ITRF2020: The ILRS Contribution and Operational Implementation

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AGU FALL MEETING
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SCIENCE LEADS THE FUTURE

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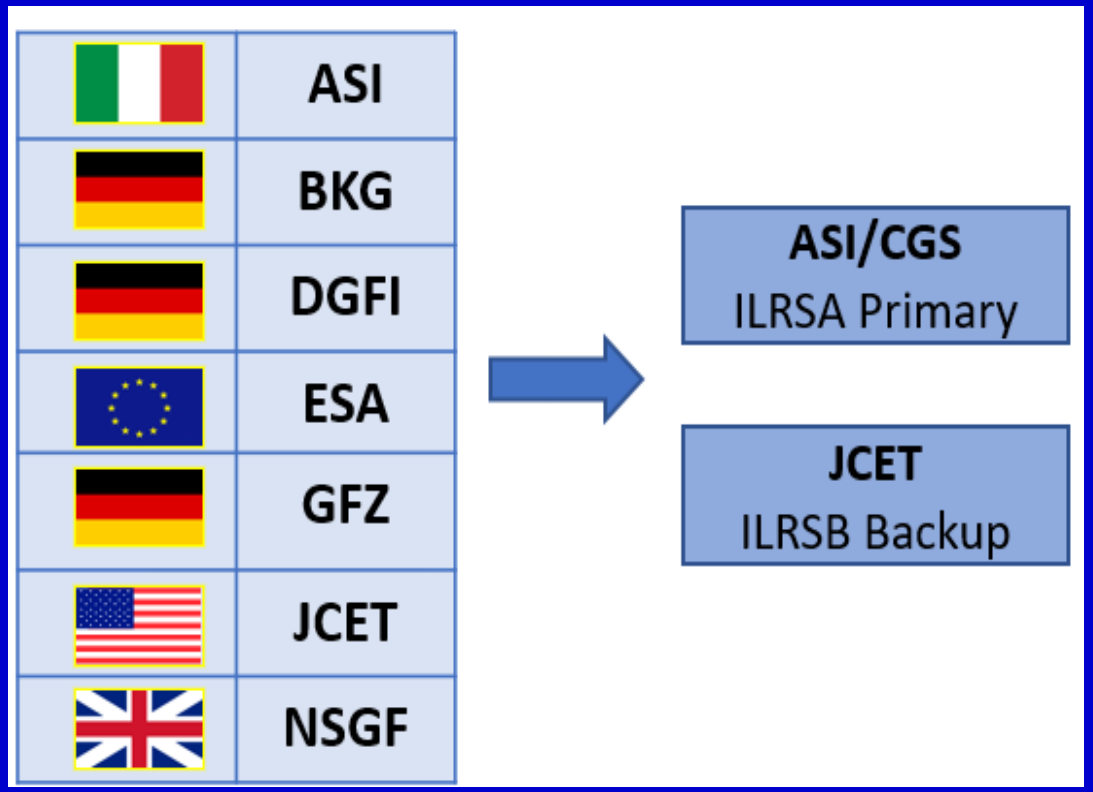
Overview of the ILRS ASC REPRO2020 Effort

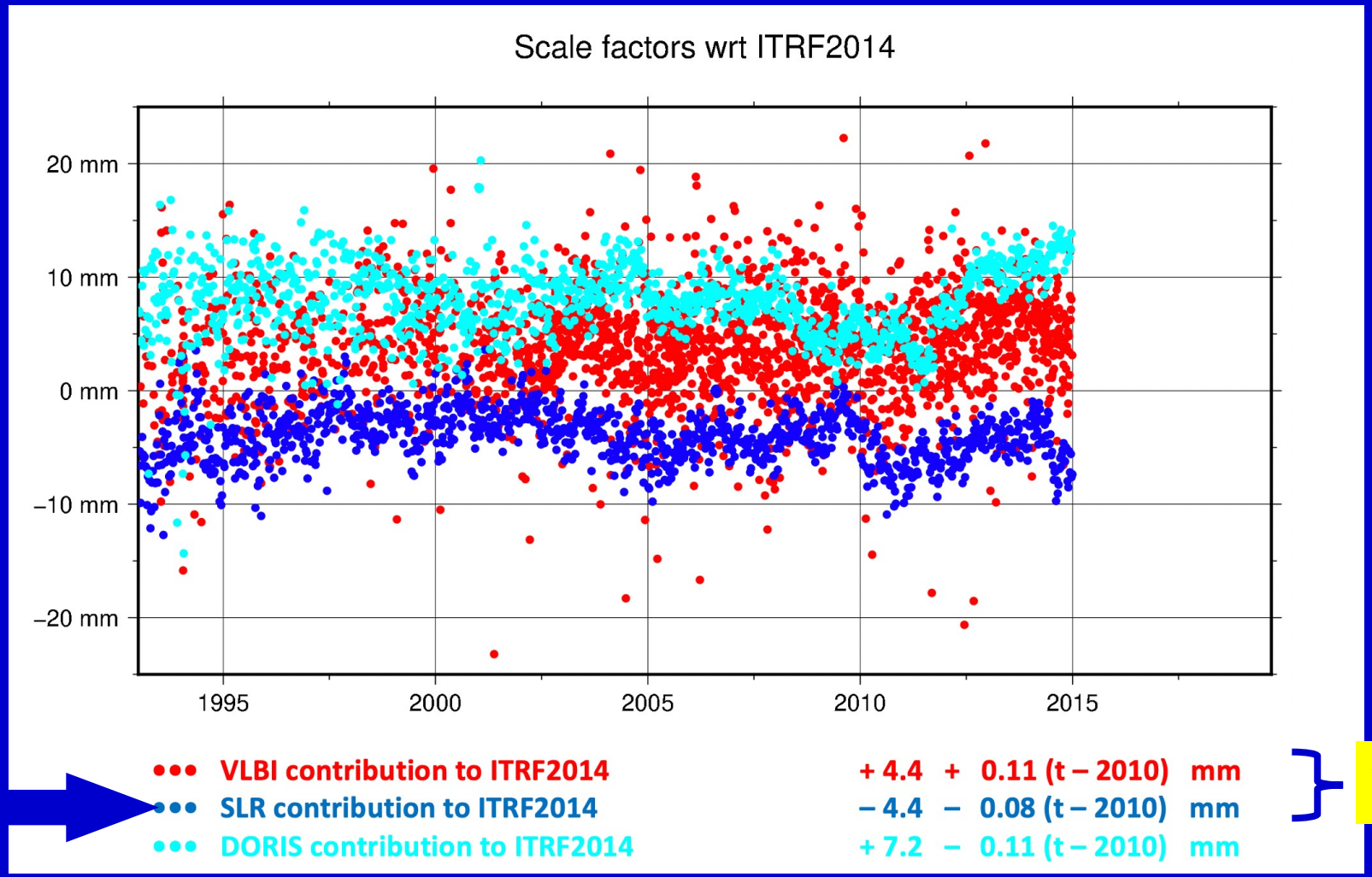
- The seven Analysis Centers comprising the ILRS ASC worked diligently since 2015 to prepare for the development of the SLR contribution to ITRF2020.

- This summary provides an overview of the work performed and the key results that shaped the final product and must be understood by SLR analysts using ITRF2020, to ensure they obtain the best results in their applications.

- We firstly review the main areas of modeling updates that resulted in the major improvement seen in the SLR contribution to ITRF2020.



SLR - VLBI Scales Systematically Different in ITRF2014



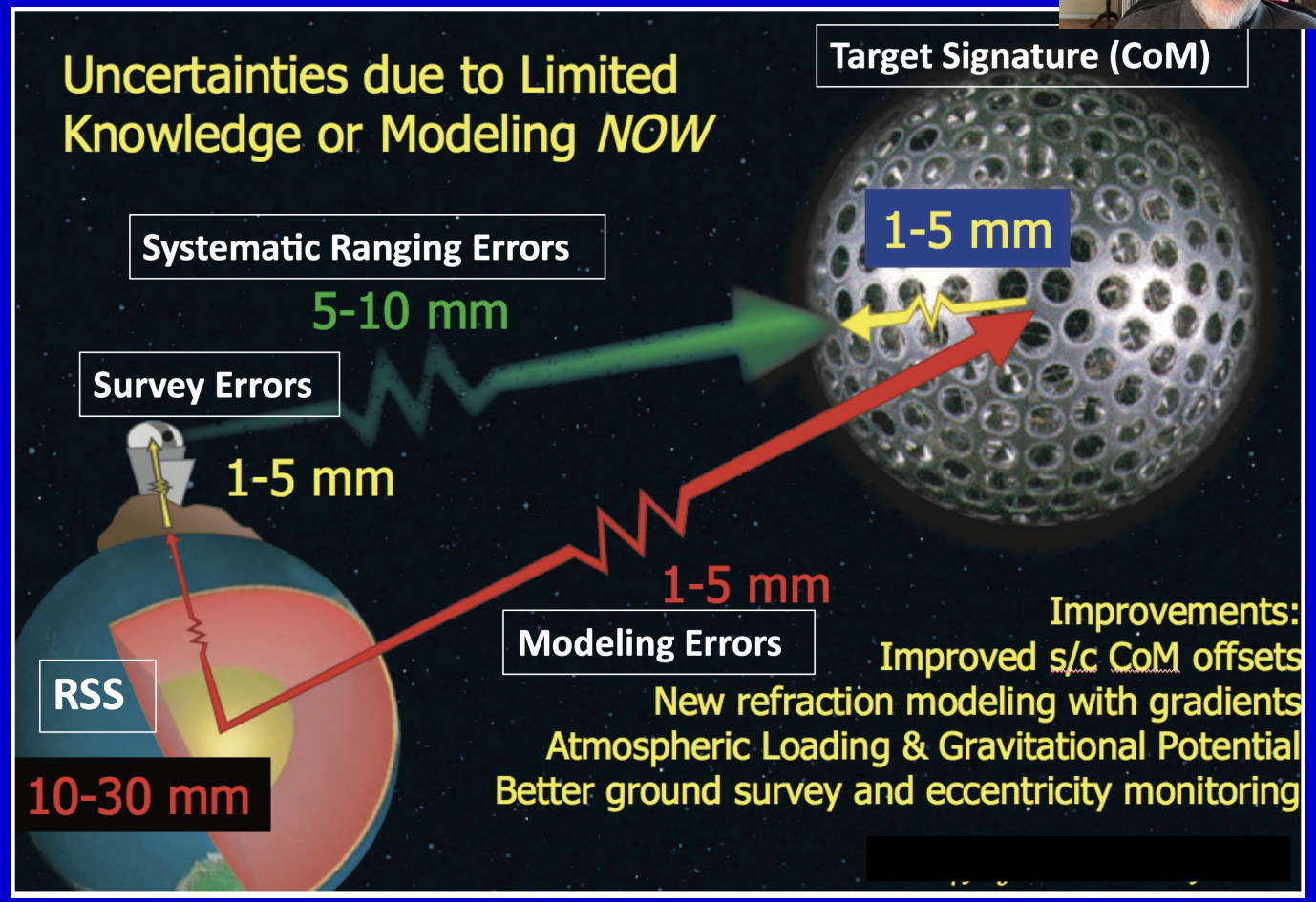
In 2015 ILRS launched a multi-year effort to address and resolve the SLR scale issue: Station Systematic Error Modeling Pilot Project (**SSEM PP**).

VLBI - SLR = 8.8 mm ≈ 1.375 ppb

Credits: ITRS Center, ILRS ASC Meeting, Oct. 1st, 2019, Observatoire de Paris

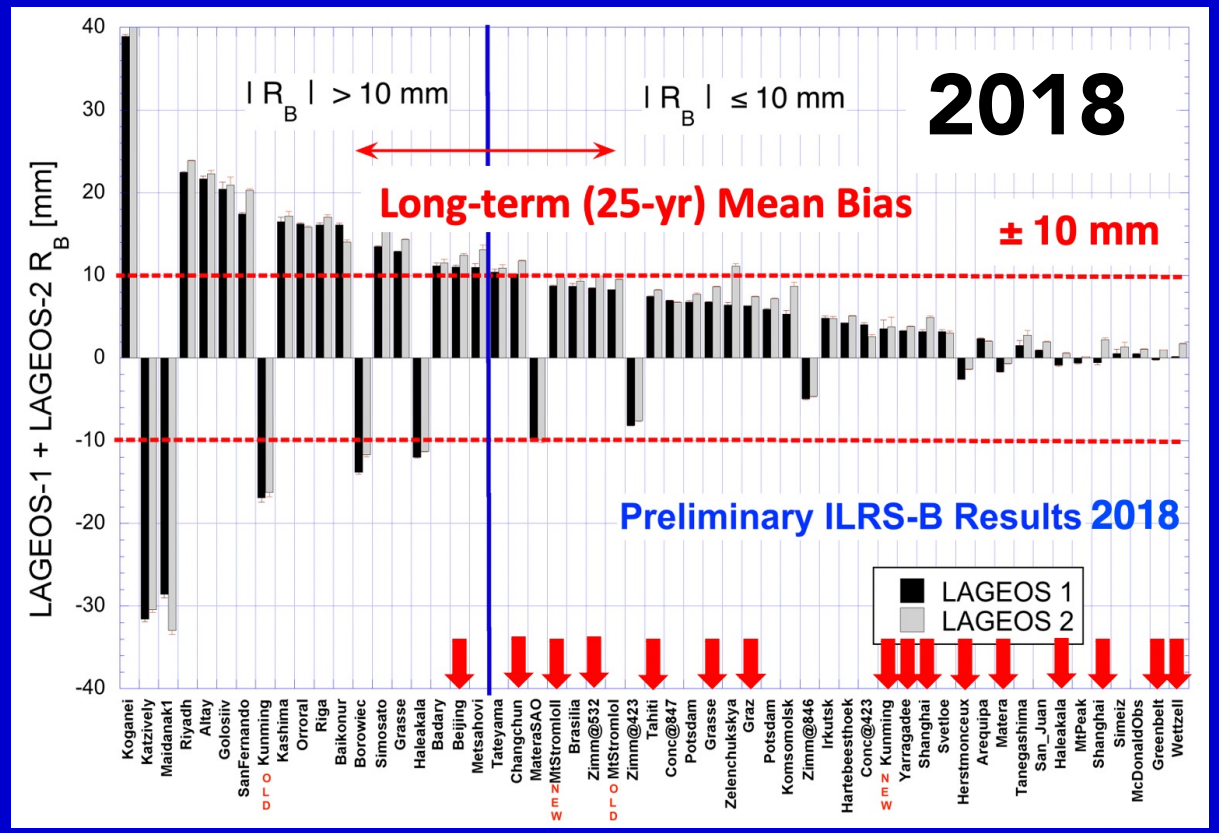
Pre-Analysis Investigations:

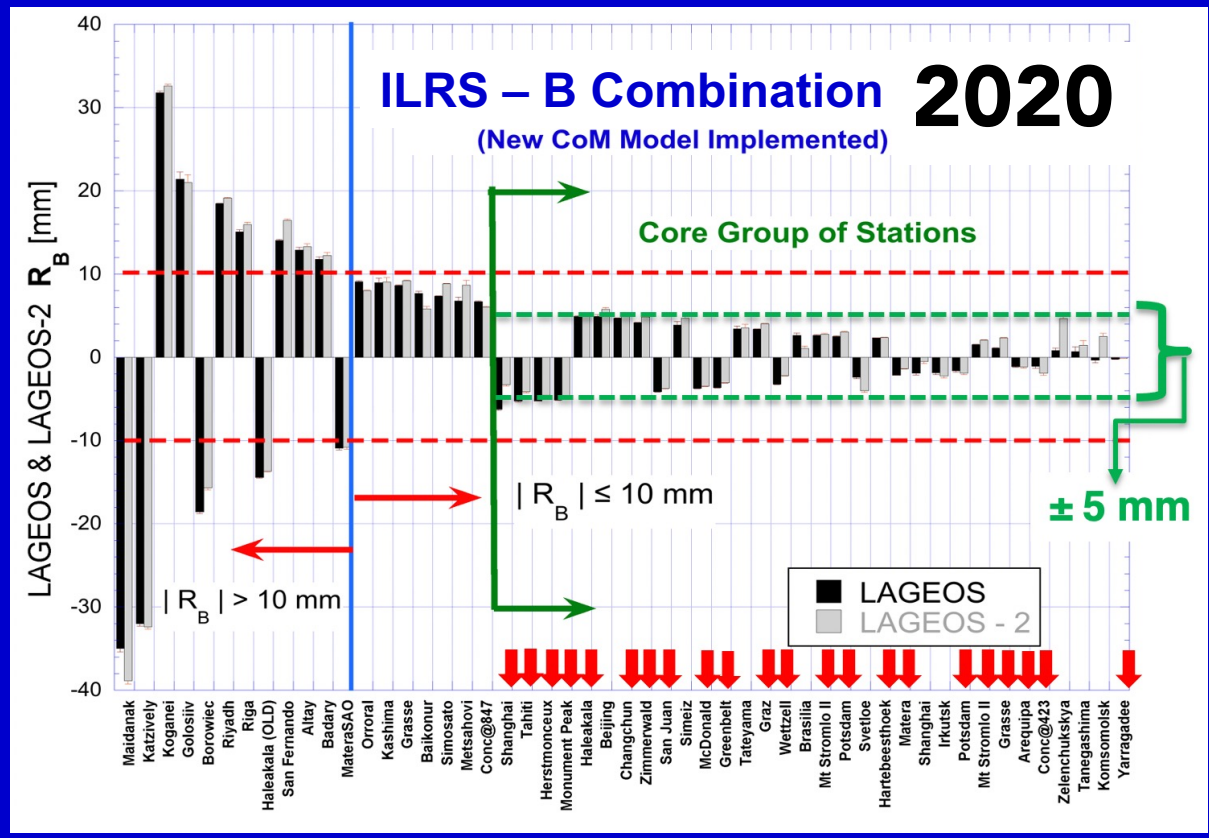
- Complete re-evaluation of stations' operating practices and recalculation of all station- and satellite-specific (time dependent) "target signature corrections"
- Simultaneous estimation of station positions and systematic errors (weekly resolution) adopted
- Review of station surveys and correction of eccentricity errors



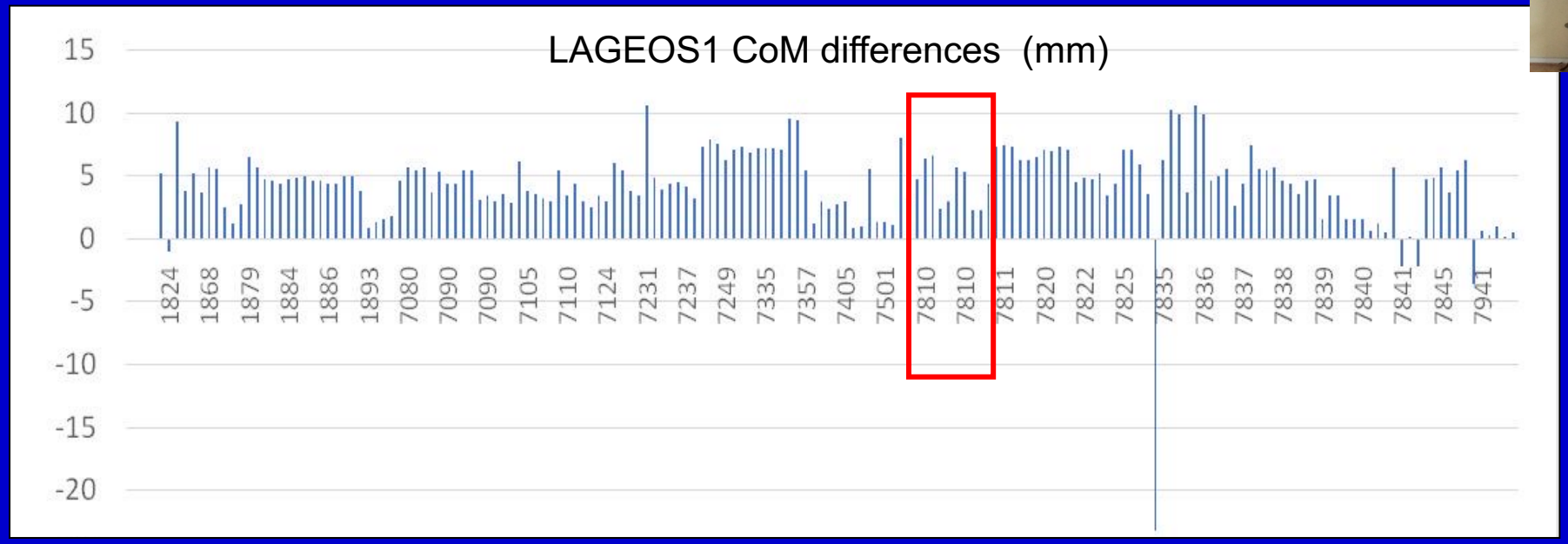
New modeling vastly improved the solution:

- Long-term mean biases for Core stations **reduced by > 50% !!!**
- Biases randomly distributed about zero ➠ net effect on scale ≈ 0





Improved Target Signature Corrections

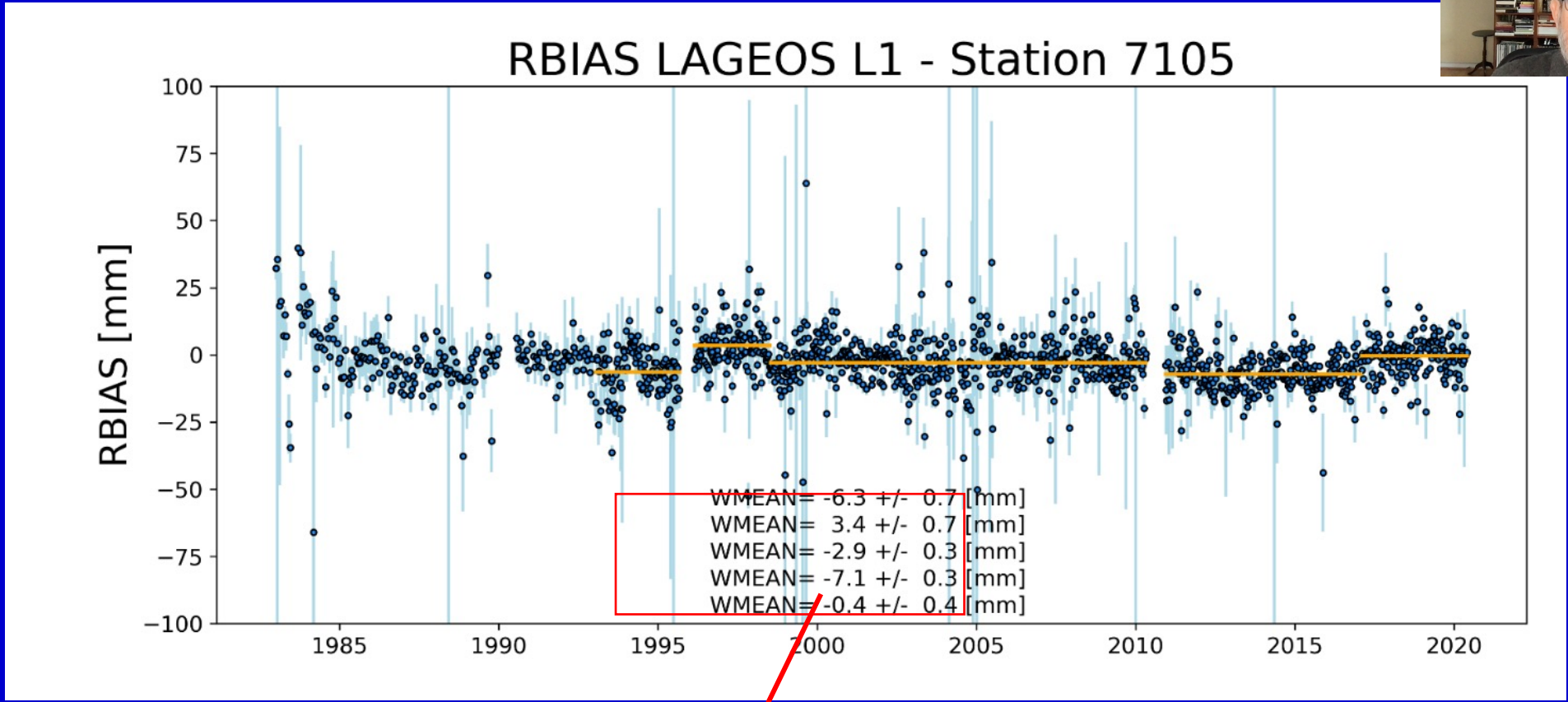


Zimmerwald, CH (7810)

Old CoM model					New CoM model		
7810	1/1/1980	30/4/1995	**251**		01/01/1983	01/06/1995	**244,6**
					01/01/1986	01/06/1995	**244,4**
7810	2/1/1996	9/3/2001	**245**		01/01/1997	09/03/2001	**242,6**
7810	9/3/2001	18/2/2008	**248**		09/03/2001	11/03/2003	**245,0**
7810	4/3/2008	31/12/2050	**249**		11/03/2003	03/02/2006	**243,4**
					03/02/2006	18/02/2008	**243,7**
					01/01/2002	18/02/2006	**246,8**
					18/06/2006	18/02/2008	**246,7**
					18/02/2008	01/01/2050	**244,7**

Rodríguez, J. et al., *J Geod* **93,** (2019). https://doi.org/10.1007/s00190-019-01315-0

Each station series were examined to identify all breaks:



+MODEL/RANGE_BIAS

*CODE PT SOLN T START_DATE__ END_DATE____ M __E-VALUE___ STD_DEV _E-RATE__ UNIT CMNTS

.....

7105 51 501 A 93:017:00000 95:253:00000 R -6.3 0.7 mm

7105 51 501 A 96:056:00000 98:193:00000 R 3.4 0.7 mm

7105 51 501 A 98:193:00000 10:122:00000 R -2.9 0.3 mm

7105 51 501 A 10:339:00000 17:029:00000 R -7.1 0.3 mm

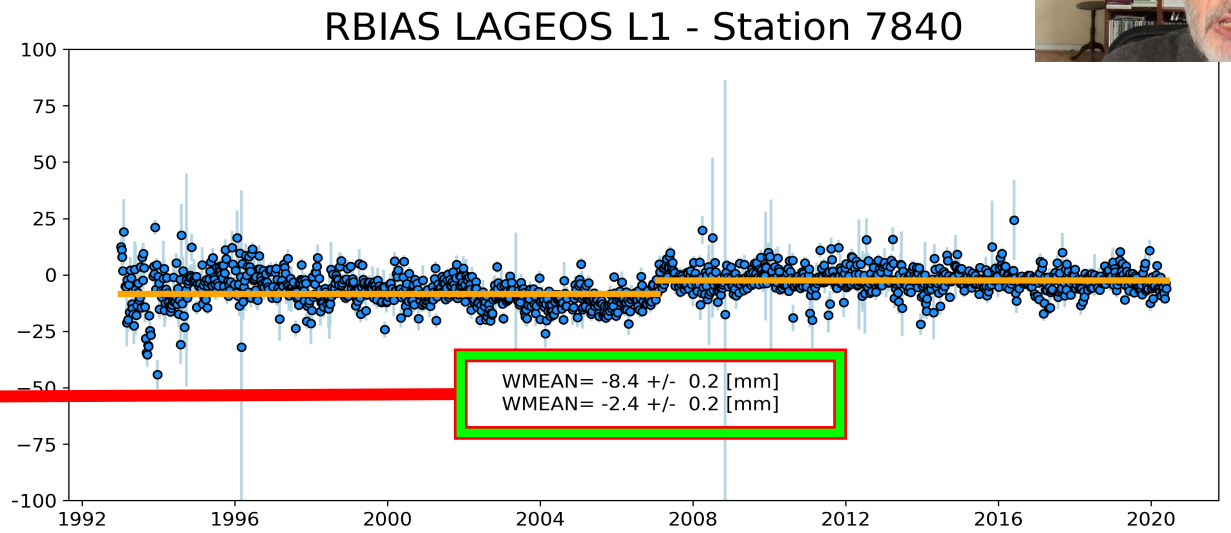
.....

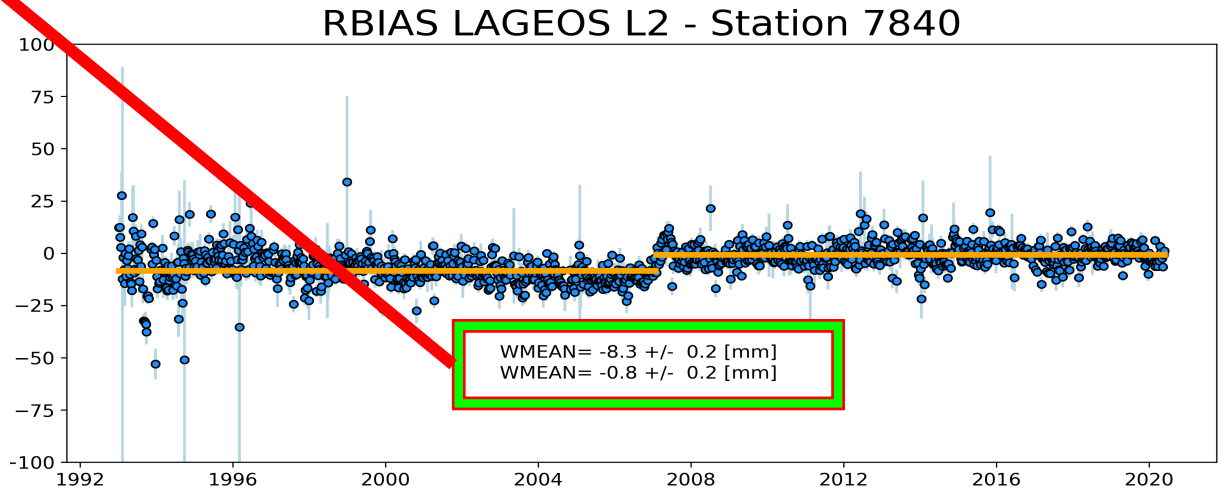
Data Handling File Entries

A priori range bias documentation:

Weekly SINEXs now contain the systematics applied *a priori:*

```
*       1         2         3         4         5         6         7         8
*2345678901234567890123456789012345678901234567890123456789012345678901234567890
*--------------------------------------------------------------------------------
+MODEL/RANGE_BIAS
*SITE PT SOLN T START_DATE__ END_DATE____ M RANGE_BIAS STD_DEV UNIT
 1873 51   501 L 08:288:00000 08:295:00000 R    -0.0193   0.002    m
 7810 51   501 L 08:288:00000 08:290:54321 R     0.0173   0.002    m
 7810 51   501 L 08:290:54321 08:295:00000 R     0.0183   0.002    m
 7810 60   501 L 08:288:00000 08:295:00000 R     0.0163   0.002    m
-MODEL/RANGE_BIAS

*       1         2         3         4         5         6         7         8
*2345678901234567890123456789012345678901234567890123456789012345678901234567890
*--------------------------------------------------------------------------------
+MODEL/TIME_BIAS
*SITE PT UNIT T START_DATE__ END_DATE____ M __E-VALUE___ STD_DEV _E-RATE__ CMNTS
 1824 -- us   A 02:084:68460 12:085:00000 T      -24.400   5.000    0.0000 -----
 1873 -- us   A 07:059:00000 09:110:00000 T      -21.750  50.000   -0.2600 drift
-MODEL/TIME_BIAS

*       1         2         3         4         5         6         7         8
*2345678901234567890123456789012345678901234567890123456789012345678901234567890
*--------------------------------------------------------------------------------
+MODEL/TARGET_SIGNATURE_GEOMETRY
*SITE PT SOLN T START_DATE__ END_DATE____ M   COM_CORR STD_DEV UNIT
 1873 51   501 L 08:288:00000 08:295:00000 C     0.1234   0.002    m
 1879 52   501 L 08:288:00000 08:295:00000 C     0.1234   0.002    m
 7810 53   501 L 08:288:00000 08:295:00000 C     0.9373   0.005    m
 7810 60   501 L 08:288:00000 08:295:00000 C     0.0163   0.002    m
-MODEL/TARGET_SIGNATURE_GEOMETRY
```





The Data Handling file

+MODEL/RANGE_BIAS
*List of mandatory systematic errors to be applied on observations by station & satellite

+SOLUTION/DATA_HANDLING
* list of data to be deleted
* list of mandatory arc-dependent biases to be estimated
* meteo data corrections

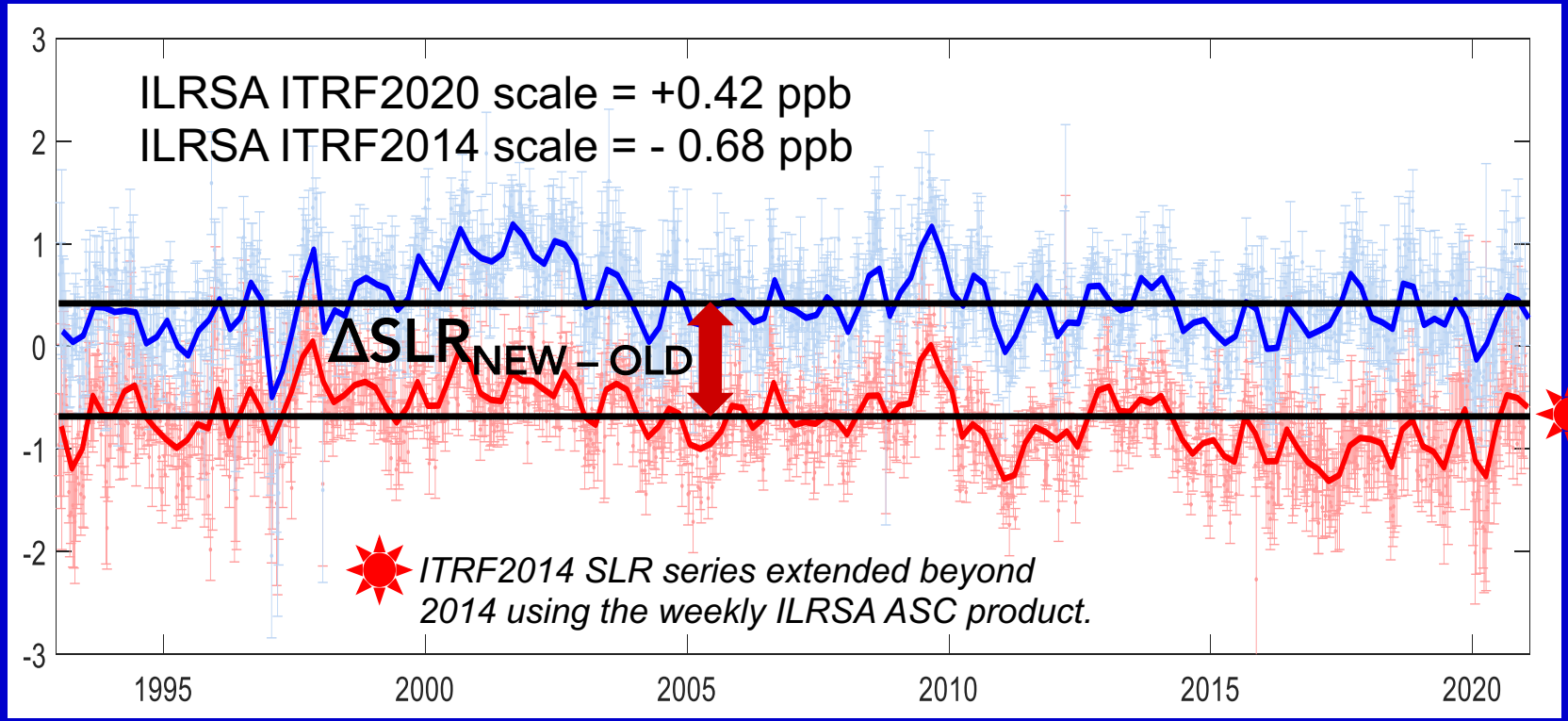
+MODEL/TIME_BIAS
* Time Biases (T_B) including the
* T2L2 T_B and T_B -rate DATA RECORDS
* Includes entries significant for LARES and higher orbits (range equivalent >10 mm)

and

** SECTION WITH OPTIONAL CORRECTIONS COMMENTED with "*" for other LEO s/c

SLR Scale From the ITRF2020 Reanalysis:

- Upper curve:
  - SLR scale from SSEM
  - Mean: +0.42 ppb
- Lower curve:
  - SLR scale in ITRF2014
  - Mean: - 0.68 ppb
- Mean difference:



0.42 ppb – (- 0.68 ppb) = 1.10 ppb

- $\Delta SLR_{NEW - OLD} \approx 1.10$ ppb

- VLBI - SLR ≈ 0.28 ± 0.10 ppb

WRT VLBI @ ITRF2014 !!!

Operational Data Handling file extension

- Extension of the SSEM to end of 2022,
- Weekly series of SSEM-like SINEX files to routinely extend the mean R_B series
- Periodic update of the DH file as needed

DH file for ITRF2020 ended on 2021.0

Old_records.snx — Edited

```
608: 1890 51   501 A 12:001:00000 21:001:00000 R        12.9      1.1
609: 1893 51   501 A 05:212:00000 21:001:00000 R       -33.4      1.6
613: 7090 51   501 A 14:208:00000 21:001:00000 R         2.3      0.2
621: 7110 51   501 A 96:287:00000 21:001:00000 R        -5.2      0.2
624: 7119 51   501 A 15:067:00000 21:001:00000 R         9.4      0.4
634: 7237 51   501 A 12:120:00000 21:001:00000 R         4.4      0.4
643: 7501 51   501 A 19:048:00000 21:001:00000 R        13.6      1.4
647: 7810 51   501 B 16:080:00000 21:001:00000 R         6.7      0.3
651: 7825 51   501 A 04:214:00000 21:001:00000 R         1.0      0.2
659: 7839 51   501 A 03:285:00000 21:001:00000 R         3.8      0.1
662: 7840 51   501 A 07:035:00000 21:001:00000 R        -2.4      0.2
663: 7841 51   501 A 04:053:00000 21:001:00000 R         1.9      0.3
668: 7845 51   501 A 15:004:00000 21:001:00000 R        -6.0      0.4

681: 1890 52   501 A 12:001:00000 21:001:00000 R        13.3      1.3
682: 1893 52   501 A 05:212:00000 21:001:00000 R       -32.7      1.6
686: 7090 52   501 A 14:208:00000 21:001:00000 R         2.5      0.2
694: 7110 52   501 A 96:287:00000 21:001:00000 R        -4.8      0.2
697: 7119 52   501 A 15:067:00000 21:001:00000 R        10.3      0.5
707: 7237 52   501 A 12:120:00000 21:001:00000 R         5.6      0.5
716: 7501 52   501 A 19:048:00000 21:001:00000 R        13.4      1.4
720: 7810 52   501 B 16:080:00000 21:001:00000 R         8.1      0.3
724: 7825 52   501 A 04:214:00000 21:001:00000 R         1.7      0.2
732: 7839 52   501 A 03:285:00000 21:001:00000 R         4.6      0.2
735: 7840 52   501 A 07:035:00000 21:001:00000 R        -0.8      0.2
736: 7841 52   501 A 04:053:00000 21:001:00000 R         3.0      0.3
741: 7845 52   501 A 15:004:00000 21:001:00000 R        -3.8      0.4
```

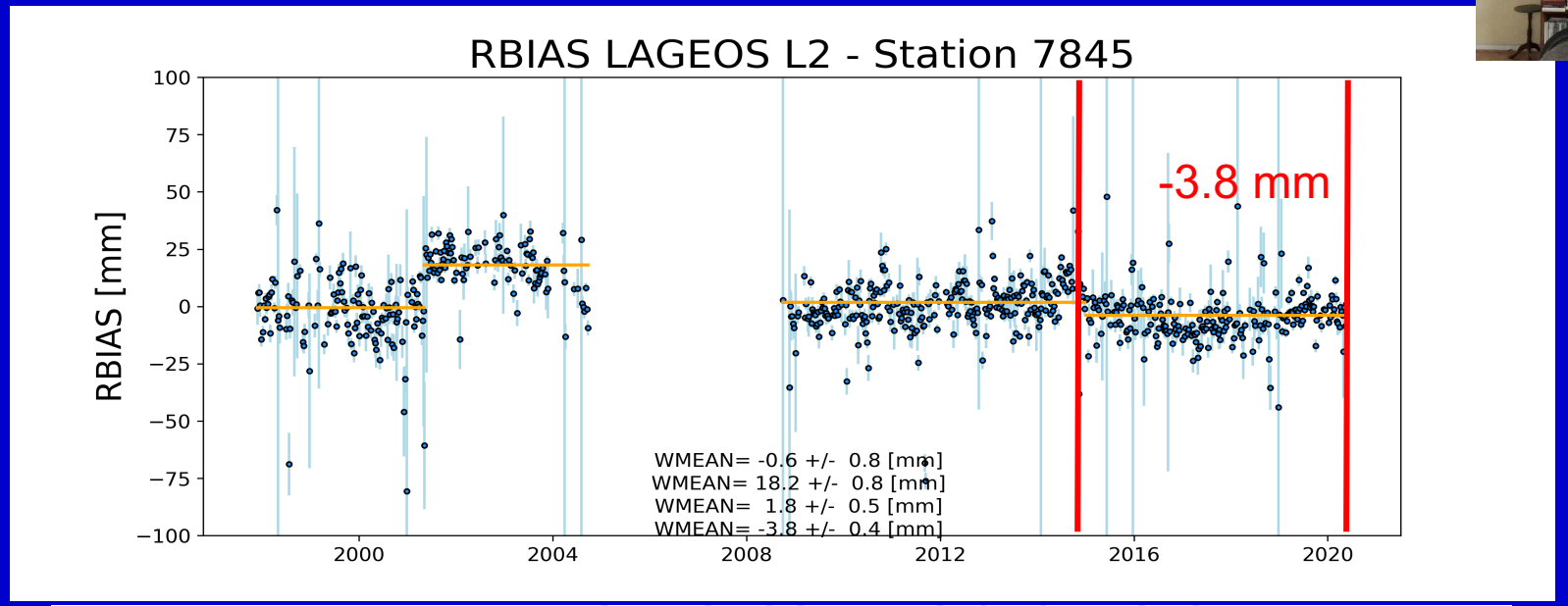
Extended DH file to June 2022

New_records.snx

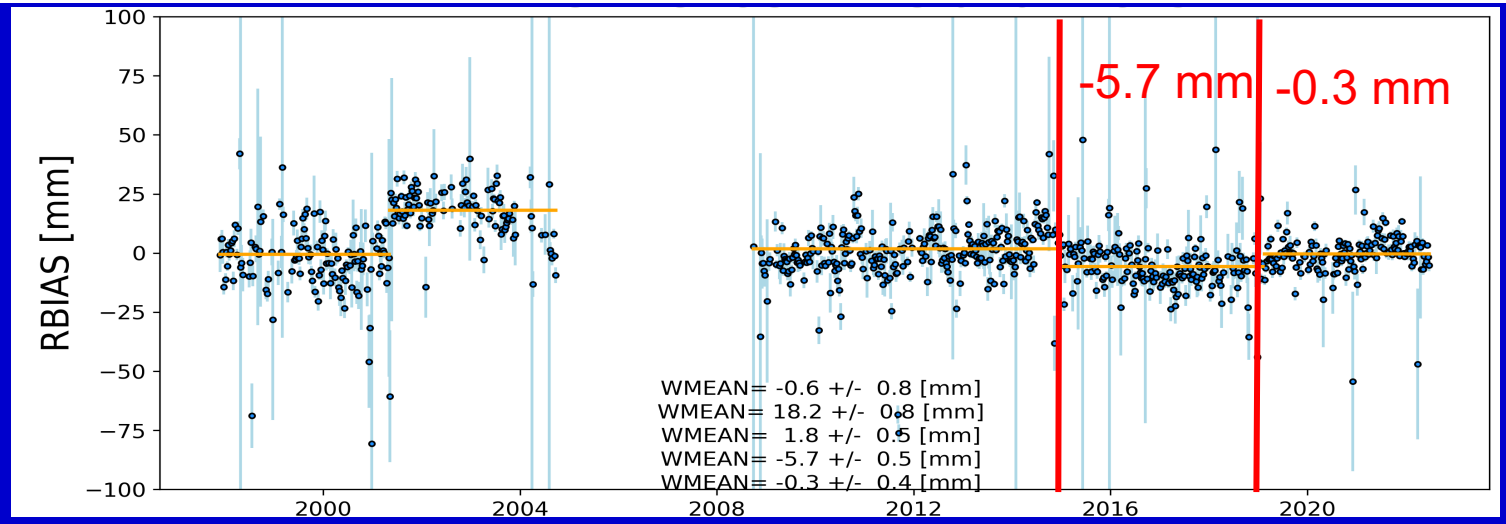
```
1890 51   501 A 12:001:00000 22:149:00000 R        14.0      1.0
1893 51   501 A 05:212:00000 22:177:00000 R       -33.2      1.4
7090 51   501 A 14:208:00000 22:177:00000 R         2.4      0.2
7110 51   501 A 96:287:00000 22:177:00000 R        -5.3      0.2
7119 51   501 A 15:067:00000 22:177:00000 R         9.8      0.4
7237 51   501 A 12:120:00000 22:177:00000 R         5.4      0.4
7501 51   501 A 19:048:00000 22:142:00000 R        10.9      1.1
7810 51   501 B 16:080:00000 22:051:00000 R         7.0      0.3
7825 51   501 A 04:214:00000 22:177:00000 R         0.8      0.2
7839 51   501 A 03:285:00000 22:177:00000 R         3.9      0.1
7840 51   501 A 07:035:00000 22:177:00000 R        -2.2      0.1
7841 51   501 A 04:053:00000 22:177:00000 R         2.2      0.3
7845 51   501 A 15:004:00000 22:177:00000 R        -3.3      0.4

1890 52   501 A 12:001:00000 22:149:00000 R        14.0      1.1
1893 52   501 A 05:212:00000 22:177:00000 R       -32.4      1.5
7090 52   501 A 14:208:00000 22:177:00000 R         2.7      0.2
7110 52   501 A 96:287:00000 22:177:00000 R        -4.9      0.2
7119 52   501 A 15:067:00000 22:177:00000 R        10.9      0.4
7237 52   501 A 12:120:00000 22:177:00000 R         6.5      0.4
7501 52   501 A 19:048:00000 22:142:00000 R        10.9      1.1
7810 52   501 B 16:080:00000 22:051:00000 R         8.2      0.3
7825 52   501 A 04:214:00000 22:177:00000 R         1.4      0.2
7839 52   501 A 03:285:00000 22:177:00000 R         4.7      0.1
7840 52   501 A 07:035:00000 22:177:00000 R        -0.7      0.1
7841 52   501 A 04:053:00000 22:177:00000 R         3.3      0.3
7845 52   501 A 15:004:00000 22:177:00000 R        -2.1      0.3
```

Extension of R_B series for Grasse (7845):

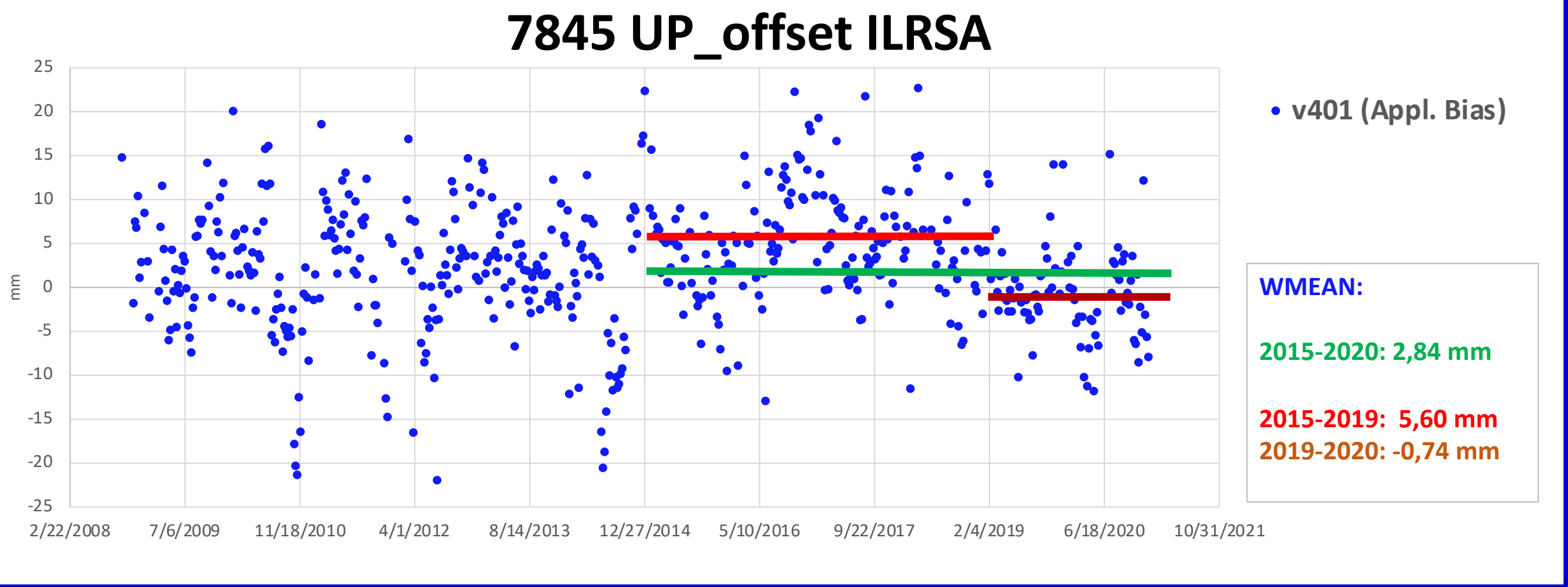
Original version used in ITRF2020



Revised version after the extension



Revised R_B effect on Grasse (7845) height

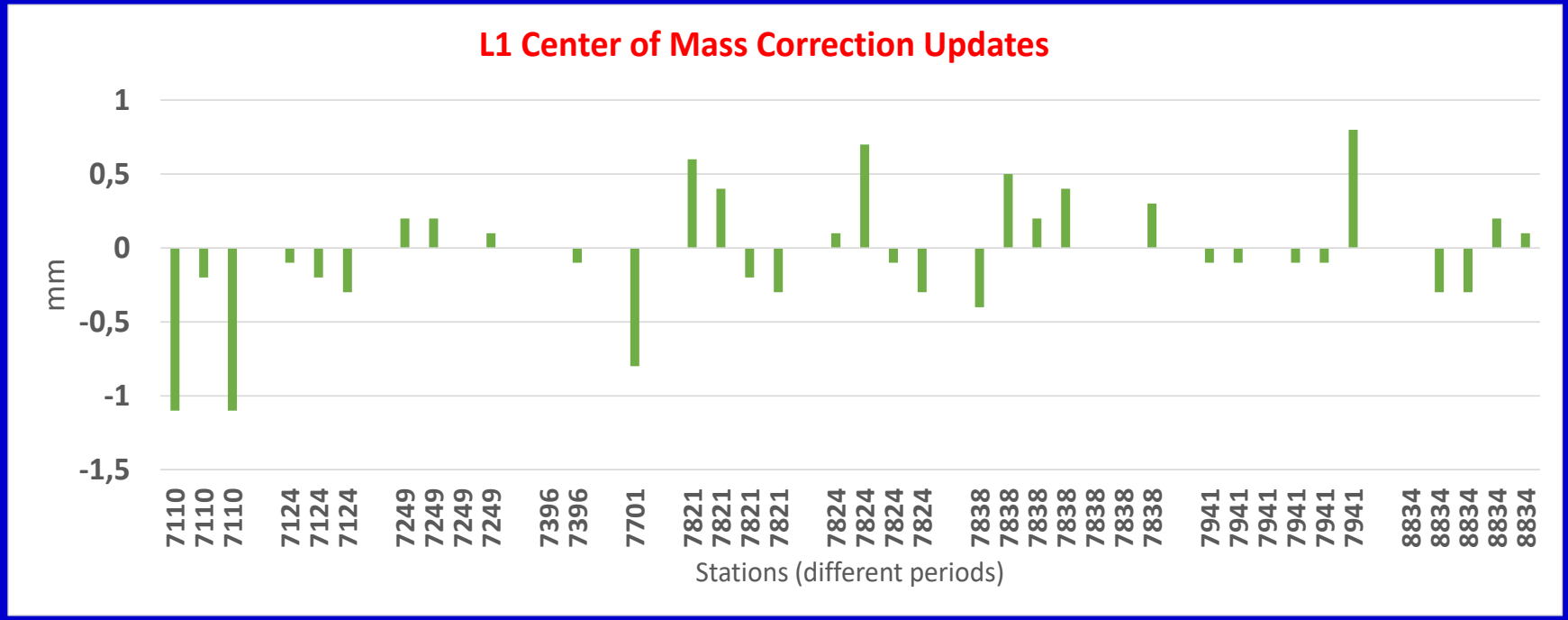


Latest Update of the Target Signature Correction Model

- Reevaluation of the operating practices of stations and computation of station and satellite specific (time-dependent) target signature corrections frequently

Latest Release:

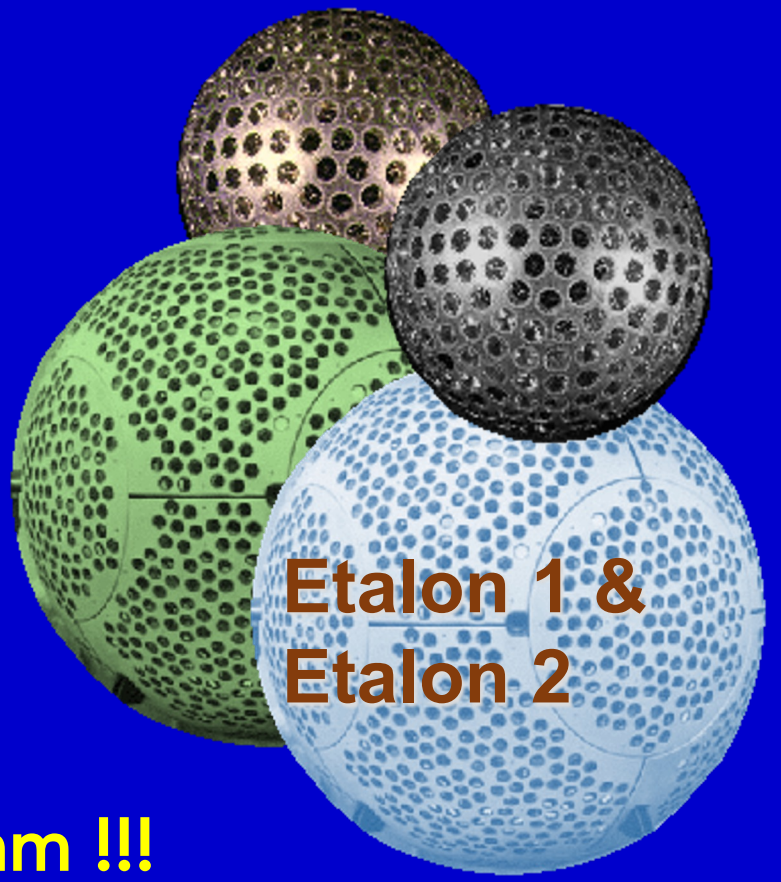
- **J. Rodriguez 11/05/2021**
- **Update with minor changes**
- **Model version is listed in every DH File release**



Rodríguez, J. et al., *J Geod* **93,** (2019). https://doi.org/10.1007/s00190-019-01315-0

Summary

- The ILRS ASC stablished a new analysis approach for its contribution to ITRF2020;
- It will be implemented in the operational series after adoption of ITRF2020 (2023);
- The complete SLR series for the 38-year period 1983 – 2021 will be reanalyzed (2023);
- The new bias model (SSEM-X) will be publicly available and maintained current over the coming years.



From nearly 1 cm ΔScale(SLR-VLBI) to 1 mm !!!

Thank you!