

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

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Why use Space Ties!?



- GNSS could do scale but...
 - GNSS satellite phase center offsets (PCO) and
 - GNSS satellite phase centre variations (PCV) not known
- To estimate these, especially PCV, we have to adopt the (or 'a') terrestrial scale.
 - Procedure used for IGS05 satellite PCO/PCV:
 - Use scale from ITRF2000, i.e., use the coordinates of the GPS stations as given in ITRF2000 and apply a 'no not scale' condition.
 - Scale was determined by SLR
 - GPS scale derived by using local ties between SLR and GPS stations
 - And indirectly also through local ties between VLBI and GPS
- Main Issues
 - ITRF2000 SLR scale may have been wrong
 - Local ties may have introduced (additional) scale errors for GPS
 - Inhomogeneous SLR and local tie network may have caused additional scale distortions

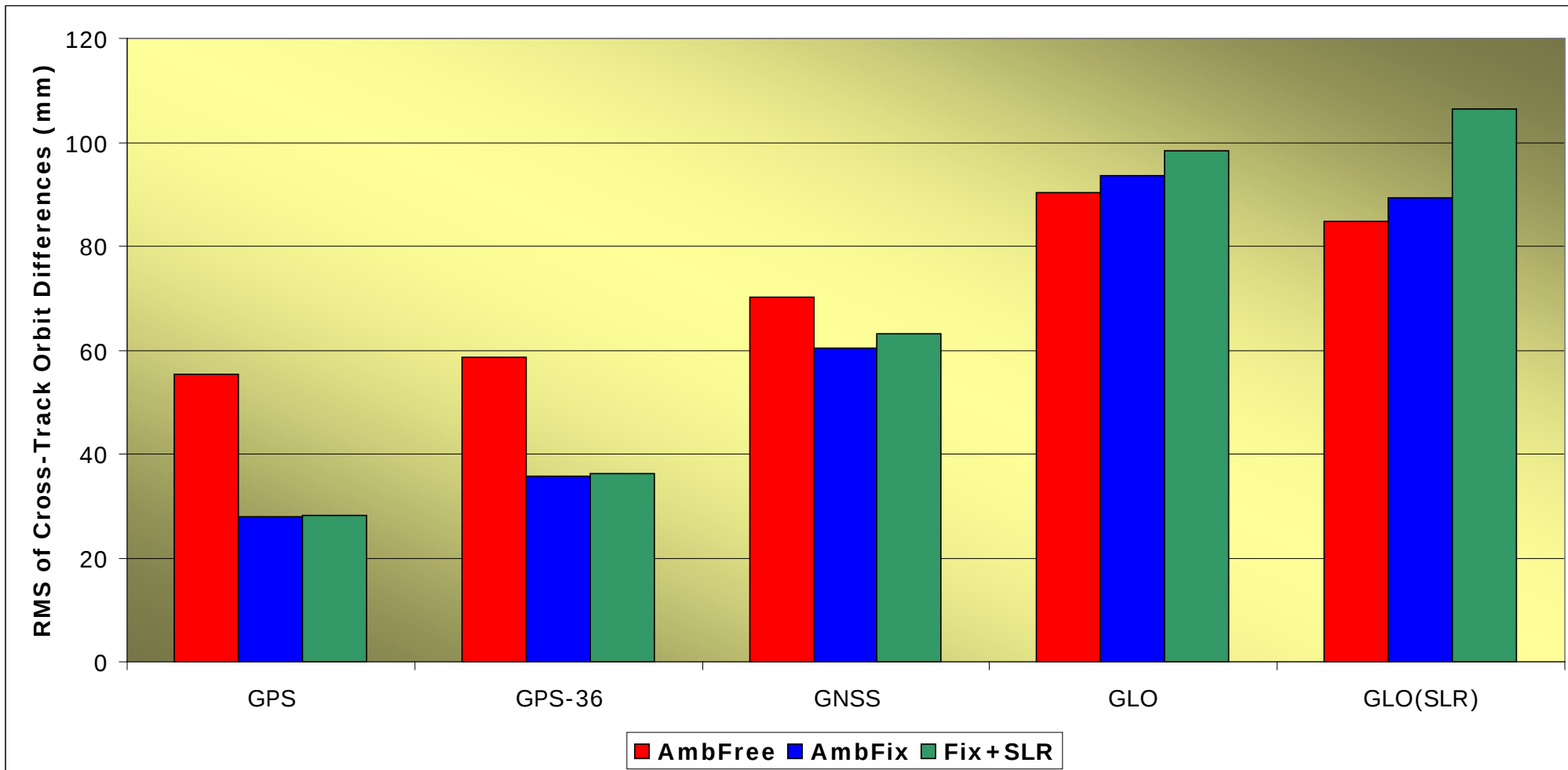
**Main goal with Space Ties:
Directly derive GNSS satellite PCO and PCV**

SLR Observed – Computed Statistics GNSS OMC for GNSS Satellites



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

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



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

- SLR observations from GPS satellites:
 - Very small bias $\sim 6\text{mm}$
 - Small RMS $\sim 20\text{mm}$
- SLR observations from GLONASS satellites:
 - Biases are at the $\pm 20\text{mm}$ level, but...
 - ...the biases differ significantly from satellite to satellite
 - The RMS is at the 40mm level

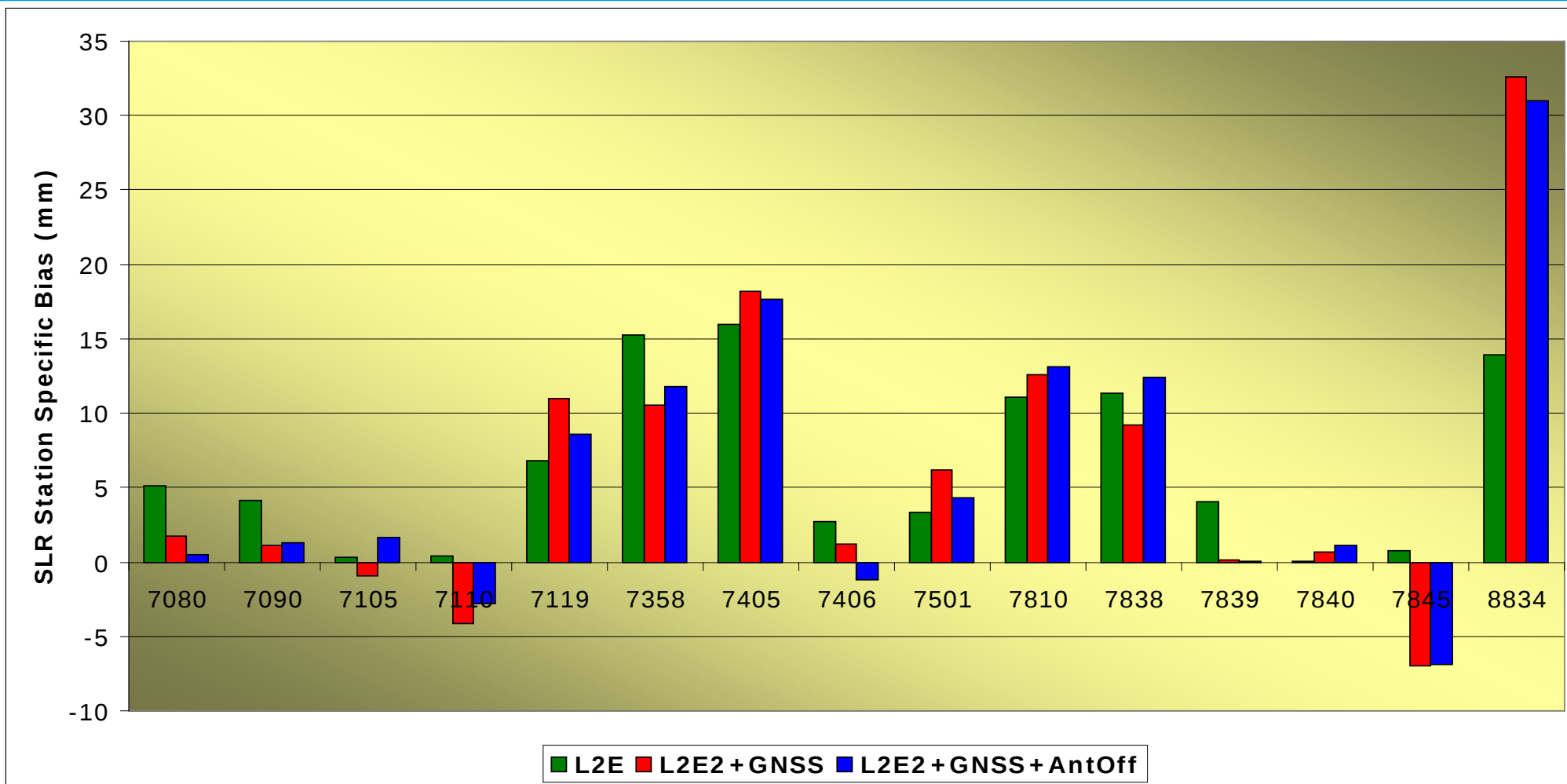
SLR(GNSS) Combination issues

- 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 $\sim 1\text{ppb}$

For the combination of GNSS and SLR observations we need to:

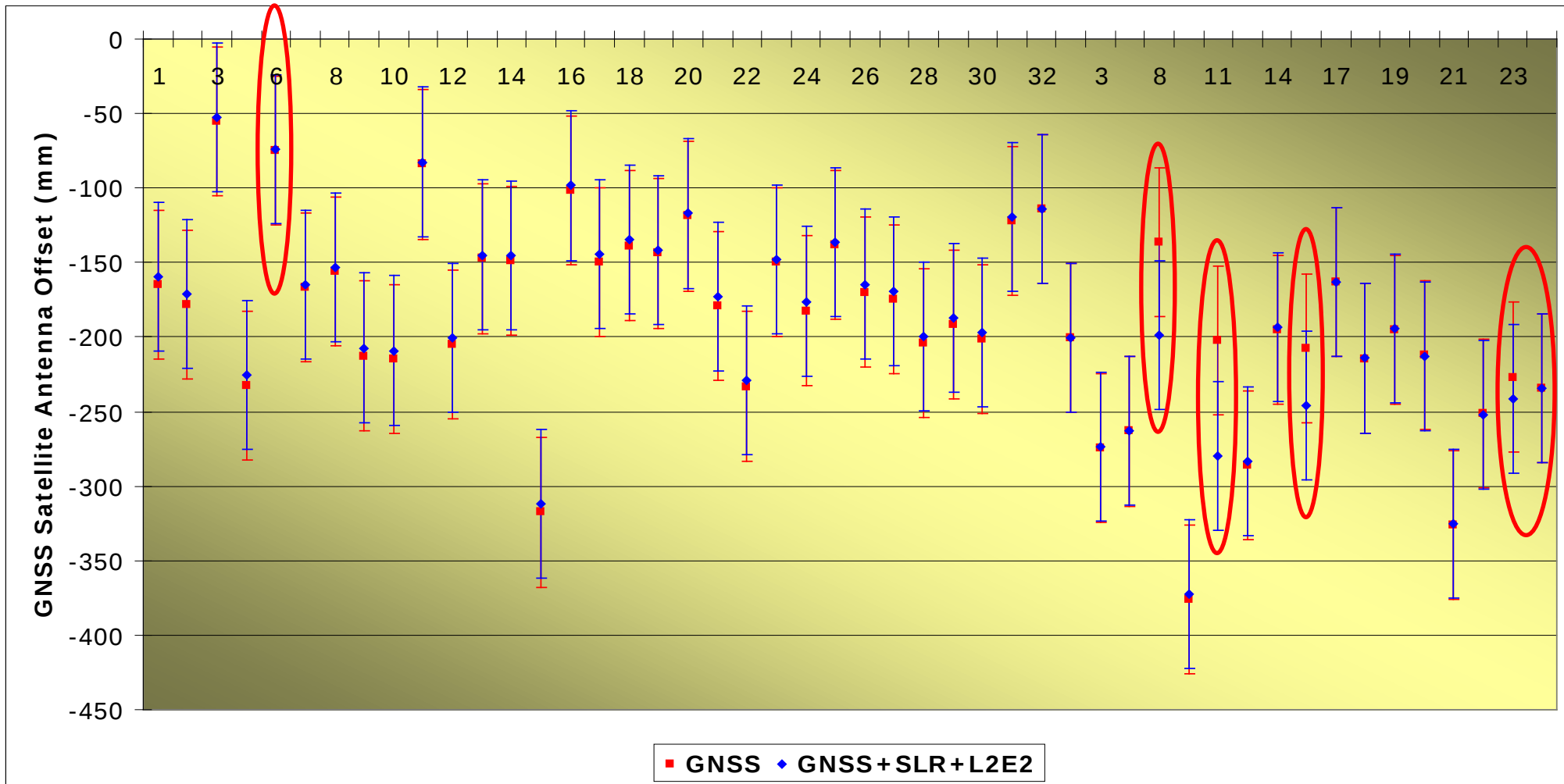
- Estimate the SLR station coordinates
- Estimate SLR station specific biases (but not for all stations)
 - Consequently: add SLR data from Lageos and Etalon!

SLR Station Specific Range Biases GNSS + SLR(GNSS) + SLR(L2E2)



**Combination of GNSS and SLR works.
Biases in good agreement. Some significant GNSS influence visible**

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
 - Compare local site ties to obtained results
 - Add local site tie information to combination
 - Redo daily solutions with proper SLR coordinates and biases