The space tie between GNSS and SLR

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Overview

- Determination of LRA offsets from SLR data only:

    - «Zero estimation» for a new satellite

- LRA offsets estimated from combined GNSS–SLR solutions:

    - Corrections to official values

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LRA offset estimated for a new satellite

➢ GLONASS–125 (GLONASS–K), launched February 2011

➢ First assumption: **LRA_0 = (0, 0, 0)**

SLR residuals for satellite R04 (LRA = 0)

Legend:
- 7090
- 7237
- 7308
- 7501
- 7810
- 7821
- 7839
- 7840
- 7941
- 8834

#Residuals = 306, Mean = –1394.2 mm, RMS = 112.5 mm
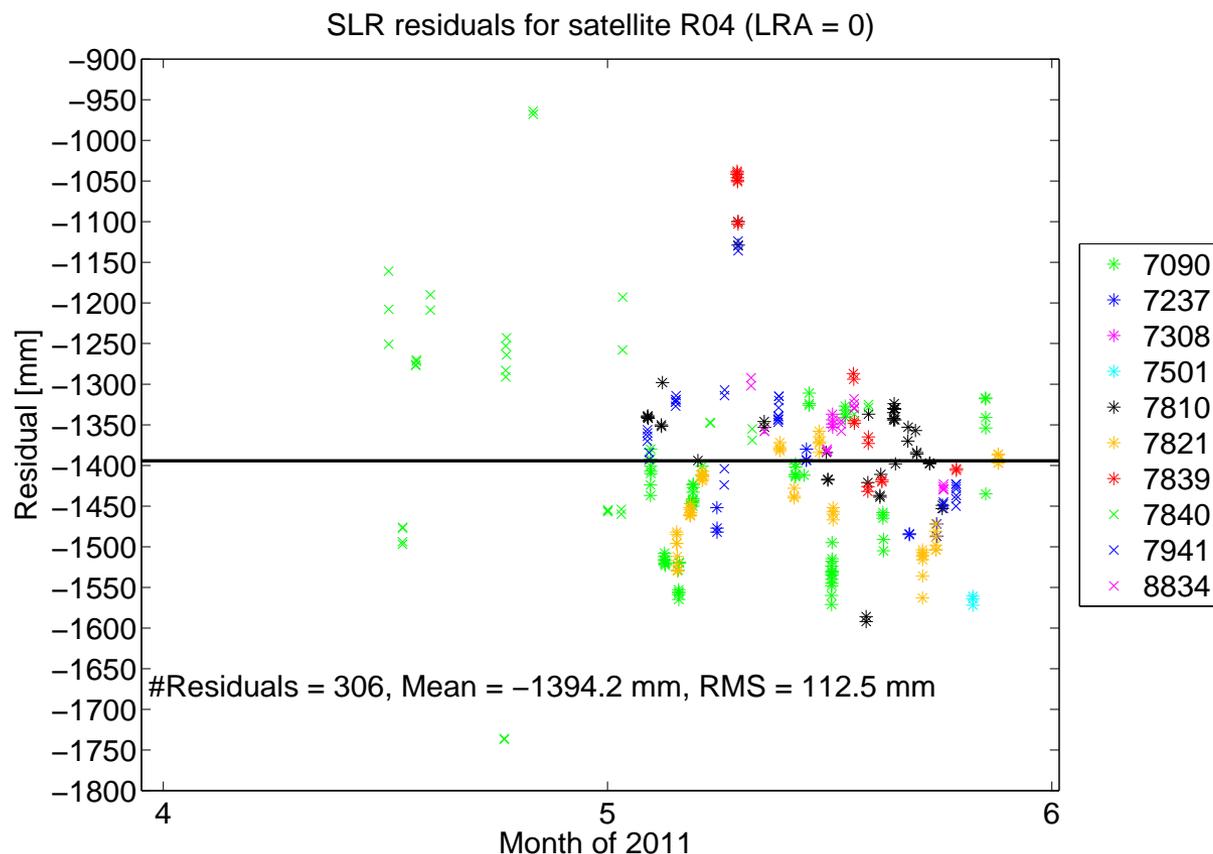
306 SLR NP; Mean residual w.r.t. microwave orbit:

–1394.2 mm

(RMS 112.5 mm)

Remark: Microwave antenna offset was not known accurately as well

LRA offset estimated for a new satellite

- ➤ Estimation based only on SLR data:
  - ➤ Orbit + ERPs fixed to microwave solution
  - ➤ Station coordinates fixed to SLRF2008
  - ➤ Assumption: No range biases

Solution 1: estimate offset for **z-direction** (nadir) only

Solution 2: estimate offset for **x-, y-, z-direction**

|	# NP	Z [mm]	Z [mm]	X [mm]	Y [mm]
May 30	306	1400 ±16.7	1393 ±19.6	−127 ±196.4	−85 ±140.6
June 5	383	1417 ±13.4	1402 ±16.8	−231 ±155.4	−30 ±117.9
June 12	494	1442 ± 4.9	1432 ± 5.9	−148 ± 51.5	−19 ± 42.5
June 21	577	1451 ± 5.4	1448 ± 6.7	−55 ± 59.1	81 ± 47.7

Official value for   90°: 1473.02 mm
75°: 1469.59 mm

LRA offset estimated for a new satellite

➢ SLR residuals using z–offsets for LRA:

Type 1: own estimated offset (1450.8 mm)

Type 2: official value (1471.3 mm)
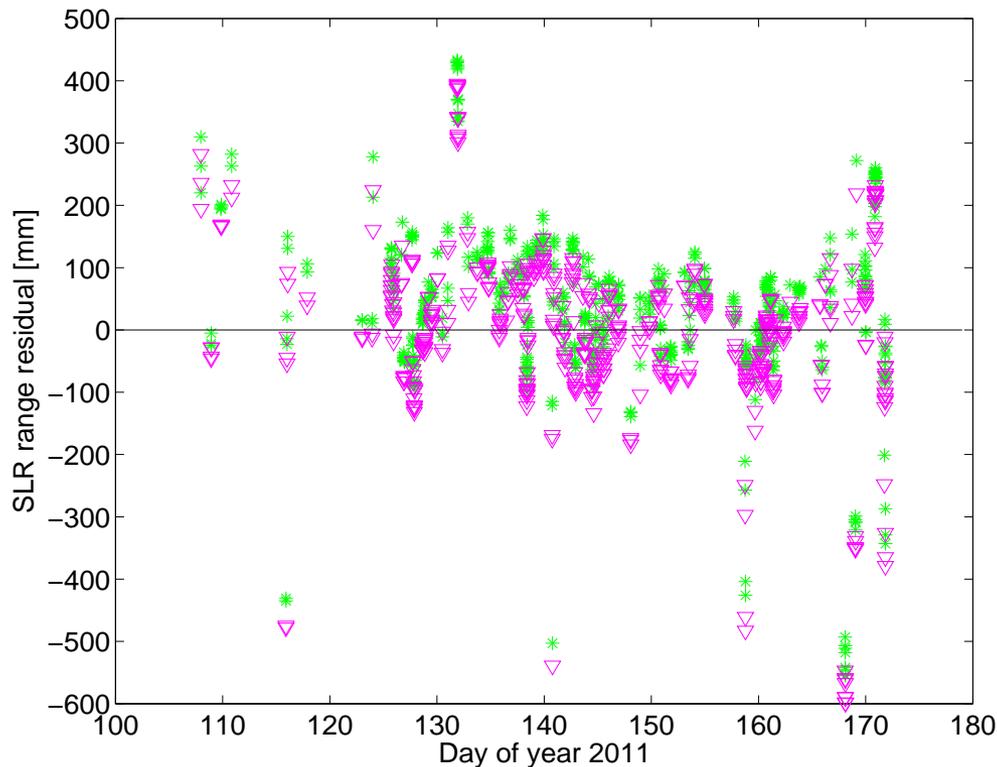

Mean Residual = –1.6 mm, RMS = 135.5 mm

Mean Residual = 37.1 mm, RMS = 133.5 mm

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# LRA offset estimated for a new satellite

Summary (part 1):

➢ LRA **Z-offsets** can be determined from SLR data

➢ Level of accuracy reached: **~ 2 cm**

➢ A **few hundreds of SLR NP** are needed

➢ **X-, Y-offsets** are more difficult to determine

➢ But: Estimation mainly depends on the **quality of the orbit** based on microwave data

➢ Estimation could be improved in a **fully combined GNSS-SLR analysis** (*see next part...*)

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Combined GNSS–SLR solutions
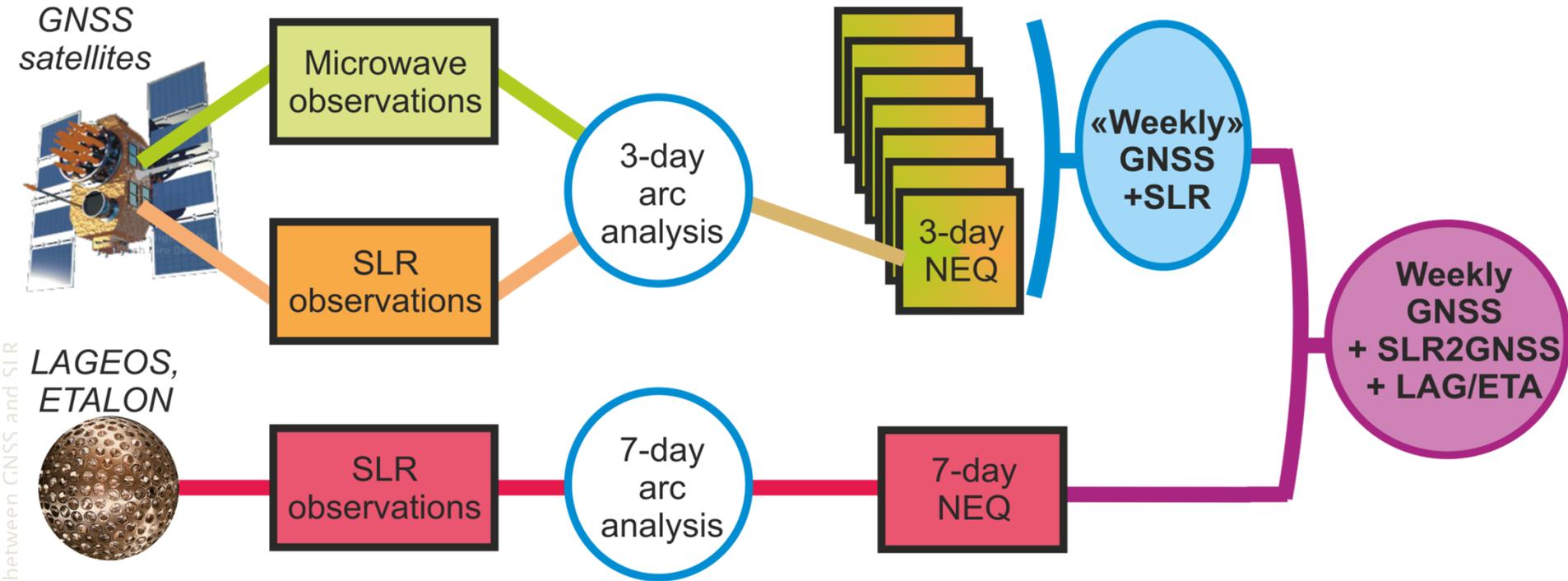
> ➤ Connection of SLR and GNSS at the GPS / GLONASS satellites („satellite co–location")

> ➤ No local ties applied

> ➤ 2000 – 2010
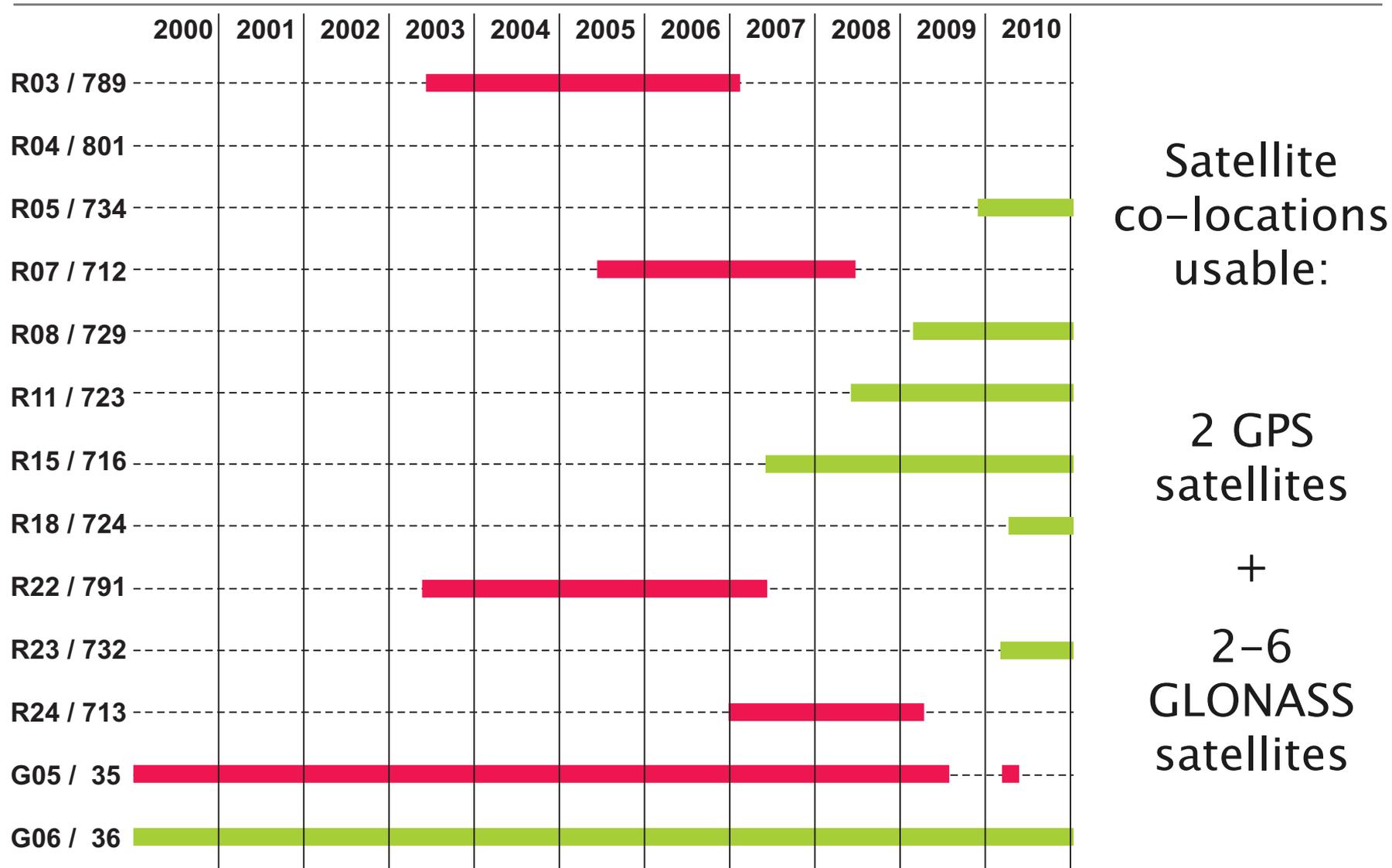
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Satellite co-location GPS / GLONASS

Satellite co-location GPS / GLONASS

Co-location at GNSS satellites =

Common orbit parameters from GNSS microwave and SLR range data

"Space Tie"

CoM

**SAO + PCV**

LRA Offset
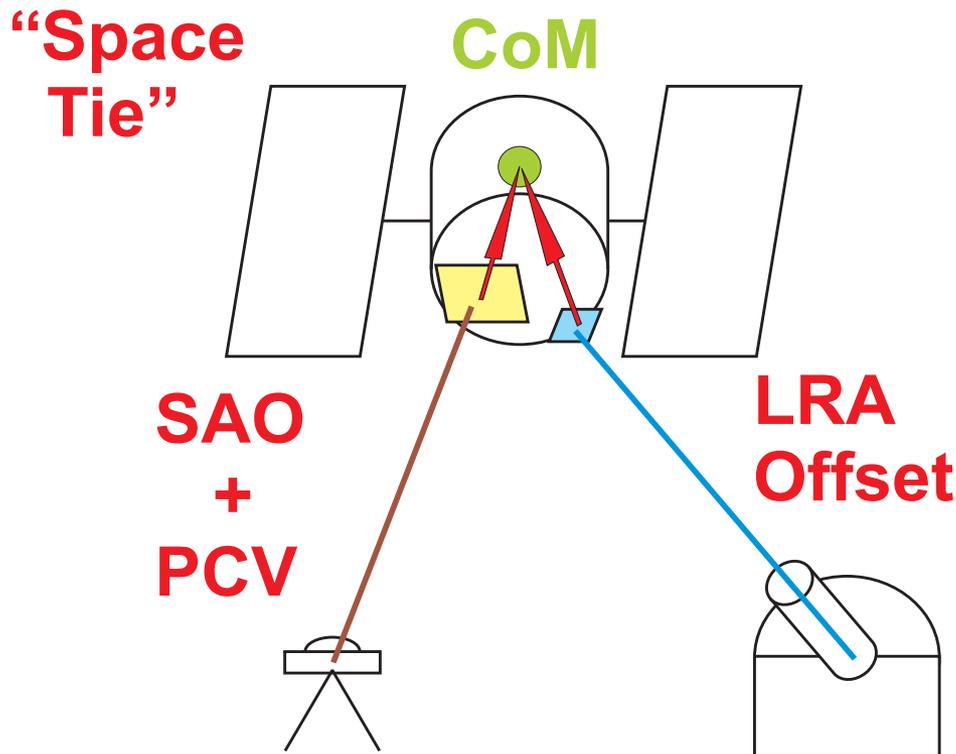
1) Microwave part:

Offset of microwave transmitting antenna (SAO)

2) SLR part:

Offset of laser retro-reflector array (LRA)

LRA estimated from multi–year solution

GNSS–SLR solution (A73_6)

Legend:
- □ SLR tracking HERL only
- ■ SLR tracking all sites

Mean GPS = –1.4 mm

Mean GLONASS = –16.1 mm

Y-axis: Δ LRA–Z [mm]
X-axis: Satellite PRN (GLONASS = PRN + 10)
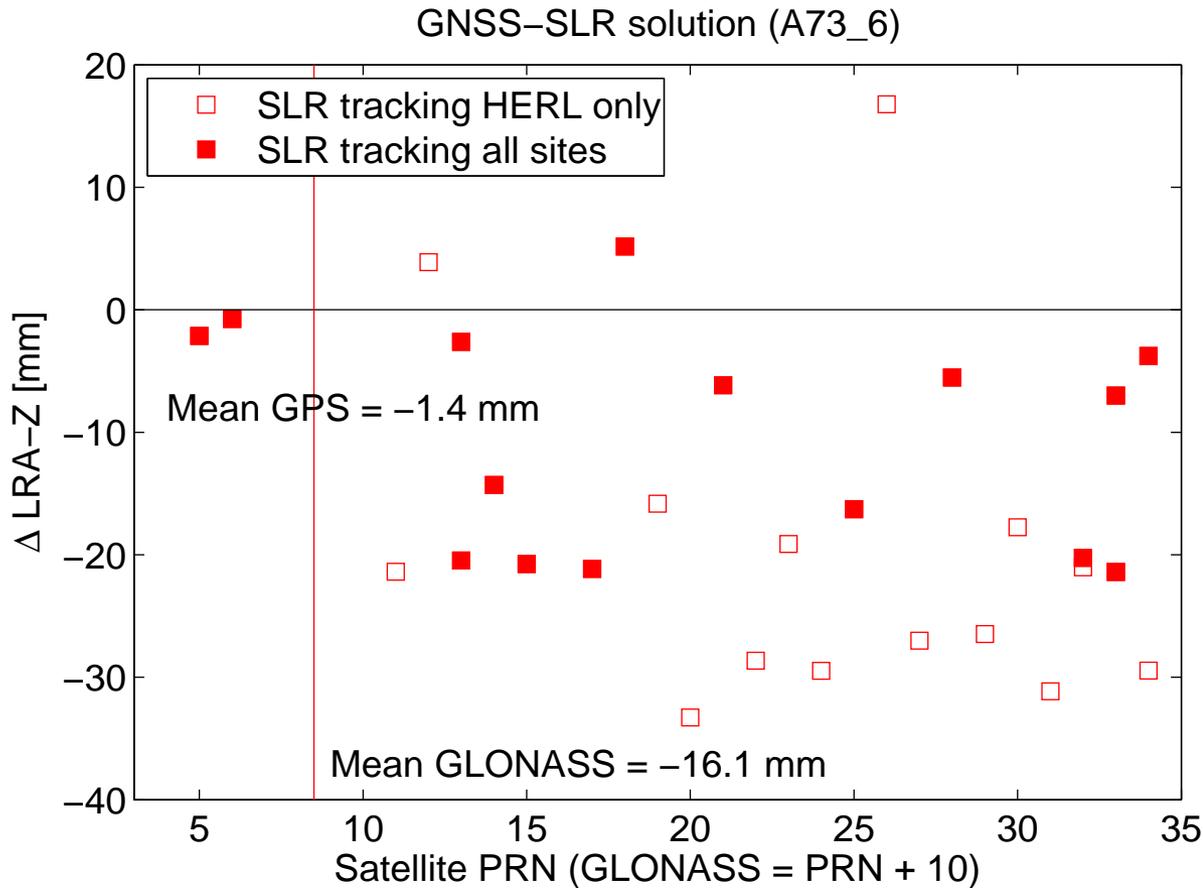
Mean correction w.r.t. the ILRS values:

GPS:

–1.4 mm

GLONASS:

–16.1 mm

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SAO estimated from multi-year solution

GNSS–SLR solution (A73_6)

Legend:
- □ w/o SLR tracking
- ■ with SLR tracking

Y-axis: Δ SAO–Z w.r.t. IGS08 [mm]
X-axis: Satellite PRN (GLONASS = PRN + 40)

Mean GPS = −86.1 mm

Mean GLONASS = −110.4 mm
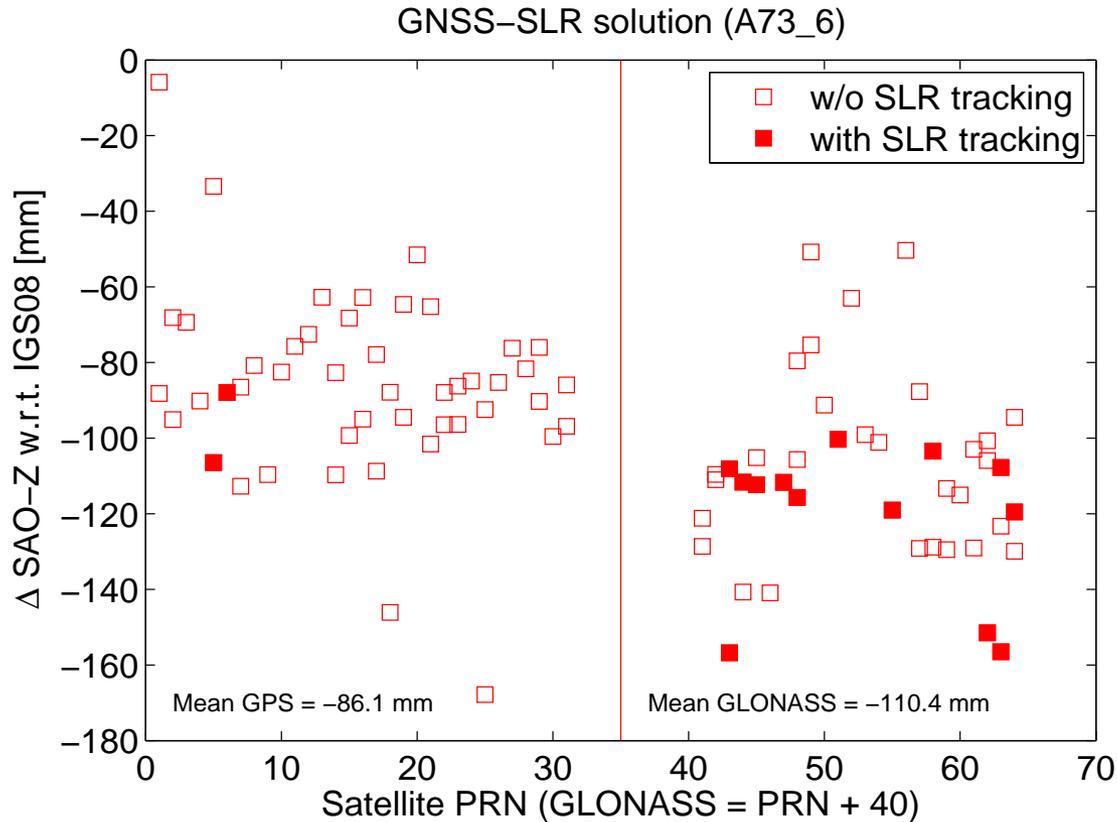
Corrections to IGS08 values:

GPS: −86.1 mm

GLONASS: −110.4 mm

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SAO estimated from multi-year solution
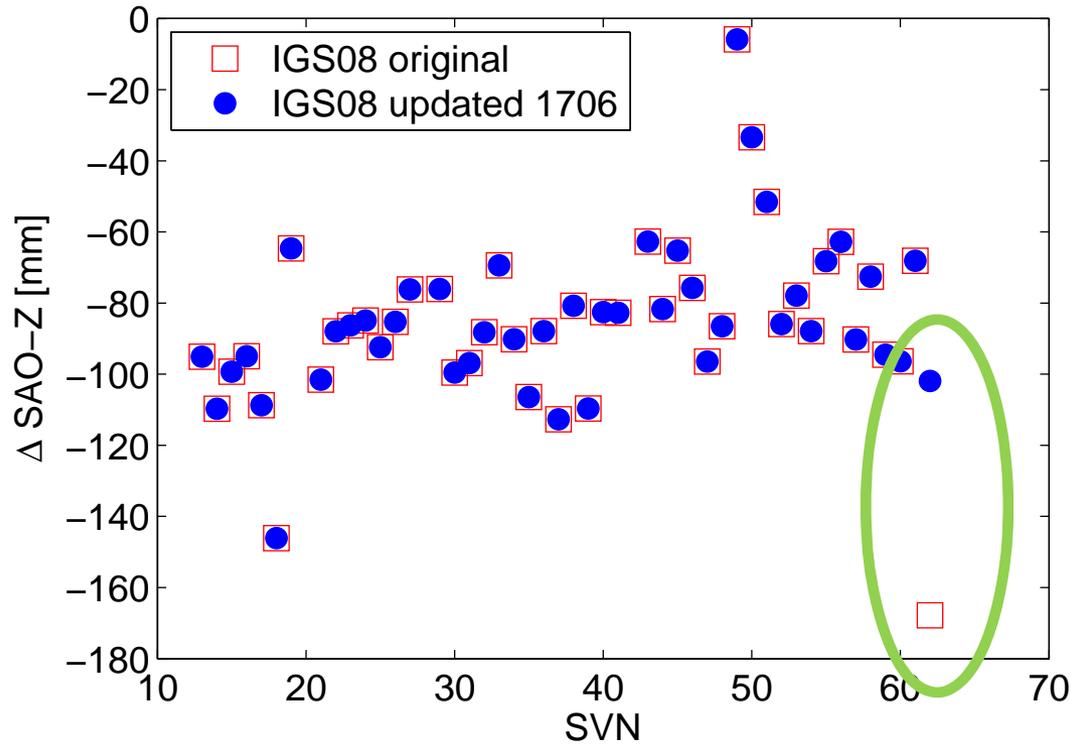
Updated IGS08 value is more consistent to the estimation in combined GNSS–SLR solution

Updated IGS08 values (week 1706, 16. Sept 2012):

GPS: −86.1 mm reduced to −84.7 mm

(GLONASS: only new satellites affected by the update)

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Combined geocenter: Impact of SAO, LRA

Considering / Ignoring corrections to SAO, LRA (RGB applied): Impact on geocenter

Legend:
- Δ X: Mean = −0.7 mm
- Δ Y: Mean = −0.1 mm
- Δ Z: Mean = −1.8 mm
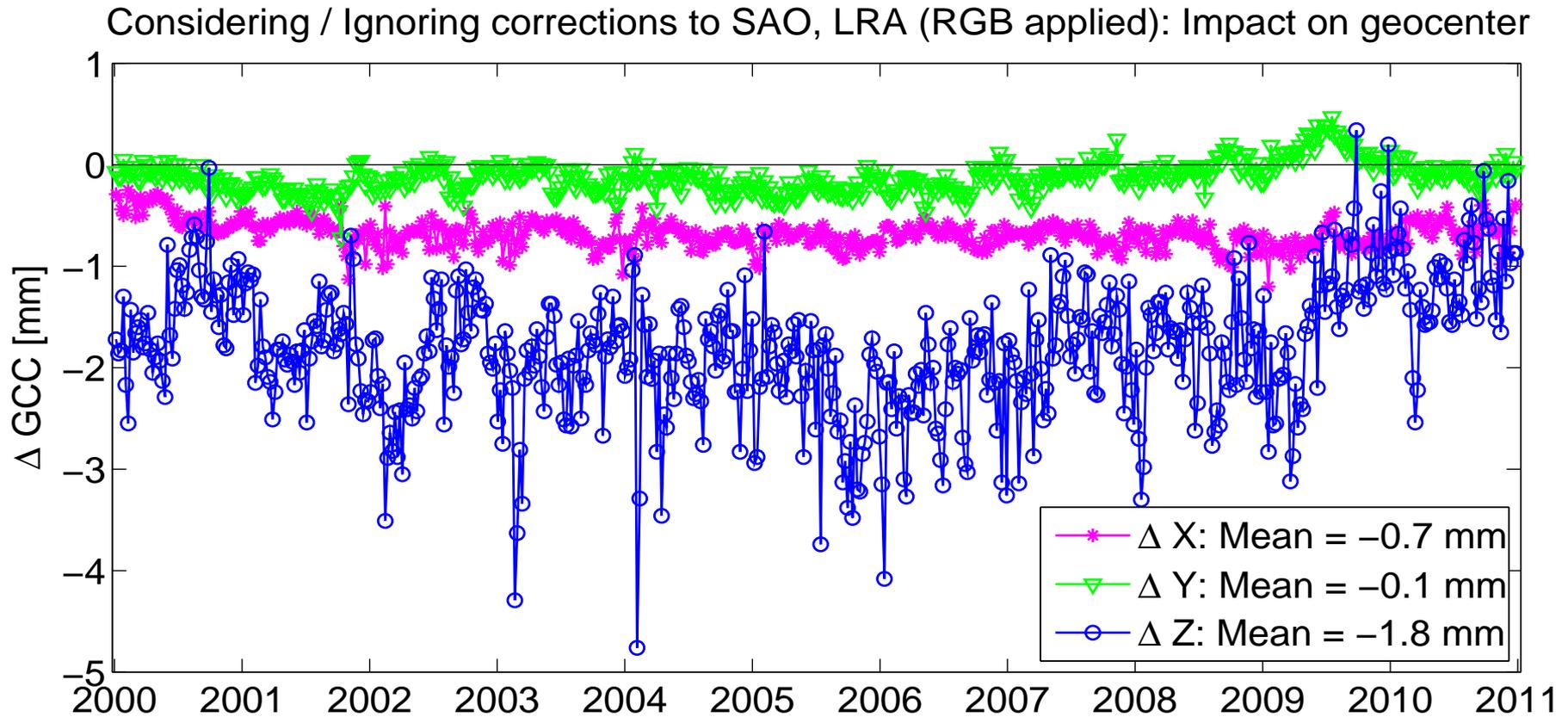
Comb 1: Range bias per station, per satellite considered

Comb 2: RGB, SAO, LRA corrections considered

⇒ **Bias** at mm−level (mainly in z−component)

Conclusions

- **Two components** of space tie: SAO, LRA

- Validated within **combined GNSS–SLR solution** (11 years)

- Mean correction for SAO:

  - GPS = –84.7 mm, GLONASS = –110.4 mm

- **Mean correction for LRA are small:**

  - GPS = –1.4 mm, GLONASS = –16.1 mm

- Impact on other parameters!

- Improvement of the validation / estimation is expected by an **extension** until «now»: several stations are **tracking the full GLONASS constellation** since mid–2011