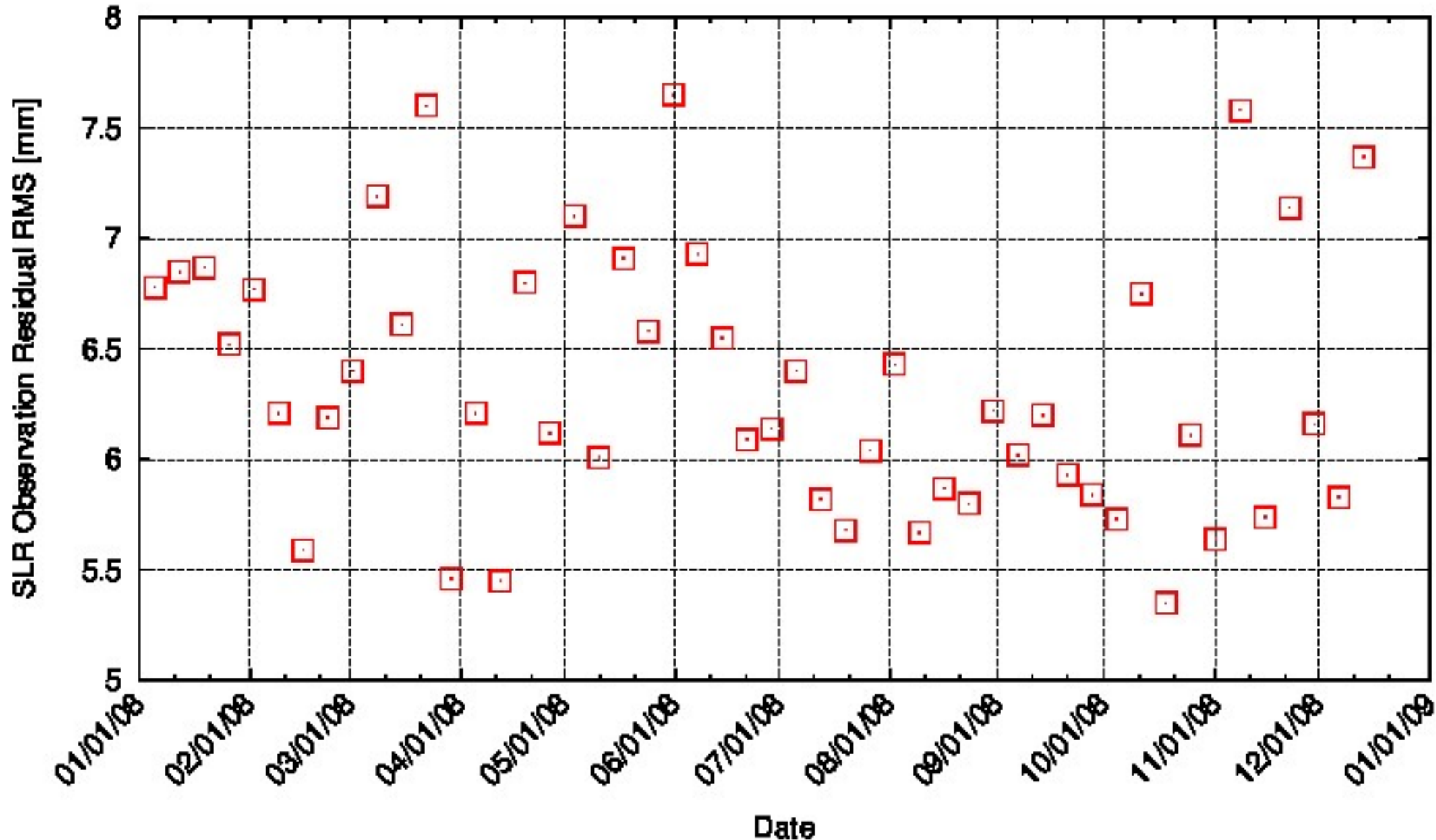
Test Cases:

- 1) **GRC-A-1WB**: one-week SLR data from GRACE-A **with** range biases
- 2) **GRC-A-1W**: one-week SLR data from GRACE-A **without** range biases **for checking station range bias effect**
- 3) **GRC-B-1WB**: one-week SLR data from GRACE-B with range biases **for internal comparison**
- 4) **GRC-A-4WB**: **four-week** SLR data from GRACE-A with range biases **for checking the effects of SLR observation numbers**
- 5) **GRC-B-4WB**: **four-week** SLR data from GRACE-B with range biases **for checking the effects of SLR observation numbers**
- 6) **GRC-AB-4WB**: **four-week** SLR data from GRACE-A and GRACE-B with range biases **for checking the effects of the LEO numbers**

GRACE-A Total One-Week or Four-Week SLR Data Number for Different SLR Stations

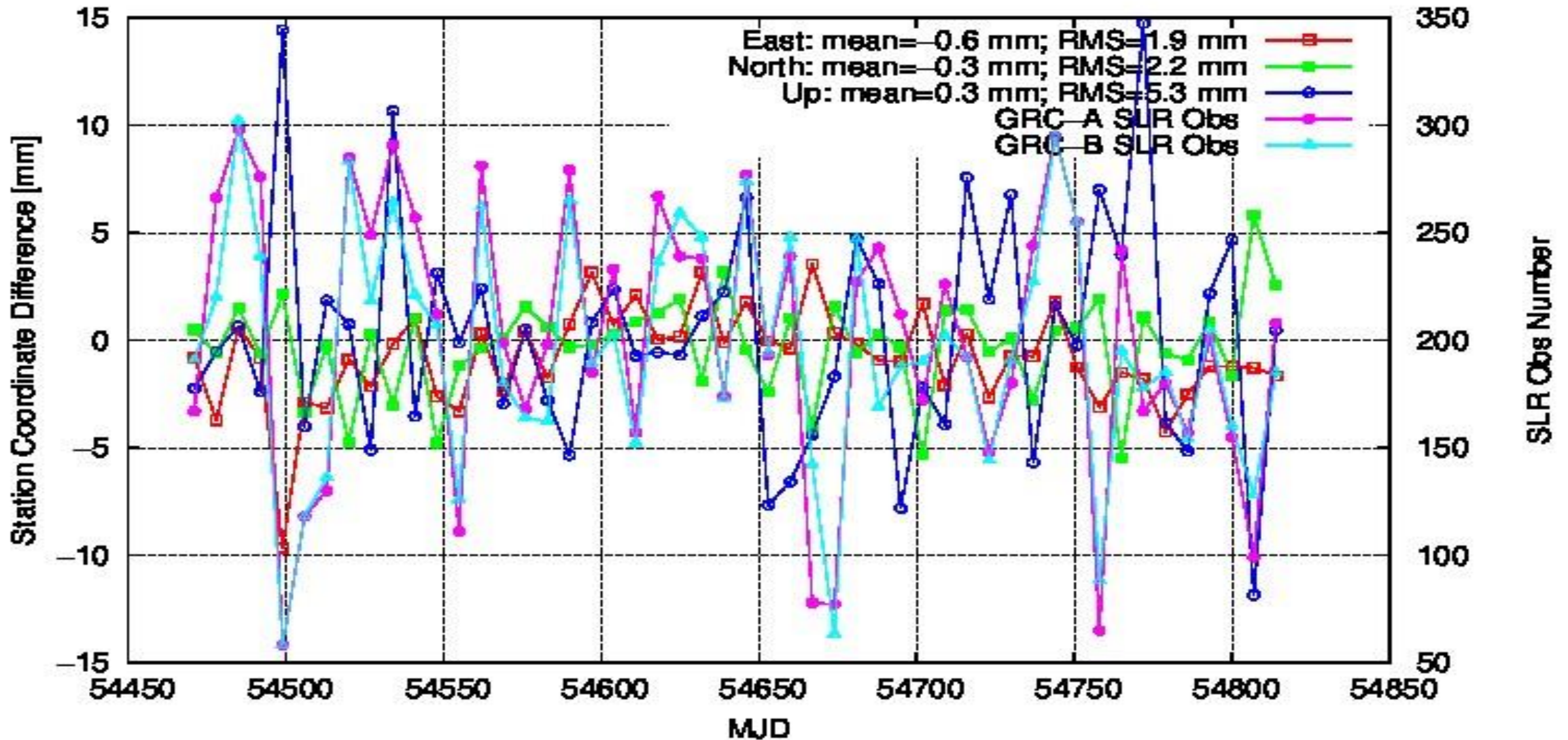


GRACE-A Weekly SLR Observation Residual RMS

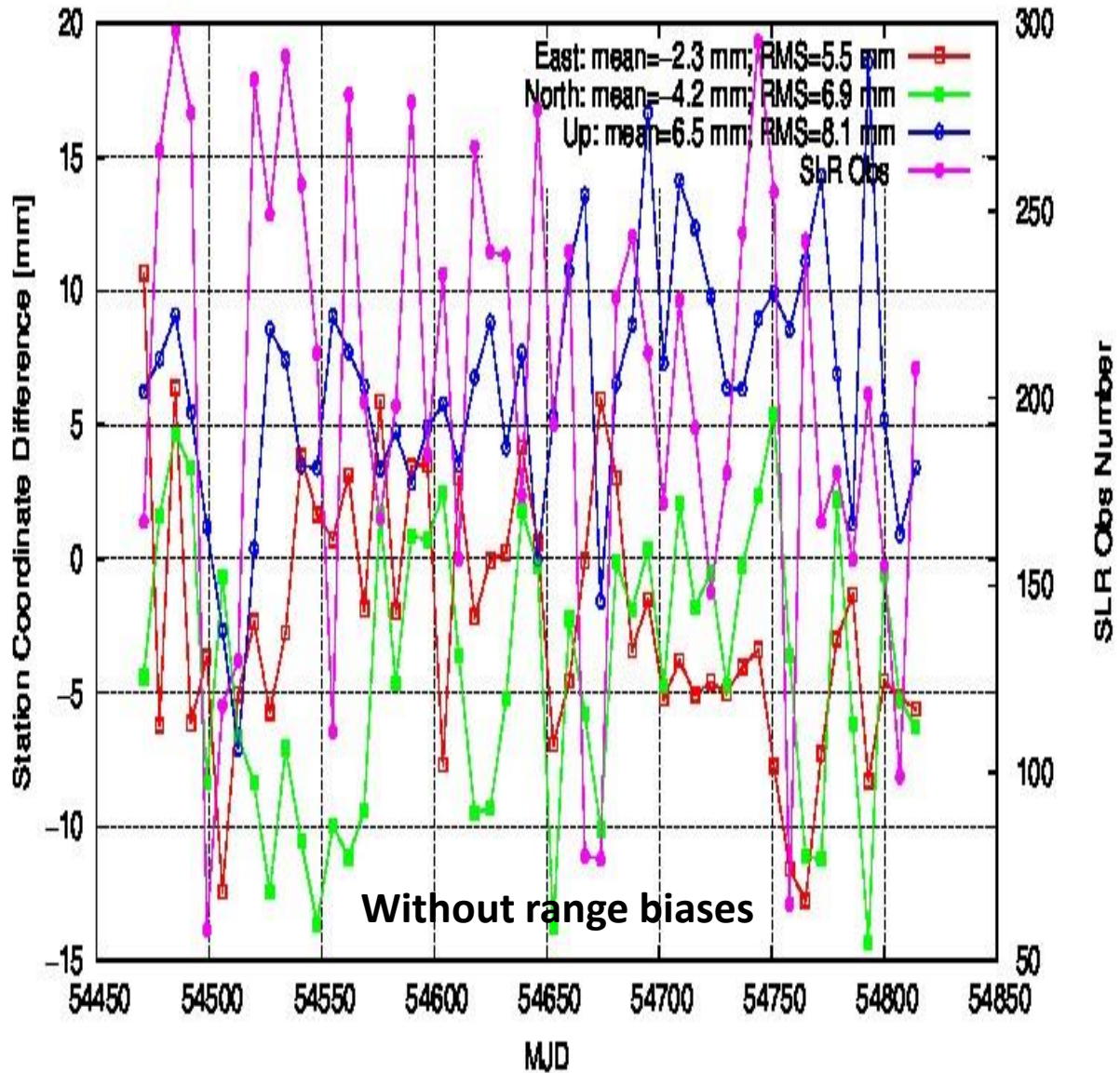
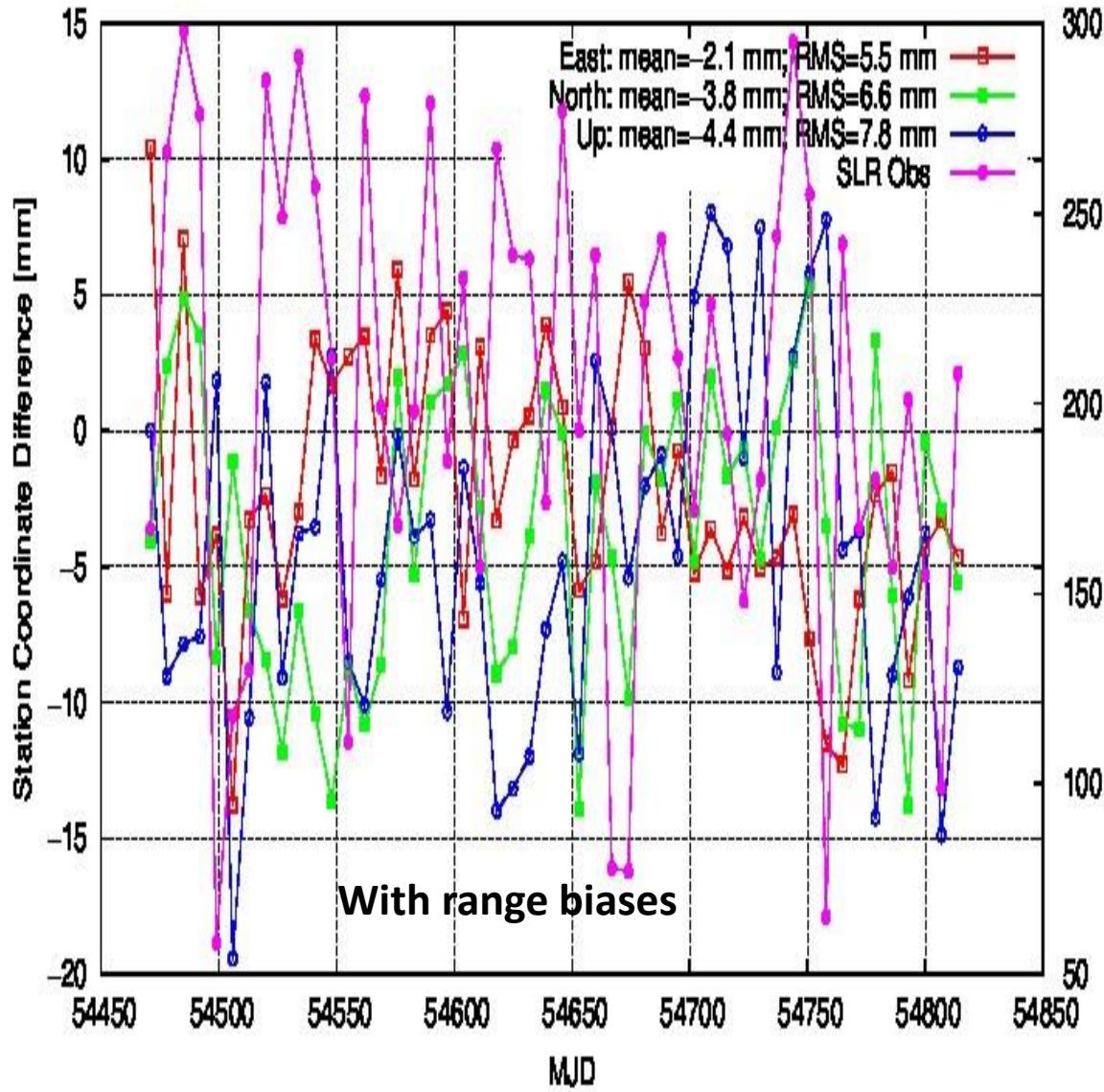


The SLR observation residuals can be used to evaluate the quality of the Fixed-orbits and observation models as well as data precision. RMS of SLR residuals is about **6.5 mm**; RMS of SLR residuals for LEO POD evaluation is more than **10 mm**. The reason for smaller RMS is due to the estimation of SLR station coordinate and other parameters.

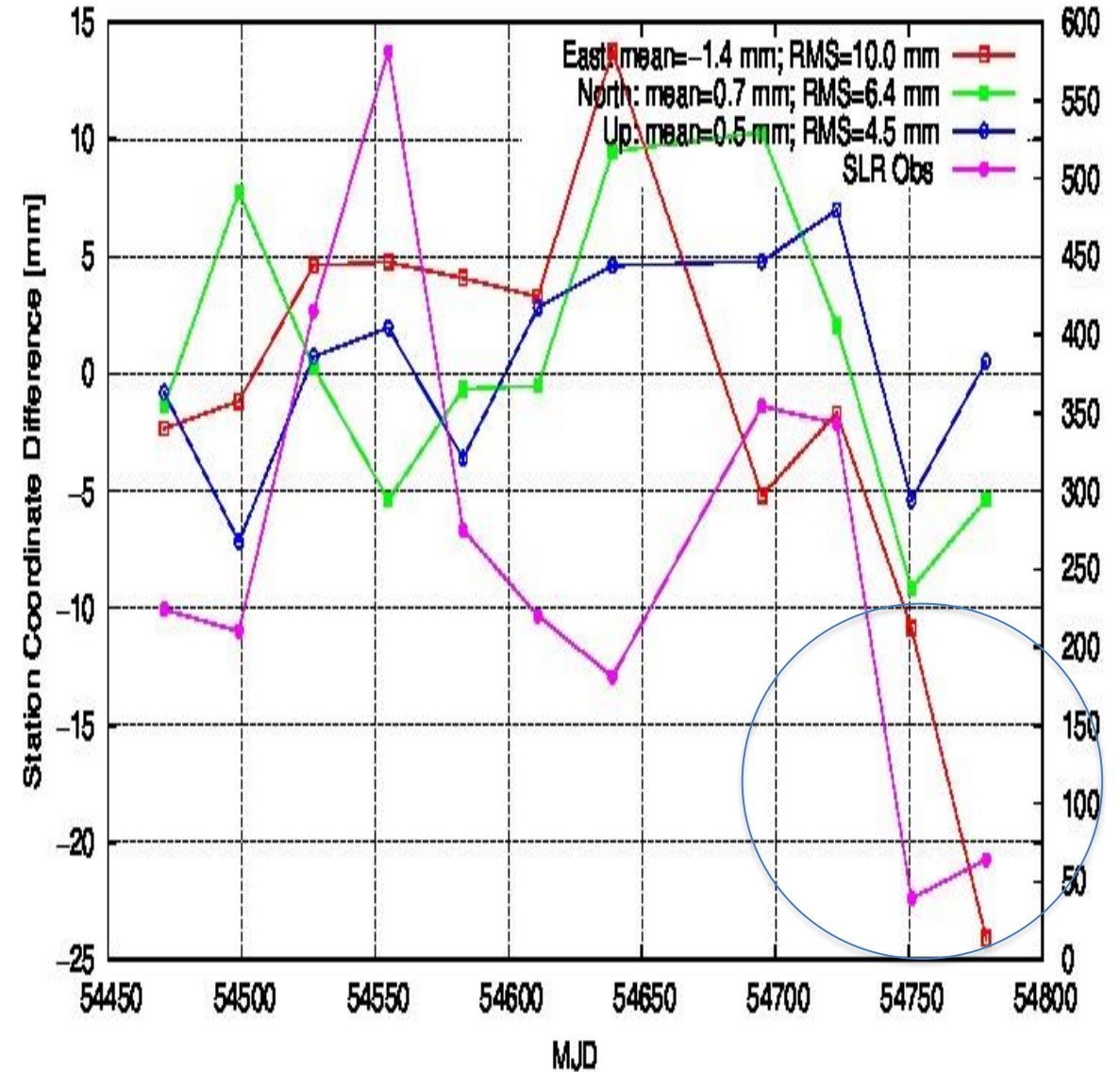
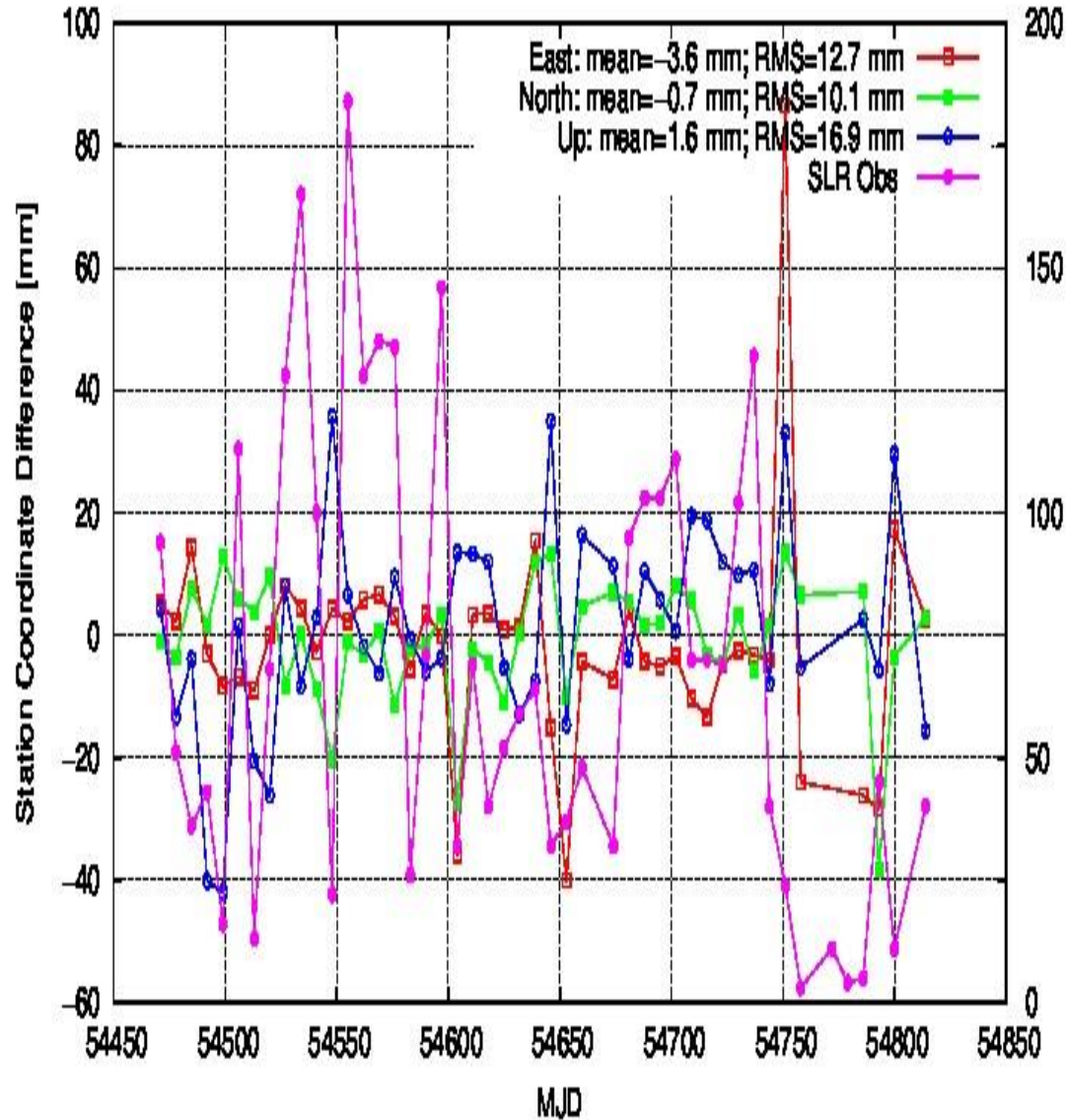
Internal Comparison: Time Series of Station Coordinate Differences for Yarrageadee (7090) between GRACE-A and GRACE-B for weekly solutions (GRC-A-1WB vs GRC-B-1WB)



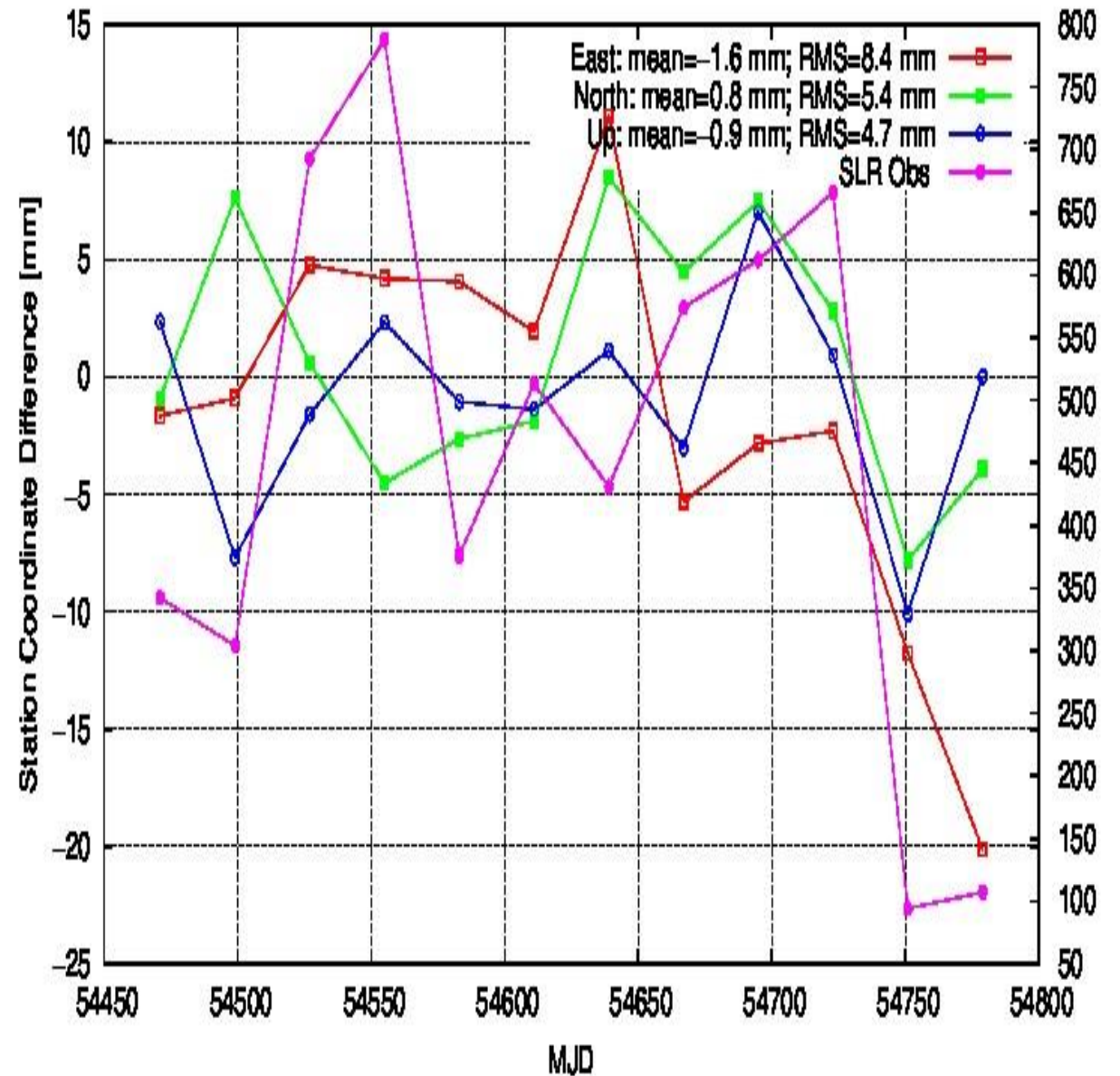
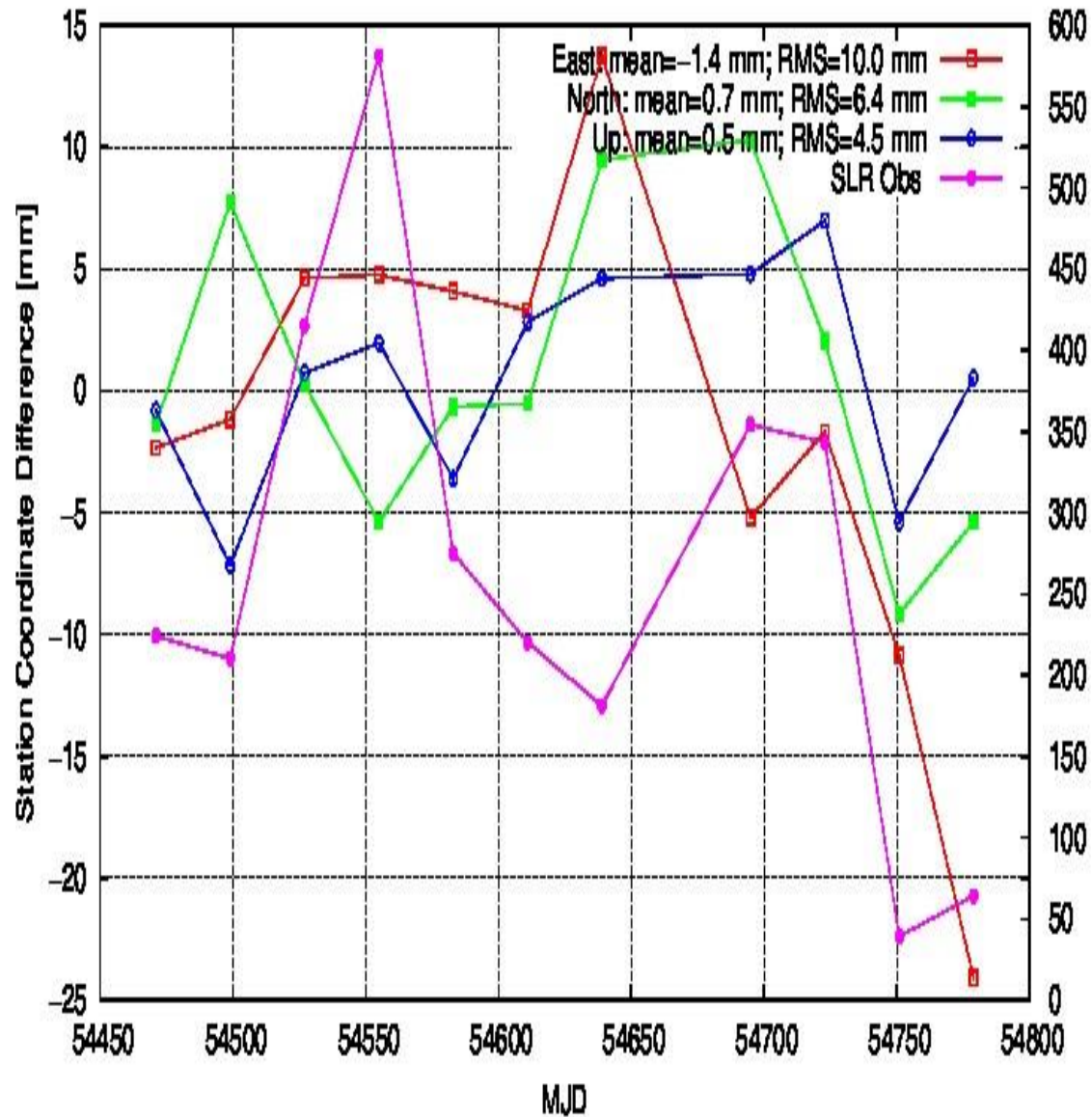
External Comparison: Time Series of Station Coordinate Differences for Yarrageadee (7090) (CSR vs IRLSB)



Obs. # Effects: Time Series of Station Coordinate Differences for Mount Stromlo (7825) (GRC-A 1W vs 4W)



LEO # Effects: Time Series of Station Coordinate Differences for Mount Stromlo (7825) (GRC-A vs GRC-AB)



Summary

- This study has demonstrated that the SLR station coordinates can be well determined **using the SLR and GPS data from LEO satellites.**
- The **direct approach** used for this study can directly detect and delete the SLR observation **outlier** by iteration.
- The results show that the **a few mm accuracy** of SLR station coordinates in all three (East, North and Up) components can be achieved when there is **enough data** from the SLR stations based on the **internal and external comparisons.**
- The number of SLR station observations can be increased through increasing **data arc length or LEO satellite number.**
- Estimating **station range biases** has a certain improvement.
- The External comparison of SLR station coordinates shows **a few mm biases** which could be due to GPS and SLR systematic biases and/or different SLR model corrections.