

GNSS satellites as co-locations for a combined GNSS and SLR analysis

D. Thaller ¹⁾, K. Sośnica ¹⁾, R. Dach ¹⁾, A. Jäggi ¹⁾,
M. Mareyen ²⁾, B. Richter ²⁾, G. Beutler ¹⁾

(1) Astronomical Institute, University of Bern (AIUB), Switzerland

(2) Bundesamt für Kartographie und Geodäsie (BKG), Frankfurt / Main, Germany

Overview

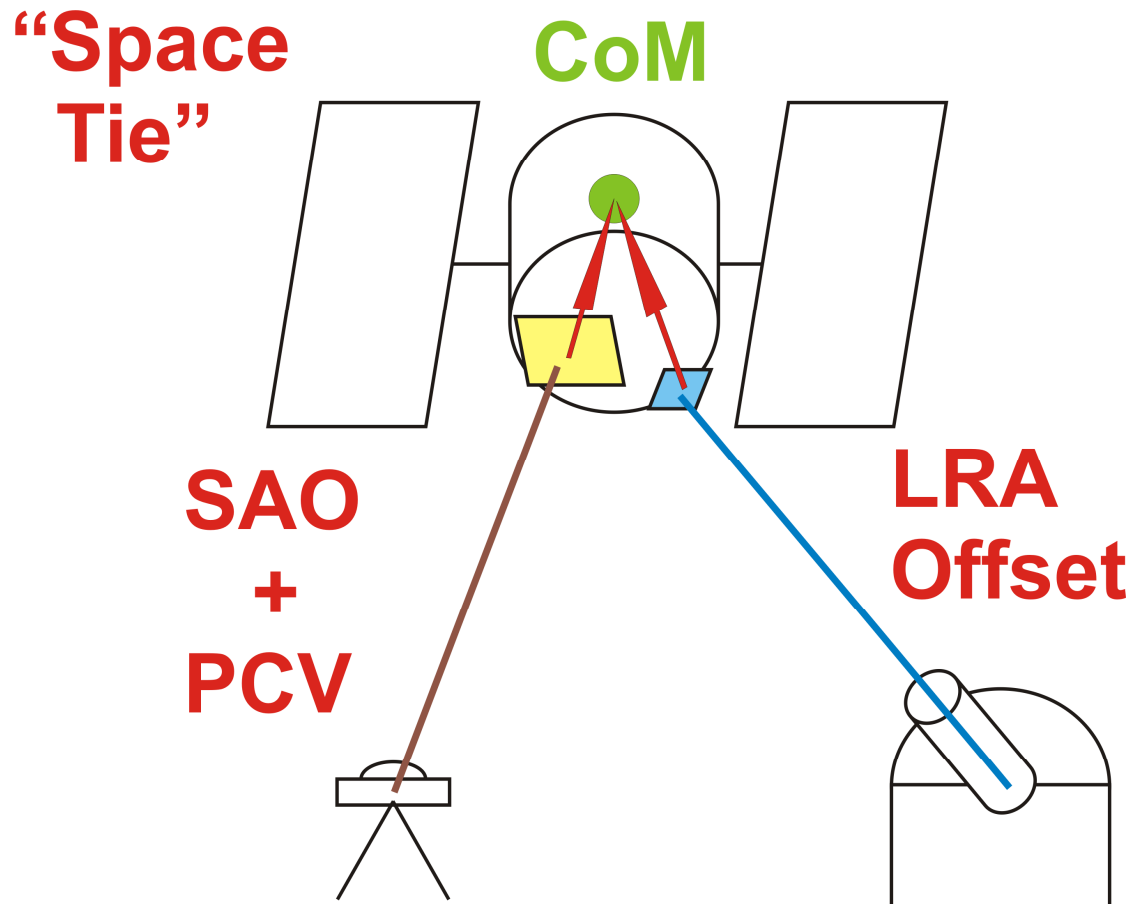
1. **Satellite co-location** of GNSS and SLR
2. **Results** from combining GNSS microwave data and SLR data to GNSS satellites, Lageos and Etalon:
 - GNSS-SLR „range“ bias parameters
 - Offsets of Laser Reflector Array (LRA)
 - GNSS Satellite Antenna Offsets (SAO)
3. **Conclusions**

Co-locations for GNSS and SLR

Co-location at GNSS satellites = Transmitting point for GNSS
Reflecting point for SLR (target)

⇒ **Estimation of common orbit parameters**

⇒ **Vectors** of GNSS and SLR reference points **w.r.t. satellite CoM** needed



Space Tie =

Microwave part:

- Antenna Offsets (**SAO**) w.r.t. CoM
- Phase Center Variations (**PCV**)

SLR part:

Offsets for Laser Retroreflector Array (**LRA**) w.r.t. CoM

Combined GNSS-SLR analysis

Combined analysis:

GNSS microwave data

+ **SLR** range data **to GNSS** satellites (GPS, GLONASS)

+ **SLR** observations to **Lageos, Etalon**

(→ stable station coordinates; no range biases for most stations)

Bernese Software for **microwave** and **SLR** data analysis

GNSS satellites: **1-day** orbital arcs

Lageos, Etalon: **7-day** orbital arcs

Time span of observations considered: **2006.0 – 2011.0**

→ 5 years of data

→ Generating a multi-year solution

→ NNR+NNT condition for GNSS sub-network w.r.t. IGS05

→ no Local Ties applied (only satellite co-location used)

Solutions to be tested

	<i>Solution 1</i>	<i>Solution 2</i>	<i>Solution 3</i>	<i>Solution 4</i>
<i>GNSS-SLR "range" bias</i>	1 parameter per station estimated	1 parameter per station estimated	1 parameter per station estimated	1 parameter per station estimated
<i>LRA offset</i>	fixed	correction for z -component estimated	fixed	correction for z- component estimated
<i>Microwave SAO</i>	fixed	fixed	correction for z -component estimated	correction for z -component estimated



⇒ all GNSS-SLR discrepancies
might show up in
„range“ bias parameters

Solutions to be tested

	<i>Solution 1</i>	<i>Solution 2</i>	<i>Solution 3</i>	<i>Solution 4</i>
<i>GNSS-SLR "range" bias</i>	1 parameter per station estimated	1 parameter per station estimated	1 parameter per station estimated	1 parameter per station estimated
<i>LRA offset</i>	fixed	correction for z -component estimated	fixed	correction for z- component estimated
<i>Microwave SAO</i>	fixed	fixed	correction for z -component estimated	correction for z -component estimated



**⇒ SAO errors might
show up in
SLR-related parameters**

Solutions to be tested

	<i>Solution 1</i>	<i>Solution 2</i>	<i>Solution 3</i>	<i>Solution 4</i>
<i>GNSS-SLR "range" bias</i>	1 parameter per station estimated	1 parameter per station estimated	1 parameter per station estimated	1 parameter per station estimated
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⇒ **LRA errors
might show up in
“range “ bias parameters**

Solutions to be tested

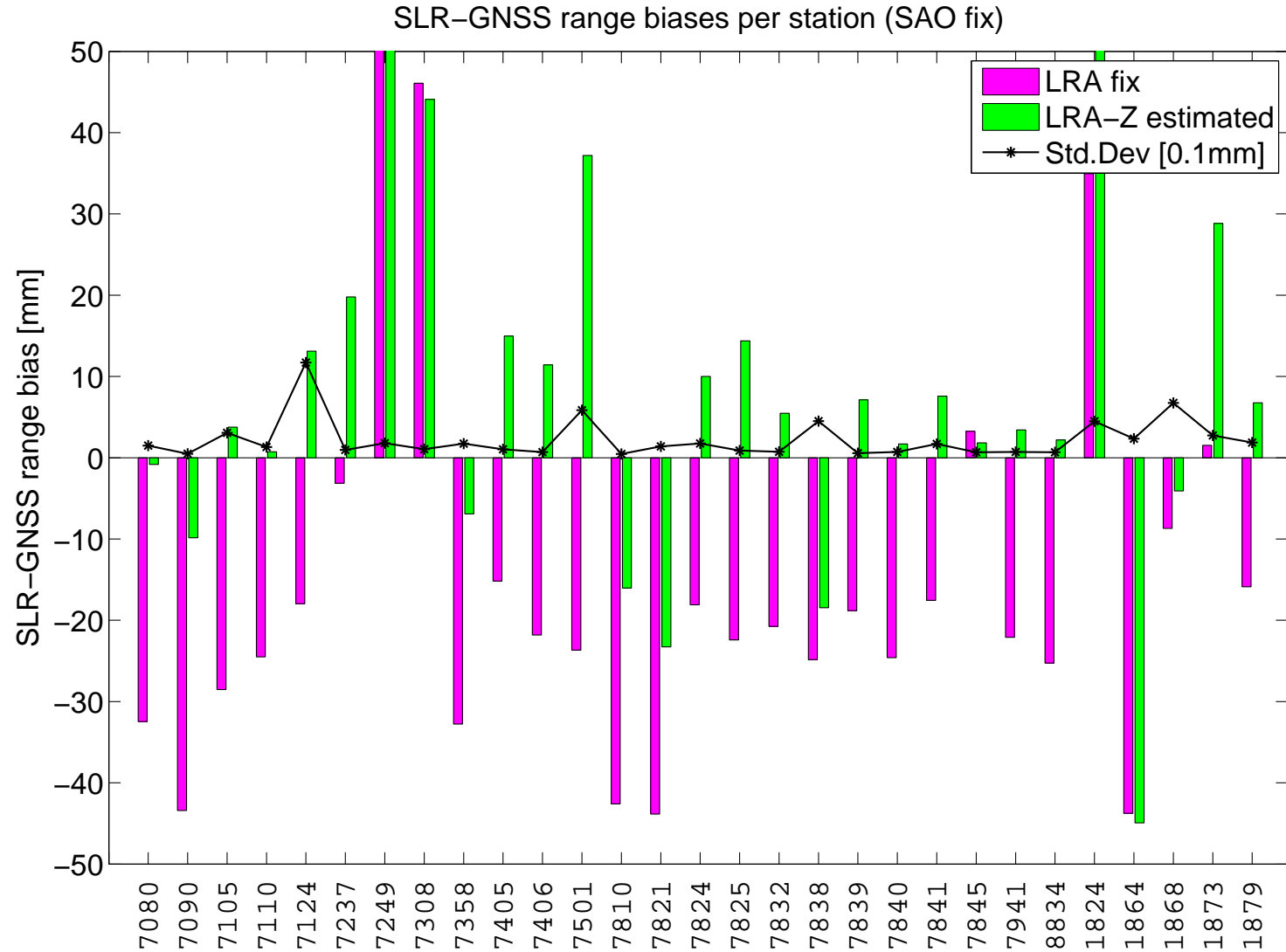
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⇒ Parameters for all error sources estimated separately.
BUT: Correlations?

SLR-GNSS „range“ biases

Microwave
SAO
fixed

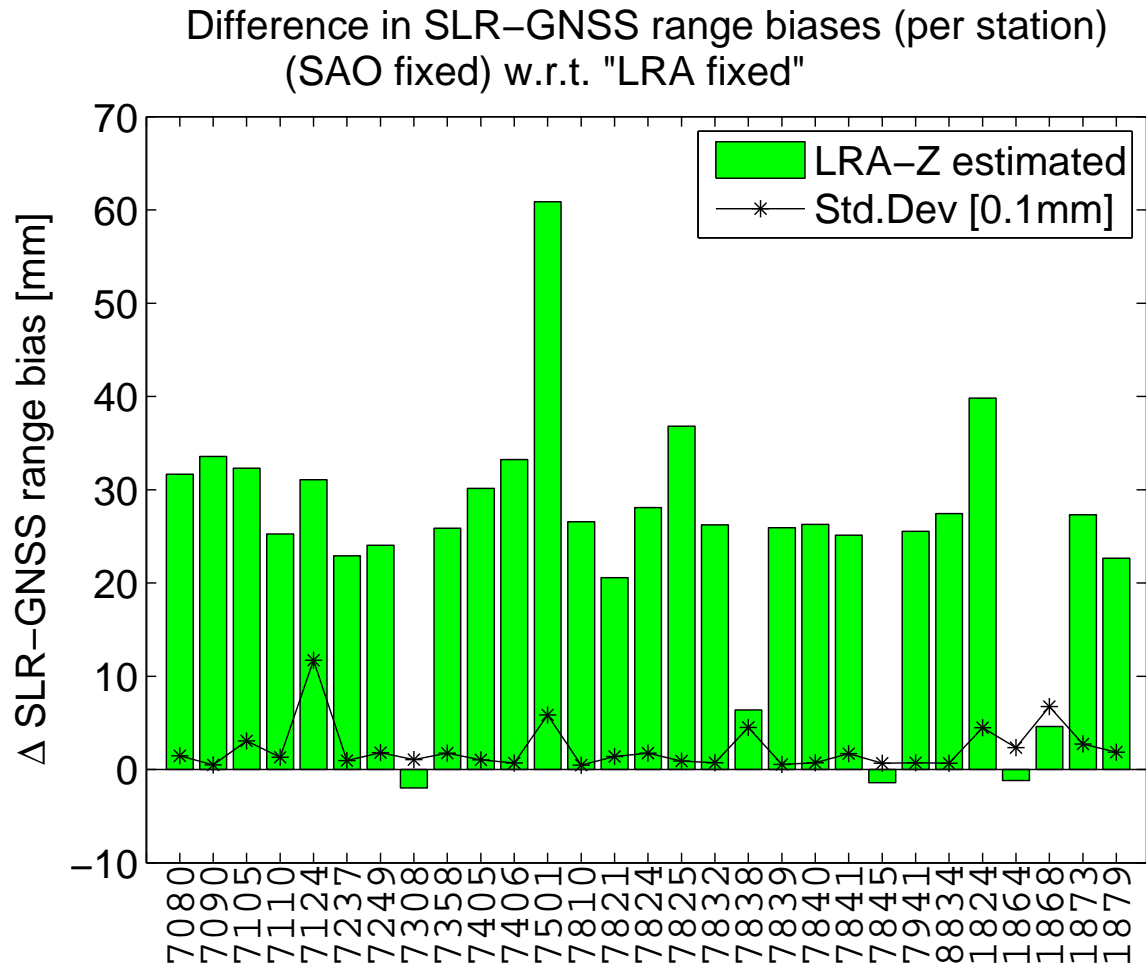


Common estimation of: LRA Offset (z -direction)
GNSS-SLR „range“ biases



- Smaller „range“ biases
- Less systematic

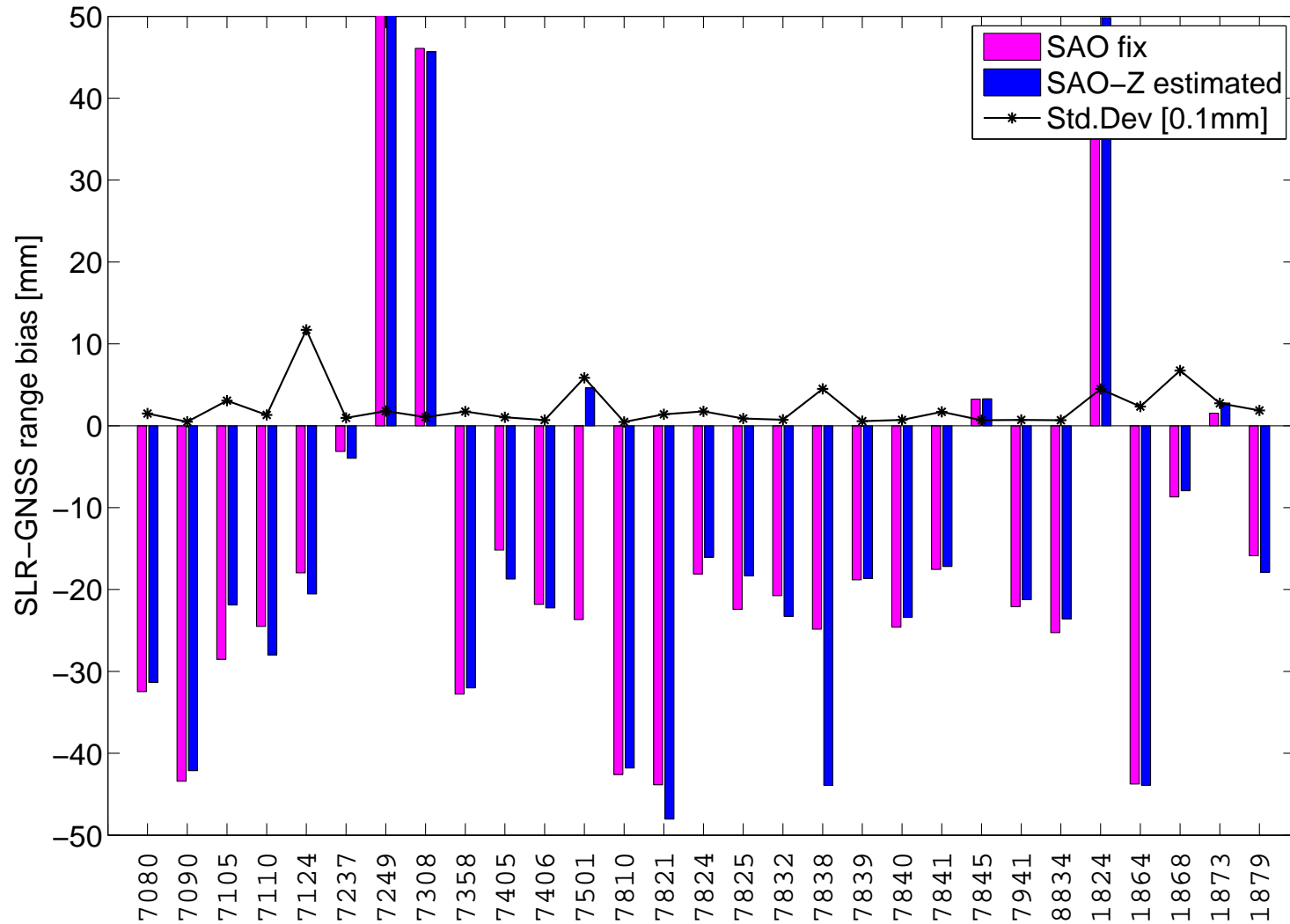
SLR-GNSS „range“ biases



GNSS-SLR bias is rather an LRA offset than an SLR range bias:
Approx. 25 mm

SLR-GNSS „range“ biases

SLR-GNSS range biases per station (LRA fix)

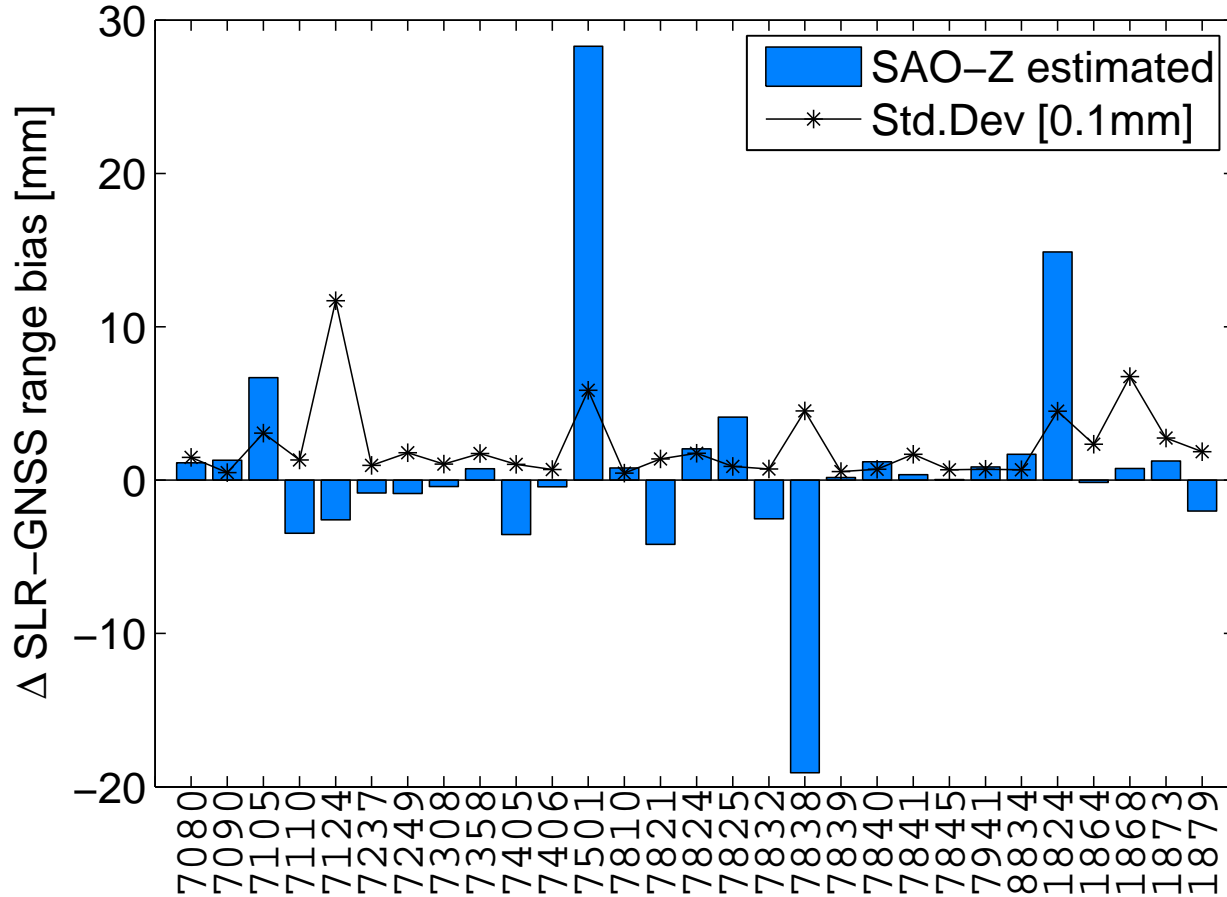


LRA
offsets
fixed

Common estimation of: GNSS Satellite Antenna Offset (z-direction)
GNSS-SLR „range“ bias parameters

SLR-GNSS „range“ biases

Difference in SLR-GNSS range biases (per station)
(LRA fixed) w.r.t. "SAO fixed"



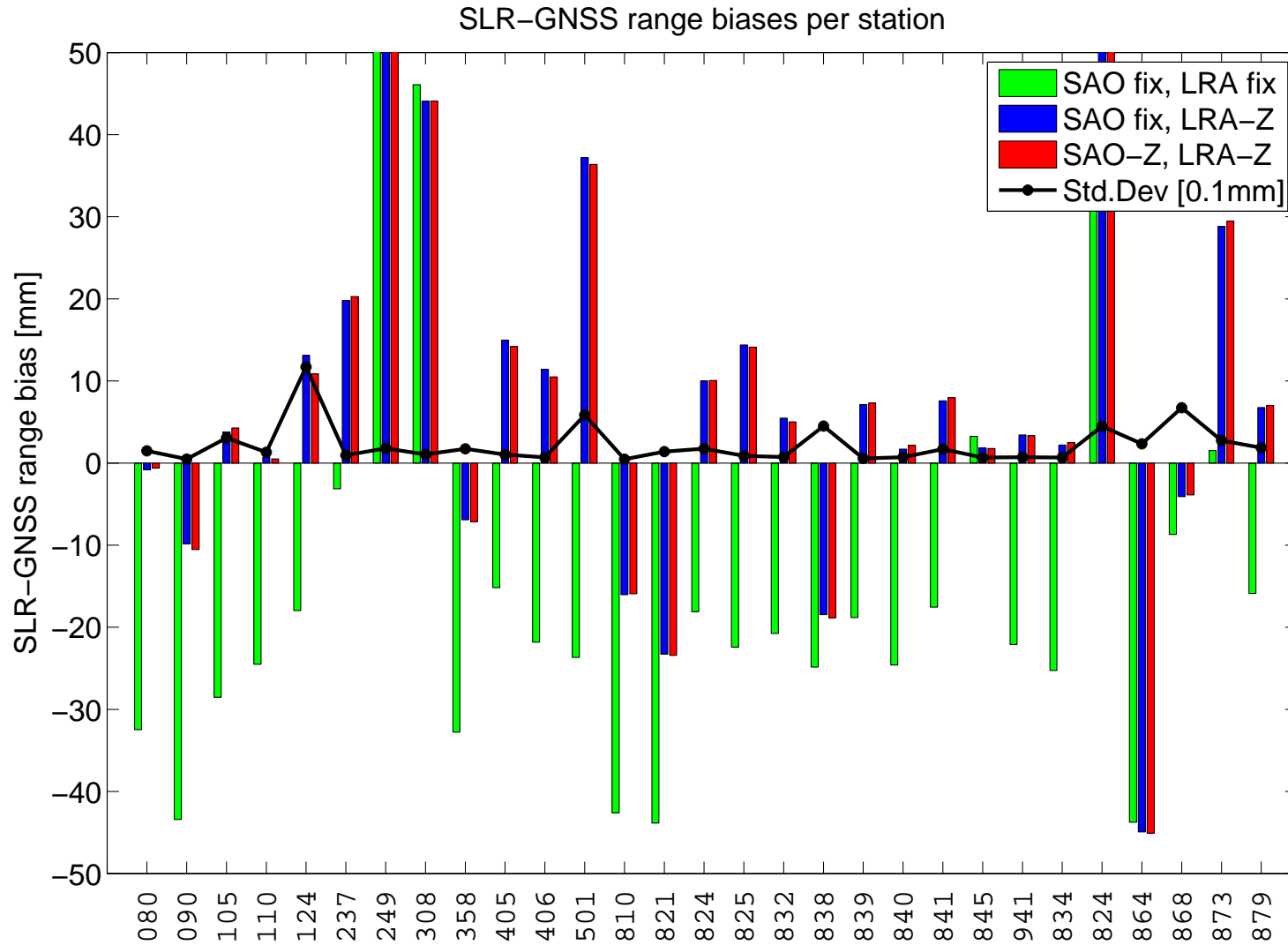
Mean diff. = 0.9 mm
Median diff. = 0.4 mm

Common estimation of: GNSS Satellite Antenna Offset (z-direction)
GNSS-SLR „range“ bias parameters

⇒ **Is possible**

⇒ errors in SAO do not map into SLR range bias parameters

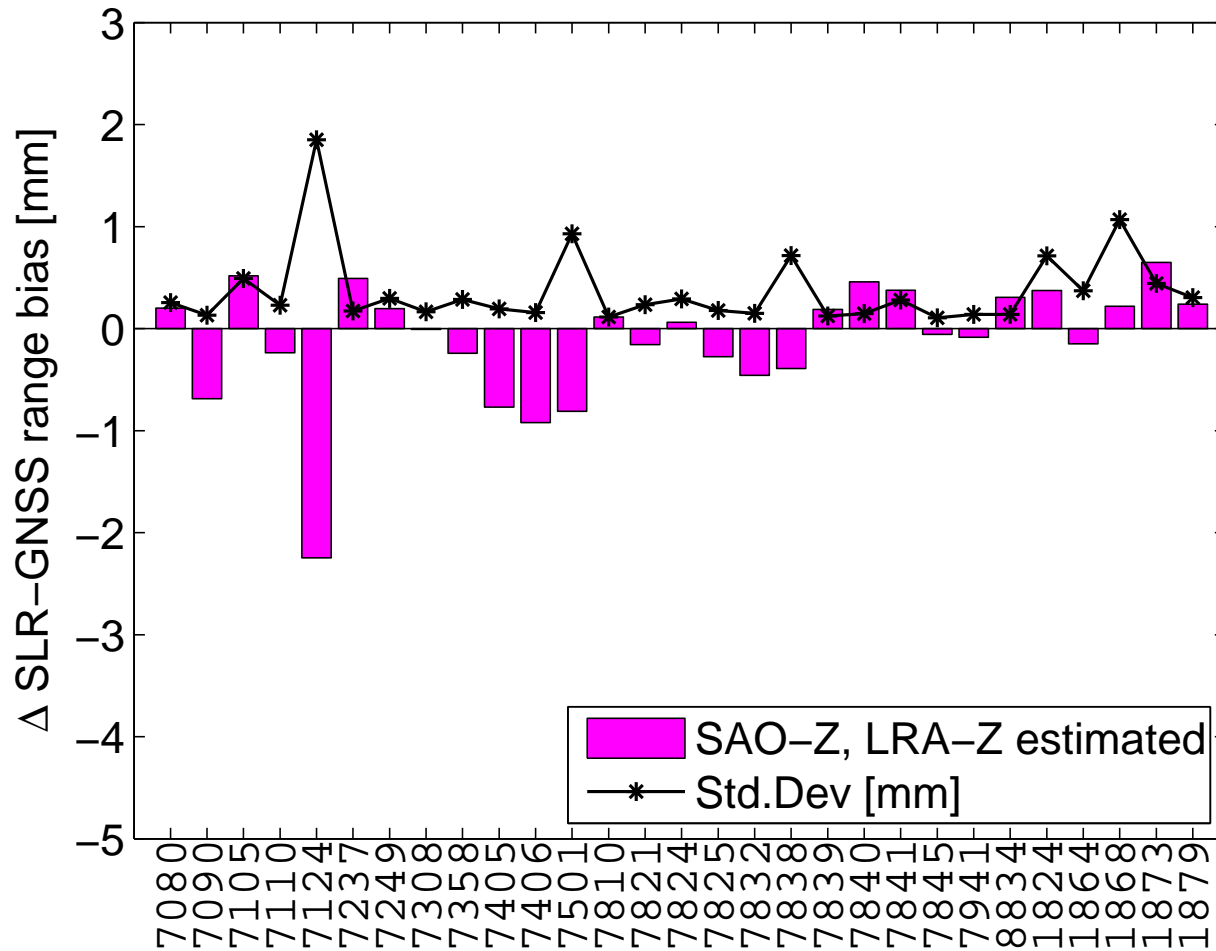
SLR-GNSS „range“ biases



Common estimation of: GNSS Satellite Antenna Offset (z -direction)
LRA offset (z -direction)
GNSS-SLR **range** biases

SLR-GNSS „range“ biases

Difference in SLR-GNSS range biases per station
w.r.t. "SAO fixed, LRA-Z estimated"

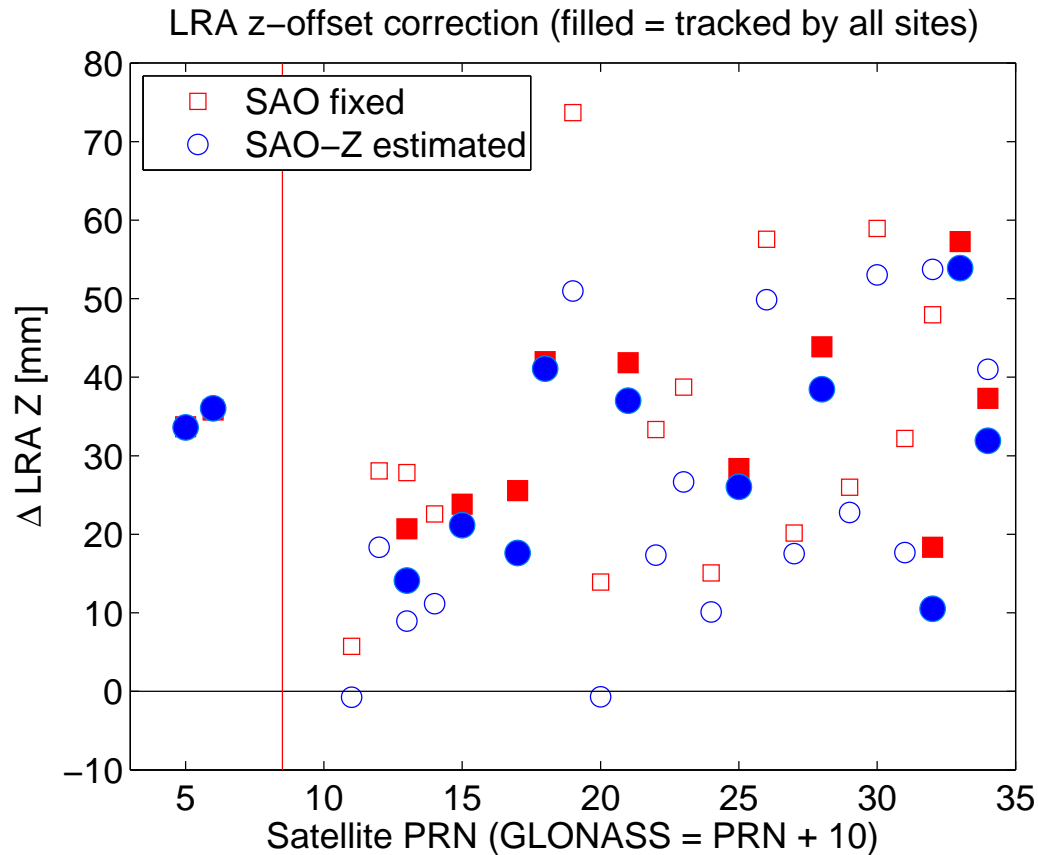


Mean diff. = 0.1 mm
Median diff. = 0.0 mm

Common estimation of: GNSS Satellite Antenna Offset (z-direction)
LRA offset (z-direction)
GNSS-SLR range biases

Feasible!

LRA offset corrections



Filled signatures:

Satellites **tracked by all SLR sites**

Others:

Satellites tracked only by

Herstmonceux (since Dec. 2009)

Mean correction:

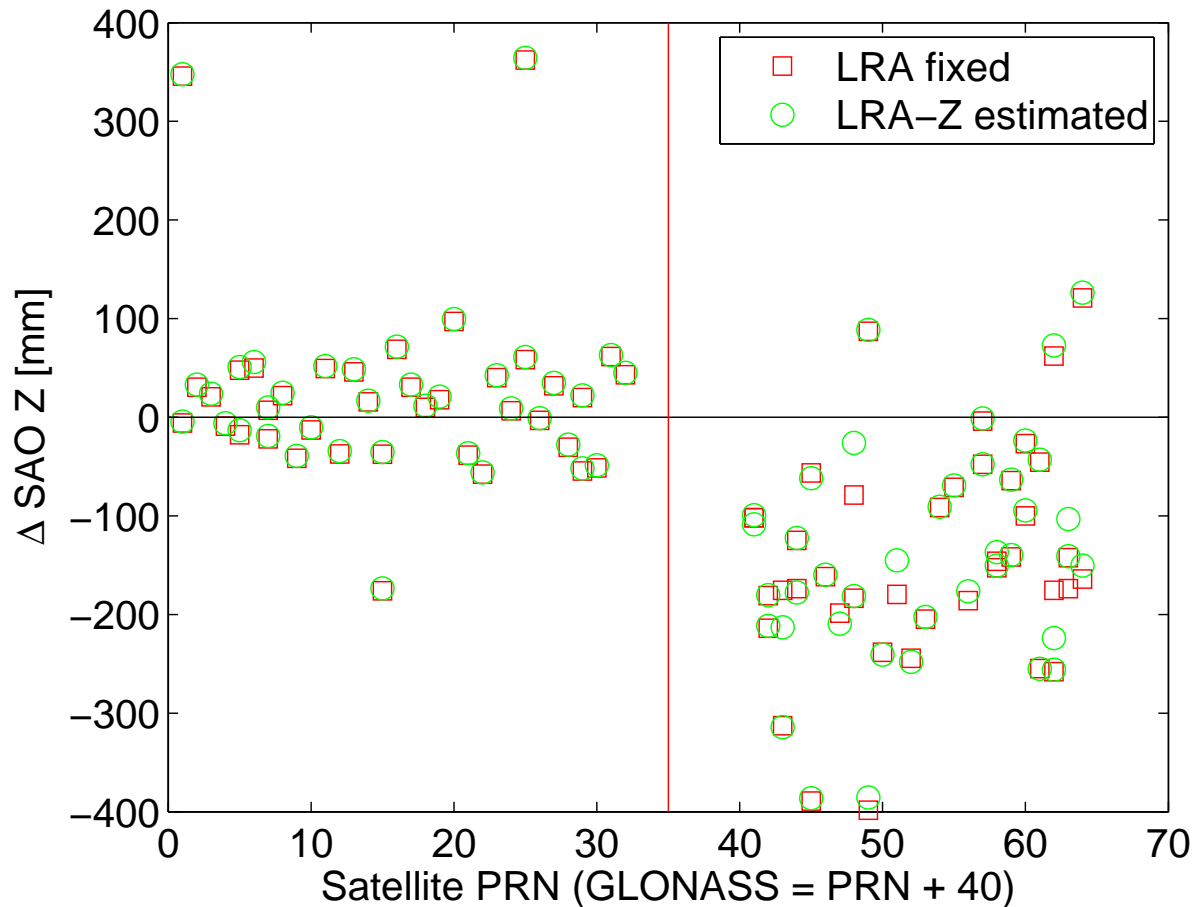
	GPS	GLONASS
SAO fixed	34.76 mm	33.56 mm
SAO-Z estimated	34.83 mm	26.52 mm
⇒ Difference	0.06 mm	7.04 mm

⇒ Significant corrections to LRA offsets

⇒ Common estimation with SAO corrections is possible

GNSS SAO corrections

Satellite antenna offset correction: Z component



⇒ Significant corrections to SAO of igs05.atx
 ⇒ Common estimation with LRA corrections is possible

Mean correction:

LRA fixed
LRA-Z estimated

GPS
 23.34 mm
 25.93 mm

GLONASS
 -142.35 mm
 -138.80 mm

⇒ **Difference**

2.59 mm

3.55 mm

Conclusions

- Combination of *GNSS and SLR* using *satellite co-location* works properly
- Connection via „*space ties*“ is possible (without local ties)
BUT:
Accurate ties (in space and on sites) required for combination
- *Scale from SLR* can be transferred to GNSS
→ allows the estimation of GNSS satellite antenna offsets
- *GNSS SAOs* from *igs05.atx* do not fit to the *SLR scale*
- *LRA offsets* show significant discrepancies (*~35 mm*)
- *Separation* of SLR *range biases*, *LRA offsets* and *GNSS SAO* is feasible