Topics of the F2F & Virtual, Fall 2022, ILRS ASC Meeting

- **Implementation of ITRF2020/SLRF2020 requires coordination with several additional SLR-specific models to achieve results with maximum accuracy:**

  - The release and adoption of an ITRF2020-consistent IERS EOP C04 series and an update of the Bulletin A series used for our operational products:
    - **IERS released such a (DRAFT) series on June 2, 2022 and we need to test it ASAP. A new format is also adopted and reference epoch has changed, from 0 hrs to 12 hrs, although it is delivered in both versions:**

eopc04.1962-now.txt

```
# EARTH ORIENTATION PARAMETER (EOP) PRODUCT CENTER CENTER (PARIS OBSERVATORY) - INTERNATIONAL EARTH ROTATION AND REFERENCE SYSTEMS SERVICE
# EOP (IERS) 20 C04 TIME SERIES  consistent with ITRF 2020 - sampled at 0h UTC
# Contact: christian.bizouard@obspm.fr
# Reference Precession-Nutation Model: IAU 2000
# format(4(i4),f10.2,2(f12.6),f12.7,2(f12.6),2(f12.6),f12.7),2(f12.6),f12.7,2(f12.6),2(f12.6),f12.7))
# YR  MM  DD  HH       MJD        x(")       y(")  UT1-UTC(s)       dX(")       dY(")       xrt(")      yrt(")      LOD(s)        x Er        y Er  UT1-UTC Er       dX Er       dY Er       xrt Er      yrt Er      LOD Er
1962   1   1   0   37665.00   -0.012700    0.213000    0.0326338    0.000000    0.000000    0.000000    0.000000    0.0017230    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1   2   0   37666.00   -0.015900    0.214100    0.0320547    0.000000    0.000000    0.000000    0.000000    0.0016690    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1   3   0   37667.00   -0.019000    0.215200    0.0315526    0.000000    0.000000    0.000000    0.000000    0.0015820    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1   4   0   37668.00   -0.021999    0.216301    0.0311435    0.000000    0.000000    0.000000    0.000000    0.0014960    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1   5   0   37669.00   -0.024799    0.217301    0.0308154    0.000000    0.000000    0.000000    0.000000    0.0014160    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1   6   0   37670.00   -0.027599    0.218301    0.0305353    0.000000    0.000000    0.000000    0.000000    0.0013820    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1   7   0   37671.00   -0.030199    0.219301    0.0302682    0.000000    0.000000    0.000000    0.000000    0.0014130    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1   8   0   37672.00   -0.032798    0.220202    0.0299280    0.000000    0.000000    0.000000    0.000000    0.0015050    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1   9   0   37673.00   -0.035198    0.221102    0.0294869    0.000000    0.000000    0.000000    0.000000    0.0016280    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1  10   0   37674.00   -0.037498    0.222002    0.0289268    0.000000    0.000000    0.000000    0.000000    0.0017380    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1  11   0   37675.00   -0.039697    0.222803    0.0282797    0.000000    0.000000    0.000000    0.000000    0.0017940    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1  12   0   37676.00   -0.041797    0.223703    0.0276136    0.000000    0.000000    0.000000    0.000000    0.0017740    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1  13   0   37677.00   -0.043797    0.224503    0.0270075    0.000000    0.000000    0.000000    0.000000    0.0016670    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1  14   0   37678.00   -0.045697    0.225203    0.0265403    0.000000    0.000000    0.000000    0.000000    0.0015100    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1  15   0   37679.00   -0.047496    0.226004    0.0262572    0.000000    0.000000    0.000000    0.000000    0.0013120    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1  16   0   37680.00   -0.049196    0.226704    0.0261751    0.000000    0.000000    0.000000    0.000000    0.0011120    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1  17   0   37681.00   -0.050796    0.227404    0.0262740    0.000000    0.000000    0.000000    0.000000    0.0009360    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1  18   0   37682.00   -0.052295    0.228005    0.0265299    0.000000    0.000000    0.000000    0.000000    0.0008110    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1  19   0   37683.00   -0.053595    0.228705    0.0268868    0.000000    0.000000    0.000000    0.000000    0.0007330    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
1962   1  20   0   37684.00   -0.054895    0.229305    0.0273077    0.000000    0.000000    0.000000    0.000000    0.0006810    0.030000    0.030000    0.0020000    0.004774    0.002000    0.000000    0.000000    0.0014000
```

eopc04.12h.1984-now.txt

```
# EARTH ORIENTATION PARAMETER (EOP) PRODUCT CENTER CENTER (PARIS OBSERVATORY) - INTERNATIONAL EARTH ROTATION AND REFERENCE SYSTEMS SERVICE
# EOP (IERS) 20 C04 TIME SERIES consistent with ITRF 2020 - sampled at 12h UTC
# Contact: christian.bizouard@obspm.fr
# Reference Precession-Nutation Model: IAU 2000
# format(4(i4),f10.2,2(f12.6),f12.7,2(f12.6),2(f12.6),f12.7),2(f12.6),f12.7,2(f12.6),2(f12.6),f12.7))
# YR  MM  DD  HH       MJD        x(")       y(")  UT1-UTC(s)       dX(")       dY(")       xrt(")      yrt(")      LOD(s)        x Er        y Er  UT1-UTC Er       dX Er       dY Er       xrt Er      yrt Er      LOD Er
1984   1   1  12   45700.50   -0.134064    0.093057    0.3968898    0.002255   -0.002791    0.034912   -0.041530    0.0014139    0.001250    0.000992    0.0002417    0.000349    0.000351    0.001226    0.000991    0.0000730
1984   1   2  12   45701.50   -0.136239    0.096494    0.3955314    0.001470   -0.001946    0.034788   -0.041499    0.0013168    0.001201    0.000990    0.0002417    0.000349    0.000351    0.001203    0.000990    0.0000730
1984   1   3  12   45702.50   -0.139537    0.099240    0.3942317    0.000860   -0.001281    0.034035   -0.041884    0.0012952    0.001156    0.000987    0.0002417    0.000349    0.000351    0.001165    0.000988    0.0000730
1984   1   4  12   45703.50   -0.143743    0.101176    0.3929177    0.000406   -0.000780    0.032852   -0.042992    0.0013437    0.001129    0.000986    0.0002417    0.000349    0.000351    0.001110    0.000993    0.0000730
1984   1   5  12   45704.50   -0.148590    0.101264    0.3915251    0.000093   -0.000427    0.032322   -0.042851    0.0014502    0.001063    0.000998    0.0002417    0.000351    0.000352    0.001136    0.000979    0.0000729
1984   1   6  12   45705.50   -0.151394    0.104927    0.3900043   -0.000097   -0.000203    0.032026   -0.042542    0.0015965    0.001144    0.000973    0.0002417    0.000368    0.000359    0.001148    0.000972    0.0000726
1984   1   7  12   45706.50   -0.153162    0.109486    0.3883270   -0.000179   -0.000093    0.031313   -0.042989    0.0017591    0.001233    0.000945    0.0002417    0.000395    0.000370    0.001148    0.000931    0.0000721
1984   1   8  12   45707.50   -0.155200    0.112946    0.3864894   -0.000173   -0.000079    0.030267   -0.043401    0.0019132    0.001152    0.000889    0.0002417    0.000425    0.000382    0.001139    0.000880    0.0000716
1984   1   9  12   45708.50   -0.157800    0.115832    0.3845110   -0.000093   -0.000145    0.029176   -0.043217    0.0020371    0.001045    0.000816    0.0002417    0.000445    0.000391    0.001066    0.000829    0.0000712
1984   1  10  12   45709.50   -0.160851    0.118432    0.3824310   -0.000043   -0.000273    0.028188   -0.042946    0.0021143    0.000980    0.000770    0.0002417    0.000457    0.000398    0.001054    0.000825    0.0000712
1984   1  11  12   45710.50   -0.163814    0.121037    0.3803018    0.000217   -0.000447    0.027569   -0.043207    0.0021339    0.001063    0.000835    0.0002417    0.000481    0.000421    0.001068    0.000839    0.0000717
1984   1  12  12   45711.50   -0.165961    0.123889    0.3781855    0.000414   -0.000649    0.027545   -0.044075    0.0020873    0.001156    0.000909    0.0002417    0.000522    0.000462    0.001143    0.000899    0.0000726
1984   1  13  12   45712.50   -0.166976    0.127234    0.3761501    0.000617   -0.000863    0.028175   -0.044826    0.0019723    0.001223    0.000963    0.0002417    0.000570    0.000508    0.001195    0.000970    0.0000736
1984   1  14  12   45713.50   -0.166969    0.131435    0.3742599    0.000807   -0.001071    0.028363   -0.045465    0.0018003    0.001234    0.001031    0.0002417    0.000605    0.000543    0.001235    0.001020    0.0000744
```

OLD FORMAT

NEW FORMAT

For the moment they are available from:
https://hpiers.obspm.fr/iers/eop/eopc04_20/
Short description:
https://hpiers.obspm.fr/iers/eop/eopc04_20/eopc04.txt

- Up-to-date station **eccentricity file** (continuously updated from local surveys, etc.), latest release is slrecc.**220429**.ILRS.{xyz/une}.snx, ***some errors in prior years corrected***;
- José released a **revised target signature model** based on the one adopted during ITRF2020 development, with new stations added-in as needed, and changes due to station equipment or procedure revision applied:
  - Latest release on or about October 12: **com6.220915**
  - The new model should be adopted by all ACs ASAP
  - ***José needs to look into recent findings/corrections of old station logs as they become available and incorporate the corrections in future releases!***
- The application of the **SSEM bias model** used in ITRF2020 development is required for the period 1993.0 - 2021.0
- The model must be extended up to present and maintained continuously as stated and agreed during our June 30 (virtual) meeting, in order to accommodate changes in the adopted values/procedures, as well as the inclusion of future stations;
- We agreed on a new WEEKLY product using the analysis style adopted for the v230 series used to generate the SSEM model extension, running with 10 days latency, delivering each Wednesday a v230-type SINEX (version **v280**), to be combined with the current model, extending the validity into the future. To this date almost no AC has maintained their v230 series current:

version	ASI	BKG	DGFI	ESA	GFZ	JCET	NSGF	ILRSA	ILRSB
v230	18-07-2022 (106 files)	22-07-08 (103 files)	27-07-12 (105 files)	27-07-2022 (106 files)	28-07-2022 (105 files)	06-09-2022 (125 files)	25-07-2022 (111 files)		
First week	200620	200606	200711	200718	200523	200620	200627		
Last week	220625	220528	220709	220723	220611	221029	220806		

- ❑ The new model will be called ***SSEM-X*** and it will either extend the currently adopted mean long-term biases at each site or, when a significant and persistent change is detected, it will introduce a brake and start a new entry for the site where the change is observed;
- ❑ The Data Handling File (DHF) used in developing ITRF2020 is under revision to include events between 2021.0 and present, and to adjust any biases for which an engineering fix was determined recently. This DHF will be adopted for use with the SLRF2020 upon its adoption and implementation.

- ❑ ***Once the ILRS ASC AC/CCs implement ITRF2020/SLRF2020 and the associated models (PSD, EOP, etc.), we will proceed with:***

  - ❑ *A complete reanalysis of the 1993-present LAGEOS and Etalon data in WEEKLY arcs, to be performed by all 7 ACs;*
  - ❑ *The two CCs will generate the combined products as it is usually done for the operational series;*
  - ❑ *The new series of SINEXs (**v80**) will become the standard available product and it will be archived at the DCs with a landing page and an associated DOI for reference.*
    - ❑ ***the IERS Rapid Service/Prediction Center has not released yet the new version of the Bulletin A that is compatible with ITRF2020, we need to provide them with our preliminary EOP from the test runs using SLRF2020. All AC s should deliver all of the WEEKLY SINEXs for 2021 & 2022 ASAP based on the REPRO models and SLRF2020. These can be combined quickly and the EOP SINEXs sent to IERS RS/PC at USNO so that they can gather the bias they need to apply to the new SLR EOP in generating the new Bulletin A.***

- ***A new series of analysis products will be initiated:***
  - *With ITRF2020/SLRF2020 adopted, the 7 ACs will work to establish a new operational DAILY series (**v180**) and WEEKLY series (**v80**) with 10 days latency, as the SSEM **v280**, using the ITRF2020/SLRF2020 model, in all of ILRS' official products (POS+EOP, Orbits, Daily QC Reports and Weekly series);*

sunday 1	…….	sat 7	sun 8	…	sat 14	sun 15	mon 16	tue 17	wed 18	…..
Data arc from 1 to 7								AC V80 V280 arc 1-7	CC V80 V280 arc 1-7	

- ***A concise "manual" for SLR data analysis** using the new ITRF2020/SLRF2020 model, the associated DHF and ancillary models e.g., the target signature model, TGV, etc., will be compiled and distributed to the SLR data user community.*

PROPOSED TIMELINE:

- ❑ *The DHF used for ITRF2020 development will be **updated** to include elements covering the period 2021 to present and it will become public since it is an integral part of the ITRF2020 implementation;-- **Expected Release: December 2022(???)***
- ❑ *The operational extension of the "SSEM" model, **SSEM-X**; -- **Ongoing***
- ❑ *ASC monitoring of SLR network h/w changes to update the "target signature correction" model, primarily for the geodetic spheres; -- **Ongoing***
- ❑ ***Full implementation of ITRF2020 in operational series (v80, v180, v280) by January 2023***
- ❑ *A complete reanalysis of the 1993-present LAGEOS and Etalon data in WEEKLY arcs by **February 2023? The reanalysis after ITRF2014 was v75, this reanalysis version could be v85.***

v70 and v170 Operational products

ILRS-ASC product	Series Designator (as of March 2020)	TRF (SLRF2014 release)	Target Signature Model (CoM corrections)	ILRS Data Handling file release date	A priori EOP Series	Secular pole model	HF-EOP
Official Products							
Daily POS+EOP	**v170**	2018-05-04 (loosely constrained)	2019-12-17	04/27/20 (9/25/2019)	IERS Bulletin A (estimated)	"ILRS"-IERS mean pole	conventional (IERS Conventions 2010)
Weekly POS+EOP	**v70**	2018-05-04 (loosely constrained)	2019-12-17	04/27/20 (9/25/2019)	IERS Bulletin A (estimated)	"ILRS"-IERS mean pole	conventional (IERS Conventions 2010)
Weekly Orbits	**v70**	2018-05-04 **(release, fixed to a priori)**	2019-12-17	04/27/20 (9/25/2019)	IERS Bulletin A **(EOP fixed to a priori)**	"ILRS"-IERS mean pole	conventional (IERS Conventions 2010)

ILRS-ASC product	Series Designator (as of March 2020)	Gravitational corrections ATM. & OCN. (AOD)	Static Gravity model	Time Varying Gravity model (TVG)	Earth & Ocean Tide models	Ocean Loading model
Official Products						
Daily POS+EOP	**v170**	None	GGM05C	JCET2018	IERS Conventions 2010 & GOT4.10c/FES2014/etc.	GOT4.7
Weekly POS+EOP	**v70**	None	GGM05C	JCET2018	IERS Conventions 2010 & GOT4.10c/FES2014/etc.	GOT4.7
Weekly Orbits	**v70**	None	GGM05C	JCET2018	IERS Conventions 2010 & GOT4.10c/FES2014/etc.	GOT4.7

Pilot Project products

Geometry

ILRS-ASC product	Series Designator (January 2023)	TRF (SLRF2020 release)	Target Signature Model (CoG corrections)	ILRS Data Handling file release date	A priori EOP Series	Secular pole model	HF-EOP
Official Products							
Daily POS+EOP	**v180**	2022 (loosely constrained)	2022-09-15	2022	IERS Bulletin A (estimated)	secular pole (UAW2017)	Desai and Sibois (2019)
Weekly POS+EOP	**v80**	2022 (loosely constrained)	2022-09-15	2022	IERS Bulletin A (estimated)	secular pole (UAW2017)	Desai and Sibois (2019)
Weekly Orbits	**v80**	2022 **(release, fixed to a priori)**	2022-09-15	2022	IERS Bulletin A **(EOP fixed to a priori)**	secular pole (UAW2017)	Desai and Sibois (2019)
Pilot Project Products							
SSEM PP POS+EOP*	**v230**	2020-04-28 (orientation loosely constrained)	2020-06-08	2019-07-31 (via email)	IERS 14 C04 (estimated)	secular pole (UAW2017)	Desai and Sibois (2019)
SSEM-X POS+EOP	**v280**	2022 (loosely constrained)	2022-09-15	2022	IERS 20 C04 (estimated)	secular pole (UAW2017)	Desai and Sibois (2019)
LARES & Gravity PP	**v300**	2022 (orientation loosely constrained)	2022-09-15	2022	IERS 20 C04 (estimated)	secular pole (UAW2017)	Desai and Sibois (2019)
LARES & Gravity PP with NT Loading Corrections	**v310**	2022 (orientation loosely constrained)	2022-09-15	2022	IERS 20 C04 (estimated)	secular pole (UAW2017)	Desai and Sibois (2019)
Discontinued Products							
REPRO 2020	**v400/v401/…**	2020-04-28 (orientation loosely constrained)	2020-06-08	2021-01-27 (via email)	IERS 14 C04 (estimated)	secular pole (UAW2017)	Desai and Sibois (2019)

* **NOTE:** To be discontinued once v280 becomes operational

Release: 2022.11.04

Pilot Project products

Gravity

ILRS-ASC product	Series Designator (January 2023)	Gravitational corrections ATM. & OCN. (AOD)	Static Gravity model	Time Varying Gravity model (TVG)	Earth & Ocean Tide models	Ocean Loading model
Official Products						
Daily POS+EOP	**v180**	None	GGM05C	JCET2022	IERS Conventions 2010 & GOT4.10c/FES2014/etc.	GOT4.10c / FES2014c
Weekly POS+EOP	**v80**	None	GGM05C	JCET2022	IERS Conventions 2010 & GOT4.10c/FES2014/etc.	GOT4.10c / FES2014c
Weekly Orbits	**v80**	None	GGM05C	JCET2022	IERS Conventions 2010 & GOT4.10c/FES2014/etc.	GOT4.10c / FES2014c
Pilot Project Products						
SSEM PP POS+EOP*	**v230**	None	GGM05C	JCET2018	IERS Conventions 2010 & GOT4.10c/FES2014/etc.	GOT4.7
SSEM-X POS+EOP	**v280**	None	GGM05C	JCET2022	IERS Conventions 2010 & GOT4.10c/FES2014/etc.	GOT4.10c / FES2014c
LARES & Gravity PP	**v300**	ON ORBIT ONLY: GGFC ERA5 & TUGO-m or AOD1B-RL06, etc.	GGM05C	JCET2022	IERS Conventions 2010 & GOT4.10c/FES2014/etc.	GOT4.10c / FES2014c
LARES & Gravity PP with NT Loading Corrections	**v310**	GGFC ERA5 & TUGO-m or AOD1B-RL06, etc.	GGM05C / EIGEN-GRGS.RL04.MD*	JCET2022	IERS Conventions 2010 & GOT4.10c/FES2014/etc.	GOT4.10c / FES2014c
Discontinued Products						
REPRO 2020	**v400**	ON ORBIT ONLY: GGFC ERA5 & TUGO-m or AOD1B-RL06, etc.	GGM05C / EIGEN-GRGS.RL04.MD*	JCET2021	IERS Conventions 2010 & GOT4.10c/FES2014/etc.	GOT4.10c / FES2014c
* **NOTE:** To be discontinued once v280 becomes operational						

Release: 2022.11.04

*Provided you use the NEW IERS (2018) « linear mean pole convention » version of the model !!!

*We may switch to GOT5 and a comparable FES model when avaialble

Lares PP Status (v300)

Solution submitted to EDC (Year: 2017):

	First	Last
- **ASI**: 52 Weekly Sinex	asi.pos+eop.170107.v300.snx	asi.pos+eop.171230.v300.snx
- **DGFI**: 53 Weekly Sinex (with cn/sn estimations)	dgfi.pos+eop.161231.v300.snx	dgfi.pos+eop.171230.v300.snx

- Estimation of Coefficients

ASI AC&CC report

e-GEOS S.p.A., CGS - Matera

G. Bianco
Agenzia Spaziale Italiana, CGS - Matera

Activities since last ASC meeting

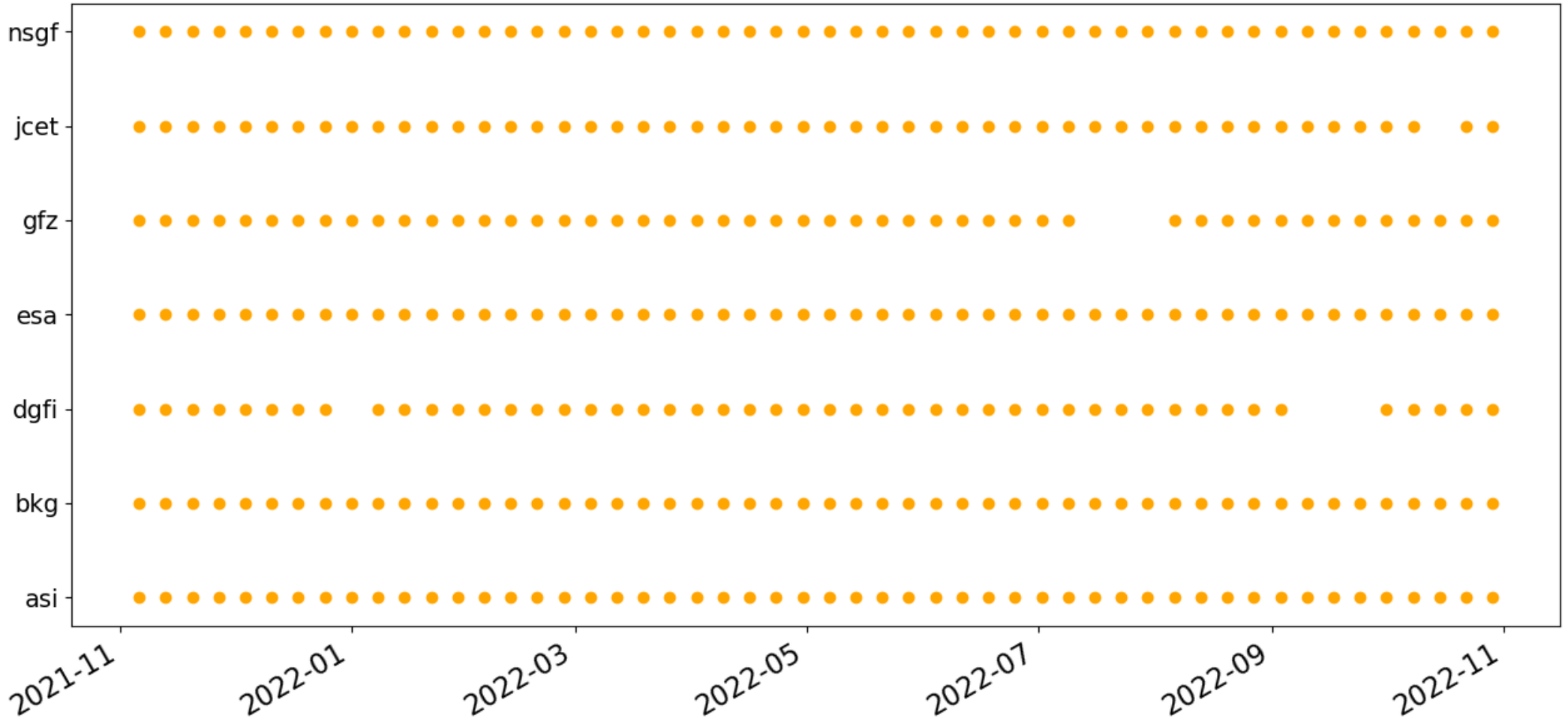
- ACs performance check
  - Data submissions
  - 3D wrms of the residuals w.r.t. SLRF (daily and weekly)
  - Scale
  - Geocenter motion
  - LOD
  - Orbits: RMS of residuals w.r.t. combination
  - ILRS ACs orbit agreement
- Activities to control systematic error, its modelling for the SLR contribution to ITRF2020, future perspectives.

Solution submissions

Daily (v170) ACs time series
2021/11/03 – 2022/11/03

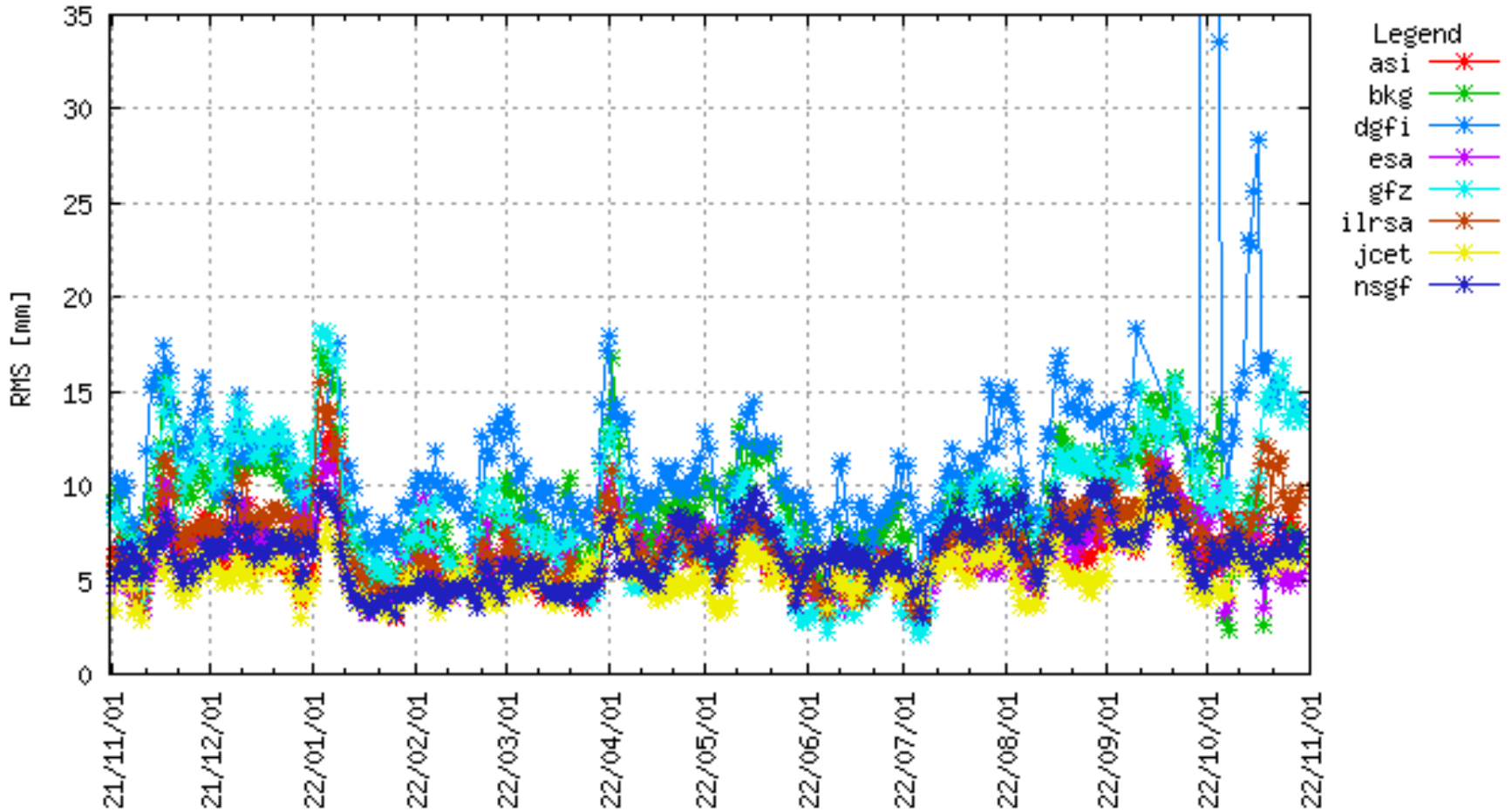
Solution submissions

Weekly (v70) ACs time series
2021/11/03 – 2022/11/03



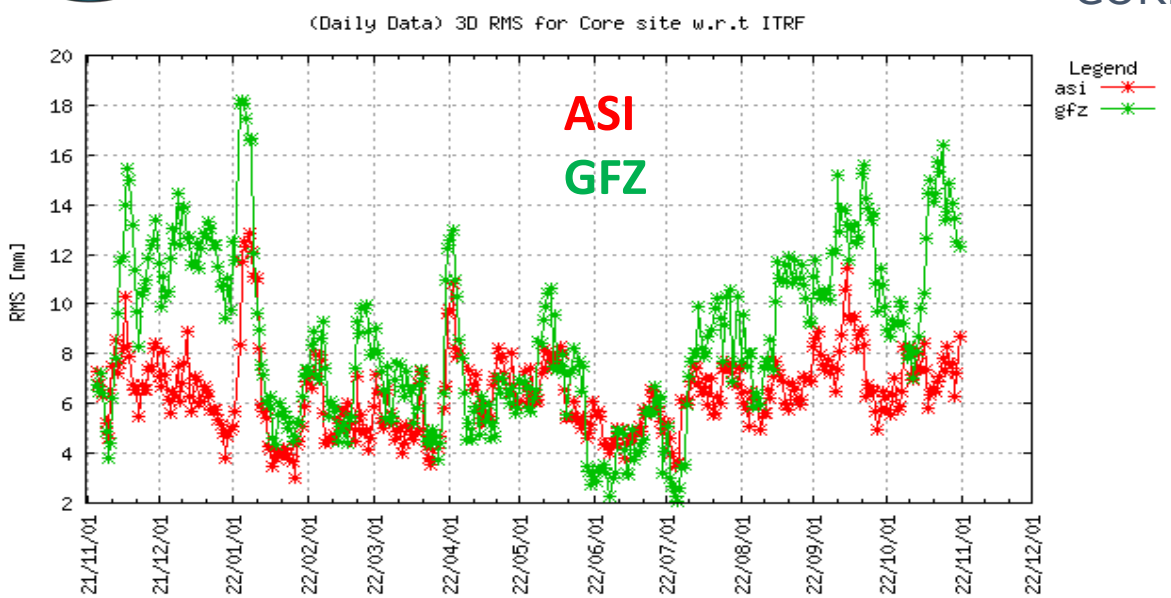
Stations coordinates from daily solutions

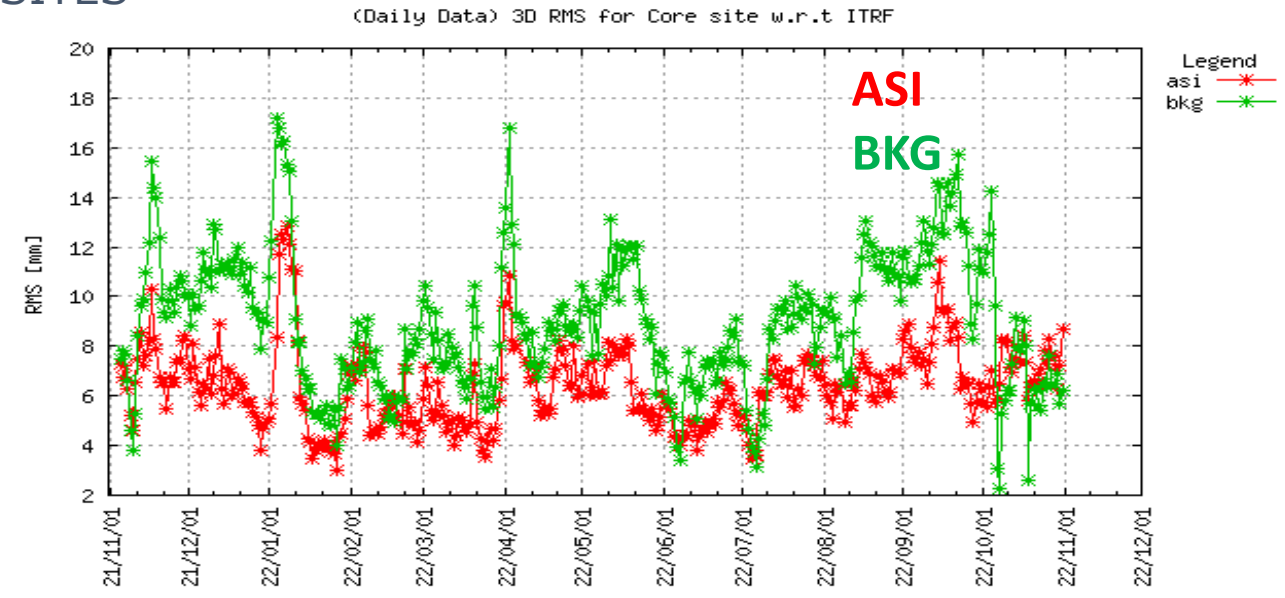
3D wrms of the residual w.r.t. SLRF2014
CORE SITES

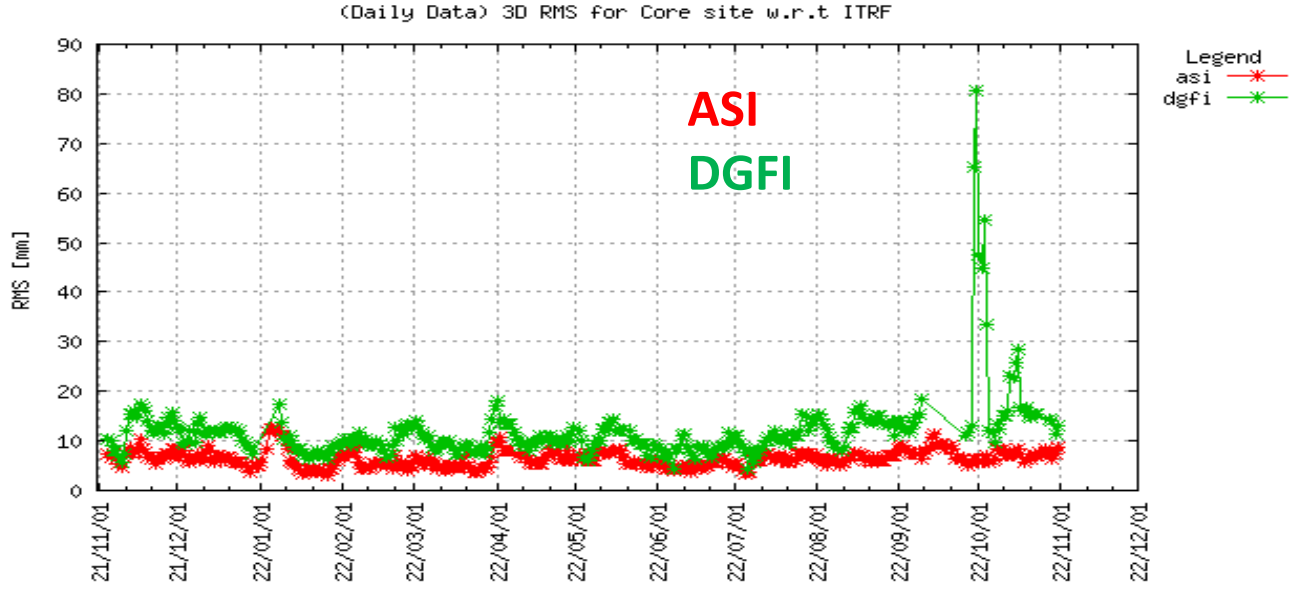


Stations coordinates from daily solutions

3D wrms of the residual w.r.t. SLRF2014
CORE SITES

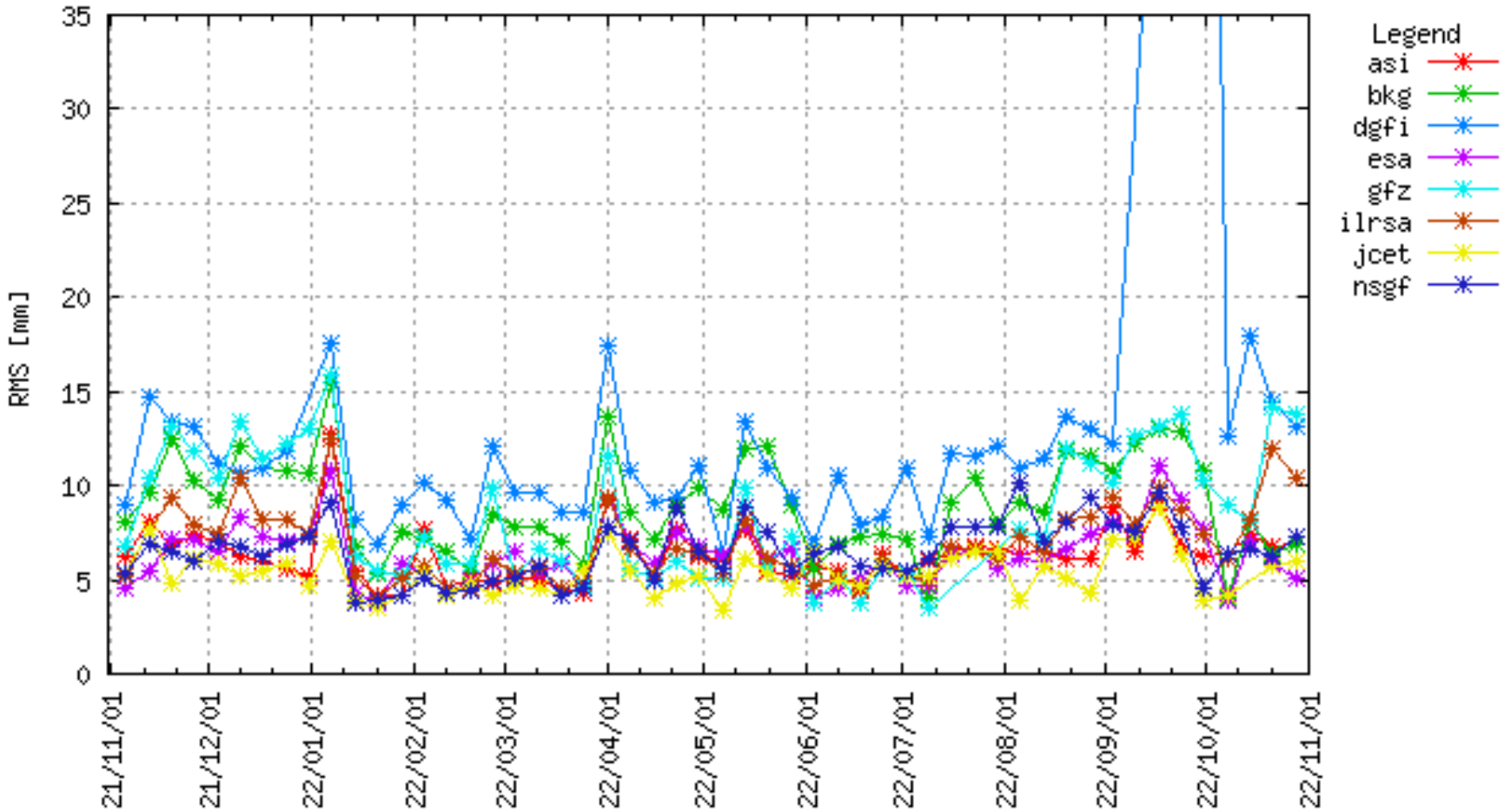




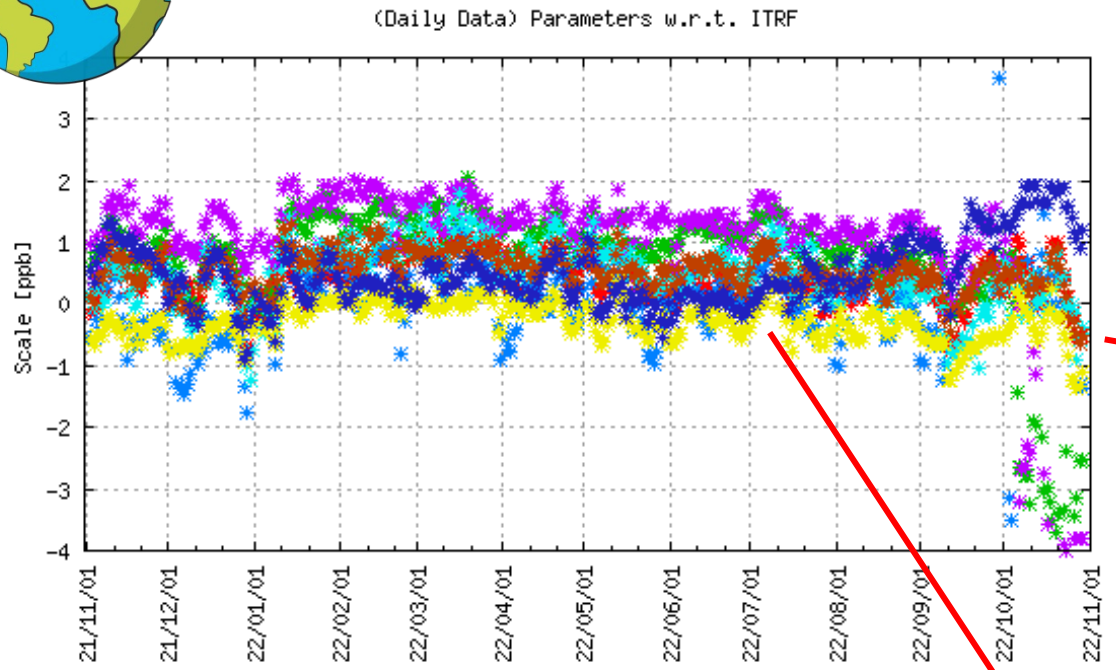


Stations coordinates from weekly solutions

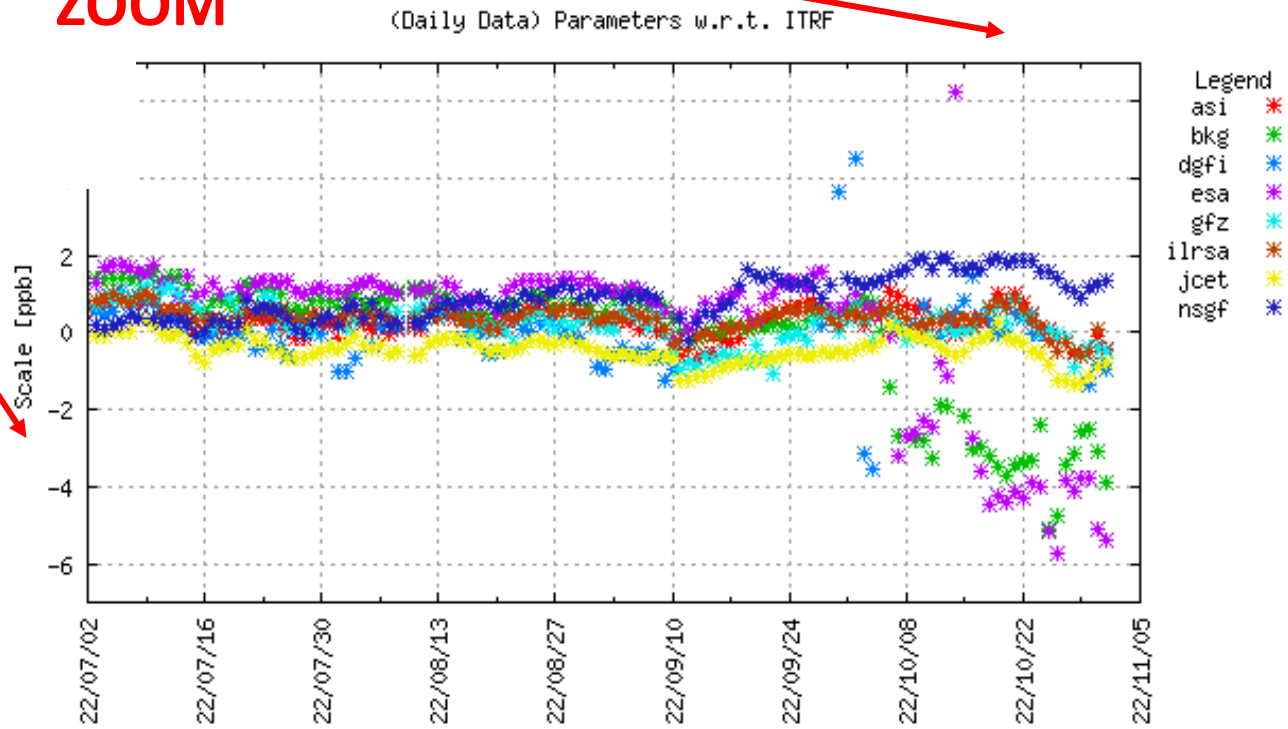
3D wrms of the residual w.r.t. SLRF2014
CORE SITES



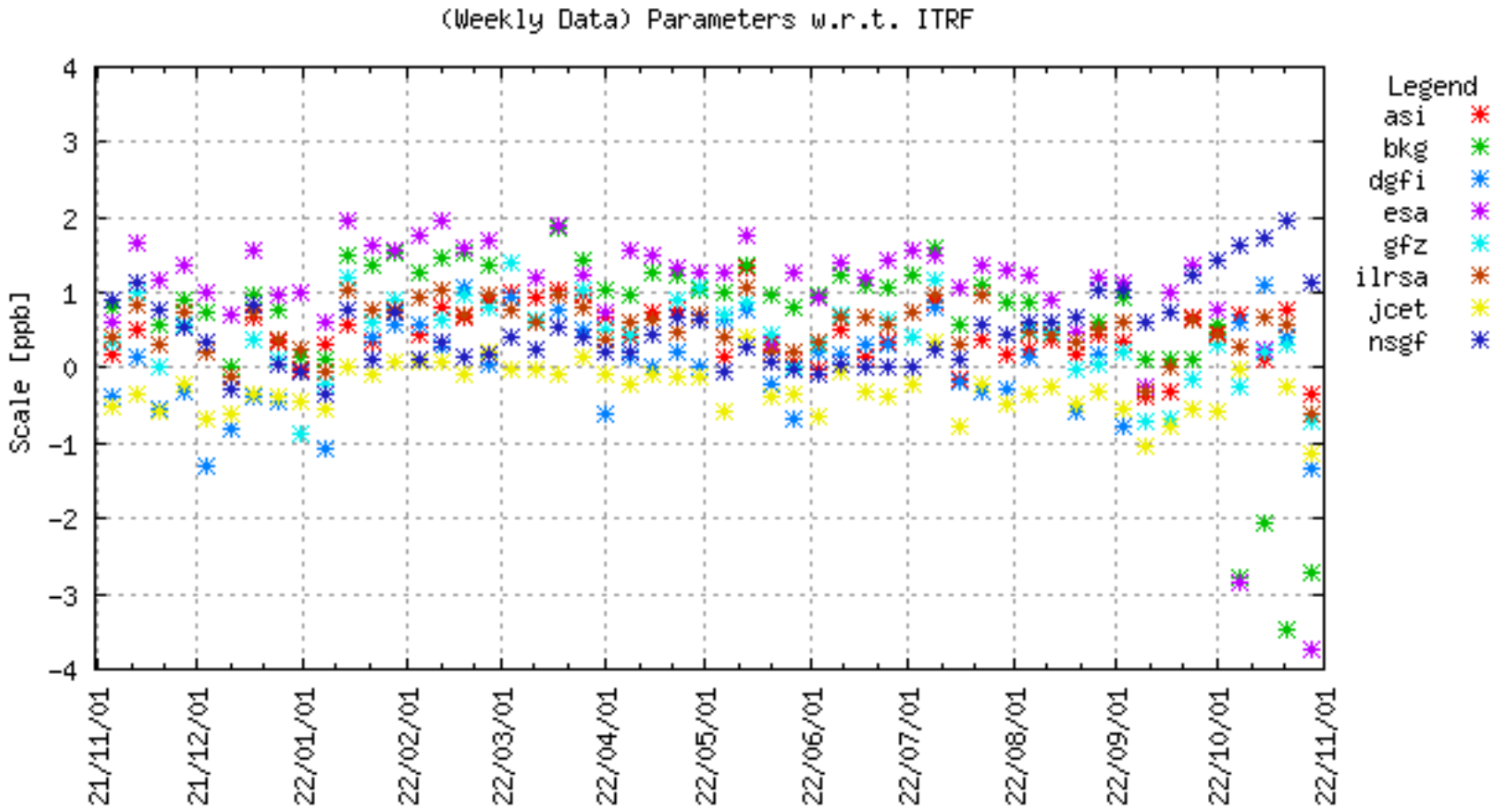
Scale from daily solutions



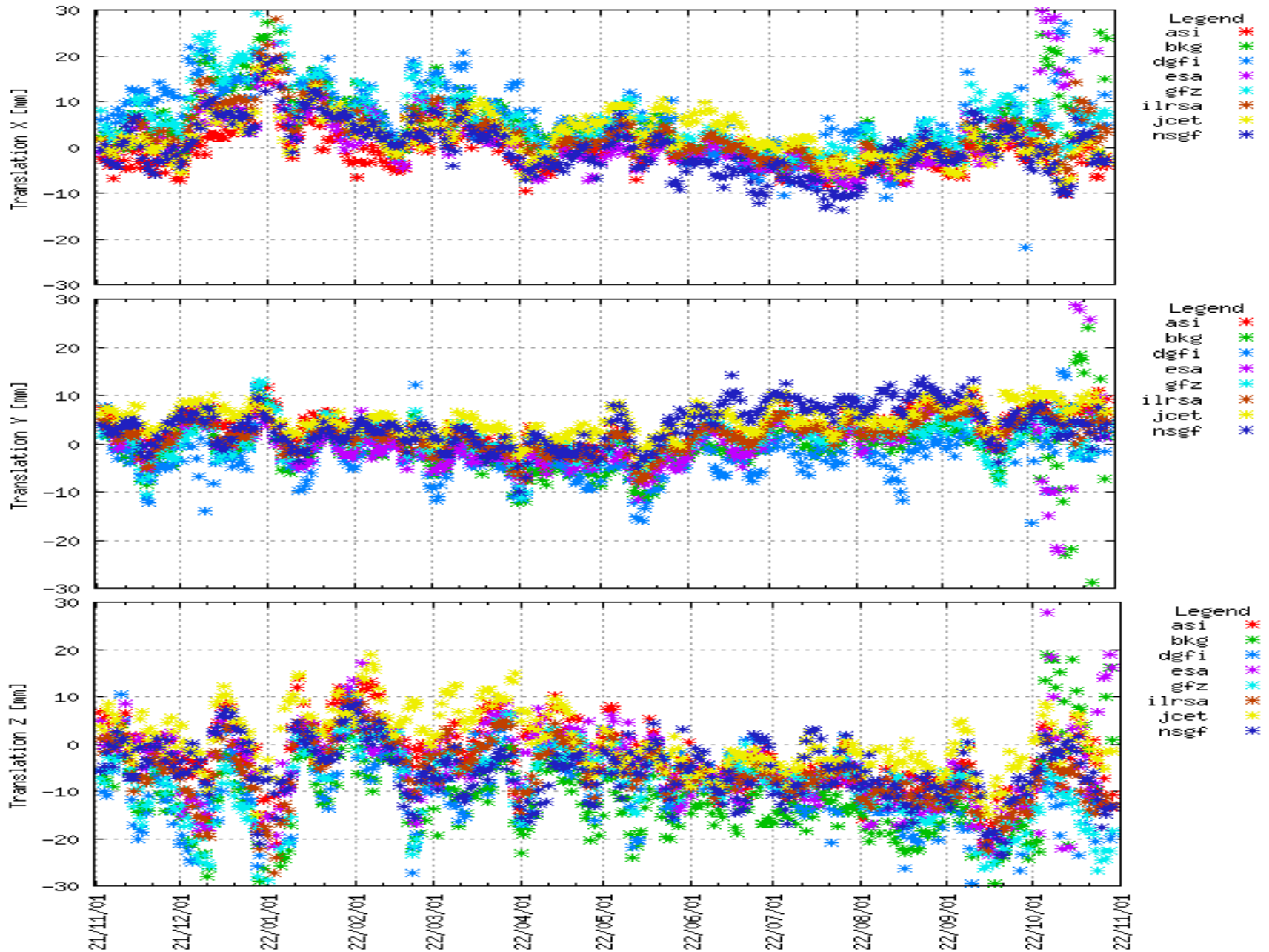
ZOOM



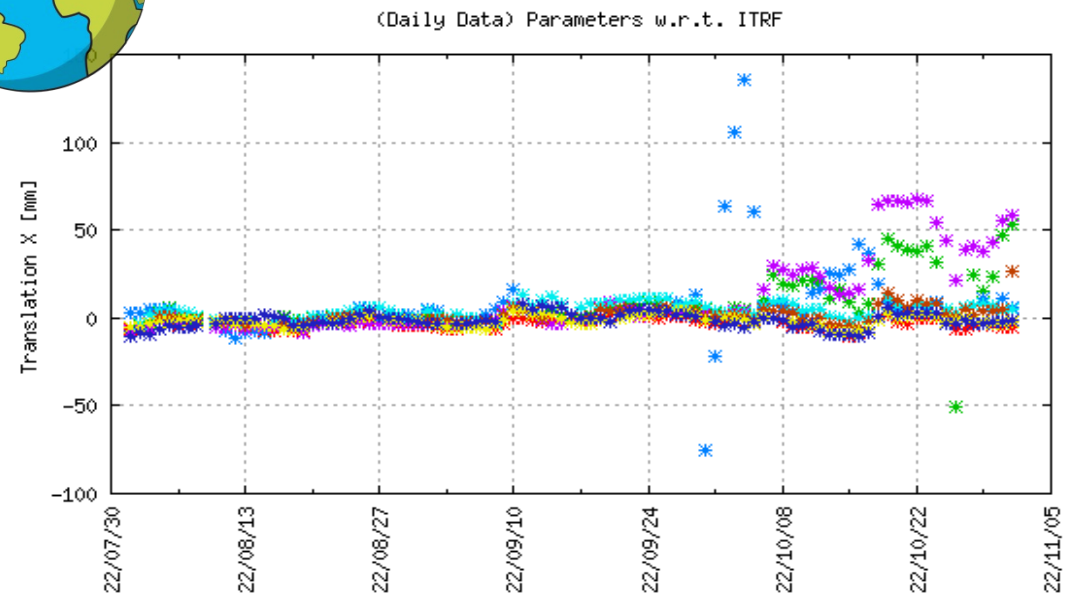
Scale from weekly solutions

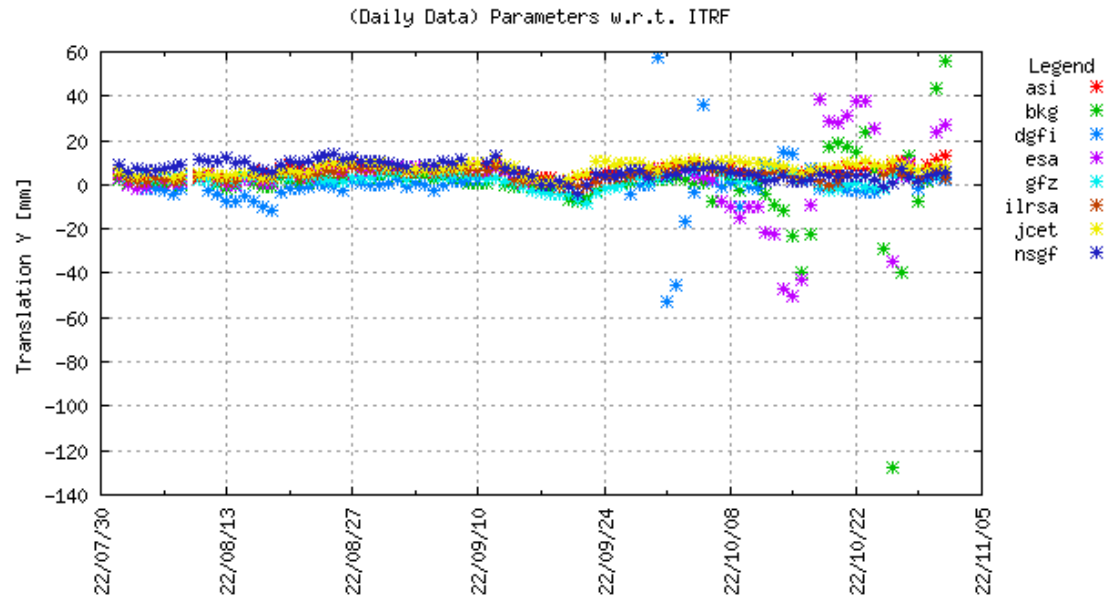


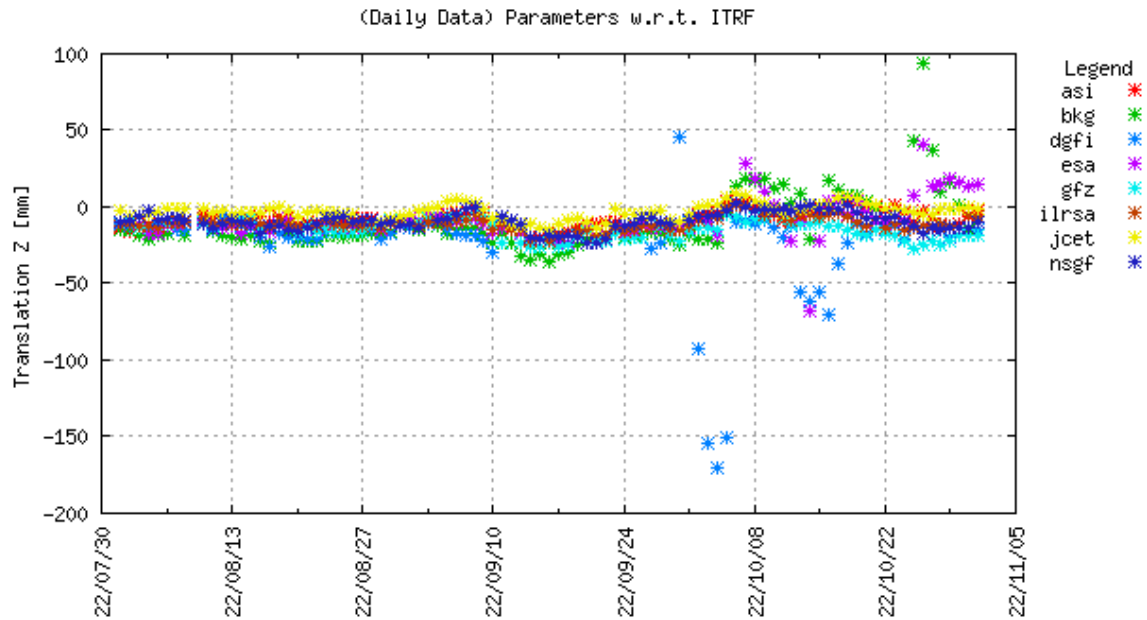
Geocenter motion from daily solutions



Geocenter motion from daily solutions (zoom)

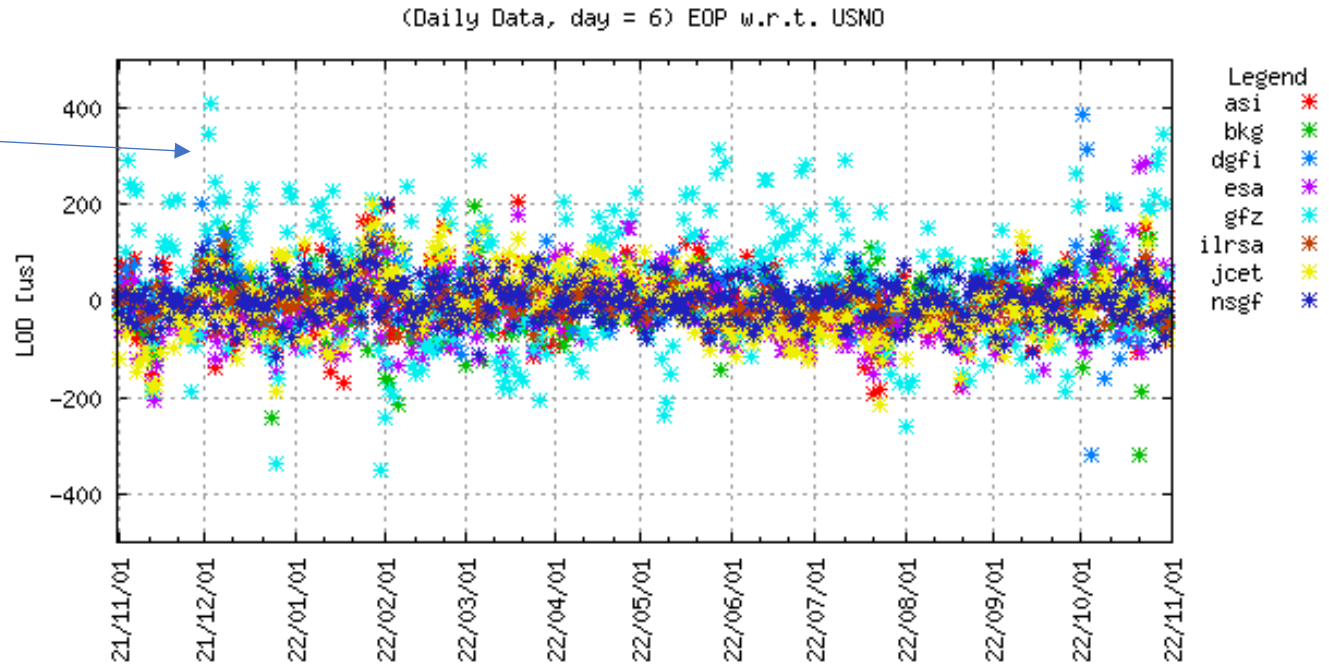




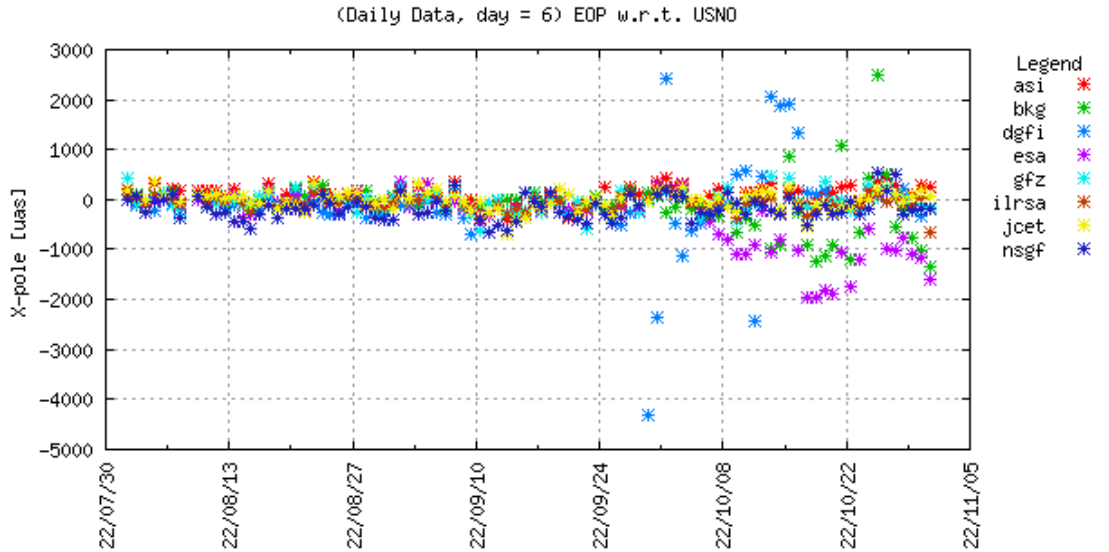


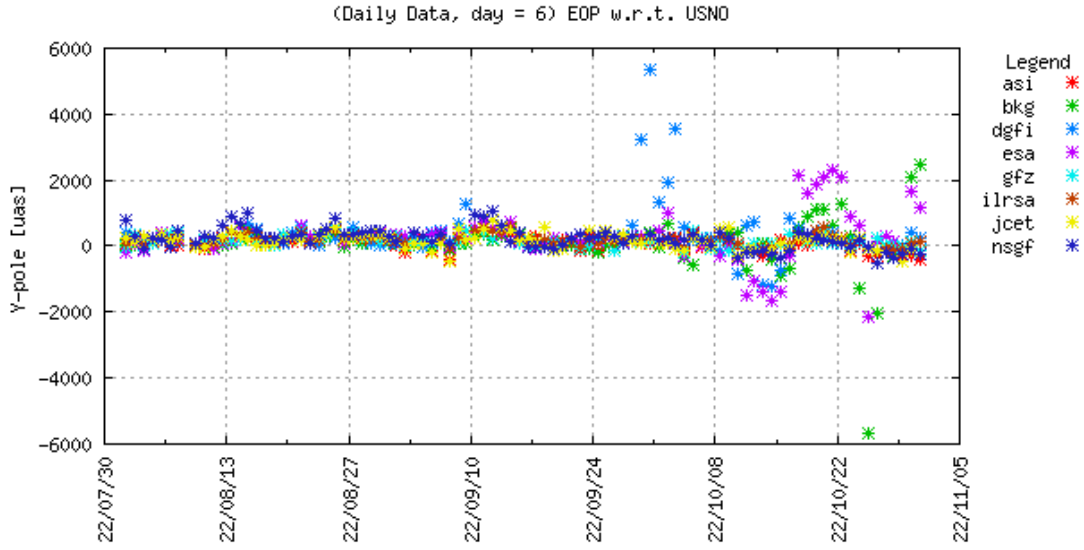
LOD from daily solutions

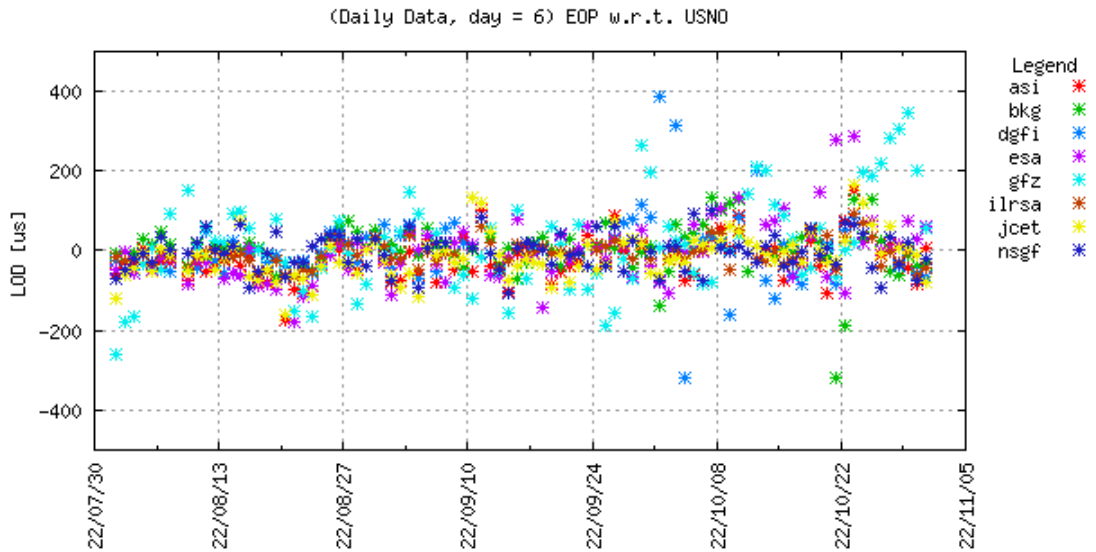
GFZ



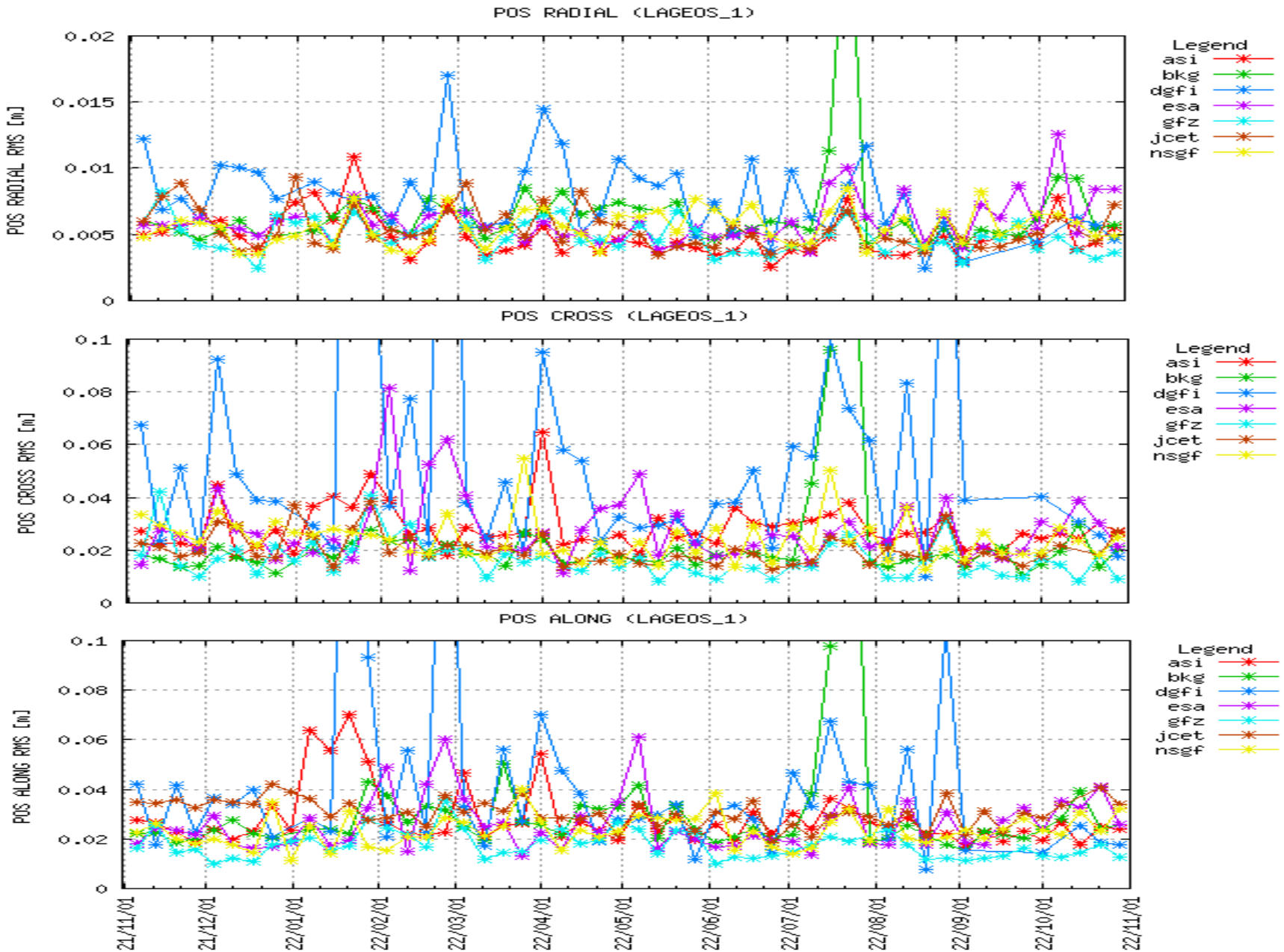
EOP from daily solutions



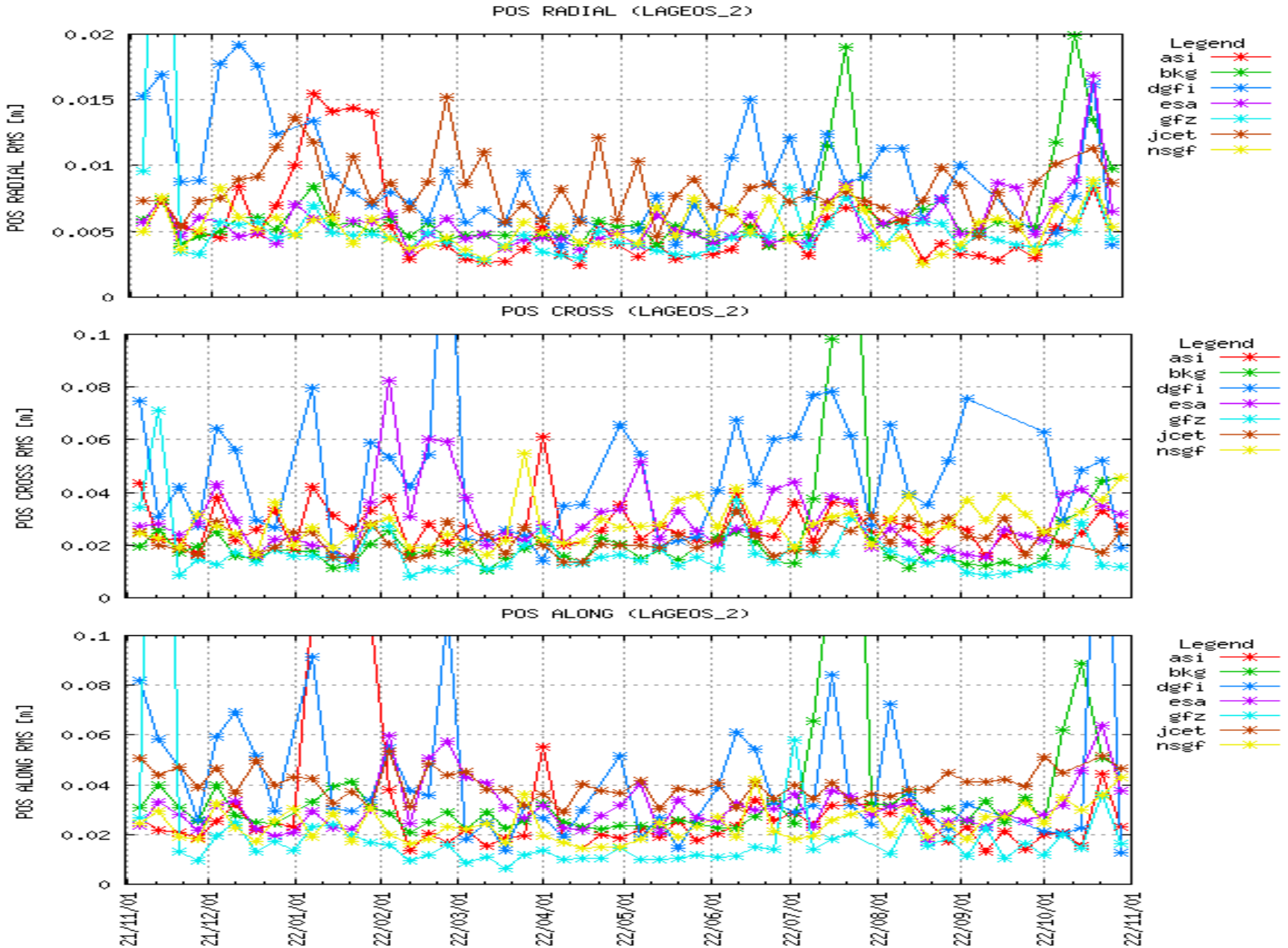




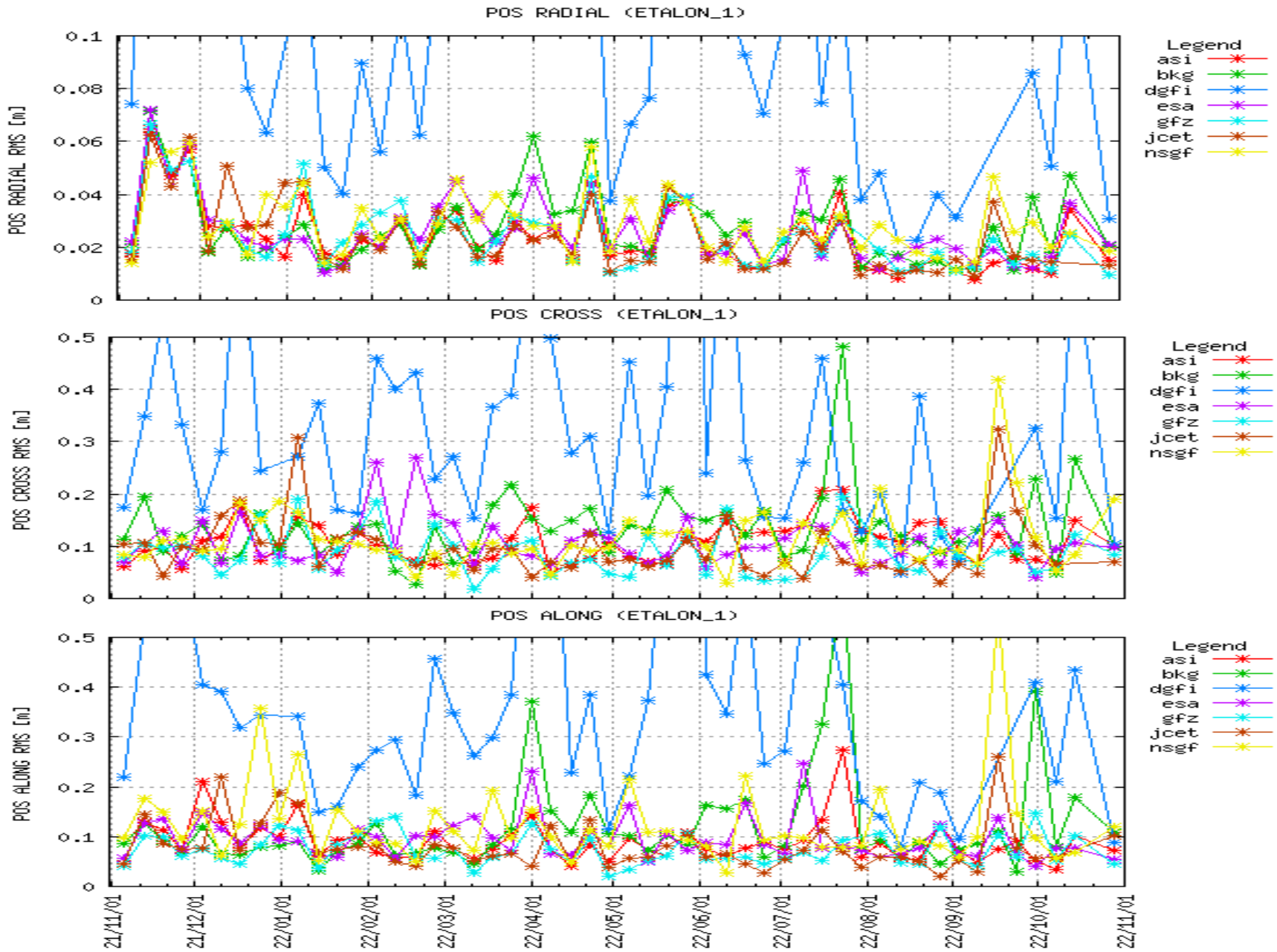
LAGEOS1 orbits – RMS of residuals w.r.t. combination



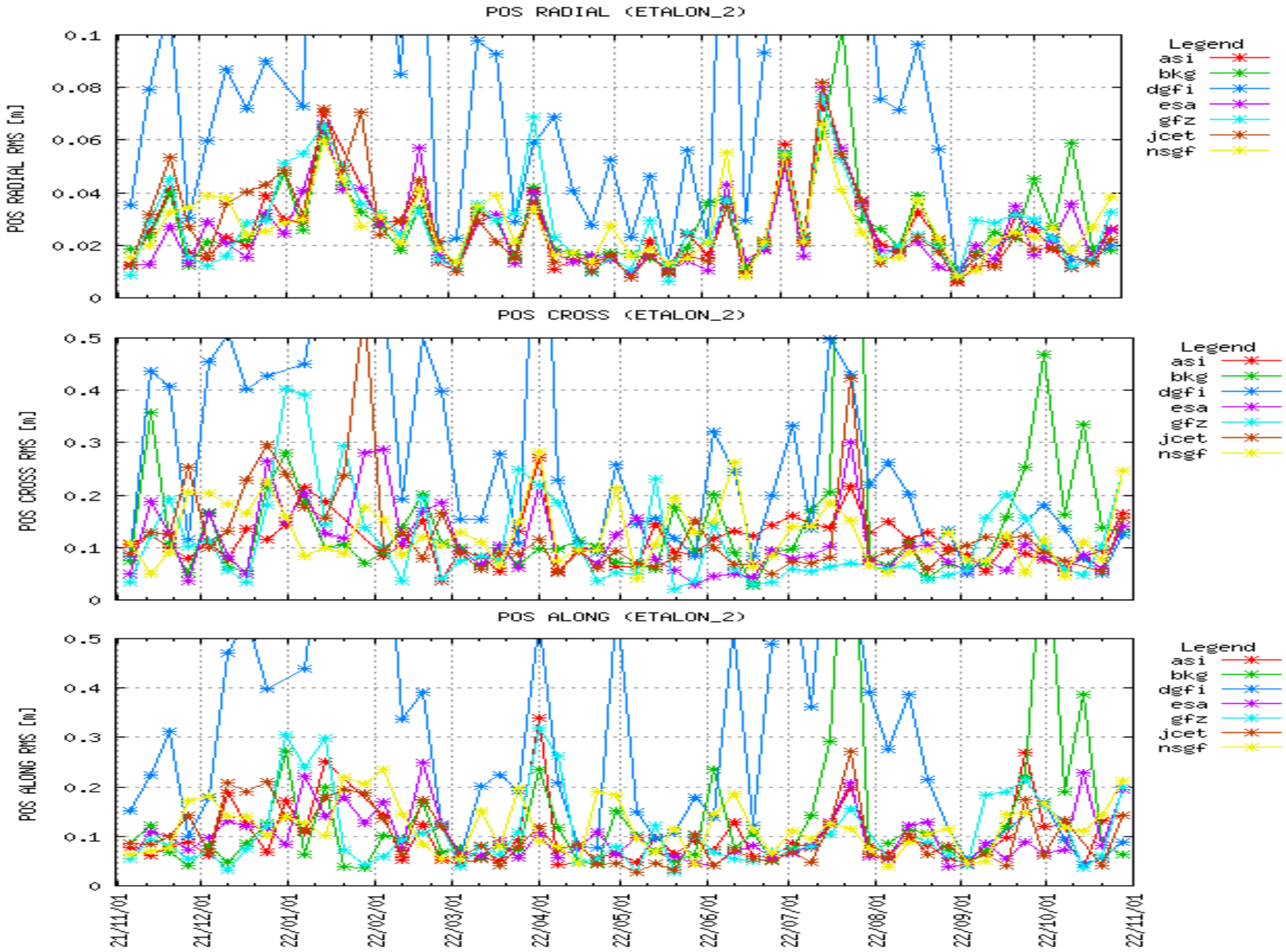
LAGEOS2 orbits – RMS of residuals w.r.t. combination



ETALON1 orbits – RMS of residuals w.r.t. combination



ETALON2 orbits – RMS of residuals w.r.t. combination



ILRS ACs orbit agreement

Satellite	Radial [mm]	Cross-track [mm]	Along-track [mm]
LAGEOS1	5.82	28.2	28,19
LAGEOS2	6.5	27.6	32.81
ETALON1	40.1	139.6	141.67
ETALON2	36.64	147.5	138.55

Mean RMS over the period 2021/11/03-2022/11/03

Systematic Errors in SLR Data Modeled in ITRF2020

Slides from the presentation at
Unified Analysis Workshop (UAW), Thessaloniki 21-23 October 2022

Station Systematic Error Modeling (SSEM) in ITRF2020

ASI/CGS
ILRSA Primary

JCET
ILRSB Backup

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

- Analysis since **01/1993.**
- Weekly estimation of coordinates, EOP and range biases RB
- Time frame for the Pilot Project: 1993 – 2020 for ITRF2020 and currently extended to 06/2022
- Data: LAGEOS , LAGEOS 2, ETALON1-2
- Time series with separate range biases for LAGEOS, combined for ETALON
- Update of the Data Handling file with a set of mean range biases obtained from the combined time series

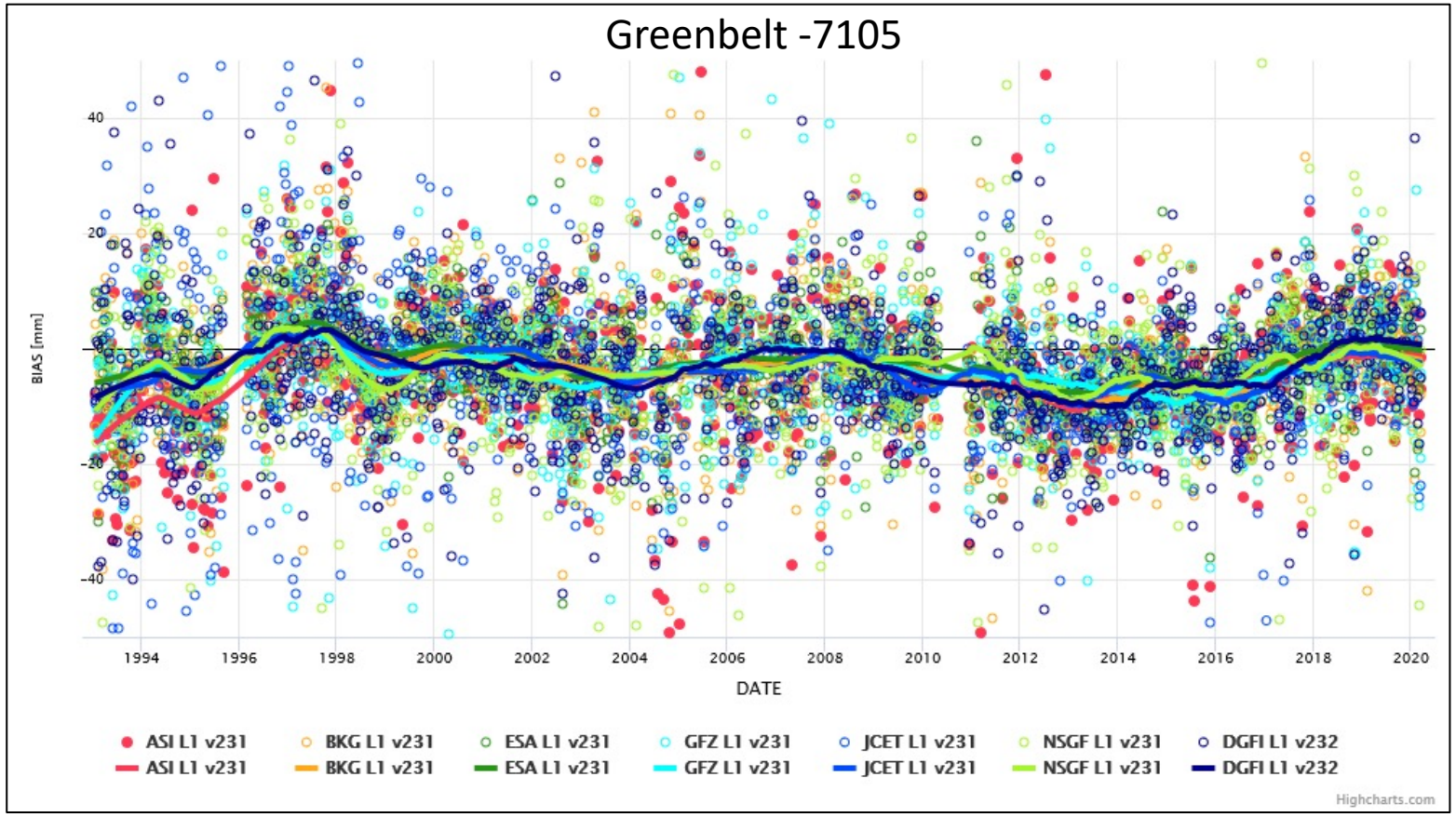
Reanalysis since 1993 (both ACs and CCs) in weekly arcs adopting the new data handling file and production of SINEX files submitted to IERS for ITRF.

Reanalysis 1983-1992 (both ACs and CCs) and production of SINEX files submitted to IERS

- 15-day estimation of coordinates, EOP and range biases RB
- Data: LAGEOS

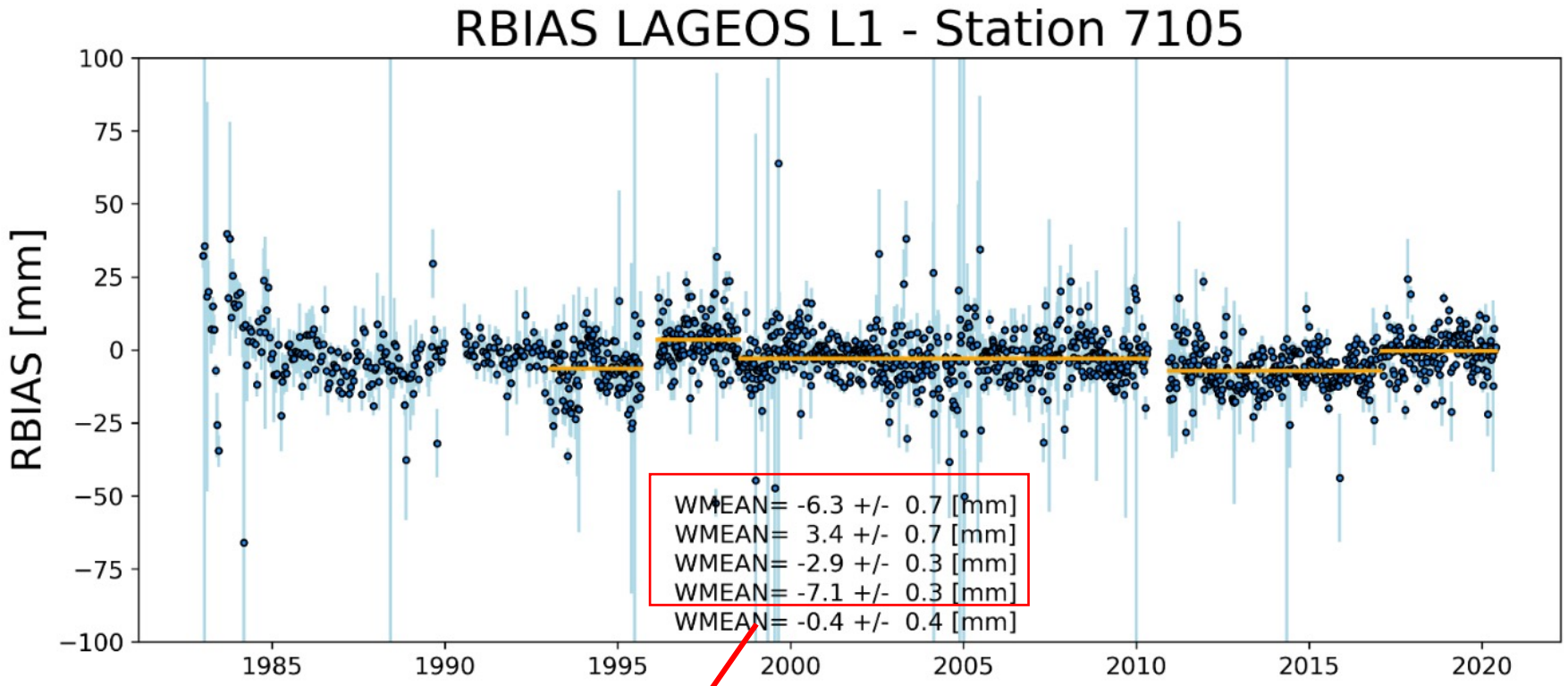
Range bias estimation in the SSEM Pilot Project

Changes in stations systematic behaviour were identified in the combined series and in consultation with available station logs. Estimates were used as *a priori* in the reanalysis for ITRF2020.



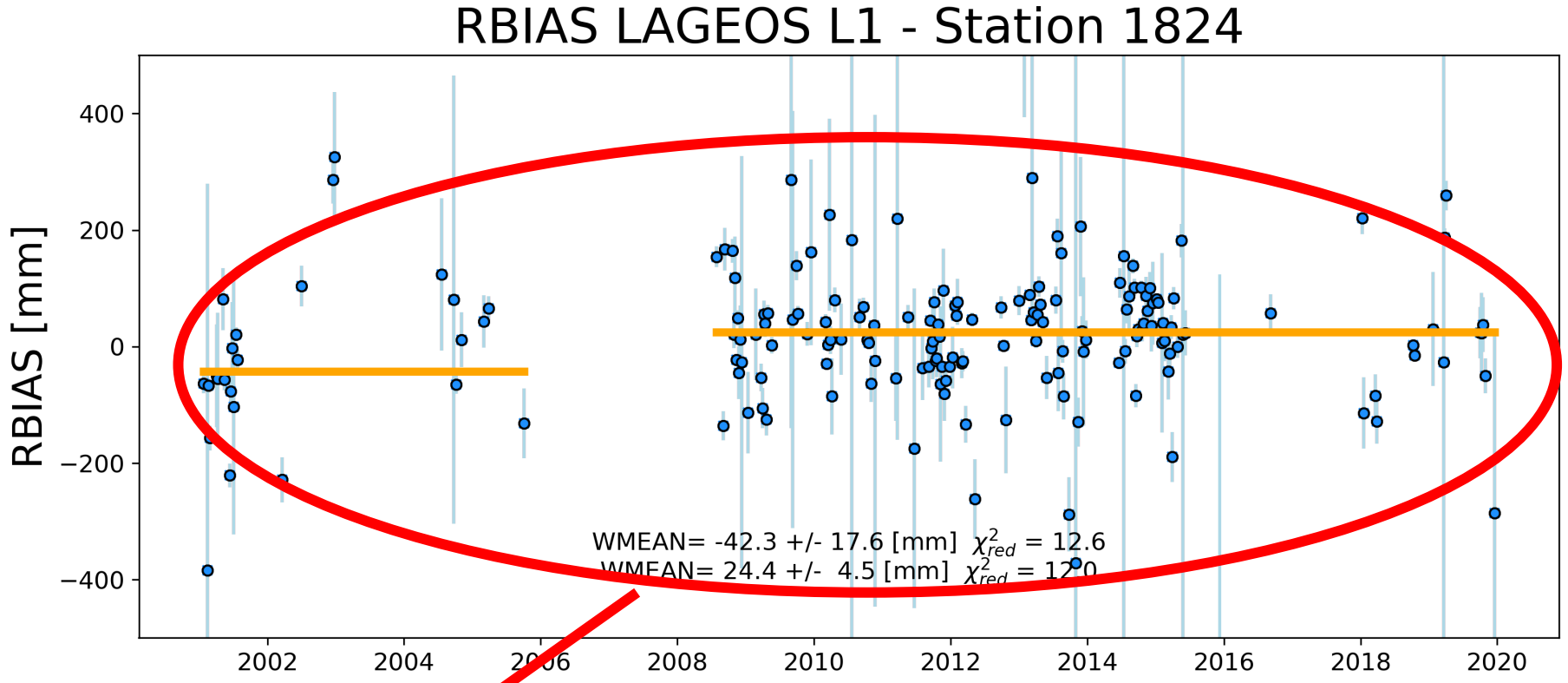
http://geodesy.jcet.umbc.edu/ILRS_AWG_MONITORING/

The construction of the Data Handling file



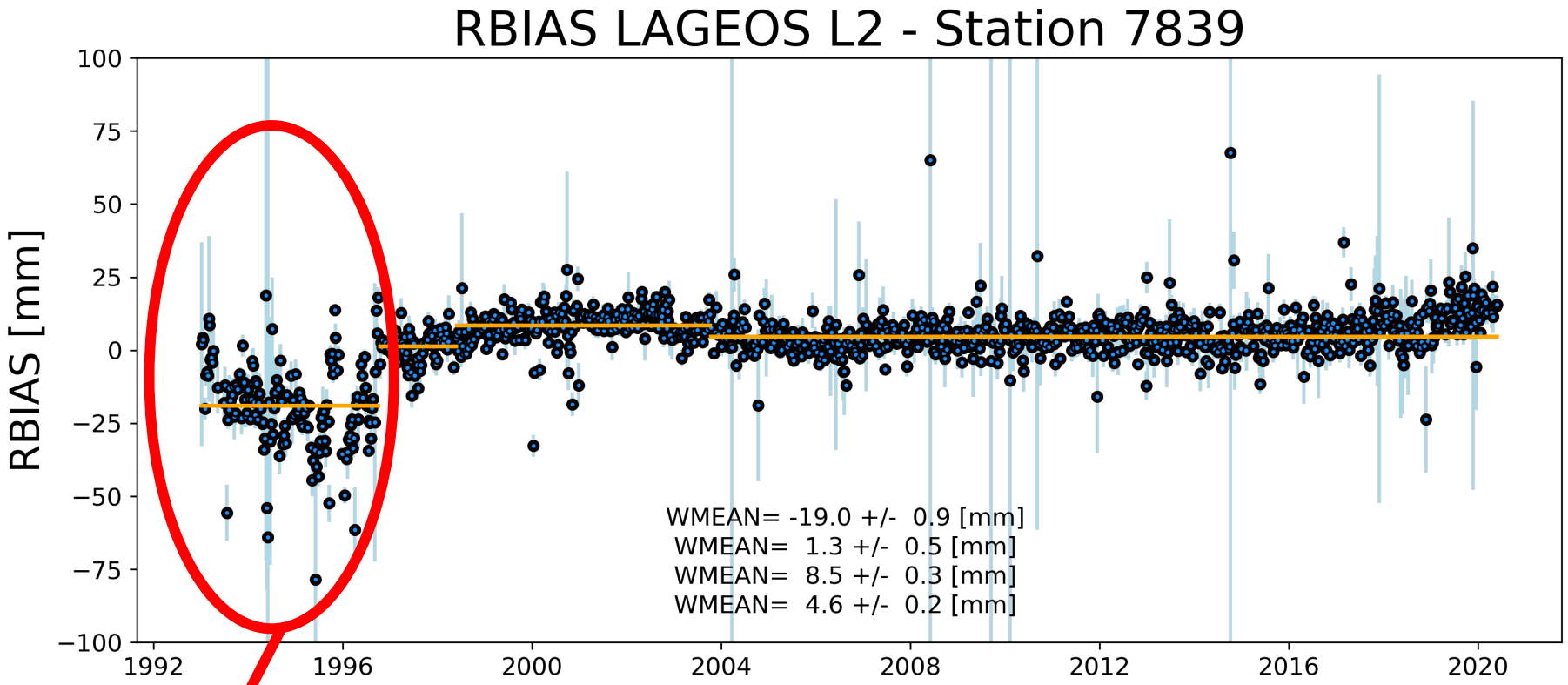
+MODEL/RANGE_BIAS
*CODE PT SOLN T START_DATE__ END_DATE____ M __E-VALUE___ STD_DEV _E-RATE__ UNIT CMNTS
.....
7105 51 501 A 93:017:00000 95:253:00000 R -6.3 0.7 mm
7105 51 501 A 96:056:00000 98:193:00000 R 3.4 0.7 mm
7105 51 501 A 98:193:00000 10:122:00000 R -2.9 0.3 mm
7105 51 501 A 10:339:00000 17:029:00000 R -7.1 0.3 mm
.....

The construction of the Data Handling file



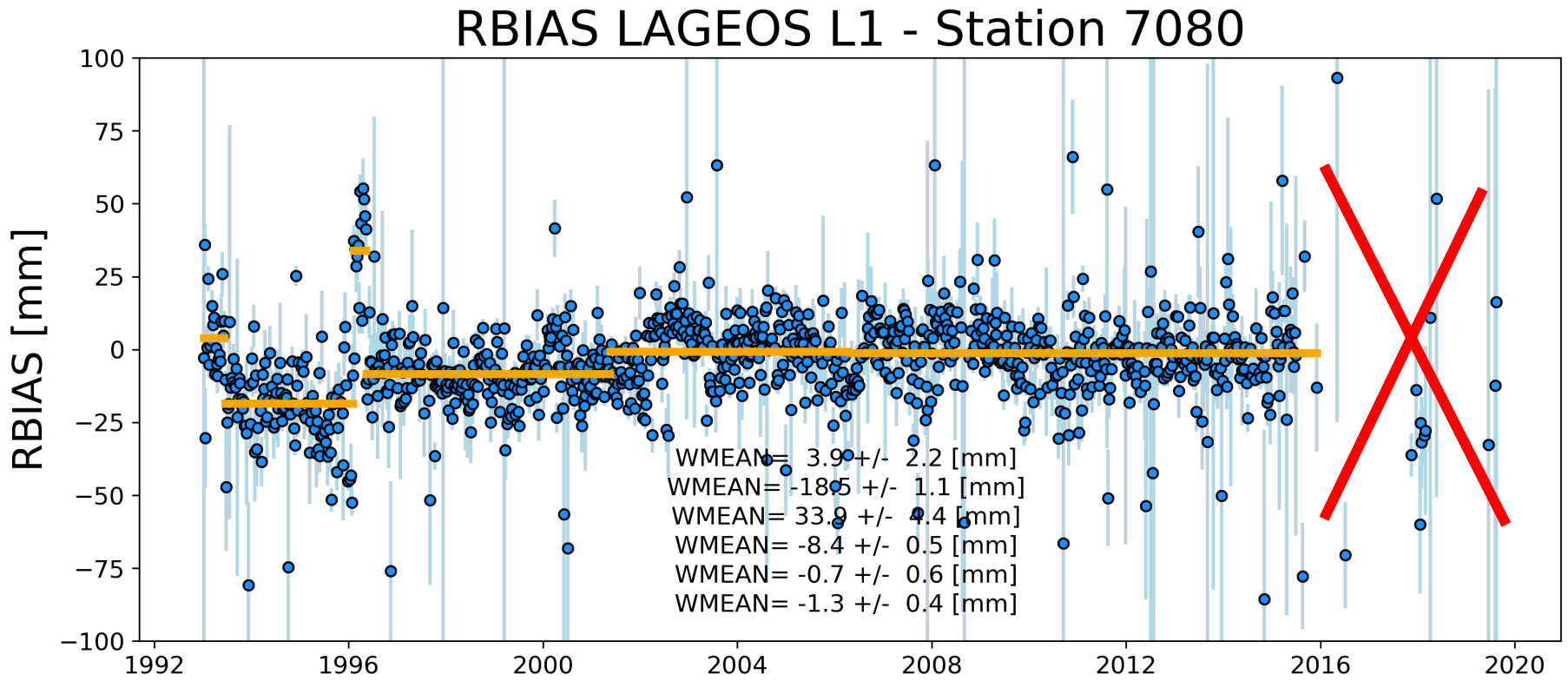

```
*--------------------------------------------------------------------------
*  list of sites with mandatory arc dependent biases to be estimated
*--------------------------------------------------------------------------
*CODE PT SOLN T START_DATE__ END_DATE____ M __E-VALUE___ STD_DEV _E-RATE__ UNIT   CMNTS
 1824 --  501 A 00:000:00000 00:000:00000 E                          mm
```

The construction of the Data Handling file




```
*-------------------------------------------------------------------------
*  list of sites with mandatory arc dependent biases to be estimated
*-------------------------------------------------------------------------
*CODE PT SOLN T START_DATE__ END_DATE____ M __E-VALUE___ STD_DEV _E-RATE__ UNIT   CMNTS
 7839 --  501 A 00:000:00000 96:294:00000 E
```

The construction of the Data Handling file



*----------

* list of data to be deleted

*----------

*CODE PT SOLN T START_DATE__ END_DATE____ M _____ _____ _____ ____ CMNTS

7080 -- ---- A 16:106:00000 00:000:00000 X

The Data Handling file

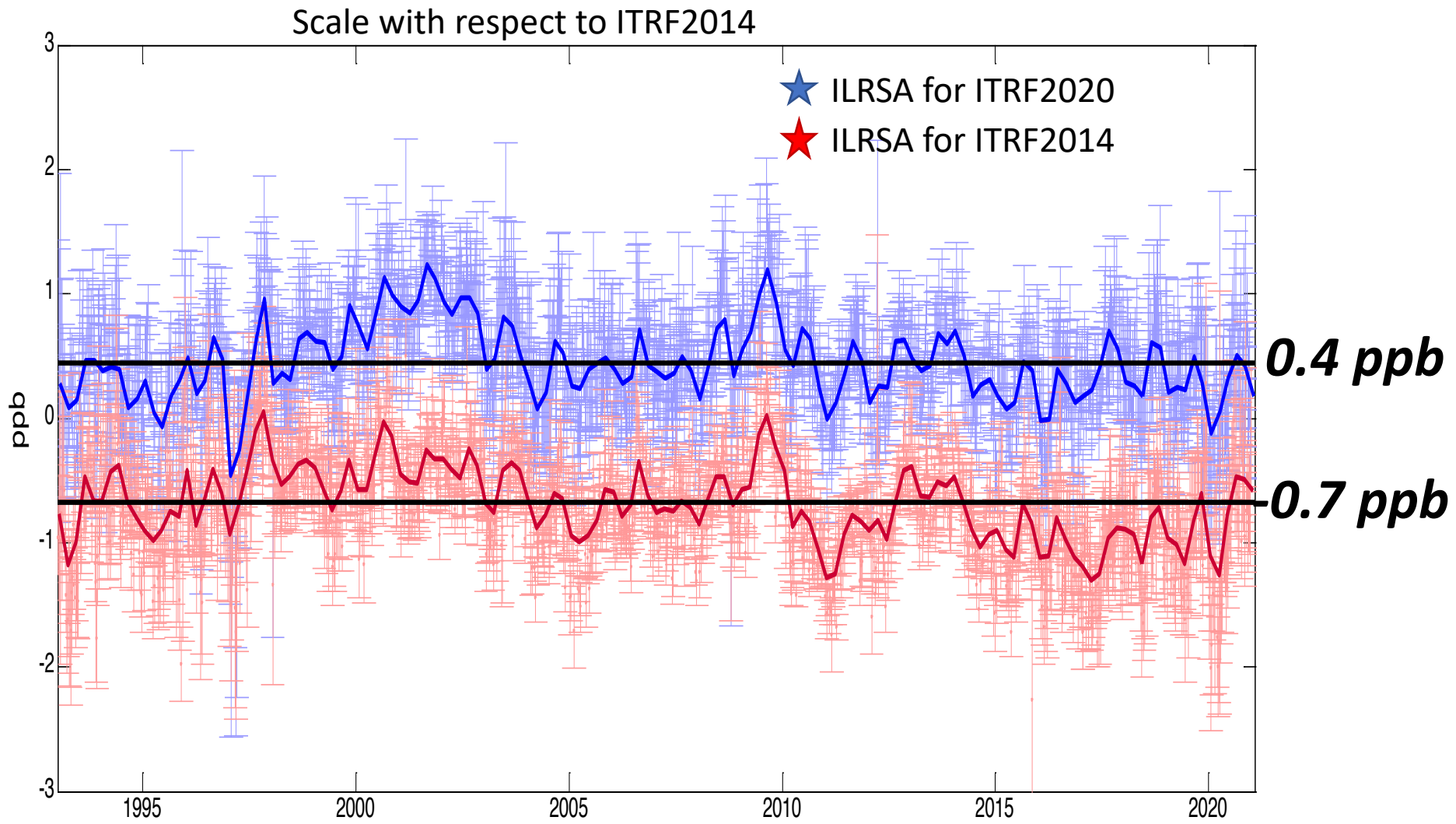
+MODEL/RANGE_BIAS
*List of mandatory systematic errors to be applied on observations

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

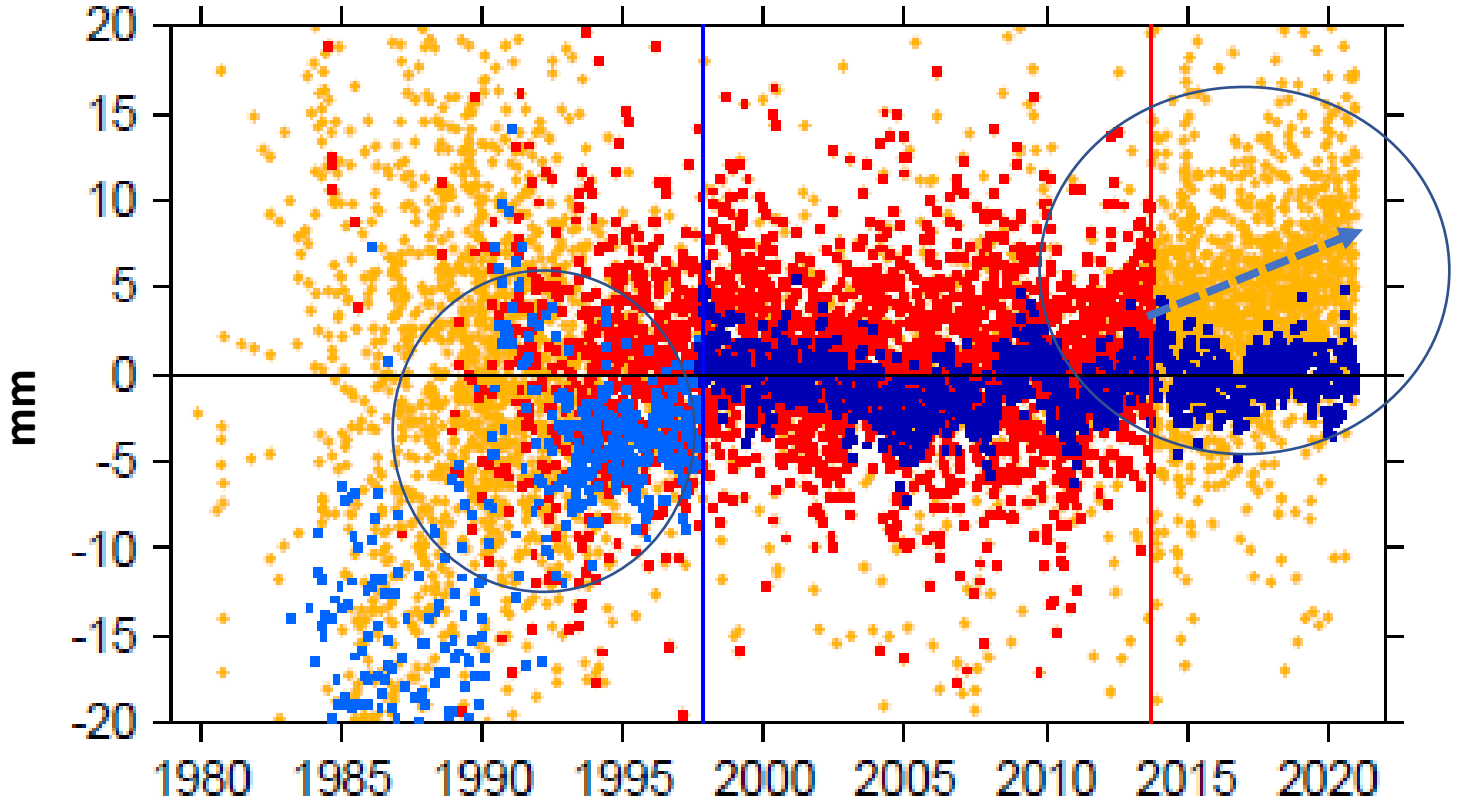
+MODEL/TIME_BIAS
* Time Biases including the
* T2L2 Tb and Tb-rate DATA RECORDS
* which are significant for LARES and higher orbits (range equivalent >10 mm)

and
** SECTION WITH OPTIONAL CORRECTIONS COMMENTED with "*"

Impact on the scale



Scales with respect to ITRF2020



- Orange: all VLBI Sessions
- **Red: Selected VLBI Sessions**
- **Light blue: all SLR time series**
- **Dark blue: Selected SLR time series**

Scale offset between SLR & VLBI is 0.15 ppb (1 mm at the equator)

Ref: Altamimi et al , 2022

Operational Data Handling file

- Extension of the SSEM to mid-2022
- Weekly production of SSEM-like SINEXs file to routinely extend the RB time series
- Periodic update of the DH file

DH file for ITRF2020

Old_records.snx — Edited

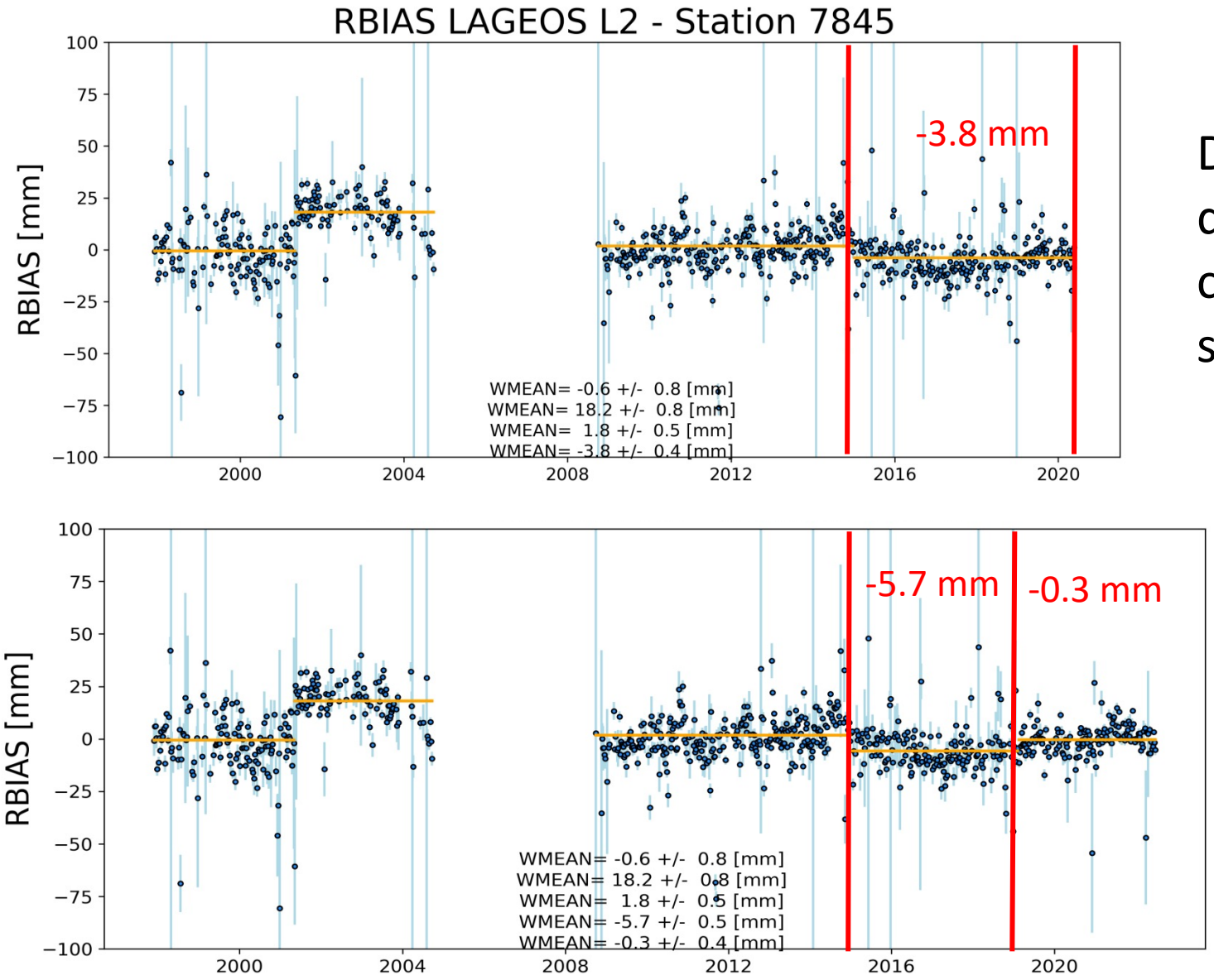
```
608: 1890 51  501 A 12:001:00000 21:001:00000 R        12.9     1.1
609: 1893 51  501 A 05:212:00000 21:001:00000 R       -33.4     1.6
613: 7090 51  501 A 14:208:00000 21:001:00000 R         2.3     0.2
621: 7110 51  501 A 96:287:00000 21:001:00000 R        -5.2     0.2
624: 7119 51  501 A 15:067:00000 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

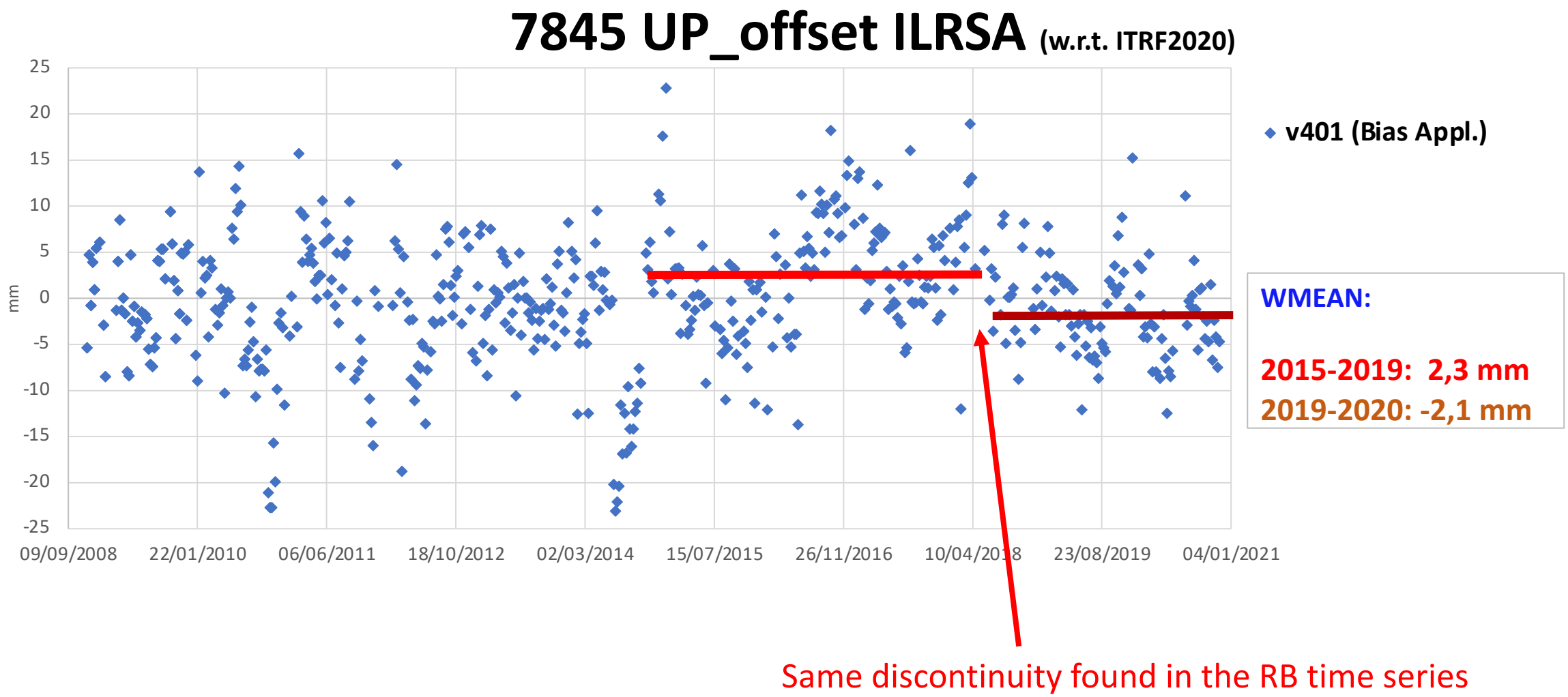
```
1890 51  501 A 12:001:00000 22:149:00000 R        14.0     1.0
1893 51  501 A 05:212:00000 22:177:00000 R       -33.2     1.4
7090 51  501 A 14:208:00000 22:177:00000 R         2.4     0.2
7110 51  501 A 96:287:00000 22:177:00000 R        -5.3     0.2
7119 51  501 A 15:067:00000 22:177:00000 R         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
```

Extended RB time series for Grasse



Date of discontinuity to be checked with the station

RB impact on the Grasse coordinates

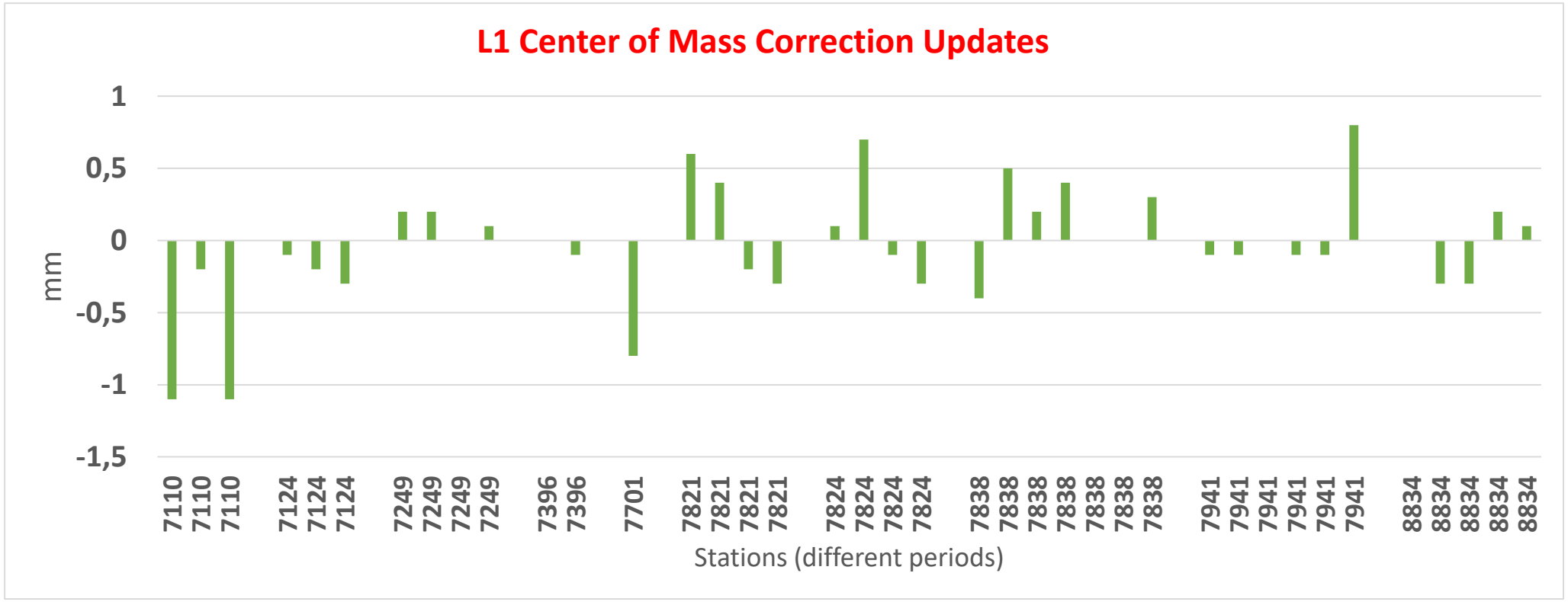


Latest Updated Target Signature Corrections

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

CoM Correction:

- **J. Rodriguez Model at 11/05/2021**
- **Updates with minor changes**



A Global SLR-only Reference Frame

Globk Workflows

Inputs

Primary Observations

+ Apriori Ref. Frame
+ Discont. File
+ Eop tables
+ Setup file

Loosely constrained solutions with a priori parameter information, parameters estimations and full covariance matrices

← Sinex files

Kalman filter
(~ sequential least square)

Historical Series

Global estimates
Station Positions
Station Velocities

Translation, rotation, and scale estimated by a **minimization** horizontal positions and velocities **residuals of core site**

- **Selection Criteria for Sinex:**
max X^2 / max prefit differences /max rotations

- **Selection Criteria for stations**
Geographically / minimun datas

Parameters to be estimated

Loose solution

- **Selection of core site**
By name or sigmas criterion.

- **Selection of Helmert Parameters**
Translation , Rotations , Scale

- **Iterations**

Historical Series

Reference Frame

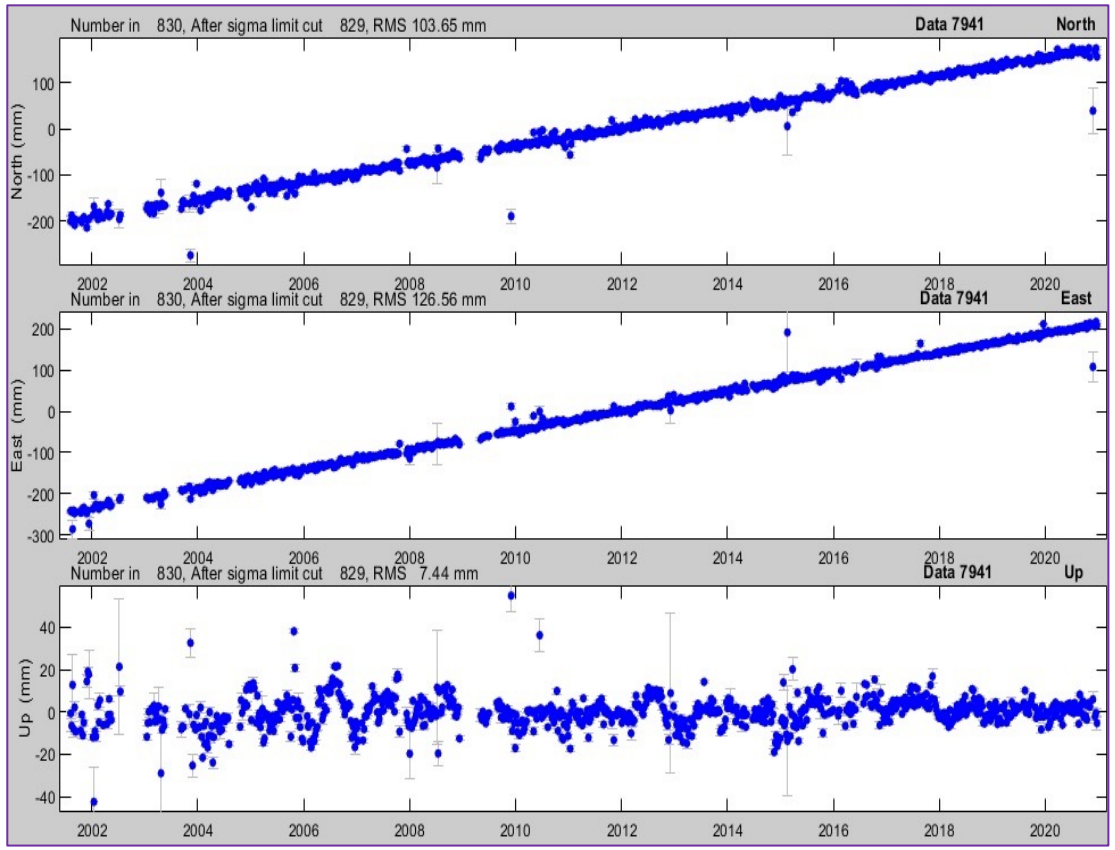
+ Helmert Parameters

Constrained solution

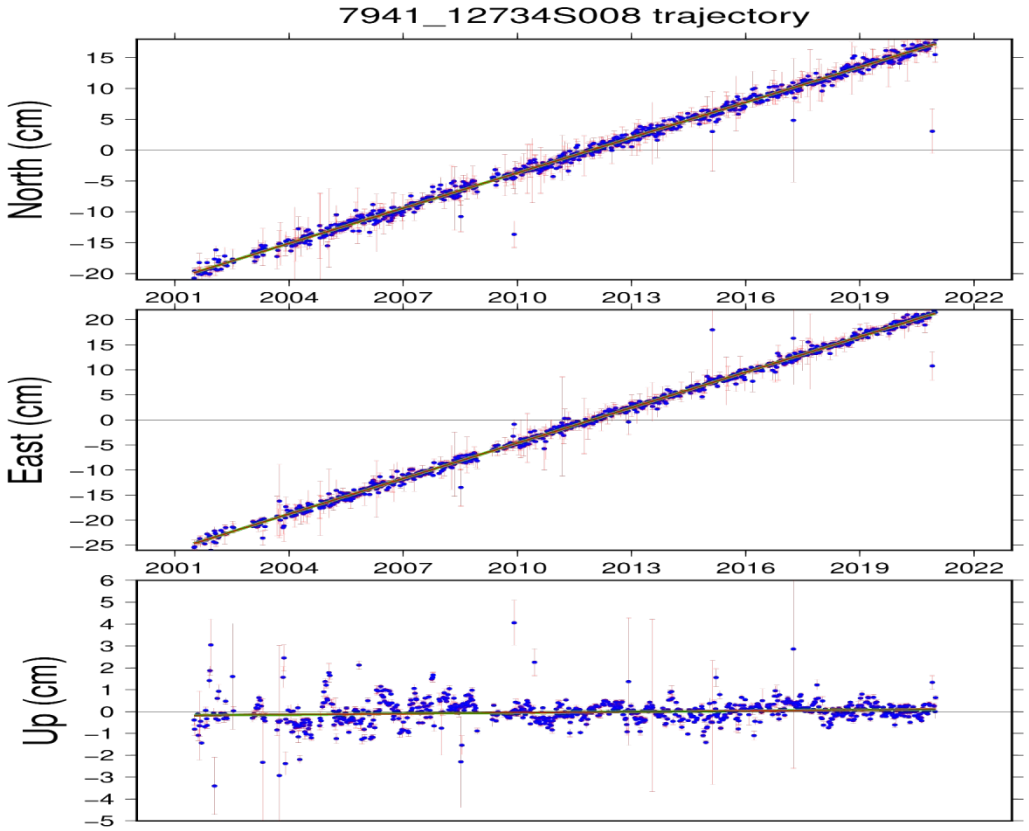
Historical Series

Matera (7941): Trended

Globk Estimates



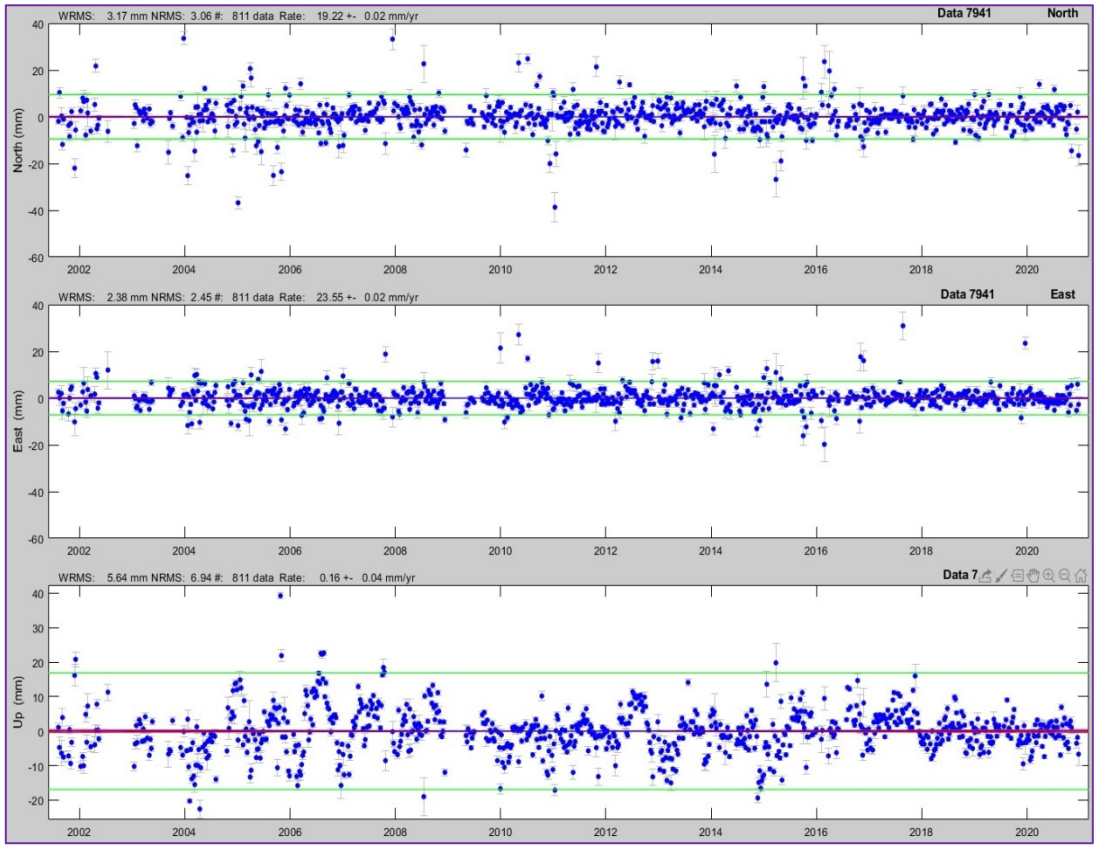
From IGN (ITRF2020)



Historical Series

Matera (7941): DeTrended

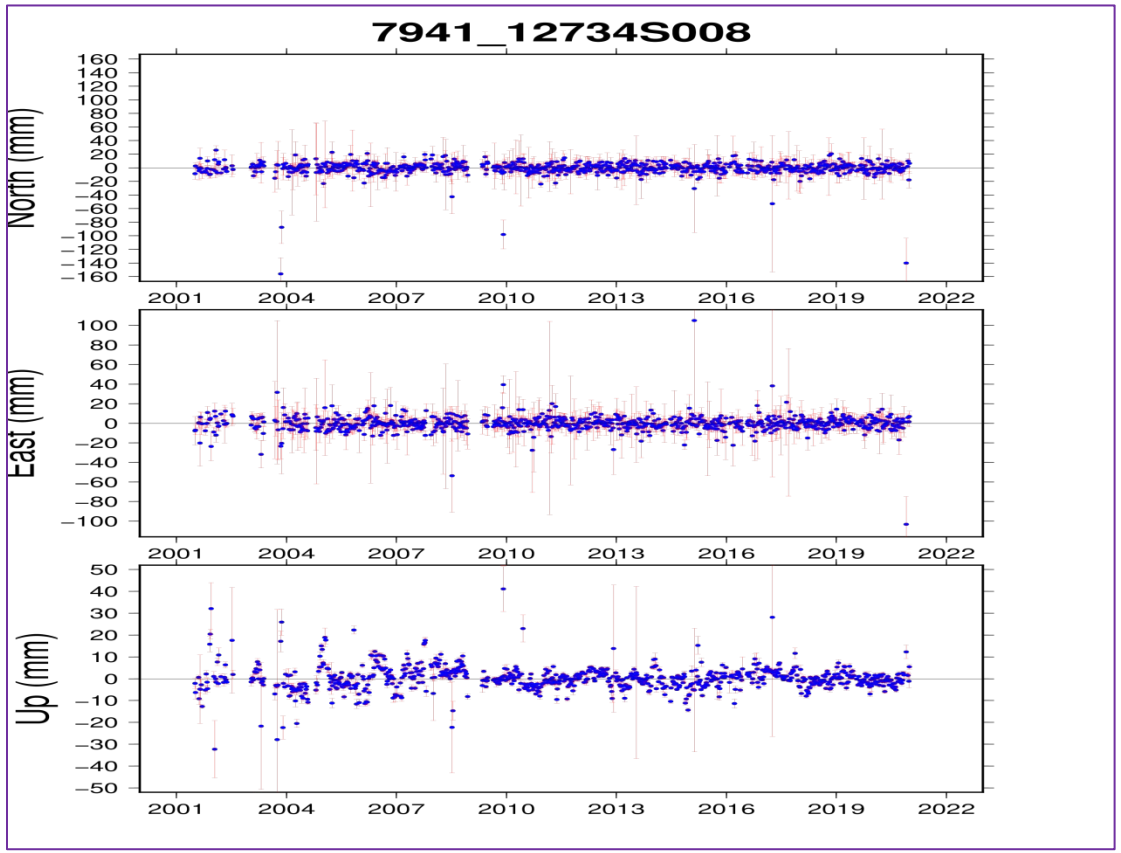
Globk Estimates



WRMS	
Nord	3,17 mm
East	2,38 mm
Up	5,64 mm

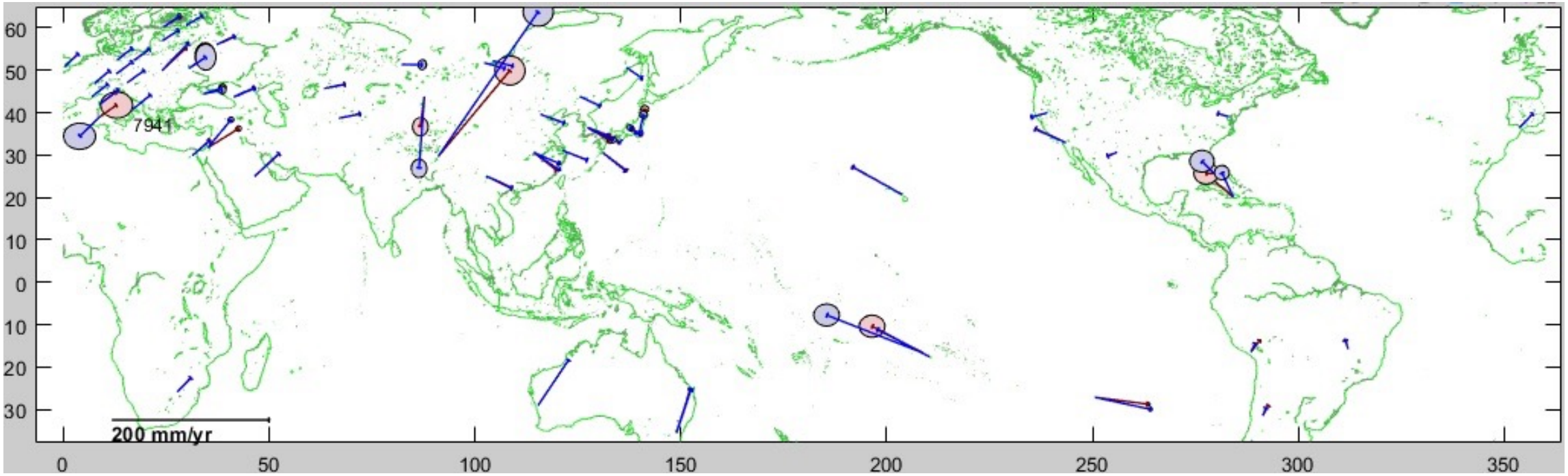
WRMS of residuals of globk Estimates w.r.t. ITRF2020

From IGN (ITRF2020)



Ref. Frame Estimates

Blue: Globk Estimate Red: ITRF2020



Sigma Up to:

10 mm/yr

e-geos
AN ASI / TELESPAZIO COMPANY

International Laser Ranging Service

ASI
Agenzia Spaziale Italiana

Thank you

Updates to the centre of mass corrections in preparation for ITRF2020 products

José Rodríguez
IGN-Yebes ASC
Nov 06, 2022

Gobierno de España · Ministerio de Transportes, Movilidad y Agenda Urbana · Instituto Geográfico Nacional
Unión Europea
Fondo Europeo de Desarrollo Regional
"Una manera de hacer Europa"
Infraestructuras Científicas y Técnicas Singulares
YEBES

Where are we

- For the final run of the PP on systematic errors, and the first batch of REPRO2020 solutions (1993–2020), the CoM version adopted was v200608
- For the ITRF2020 reanalysis, the ASC was asked to deliver solutions for the 1983–1993 period, valuable for the computation of the different global TRF solutions (IGN, DGFI, JPL)
- Given the inferior quality of the observations, and the sparse information available, a coarse approach was followed to provide the corrections for several missing pre-ILRS stations → v210511 adopted for the reanalysis
- The ILRS ASC will soon transition to ITRF2020 standards for their daily and weekly products
- Recent station updates and missing stations motivate the last update of the corrections

Updates

- Christian Schwatke's automatic service emails me every time there is a site log change, with all the details
- If changes do not impact the CoM computation, they are ignored
- Otherwise I archive them for future inspection
- 17 stations were in the list for examination in this update:

  1824, 7080, 7105, 7110, 7124, 7249, 7396, 7701 (new), 7816 (new),

  7821, 7824, 7825, 7838, 7839, 7841, 7941, 8834

- Only the changes in 10 stations required a recomputation:

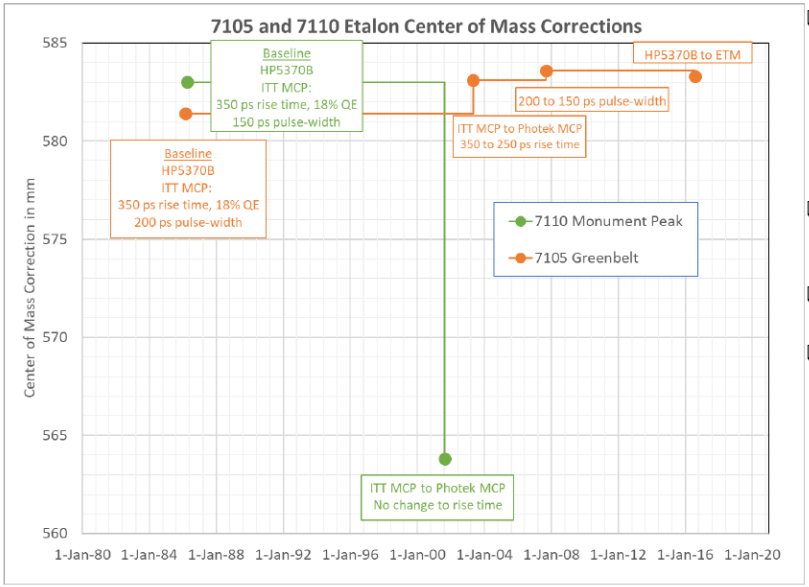
  7110, 7124, 7249, 7396, 7701 (new), 7821, 7824, 7838, 7941, 8834

Updates

- Some stations were contacted for clarifications
  - Replies from 1824 GLSL, 7249 BEIL, 7821 SHA2, 8834 WTZL
  - No reply yet from 7396 JFNL (minor issue)
- The changes detailed in the site logs were very minor, e.g. slight changes in laser pulse widths or detector jitter
- I fixed some minor inconsistencies in my logs, discovered while checking the new changes
- I updated the NP database to estimate return rates for the latest system configurations
- The results are not very exciting…which means that minor changes don't derail the model

The interesting case: 7110

7110 and 7105 Etalon CoMs



- This is a time series of 7110 (MOBLAS-4) and 7105 (MOBLAS-7) Etalon CoM corrections. The system configuration changes are annotated inside the boxes. Based on the 7110 MCP-PMT change there was a 20 mm drop in the MOBLAS-4 CoM correction on 19-August-2001
- 7110 and 7105 currently have the same system configuration, but the CoM corrections are quite different
- Did the 20 mm drop in the 7110 Etalon CoM impact the estimated range bias?
- If the CoM correction is in error by 'z', it will induce an apparent range bias = 'z'. For example, if the CoM is too small by 1 mm, it will induce an apparent -1 mm range bias.

4

Van Husson. *CoM and SSEM Range Bias Analysis.* QCB presentation

The interesting case: 7110

- Confirmed anomaly in the modelling chain:
  - Single variable that defines the discriminator threshold in multi-photon stations
- This is not computed automatically, but adjusted manually according to the best agreement with the NP RMS
- Set to 1, 2, or 3 photoelectrons. Probably there is no 1:1 equivalent to a tunable accesible by stations (they set voltages)
- Big impact for large targets → Etalon, Ajisai
- Reason for odd value compared to rest of MOBLAS unclear, it seems clear now that it should be the same

The interesting case: 7110

LAGEOS-1 (old/new values)

```
7110 15 08 1983 31 03 1986  com  243.6
7110 31 03 1986 19 08 2001  com  245.6
7110 19 08 2001 01 01 2050  com  244.6
-----------------------------------------
7110 15 08 1983 31 03 1986  com  244.7
7110 31 03 1986 19 08 2001  com  245.8
7110 19 08 2001 01 01 2050  com  245.7
```

LAGEOS-2 (old/new values)

```
7110 31 03 1986 19 08 2001  com  245.4
7110 19 08 2001 01 01 2050  com  243.9
-----------------------------------------
7110 31 03 1986 19 08 2001  com  245.3
7110 19 08 2001 01 01 2050  com  245.2
```

LARES (old/new values)

```
7110 19 08 2001 01 01 2050  com  130.0
-----------------------------------------
7110 19 08 2001 01 01 2050  com  130.1
```

ETALON-1 (old/new values)

```
7110 31 03 1986 19 08 2001  com  583.0
7110 19 08 2001 01 01 2050  com  563.8
-----------------------------------------
7110 31 03 1986 19 08 2001  com  583.3
7110 19 08 2001 01 01 2050  com  583.4
```

STARLETTE (old/new values)

```
7110 15 08 1983 31 03 1986  com   75.5
7110 31 03 1986 19 08 2001  com   76.1
7110 19 08 2001 01 01 2050  com   75.6
-----------------------------------------
7110 15 08 1983 31 03 1986  com   75.8
7110 31 03 1986 19 08 2001  com   76.1
7110 19 08 2001 01 01 2050  com   76.2
```

AJISAI (old/new values)

```
7110 15 08 1983 31 03 1986  com  981.1
7110 31 03 1986 19 08 2001  com  994.5
7110 19 08 2001 01 01 2050  com  983.1
-----------------------------------------
7110 15 08 1983 31 03 1986  com  992.9
7110 31 03 1986 19 08 2001  com  995.0
7110 19 08 2001 01 01 2050  com  996.9
```

The interesting case: 7110

LAGEOS-1 (old/new values)

```
7110 15 08 1983 31 03 1986  com  243.6
7110 31 03 1986 19 08 2001  com  245.6
7110 19 08 2001 01 01 2050  com  244.6
-----------------------------------------
7110 15 08 1983 31 03 1986  com  244.7
7110 31 03 1986 19 08 2001  com  245.8
7110 19 08 2001 01 01 2050  com  245.7
```

LAGEOS-2 (old/new values)

```
7110 31 03 1986 19 08 2001  com  245.4
7110 19 08 2001 01 01 2050  com  243.9
-----------------------------------------
7110 31 03 1986 19 08 2001  com  245.3
7110 19 08 2001 01 01 2050  com  245.2
```

LARES (old/new values)

```
7110 19 08 2001 01 01 2050  com  130.0
-----------------------------------------
7110 19 08 2001 01 01 2050  com  130.1
```

ETALON-1 (old/new values)

```
7110 31 03 1986 19 08 2001  com  583.0
7110 19 08 2001 01 01 2050  com  563.8
-----------------------------------------
7110 31 03 1986 19 08 2001  com  583.3
7110 19 08 2001 01 01 2050  com  583.4
```

STARLETTE (old/new values)

```
7110 15 08 1983 31 03 1986  com   75.5
7110 31 03 1986 19 08 2001  com   76.1
7110 19 08 2001 01 01 2050  com   75.6
-----------------------------------------
7110 15 08 1983 31 03 1986  com   75.8
7110 31 03 1986 19 08 2001  com   76.1
7110 19 08 2001 01 01 2050  com   76.2
```

AJISAI (old/new values)

```
7110 15 08 1983 31 03 1986  com  981.1
7110 31 03 1986 19 08 2001  com  994.5
7110 19 08 2001 01 01 2050  com  983.1
-----------------------------------------
7110 15 08 1983 31 03 1986  com  992.9
7110 31 03 1986 19 08 2001  com  995.0
7110 19 08 2001 01 01 2050  com  996.9
```

The interesting case: 7110

- Double win:
  - Corrected Etalon 20 mm error (and Ajisai 14 mm)
  - Found out reason for the strange value → other instances lurking in the data?

The rest: boring

- Very small differences (mostly sub-mm), as expected from the modest system changes

- Exception for LAGEOS:
  - 7821 SHAO2 tweaked leading edge filter in 2021
  - ~3.4 mm difference in both LAGEOS and LAGEOS-2
  - Probably too early to tell if correct

- The adoption of this latest udpate should be quite painless

- Models are now uploaded to: `https://icts-yebes.oan.es/slr`
- Description of all changes in technical report to be released soon

Deutsches Geodätisches Forschungsinstitut (DGFI-TUM)
Technische Universität München

DGFI-TUM ILRS AC report

Mathis Bloßfeld

Deutsches Geodätisches Forschungsinstitut, Technische Universität München (DGFI-TUM)

ILRS Analysis Standing Committee Meeting 2022, Guadalajara, Spain

DGFI-TUM ILRS AC activities in 2022

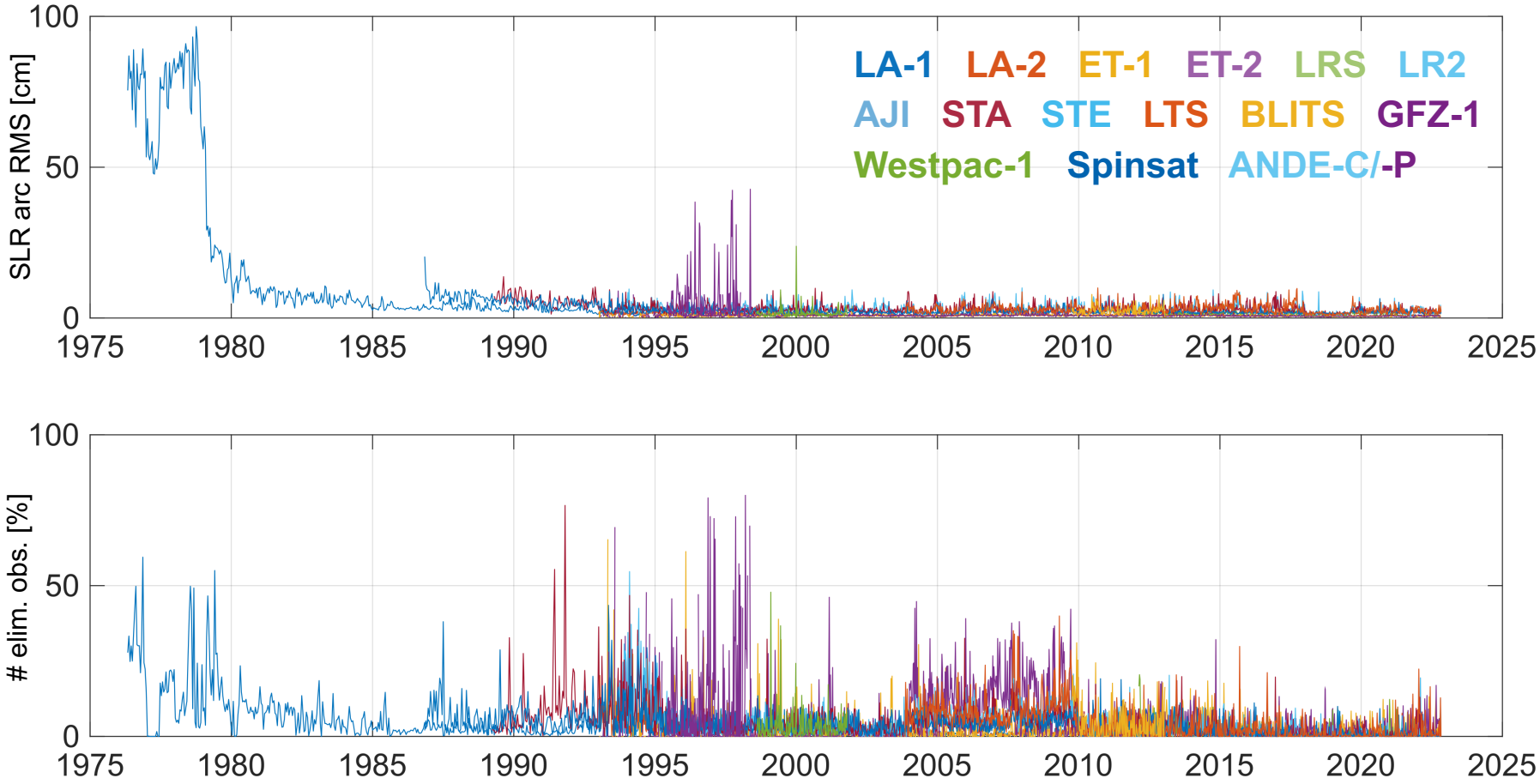
- Operational products & Re-analysis 2020

Solution	time interval (as produced by MB)	Submission basis (to ILRS-A/-B)	Produced by DGFI-TUM?
v170	11.01.2018 – now	daily	✓
v70	13.01.2018 - now	weekly	✓
V230 (SSEM-PP)	09.01.1993 – 09.07.2022	once	✓
v40x (ITRF repro)	10.01.1983 – 02.01.2021	once	✓

- Since 2020, also a **multi-satellite daily/weekly combination** is computed on a routine basis (multiple applications)
- Other routinely provided products
  - **(weekly) orbit solutions** for ILRS-A combination (LA-1/-2 ET-1/-2)
  - **(weekly) orbit solutions** for spherical satellites LRS, **LR2**, AJI, STA, STE, LTS
  - **(daily) orbit predictions** in CPFv2 format for LA-1/-2, ET-1/-2, LRS, **LR2**, AJI, STA, STE, LTS

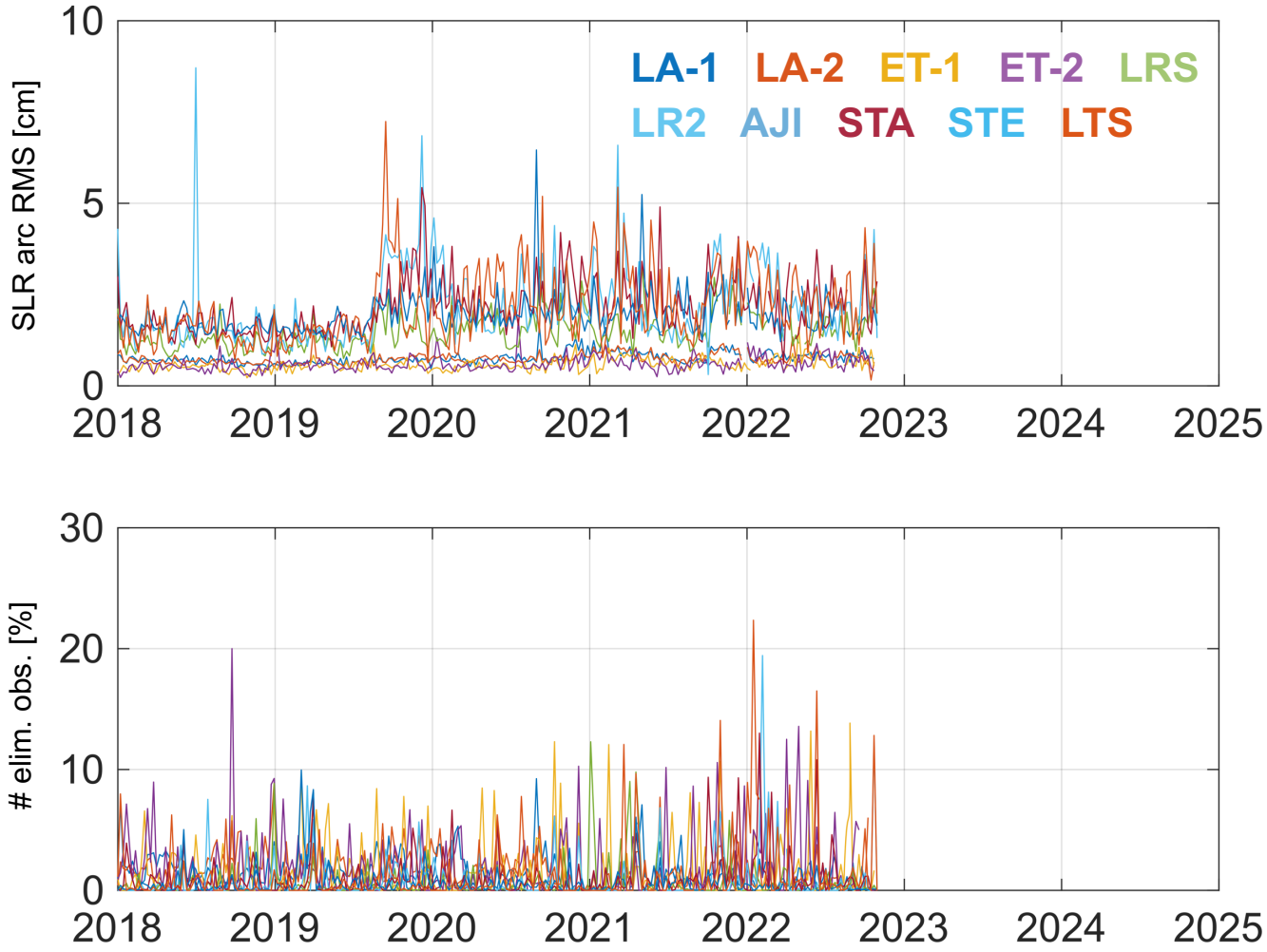
DGFI-TUM ILRS AC activities in 2022

- Analysis of spherical satellites (LA-1/-2, ET-1/-2, LRS, LR2, AJI, STA, STE, LTS, BLITS, GFZ-1, Westpac-1, Spinsat, ANDE-C/-P)
  - **LA-1 since 1976**
  - currently working on early years of STA and AJI



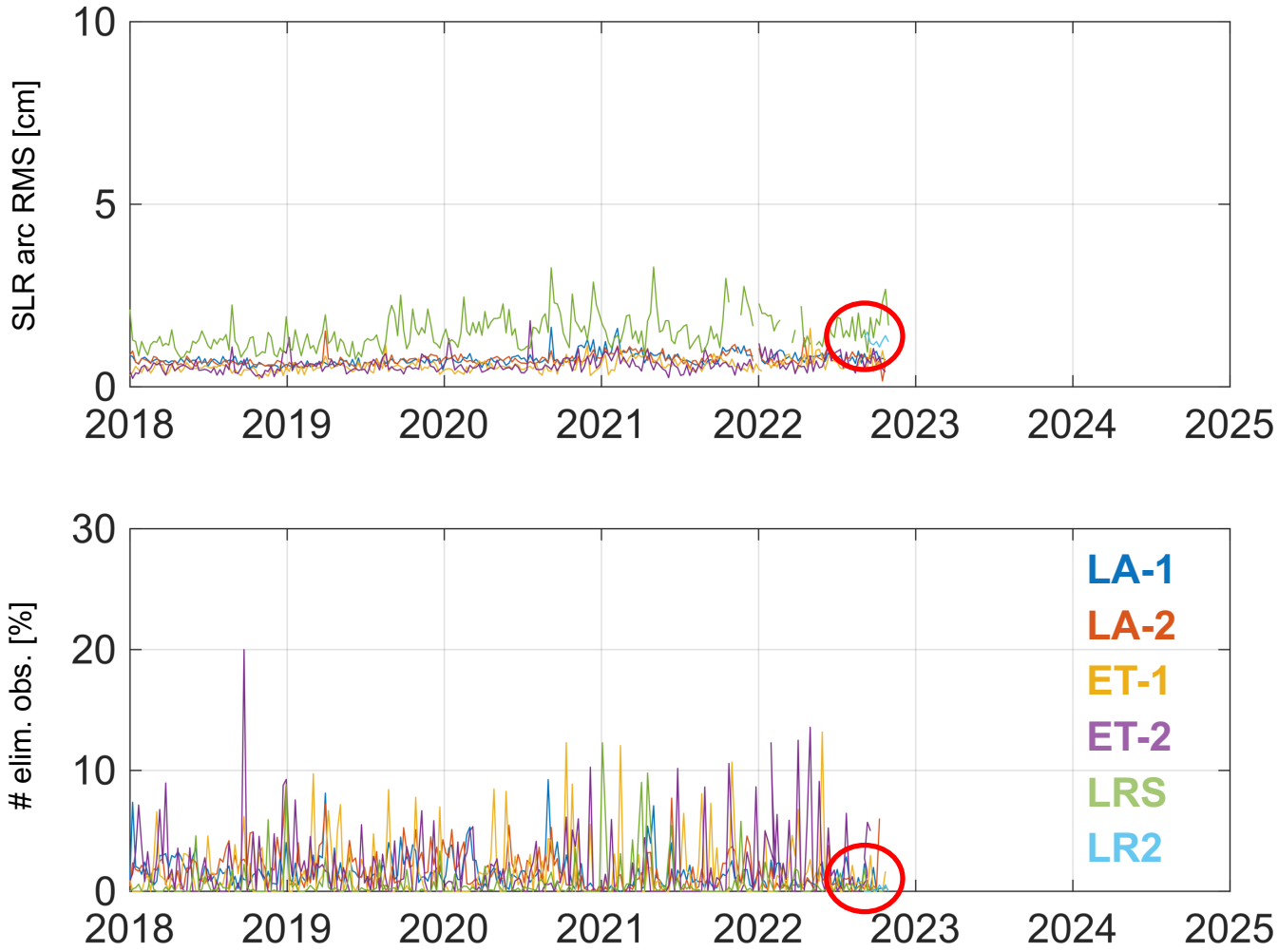
DGFI-TUM ILRS AC activities in 2022

- Analysis of spherical satellites (LA-1/-2, ET-1/-2, LRS, LR2, AJI, STA, STE, LTS, BLITS, GFZ-1, Westpac-1, Spinsat, ANDE-C/-P)
  - **LA-1 since 1976**
  - currently working on early years of STA and AJI
  - zoom into 2018-2023 time period reveals **higher level of accuracy of LA-1/-2 and ET-1/-2** compared to LEOs



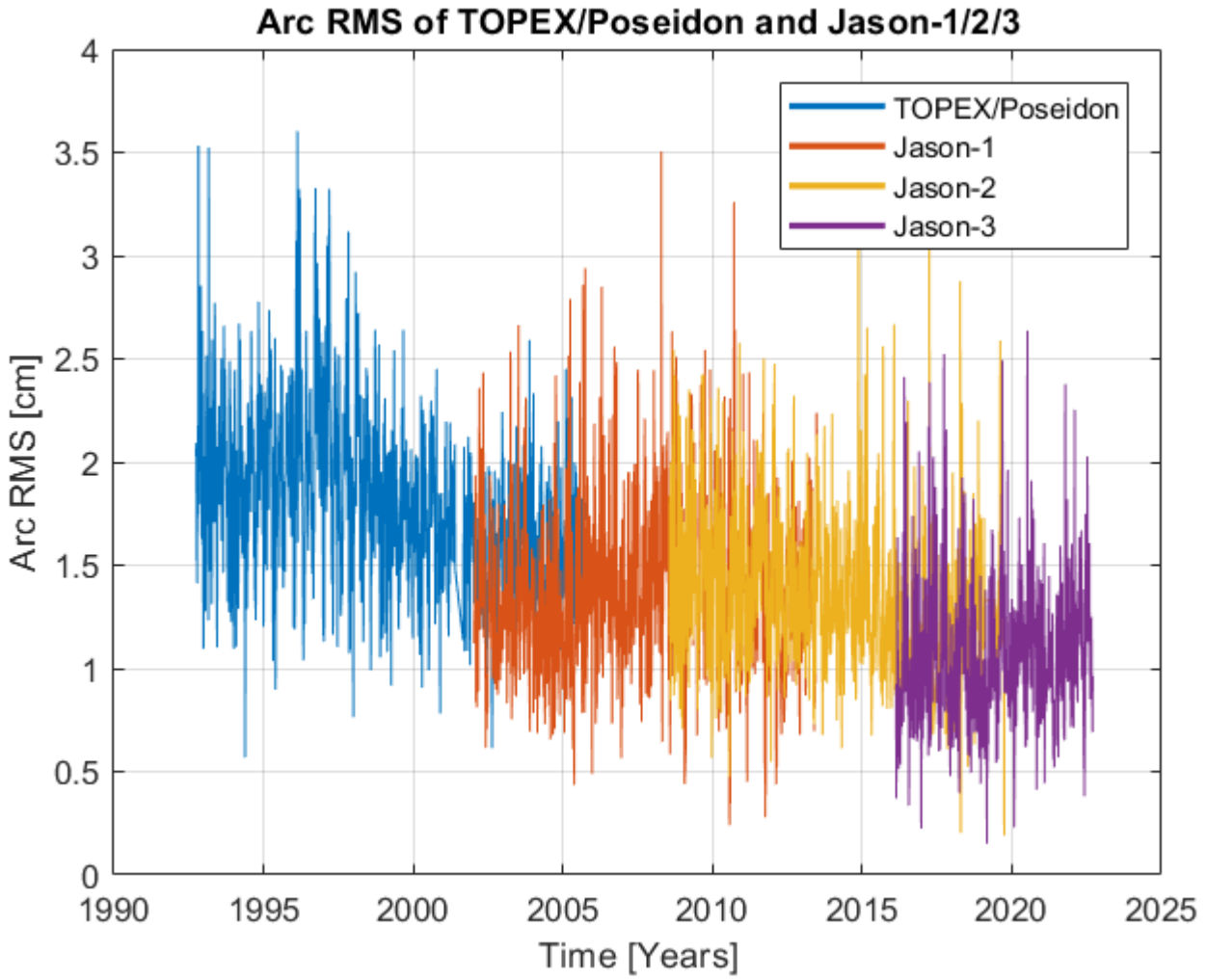
DGFI-TUM ILRS AC activities in 2022

- Analysis of spherical satellites (LA-1/-2, ET-1/-2, LRS, LR2, AJI, STA, STE, LTS, BLITS, GFZ-1, Westpac-1, Spinsat, ANDE-C/-P)
  - **LA-1 since 1976**
  - currently working on early years of STA and AJI
  - zoom into 2018-2023 time period reveals **higher level of accuracy of LA-1/-2 and ET-1/-2** compared to LEOs
  - New LARES-2 satellite implemented in DOGS-OC
    - **Very good quality** of LARES-2 data
    - TS and RBs of LARES currently used
    - Mean SLR RMS: **1.27 cm** (based on standard sol setup)
    - Up to now, **less than 0.5 %** outliers reduced every 7d arc



DGFI-TUM ILRS AC activities in 2022

- Analysis of non-spherical satellites (TOPEX/Poseidon, Jason-1/-2/-3)
  - **very high consistency** over all missions
  - linearly **increasing accuracy**



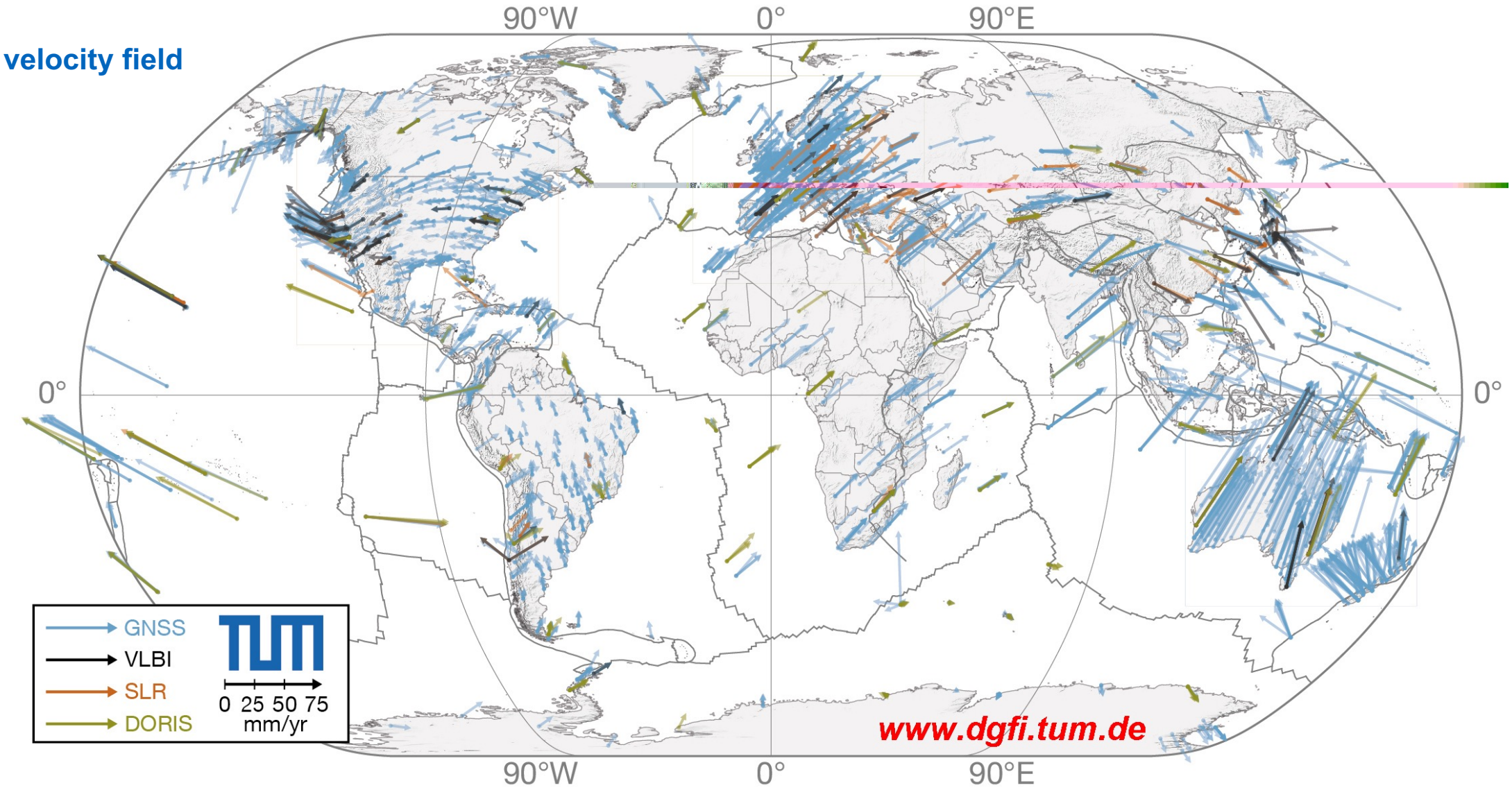
DGFI-TUM ILRS AC activities in 2022

- Model updates within DOGS-OC
  - NT-L (ATM+OCN+HYD): **GGFC** (stations)
  - NT-L (ATM+OCN+HYD): **ESMGFZ** (stations) + **AOD1B RL06 + HSD1B** (satellite)
  - New ocean tide models implemented (**EOT20**, **FES2014b.v1**)
  - **New IERS C04 format** implemented (currently used at 0h epochs! → problems when witching to 12h?)
  - **"New" CRD v2 format** directly imported into DOGS-OC now → advantage of extensive metadata usage
  - Several **DOGS-OC-internal refinements** (e.g., code optimization, unified type definitions, etc.)

- Critical issue is the **sensitivity of the routine procedures on input data errors** (e.g., format issues, non-availability)

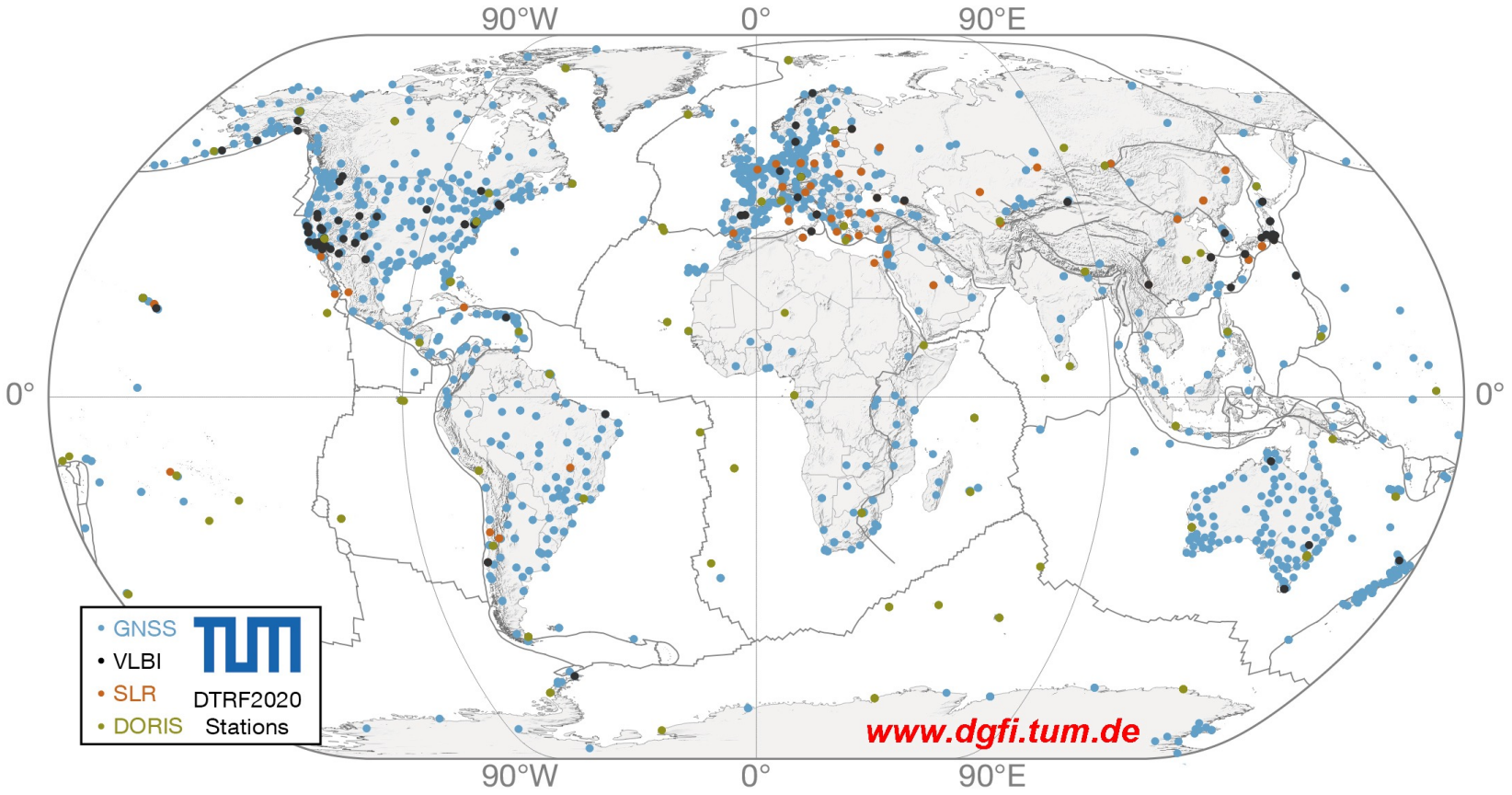
DTRF2020 preliminary solution

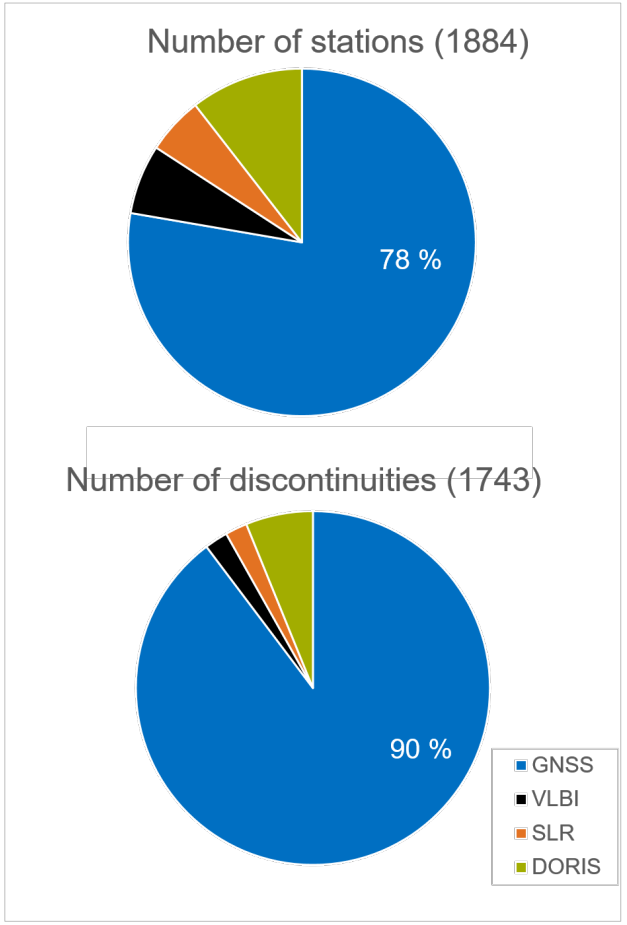
- **Horizontal velocity field**



DTRF2020 station network: discontinuities

- for the **DTRF2020**, about 1880 observing stations are processed
- GNSS provides by far the largest number of stations



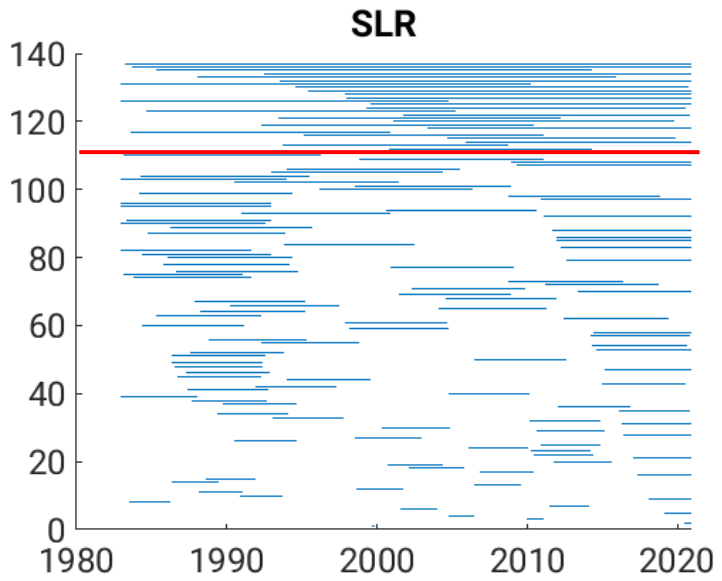


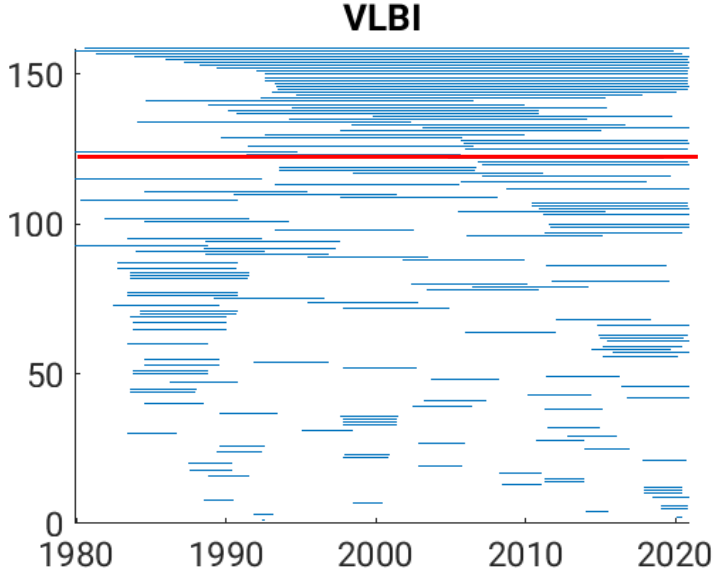
DTRF2020 station network: discontinuities

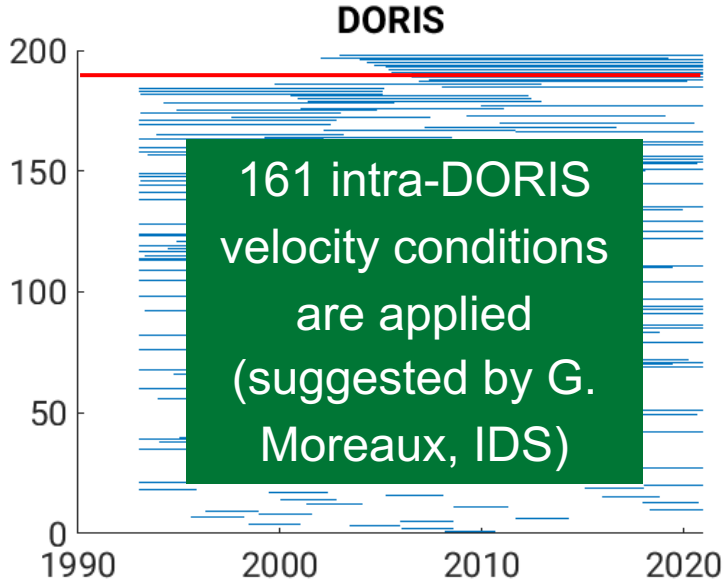
- Stations sorted by length of observation time span
- **SLR and VLBI provide a solid basis** of overlapping station observation time spans of 15 years and more
- The large number of discontinuities leads to a **fragmentation of GNSS and in particular DORIS TRF**

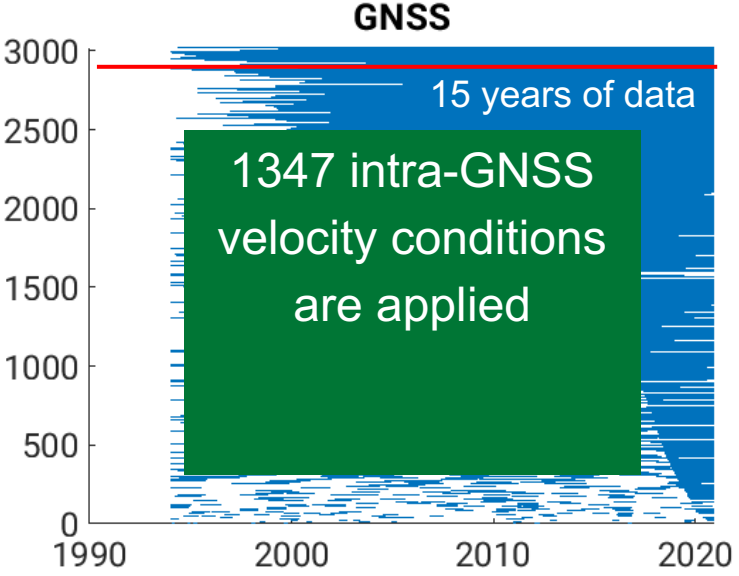
→ drift changes in translation time series at reference epoch

- **Long-term stability of TRF can be ensured only by a combination of station velocities** of
  - solution numbers or
  - intra-technique co-locations
- **How to decide**, which velocity constraints shall be applied when TRF solutions are unstable?





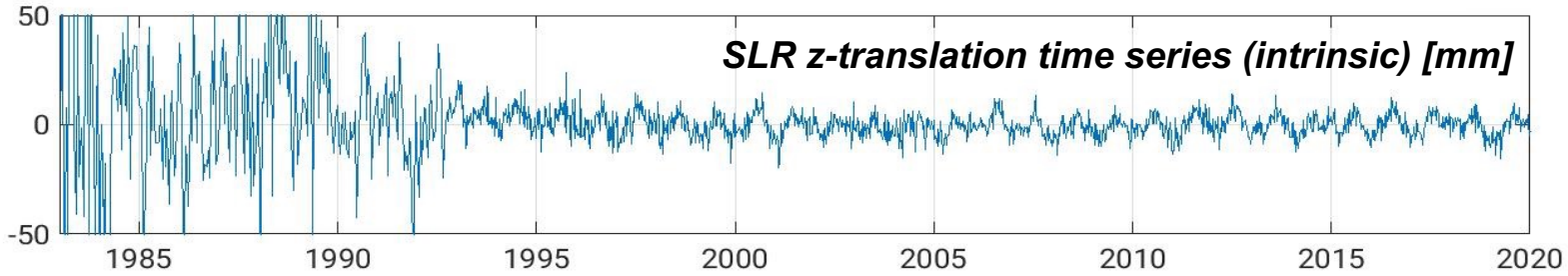




Datum realization of DTRF2020 – origin and orientation

DTRF2020 origin

- Realized from the **full history** of SLR observation data



DTRF2020 orientation

- By no-net-rotation conditions for positions and velocities w.r.t. DTRF2014 using a subset of globally distributed GNSS stations; **reference epoch 2010.0**

Datum realization of DTRF2020 - scale

- VLBI, SLR and for the first time GNSS provide an independent scale

Analysis of scale agreement

- by solving DTRF2020 solutions setting up **individual scale parameters for GNSS, SLR** and **VLBI** or both of them.

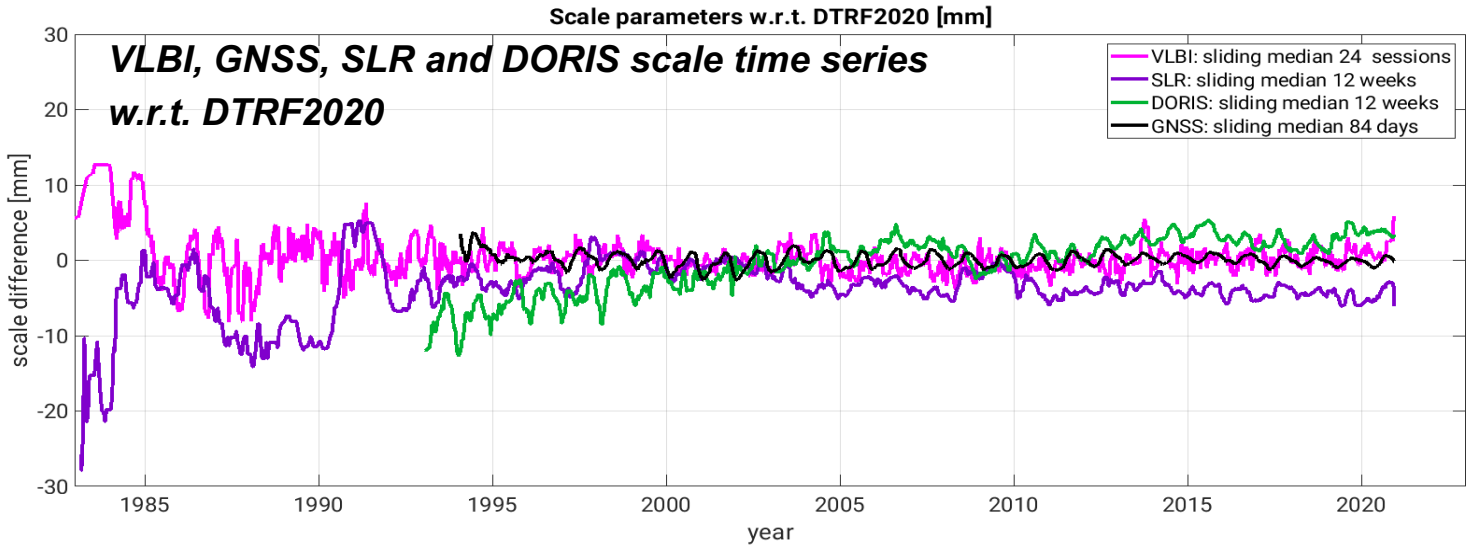
Results

- **VLBI and GNSS**: agree within **0.25 mm** (epoch 2010.0) and **0.05 mm/yr**
- **SLR**: small offset and drift w.r.t. **GNSS and VLBI** of **2.2 mm (epoch 2010.0)** and **-0.1 mm/yr**

→ SLR does not affect the DTRF2020 scale

→ But to keep the small offset and drift “visible” for further studies, DTRF2020 scale is realized from VLBI and GNSS only.

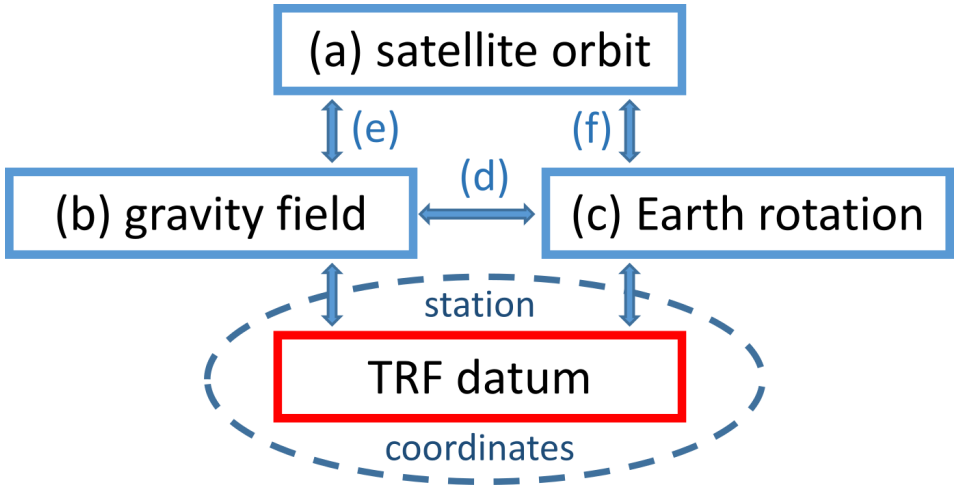
→ no decision about “right” or ”wrong”



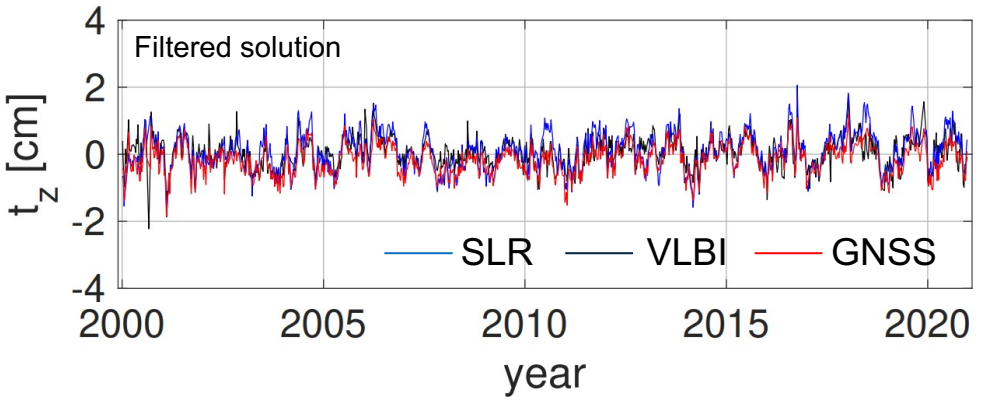
Relevance of SLR for geocentric epoch reference frames

- The geodetic parameter groups estimated from SLR are inter-dependent
- The quality and stability of derived datum parameters suffers from the inhomogeneous station distribution and non-continuous station operation, the so-called **network effect** of SLR (e.g., Collilieux et al., 2009)
- The relevance of stable datum parameters increases significantly in the view of **epoch reference frames** (ERFs; e.g., Bloßfeld et al., 2015)
- **Filter approaches** can help to overcome some of the problems related to the network effect (e.g., Kehm et al., 2022)
- However, a reliable de-correlation of the parameter groups can be achieved only by **extending the SLR ground and space segments** (e.g. Bloßfeld et al., 2018)

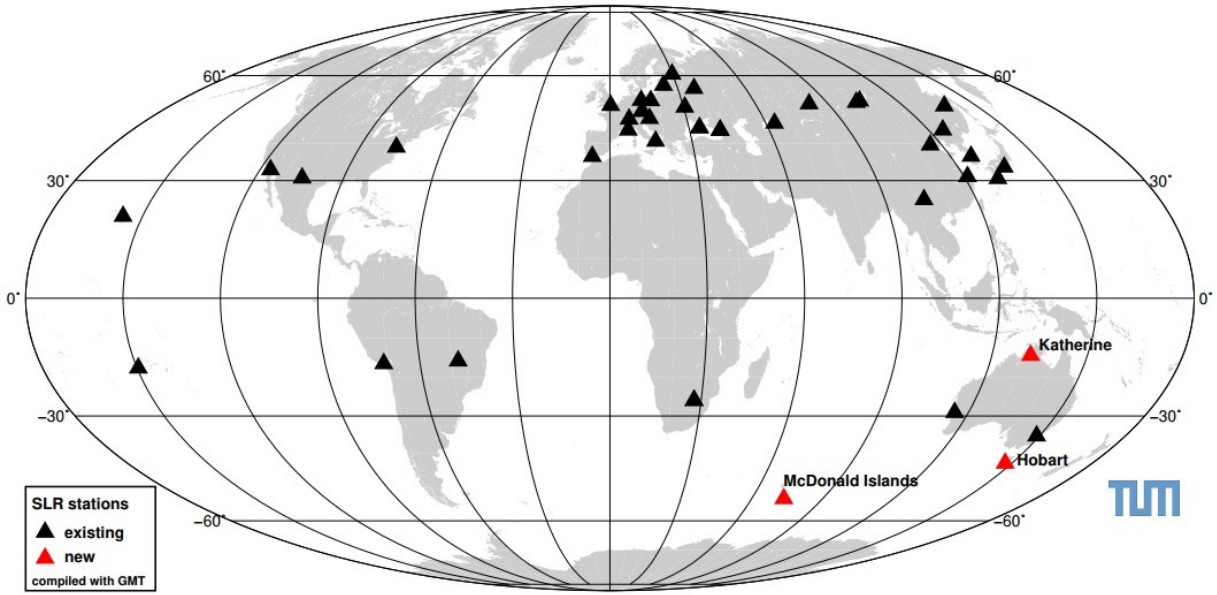
Correlations between geodetic parameter groups



SLR-based origin realisation for a combined ERF



SLR simulation studies on an additional SLR system in Australia



McDonald is most beneficial for ERPs and the TRF origin, (WRMS improvement up to 4% in y_{pole} and 8 % in t_z)
→ station fills a significant gap in the current SLR network

McDonald and **Hobart** both yield improvements in the origin, predominantly t_z (8% and 3%, WRMS reduction resp.)
→ stations improve the weak observation geometry for this parameter

Adding **two of the stations** yields improvements in LOD (up to 3 % WRMS reduction)

Adding **all three stations** together yields the largest improvement in scale (3 % WRMS reduction)

Further improvements for combined ERFs can be expected from **additional co-locations with *GNSS and VLBI***

Weekly SLR-derived epoch reference frames

5 satellites (incl. LARES)
time span: 2014-12-28 to 2019-07-06

Average of two simulation runs with 15 % or 30 % minimum station performance for the new stations

Federal Agency for
Cartography and Geodesy

BKG
Wir geben Orientierung.

BKG Report

D. Koenig, U. Meyer (AIUB), D. Thaller

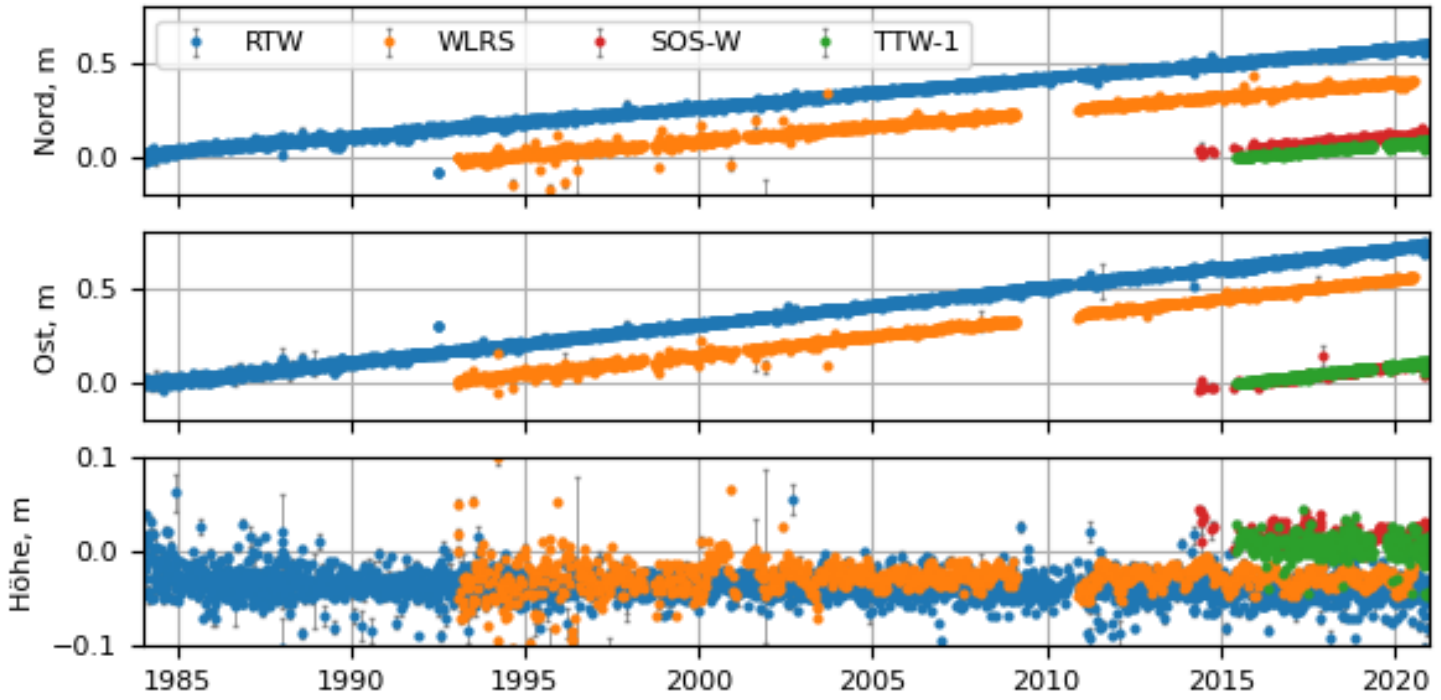
Overview

Work Done

- Introduction of ITRF2020 pending
  - moving to new machine in 08/09 2022
  - new Bernese version released
- Modified solution generated
  - based on ITRF2020 reprocessing
  - modified datum definition: **NNR** instead of Loose Constraints
  - output: 1468 weekly solutions (time series)
  - internally called „**BKG-SLR-2020**“

Results: Solution Statistics

„BKG-SLR-2020“



RTW, TTW-1: **VLBI** / WLRS, SOS-W: **SLR**
Periodic pattern in height for SLR stations

Federal Agency for
Cartography and Geodesy

BKG
Wir geben Orientierung.

Thank you for your kind attention!

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CRDv2 issues

Mathis Bloßfeld

Deutsches Geodätisches Forschungsinstitut, Technische Universität München (DGFI-TUM)

ILRS Analysis Standing Committee Meeting 2022, Guadalajara, Spain

CRDv2 issues

- Since **August, 1st, 2022**, the ILRS uses a new conventional format for the SLR observations, the **CRD v2 format**
- On the ILRS website, a detailed description of the **CRD format v2.01** is provided to the user (**https://ilrs.gsfc.nasa.gov/docs/2022/crd_v2.01e3.pdf**)
- DGFI-TUM ILRS AC now **directly imports the CRD v2** format into its POD s/w
- Up to now, different errors and inconsistencies to the official format description arise
  - several variables are “na” but **only some variables are explicitly allowed** to be “na” in the format description

CRDv2 issues – e.g. lageos1_202210.np2

- Only one example for numerous other cases
  - In principle, **easy to fix** for either the ACs or the stations (but only if they know about this “error”)

30	Pointing Angles	Elevation rate (deg/sec)				
30	Pointing Angles	Other 30 Check		The record length must contain 7 (9) fields	Error	
40	Calibration	40	“40”	“40”	Error	
40	Calibration	Seconds of day		[0,…,86400]	Error	Normal data would be 00000 through 86399. A leap second would use 86400.
40	Calibration	Seconds of day		Within 2 hours of the pass E.g. H4 start date/time - 2hr ≤ 40 record seconds of day ≤ H4 end date/time + 2hr	Warning	
40	Calibration	Type of data	[0,1,2,3,4,5]	[0,…,5]	Error	
40	Calibration	System configuration id		Valid System configuration ID must be in C0 record	Error	
40	Calibration	Number of data points recorded	[na,0,1,…]	[na,…,1.e8]	Warning	
40	Calibration	Number of data points used	[na,0,1,…]	[na,…,1.e8]	Warning	
40	Calibration	One way target distance (m)	[na,0,1,…]	[na,0.0,…1.e4]	Warning	
40	Calibration	Calibration System Delay (ps)		[-1.e5,…,1.e6]	Error	
40	Calibration	Calibration Delay Shift (ps)		[-6671,…,6671]	Error	Based on 1m
40	Calibration	RMS of raw system delay	[na,…,2.e5]	[na,0,…,667]	Error	Based on 10cm

66

ILRS Consolidated Laser Ranging Data Format (CRD)

```
h1 CRD  2 2022 10  1  0
h2 MONL       7110  4 12 3       ILRS
h3 lageos1     7603901 1155     8820 0 1 1
h4  1 2022 10  1  0  0 28 2022 10  1  0  7 30  0 0 0 0 1 0 2 0
h5  1 22 092900 SGF 27301
c0 0  532.000 new la1 mcp ti1 swm    met cac
c1 0 la1 Nd:Yag    1064.00       5.00     100.00  150.0  7.44    1
c2 0 mcp MCP-PMT    532.000  12.0 3300.0  31.0 analog 400.0  1.00  80.0 30.00 none    na     na  0
c3 0 ti1 SRS_FS740 SRS_FS740 Cybi_ETM na    0.3
c5 0 swm  sattrk 6.10 HPLDP,GNP 9.11.3,2.8.3
c6 0 met  Paroscientific MET-4 146634 Paroscientific MET-4 146634 Paroscientific MET-4 146634
c7 0 cac A            187.00260   1.00   0.1644 na                    HPLDP 9.11.3
40   802.650662977248 0 new     2788     2774 187.0026    82677.9     -8.0   15.3 na      na      na     2 2 0 3 na
41 86121.100664092228 0 new     1147     1140 187.0026    82683.2 na          14.7 na      na      na     2 2 0 1 na
41  1859.450663463213 0 new     1641     1634 187.0026    82674.5 na          14.7 na      na      na     2 2 0 2 na
20    82.701  812.10 294.30  35. 0
11    82.700663300000     0.041188581457 new 2  120.0    145   48.0  -0.125  -0.052 na         24.17 0 na
20   182.301  812.10 294.30  35. 0
11   182.300662600000     0.041361628794 new 2  120.0    301   50.0   0.151  -0.073 na         50.17 0 na
20   299.201  812.10 294.20  35. 0
11   299.200663300000     0.041809446581 new 2  120.0    336   49.0   0.339   0.237 na         56.00 0 na
20   403.601  812.10 294.00  35. 0
11   403.600663300000     0.042426030777 new 2  120.0    168   53.0  -0.029  -0.097 na         28.00 0 na
50 new   49.9   0.142   0.053 na     0
h8
h1 CRD  2 2022 10  1  0
h2 MONL       7110  4 12 3       ILRS
h3 lageos1     7603901 1155     8820 0 1 1
h4  1 2022 10  1  0  7 36 2022 10  1  0 15 18  0 0 0 0 1 0 2 0
h5  1 22 092900 SGF 27301
c0 0  532.000 new la1 mcp ti1 swm    met cac
c1 0 la1 Nd:Yag    1064.00       5.00     100.00  150.0  7.44    1
c2 0 mcp MCP-PMT    532.000  12.0 3300.0  31.0 analog 400.0  1.00  80.0 30.00 none    na     na  0
c3 0 ti1 SRS_FS740 SRS_FS740 Cybi_ETM na    0.3
c5 0 swm  sattrk 6.10 HPLDP,GNP 9.11.3,2.8.3
c6 0 met  Paroscientific MET-4 146634 Paroscientific MET-4 146634 Paroscientific MET-4 146634
c7 0 cac A            187.00260   1.00   0.1644 na                    HPLDP 9.11.3
40   802.650662977248 0 new     2788     2774 187.0026    82677.9     -8.0   15.3 na      na      na     2 2 0 3 na
"/DGFI1/data/obs/slr/crd_v2/lageos1/2022/lageos1_202210.np2" [readonly] 30468L, 1953861C                                1,23          Top
```

CRDv2 issues

- Since **August, 1st, 2022**, the ILRS uses a new conventional format for the SLR observations, the **CRD v2 format**
- On the ILRS website, a detailed description of the **CRD format v2.01** is provided to the user (**https://ilrs.gsfc.nasa.gov/docs/2022/crd_v2.01e3.pdf**)
- DGFI-TUM ILRS AC now **directly imports the CRD v2** format into its POD s/w
- Up to now, different errors and inconsistencies to the official format description arise
  - several variables are “na” but **only some variables are explicitly allowed** to be “na” in the format description
  - CRDv2 record „21“: sky temperature should be of type integer, not real

CRDv2 issues – e.g. lageos1_202209.np2

- The sky temperature in [K] is defined to be of type integer, some stations write them as real
  - In principle, **easy to fix** for either the ACs or the stations (but only if they know about this “error”)

21	Meterological Supp	Weather Condictions	two-digit SYNOP/WMO code or description, e.g. "rain"			replaces Precipitation Type
21	Meterological Supp	Visibility (km)		[na,0,…,100]	Warning	
21	Meterological Supp	Sky Clarity (zenith extinction coeff)		[na,0,…,100]	Warning	
21	Meterological Supp	Atmospheric seeing (arcsec)		[na,0,…,100]	Warning	
21	Meterological Supp	Cloud cover (%)		[na,0,…,100]	Warning	
21	Meterological Supp	Sky Temperature (deg K)		[220,…300]	Warning	
21	Meterological Supp	Other 21 Check		The record length must contain 9 (10) fields	Error	
30	Pointing Angles	30	“30”	“30”	Error	
30	Pointing Angles	Seconds of Day		[0,…,86400]	Error	Normal data

65

ILRS Consolidated Laser Ranging Data Format (CRD)

```
11 11849.406405199999     0.044661883851 new 2  120.0     28   29.0  -0.660   0.256 na          4.67 0 na
20 11935.807  711.40 288.70  74. 0
11 11935.806527600000     0.045721396303 new 2  120.0     49   35.0   0.172  -0.347 na          8.17 0 na
20 12001.207  711.40 288.80  74. 0
11 12001.206583400000     0.046591755360 new 2  120.0      6   39.0   1.004  -0.326 na          1.00 0 na
50 new   37.1   0.201  -0.078 na     0
h8
H1 CRD  2 2022 09 17 22
H2       STL3 7825 90 01  4 ILRS
H3 lageos1 7603901 1155     8820 0 1 1
H4  1 2022 09 16 03 32 01 2022 09 16 03 39 34  0 0 0 0 1 0 2 0
C0 0 532.10 IDAA IDAB IDAJ IDAV IDAS IDAM IDAC
C1 0 IDAB Nd-YAG 1064.00 60.00 10.00 12.0 10.00 1
C2 0 IDAJ CSPAD 532.00 20.00 11.0 100.0 ECL 12.0 2.00 90.0 0.1 na na na 0
C3 0 IDAV TrueTime_XLi TrueTime_OCXO MRCS na 0.2322
C5 0 IDAS eosTrackingServer.exe 1-0-5 Profits 7.0
C6 0 IDAM Vaisala PTB330 M4620100 Vaisala HMP155 P4711022 Vaisala HMP155 P4711022
C7 0 IDAC STN 69.5920 1.22 0.0090 0.020 Profits 7.0
H5  1 22 091500 HTS 25800
40  7230.000000000000 0 IDAA 11682 3555 69.592 158295.5 -1.3 17.7 0.100 -0.400 13.3 2 2 0 3 0.0
41 86220.000000000000 0 IDAA 5419 1645 69.592 158296.2 88.7 18.0 0.100 -0.400 13.3 2 3 0 1 0.0
41 14640.000000000000 0 IDAA 6263 1910 69.592 158294.8 86.7 17.3 0.100 -0.400 4.0 2 3 0 2 0.0
11 13071.395525570764 0.051231271156 IDAA 2  120.0     20     45.40     0.73    -0.65      -6.90    0.39  0     0.0
11 13129.422169173597 0.050467759448 IDAA 2  120.0     33     43.80     0.00    -0.28      63.40    2.11  0     0.0
30 12721.269055999999 83.808046 20.014733 0  2 0 na na
30 12722.639700000000 83.840092 20.055864 0  2 0 na na
30 13174.462563999999 97.757092 33.727743 0  2 0 na na
20 12715.349213000000 913.79 285.93 55.8 0
21 12715.349213000000 5.80 217.15  clear na na na na 256.65
20 12744.730213000003 913.80 285.91 55.2 0
21 12744.730213000003 4.60 265.28  clear na na na na 257.85
20 13164.751243000002 913.69 286.01 52.2 0
21 13164.751243000002 4.30 275.02  clear na na na na 250.15
50 IDAA 44.4 0.300 -0.420 1.5 4
H8
H1 CRD  2 2022 09 19 12
H2 GRSM       7845 78  1  7 ILRS
H3 lageos1    07603901 1155     8820 0 1 1
                                                                                    13825,1       53%
```

CRDv2 issues

- Since **August, 1st, 2022**, the ILRS uses a new conventional format for the SLR observations, the **CRD v2 format**
- On the ILRS website, a detailed description of the **CRD format v2.01** is provided to the user (**https://ilrs.gsfc.nasa.gov/docs/2022/crd_v2.01e3.pdf**)
- DGFI-TUM ILRS AC now **directly imports the CRD v2** format into its POD s/w
- Up to now, different errors and inconsistencies to the official format description arise
  - several variables are “na” but **only some variables are explicitly allowed** to be “na” in the format description
  - CRDv2 record „21“: sky temperature should be of type integer, not real
  - Critical: epoch of 1st observation in some passes

CRDv2 issues – e.g. lageos1_202210.np2

- The epoch of the 1st observation in some passes is not correct
- CRDv2 record “H4” gives **start/end day**
- CRDv2 record “11” gives **Sec_of_Day**
- pass starts at Oct. 7th (H4) but the seconds count from Oct. 8th (11) → **wrong epoch!!!**
- This should be fixed by the stations!

```
H1 CRD 2 2022 10 10 07
H2 GRZL 7839 34 02  4 EUROLAS
H3 lageos1      7603901 1155    08820 0 1 1
H4  1 2022 10  7 23 39 40 2022 10  8  0 41 40  0 0 0 0 1 0 2 0
C0 0 532.000 0902 2kHz C_SPAD1 GPS na VSLA na
C1 0 2kHz Nd:Van 1064 2000 0.400 10 10 1
C2 0 C_SPAD1 SPAD 532.0 20 5.0  400 +1V 10 0.3 35  200 WinClean2.2 na na na
C3 0 GPS HP58503A HP58503A Graz_Dassault na   0.077
C6 0 VSLA Vaisala PTU300 T0210974 Vaisala PTU300 L1110324 Vaisala PTU300 L1110324
20   675 963.56 286.63 93.1 1
20  1714 963.44 286.64 93.2 1
41      675 0 0902    10000     7951   1.742   112054.7      1.0     16  -0.018  -0.674      0 4 0 0 1 na
41     1714 0 0902    10000     7460   1.742   112055.6      1.0     16   0.023  -0.712      0 4 0 0 2 na
40     1194 0 0902    20000    15411   1.742   112055.1      1.0   16.0   0.003  -0.693    0.0 4 2 0 3 na
11   690.770063843578    0.041292982006 0902 2  120.0   9308    34.0  0.050 -0.953      1.9   3.9 0 na
11   920.326963856816    0.042050433668 0902 2  120.0   3130    36.4  0.113 -1.193    -25.4   1.3 0 na
11  1350.663163855657    0.046075201731 0902 2  120.0   2881    36.1  0.278 -1.019    -20.2   1.2 0 na
11  1671.646563850343    0.050791765614 0902 2  120.0   1459    32.2  0.173 -0.655     -3.6   0.6 0 na
11  1696.292963846028    0.051197289134 0902 2  120.0   2171    34.5  0.129 -0.960     -7.5   0.9 0 na
50 0902   34.7   0.126  -0.987   -9.5 1
H8
```