

Multi-Technique Reprocessing and Combination using "Space-Ties"

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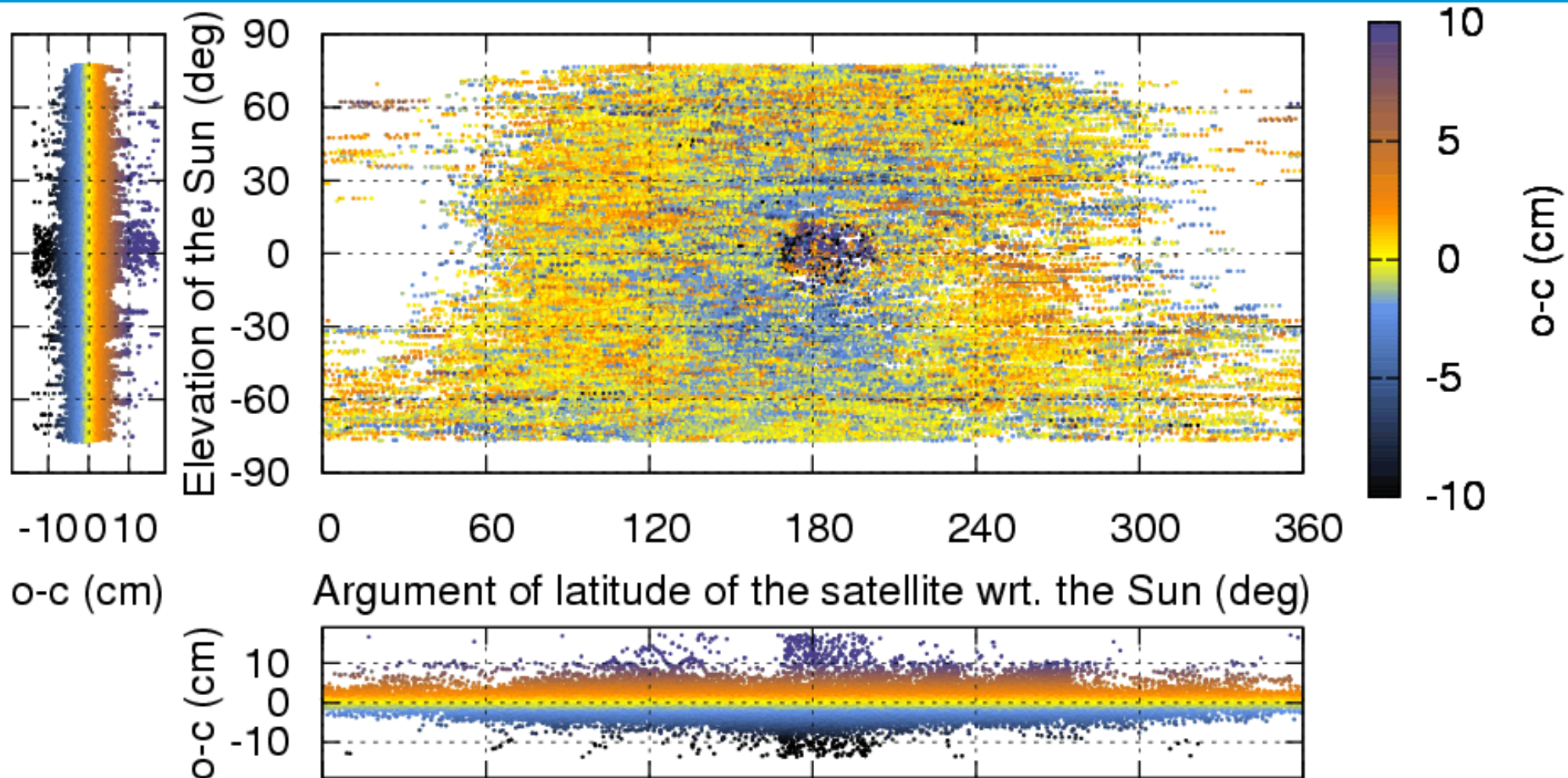
- IGS reprocessing
 - 1995 to 2008 done and submitted.
 - 1994 done but results are not good enough (early AS years)

- IDS reprocessing
 - 1992 to 2008 done and submitted.

- ILRS reprocessing
 - 1993 to 2008 done but not submitted
 - Using Lageos-1/2 and Etalon-1/2

SLR Validation of ESOC GPS Orbits

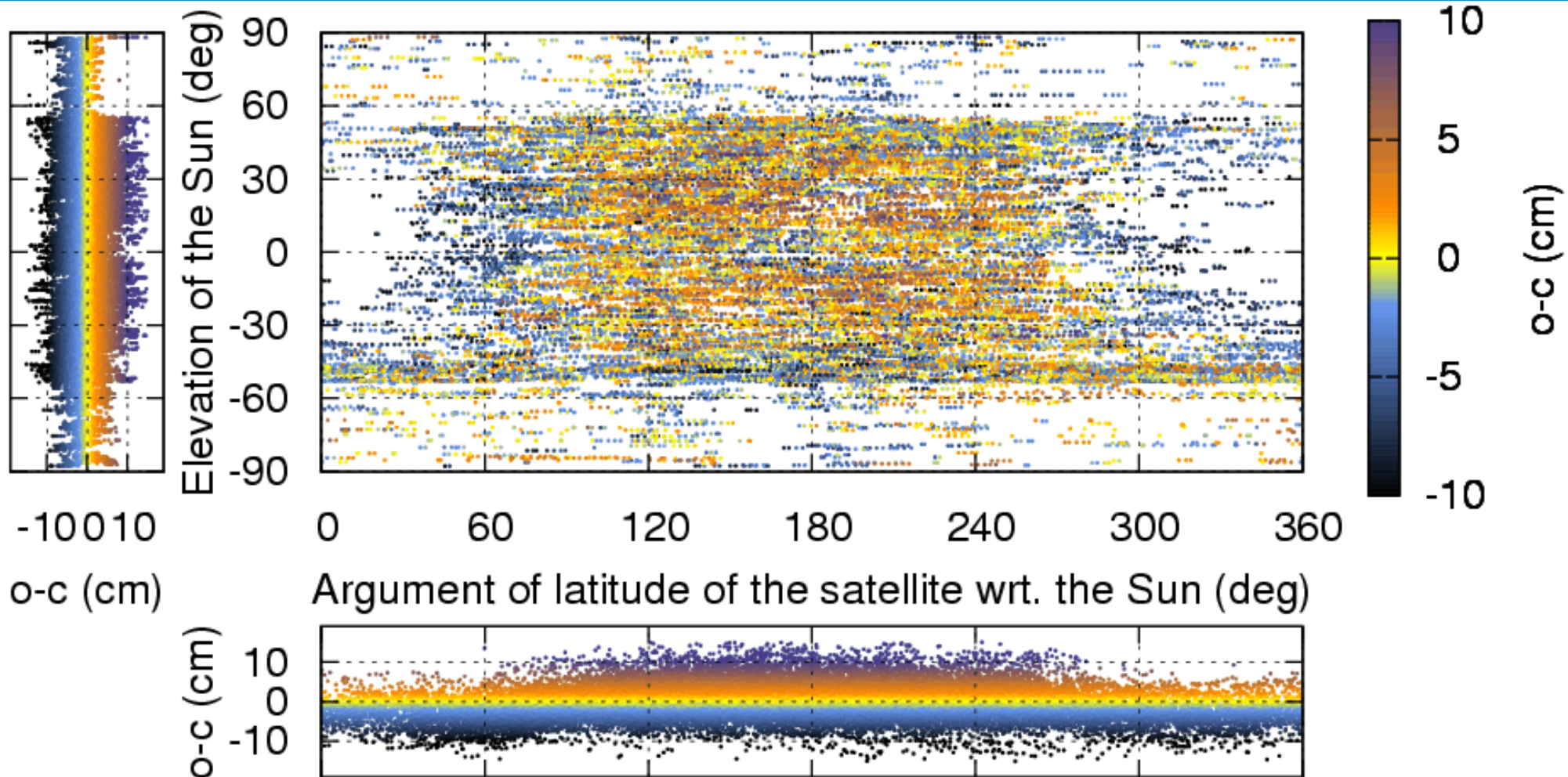
Reprocessed orbits from 1995-2008



SLR and GPS agree very well!
Only a small bias and eclipse (attitude) effects remain

SLR Validation of ESOC GLONASS Orbits

ESOC Final orbits 2008 - 2009



SLR and GLONASS agree very well!
No Bias and Residual RMS below 40 mm.

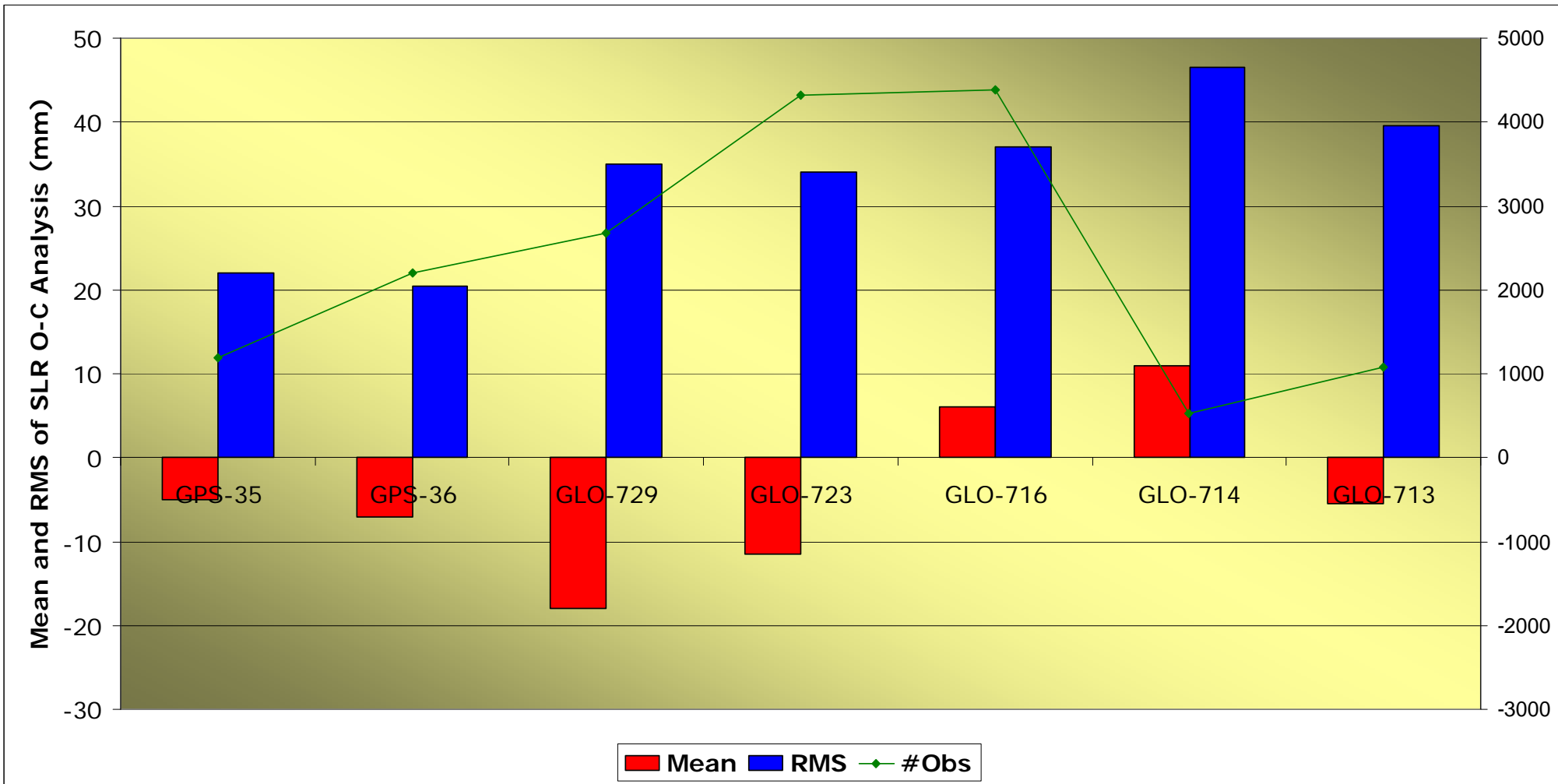
Combined GNSS and SLR Processing Initial Validation



- First step: Combined GNSS and SLR(GNSS) solutions
 - Start with ESOC GNSS Final (re)processing
 - Daily solutions: GNSS
 - Validate orbits using SLR(GNSS) observations
 - Add SLR data of the GNSS targets (excluding data during eclipse season)
 - Daily solutions: GNSS + SLR(GNSS)
 - SLR station coordinates fixed and no station specific biases
- Second step: SLR(L2E2) solutions
 - SLR solutions based on Lageos-1 and -2 and Etalon-1 and -2
 - Weekly solutions: SLR(L2E2)
- Third step: Analyze and Compare the results
 - Residual statistics, SLR station specific biases, Station coordinates
- Timeframe used:
 - 35 weeks, from 28/12/2008 – 29/8/2009
 - GPS weeks 1512 – 1546
 - 245 days

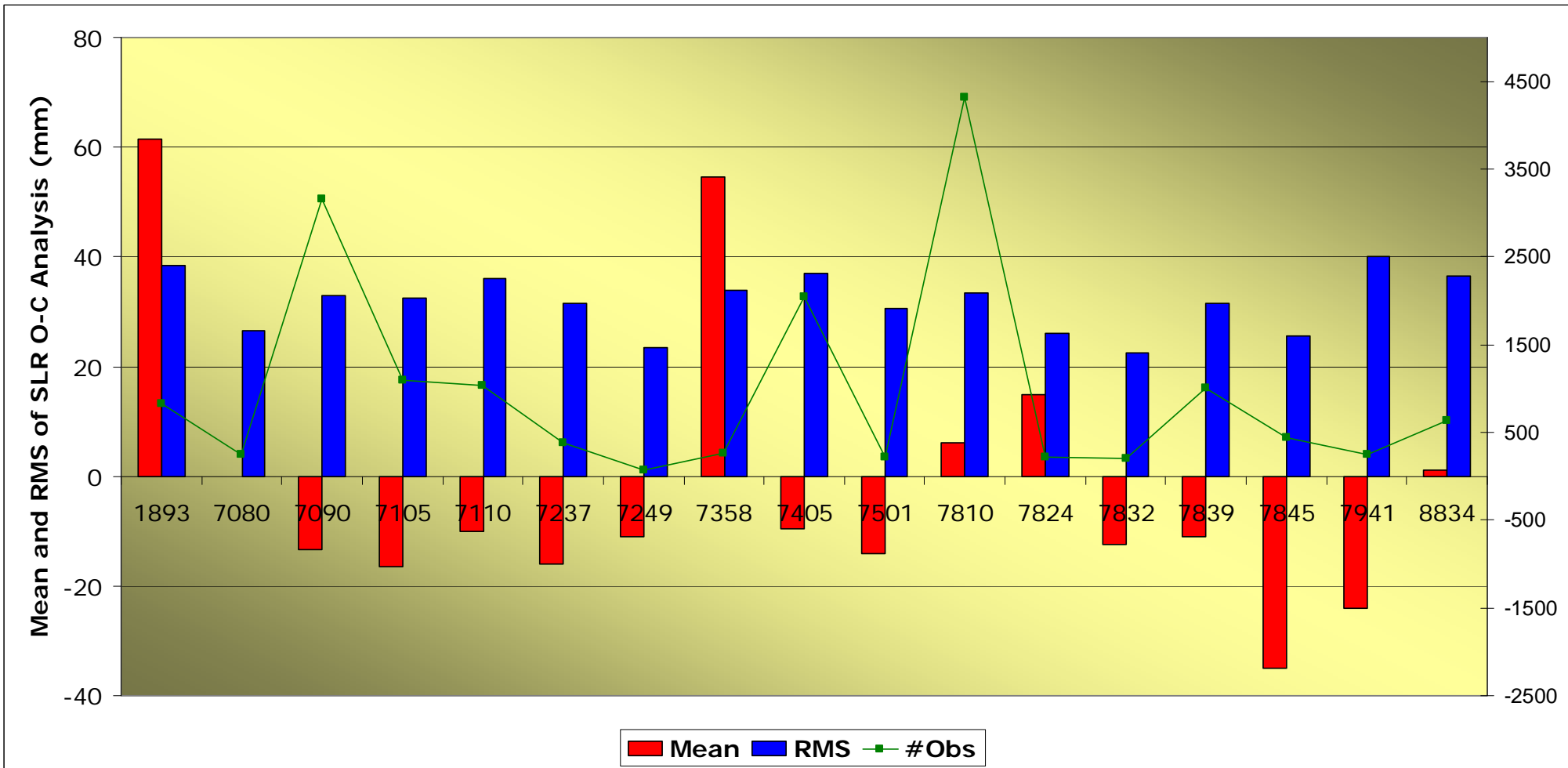
**Main goal:
Initial Validation of Combined Processing**

SLR Observed – Computed Statistics GNSS OMC for GNSS Satellites



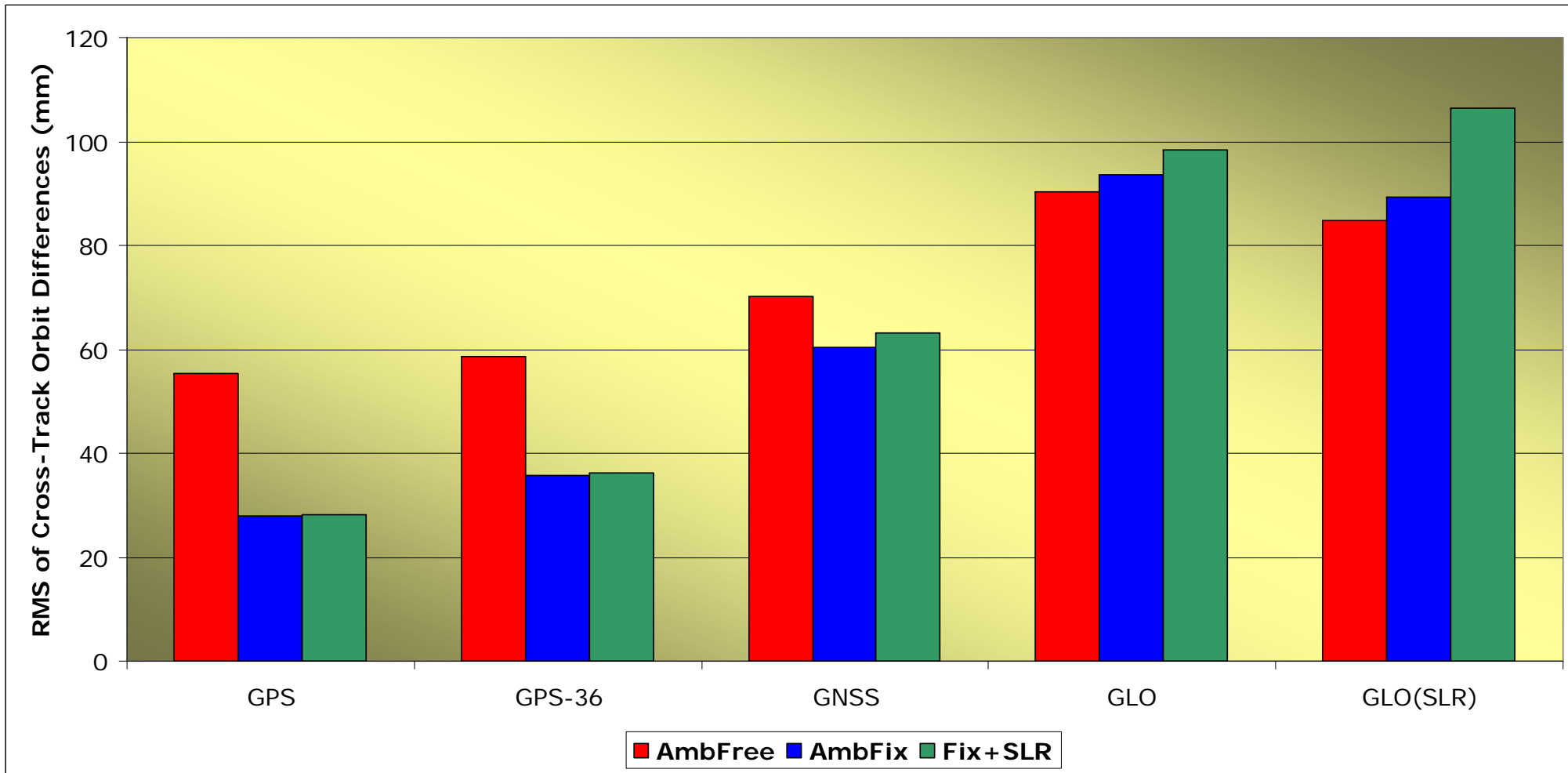
Small bias and small RMS for GPS satellites
Significant bias differences for GLONASS

SLR Observed – Computed Statistics GNSS OMC for SLR Stations



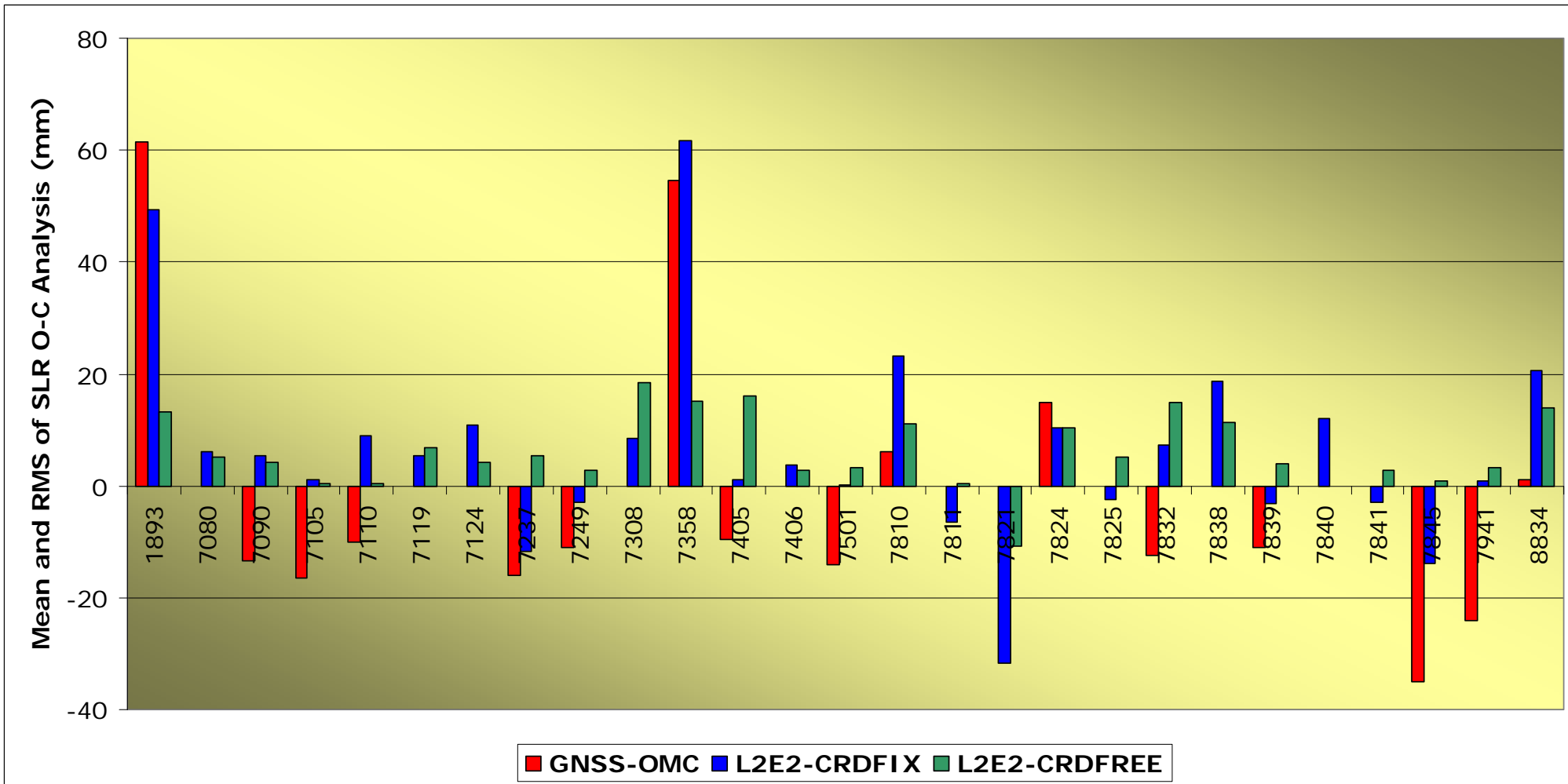
Some clear station biases.
Small Mean Bias seems to be Present

GNSS Orbit Overlap (cross-track) Ambiguity Resolution and SLR(GNSS)



**Addition of SLR(GNSS) measurements does not help!
Coordinates and/or Bias Issues?**

SLR Station Specific Range Biases GNSS OMC and SLR(L2E2)



Good agreement for large biases (coordinate issues?)!
SLR(L2E2) biases mostly positive, GNSS OMC biases negative

GNSS SLR Initial Validation Summary



- SLR observations from GPS satellites:
 - Very small bias ~6mm
 - Small RMS ~21mm
- SLR observations from GLONASS satellites:
 - Biases are at the +/- 20mm level, but...
 - ...the biases differ significantly from satellite to satellite
 - The RMS is well below the 40mm level
- SLR issues
 - Data from the GNSS targets is not enough to get accurate SLR station positions
 - Some SLR station coordinates may be off (datum problem in 2009)
 - Significant station specific biases seem to exist
 - Biases causes a change of the terrestrial reference frame scale ~1ppb!!
- For the combination of GNSS and SLR observations we need to:
 - Estimate the SLR station coordinates
 - Estimate SLR station specific biases (but not for all stations)

Combined GNSS and SLR Processing

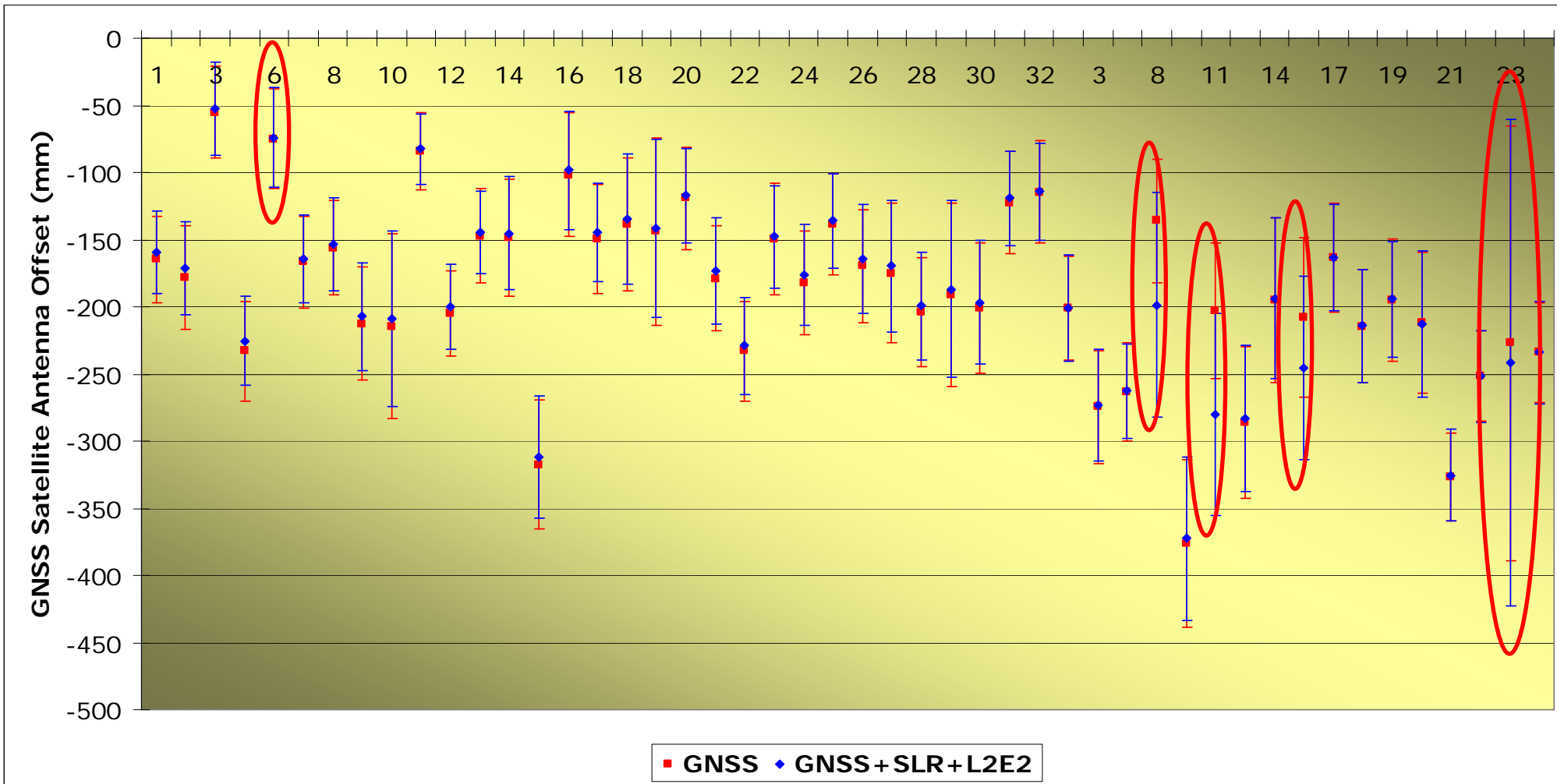
Full combination using “Space-Ties”



- Generate three different weekly solution series
 - 1) GNSS
 - 2) GNSS + SLR(GNSS)
 - 3) GNSS + SLR(GNSS) + SLR(L2E2)
- Parameters in the NEQ system:
 - Reference Frame: Station coordinates and EOP parameters (but no UT)
 - GNSS Satellite Antenna Phase Centre Offsets
 - SLR station specific biases
- Common Parameters
 - ALL 3: Earth Rotation Parameters (5 per day, no UT)
 - SOL 1, 2: GNSS satellite orbit parameters
 - SOL 2, 3: SLR station coordinates
 - SOL 2, 3: SLR station specific range biases

Main goal:
Direct estimation of the GNSS Satellite Phase Centre Offsets!

GNSS Satellite Antenna Offset Relative to current IGS05.atx values



GNSS alone seems to work!?

Addition of SLR does have a negative effect on GLONASS!

- Small bias remains between SLR and GNSS
- Satellite specific biases for the GLONASS satellites!?
- Some station specific biases in SLR observations
- Combination of GNSS and SLR will allow
 - Determination of “unified” reference frame
 - Absolute estimation of GNSS satellite antenna offsets
 - Better estimation of SLR station biases
- Next steps
 - Remove unnecessary SLR station biases and redo analysis
 - Detailed look at GLONASS specific satellite biases
 - Add local site tie information to combination
 - Redo daily solutions with proper SLR coordinates and biases

THANK YOU

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