Introduction
Current status of the SLR WG-5

GENESIS Science meeting

Brussels – March 2026

Clément Courde & Mathis Blossfeld

SLR WG-5 members

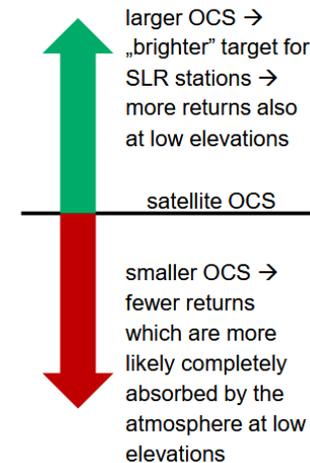| Role	Name	Surname	Email	Affiliation	Country
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SLR WG5 activities: Past & on-going activities

2024 : OCS of the GENESIS LRR

Genesis' optical cross section (as planned today)

M. Blossfeld et al., 2024,
Kunming ILRS Workshop

♦ The optical cross section (OCS) of an artificial near-Earth satellite directly impacts the expected return rate of photons (i.e. normal points – NPs) from the reflector

  – a smaller OCS will have a major impact on the return rate, i.e. a smaller OCS will not allow to get low elevation returns (since the few reflected photons are absorbed by the atmosphere)

  – with lower satellite altitude, the OCS needed to obtain laser echoes can be much lower

  – low elevation observations are required for the decorrelation of range biases and station height estimates

♦ For LAGEOS-1/2, the OCS is about $1.5*10^7 \, m^2$

♦ Requirements by ESA to Genesis (status: October 2024; same as in March 2023?)

  – minimum effective cross section of $3*10^6 \, m^2$ at apogee for laser wavelength of 532 nm

  – this is about 20% of the return rate from the ILRS standard target LAGEOS

larger OCS →
„brighter" target for
SLR stations →
more returns also
at low elevations

satellite OCS

smaller OCS →
fewer returns
which are more
likely completely
absorbed by the
atmosphere at low
elevations

=> recommandation to increase the OCS in the SRD

SLR WG5 activities: Past & on-going activities

- 2025 : Accuracy of the GENESIS LRR Range Correction

  ⇒Industry warns on the challenge to reach the initial requirement of 0.5mm @1 sigma

**S. Dell'Agnello et al.,
GENESIS Science meeting 2025, Matera**

Extreme 1σ (optical) challenges for the Genesis LRR

➢ Requested accuracy of calculated (purely optical) laser range correction is:
➢ **0.5 mm @1-sigma for Genesis**, to be compared to
   5 mm @1-sigma for LAGEOS (source: David Arnold)
   2 mm @1-sigma for LARES-2 (source: LARES-2 mission support req. form)
   ➢ **Who has better definitive numbers for LAG / LS2 ?**
   ➢ **Very challenging/critical, who knows/wants to compute @0.5mm 1σ ?**

➢ Compare requested laser ranging accuracy to accuracies of atmosph. corrections:
➢ **10/15/20° elevations, accuracies 5/2/1 mm at 1-sigma**
   ➢ **ILRS requested x2 OCS increase for low elevations, where limit is 2-5 mm.**

➢ **Why 0.5 mm if there is (at least) another limitation of 2-5 mm?**
➢ **Other multi-mm limitations (at stations, for ex.)?**
➢ **Final (optics plus mechanics …) accuracy goal of LaRCo is 1 mm.**
➢ **Achievable with optics [0.5-1.0] mm ⊕ mech/else [0.0-0.5] mm:**
   ➢ **0.75 ⊕ 0.25 = 0.8 mm, 0.8 ⊕ 0.3 = 0.85 mm, 0.9 ⊕ 0.4 < 1 mm, …**
   ➢ **Numerically, optical LaRCo accuracy can be relaxed keeping final goal.**

LaRCo (Laser Range Correction)   From ILRS NESC 13/03/2025   3

Decision to accept the best state-of-the-art standard in the PDR

SLR WG5 activities: Past & on-going activities

- 2025 : Calibration of the Center of Phase vs Center of Mass with millimetric accuracy

  $\Rightarrow$ Challenging ; object of the splinter meeting of March 2026

- <u>Measure/calibrate the optical center of the LRR</u>
  - <u>w.r.t. the center of mass of the LRR</u>
  - w.r.t. the other technics
  - w.r.t. the center of mass of the satellite after all the integration
- Important:
  - Origin of the SRF must be known better than 1mm
  - Satellite CoM must be known better than 1mm
  - LRA optical phase center must be known better than 1mm

  → All points should be calibrated on the fully mounted/equipped satellite, preferably with electronic devices switched on!

Zeitlhöfler, 2019
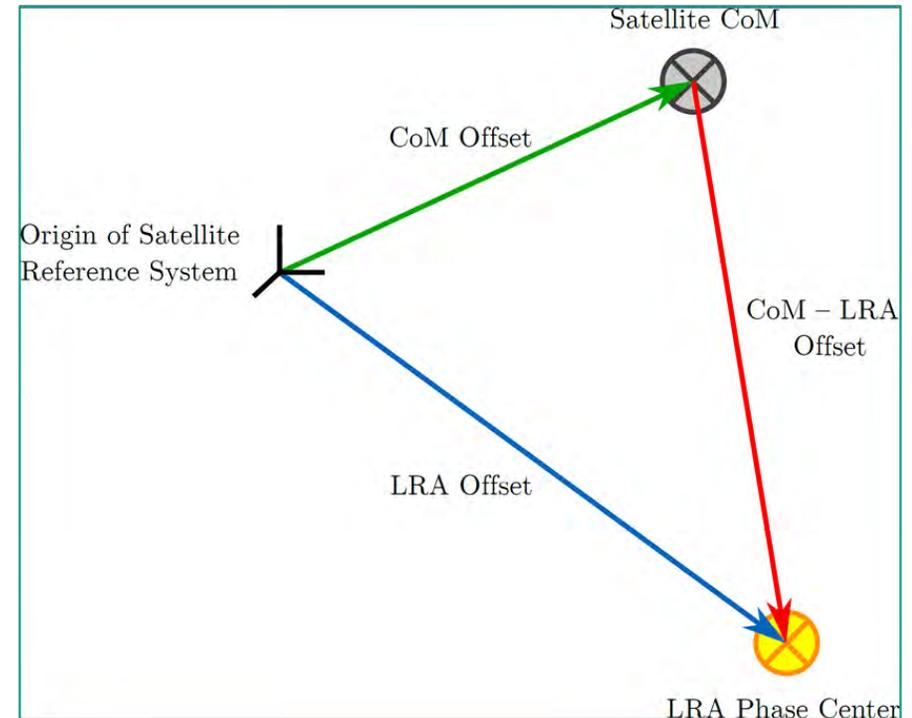
SLR WG5 activities : Future activities (non-exhaustive)

- Task 1 : GENESIS LRR requirement & design
  - Feedback from ESA on the final requirement put in the PDR?
  - Feedback from industry on the chosen design?
- Task 2 : LRR calibration
  - How has to be done the calibration ? Simulation/calculation ? Measurement before the LRR integration on the satellite ? Measurement after the LRR integration ? both ? (following discussion on LarCo (Simone's prroposal))
  - How do we tie the Center of Phase of the LRR to the Center of mass of the Satellite ?
  - How will be shared the results of the calibration ?
- Task 3 : Data & Format
  - Is the ILRS format sufficient to answer to the GENESIS goals ? (see **Requirement in *3.4.1. Level 2 Product Description*** It shall be possible to uniquely identify the SLR data format, generation time, and covered time period from the data filename => the "covered time period" is currently not a standard part of the file naming convention applied within the ILRS: So this requirement might be necessary to be changed.)
  - What kind of data has to be shared ? NP ? FR ? Additionnal information (reference points/Time scale tie) ?
  - How will be the data from the ILRS database send to the ICD ESA database ?
- Task 4 : GENESIS observation
  - How should stations observe ? full arc ? interleaving ?
  - How many passes / NPs on GENESIS per station will be required ?
  - For multi-technic Observatories, is there any coordination with other technic (i.e. VLBI, DORIS) ?
  - Is it necessary to perform a topographic survey of the various techniques on the ground and how often? (1 time per year ?) ?
  - Is there a need to share a common time scale between the different geodetic technics on ground ?
- Task 5 : GENESIS Data Analysis
  - Point of view from the ILRS Analysis Standing committee ?
  - Are simulations with current observations necessary to anticipate the GENESIS exploitation ?
  - How should be GENESIS observed regarding the other ILRS priority ? combination with other satellites (geodetic, altimetric) ?
  - How will be analyse the GENESIS SLR observations ? Solution alone? Combination with SLR observations on other satellites?

Agenda of the GENESIS-Science-meeting SLR WG5 time slot

1. José Rodriguez (online) : CoM comptutation on spherical satellites

2. Mathis Blossfeld (in person) : GENESIS Data Analysis

3. Francesco Vespe (in person) : Combination of GENESIS observations with the other Earth's Laser Ranged satellites for Optimal Estimation of Geocenter

4. Clément Courde (in person) : Grasse topographic survey & time scale
distribution between the different geodetic technics on ground

Centre of mass corrections to spherical geodetic satellites

José Rodríguez

Red de Infraestructuras Geodésicas, IGN

Genesis Science Workshop 2026
12th March 2026

Centre of mass corrections to spherical geodetic satellites

José Rodríguez (**Toshimichi Otsubo**, **Graham Appleby**)

Red de Infraestructuras Geodésicas, IGN

Genesis Science Workshop 2026
12th March 2026

Why is this relevant

- The Genesis laser retroreflector array (**LRA**) is a sector of a sphere.

- To the eyes of an SLR system, *it is* a sphere.

- We can apply the methods we currently use to calculate the CoM corrections.

*INFN-LFN*

CoM? CoG? Target signature? OCO...?

- "Centre of mass" correction is a misnomer here.

- The geodetic ILRS targets are spheres (so far) → the optical offset coincides with the CoM.

- We kept calling this optical offset correction the "Centre of Mass".

- A better name would be *Optical Centre Offset*, perhaps.

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CoM

!CoM
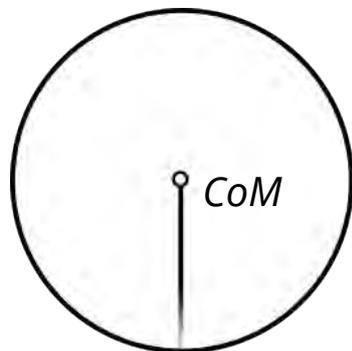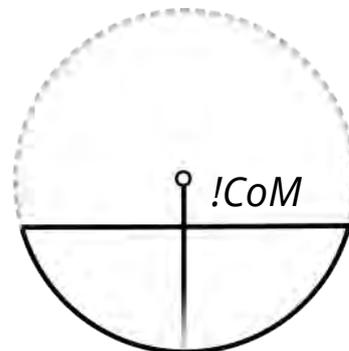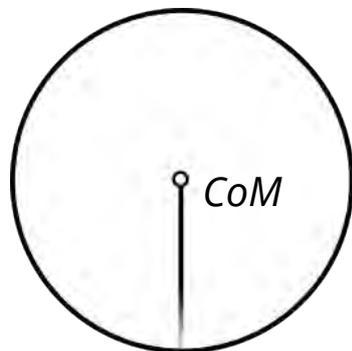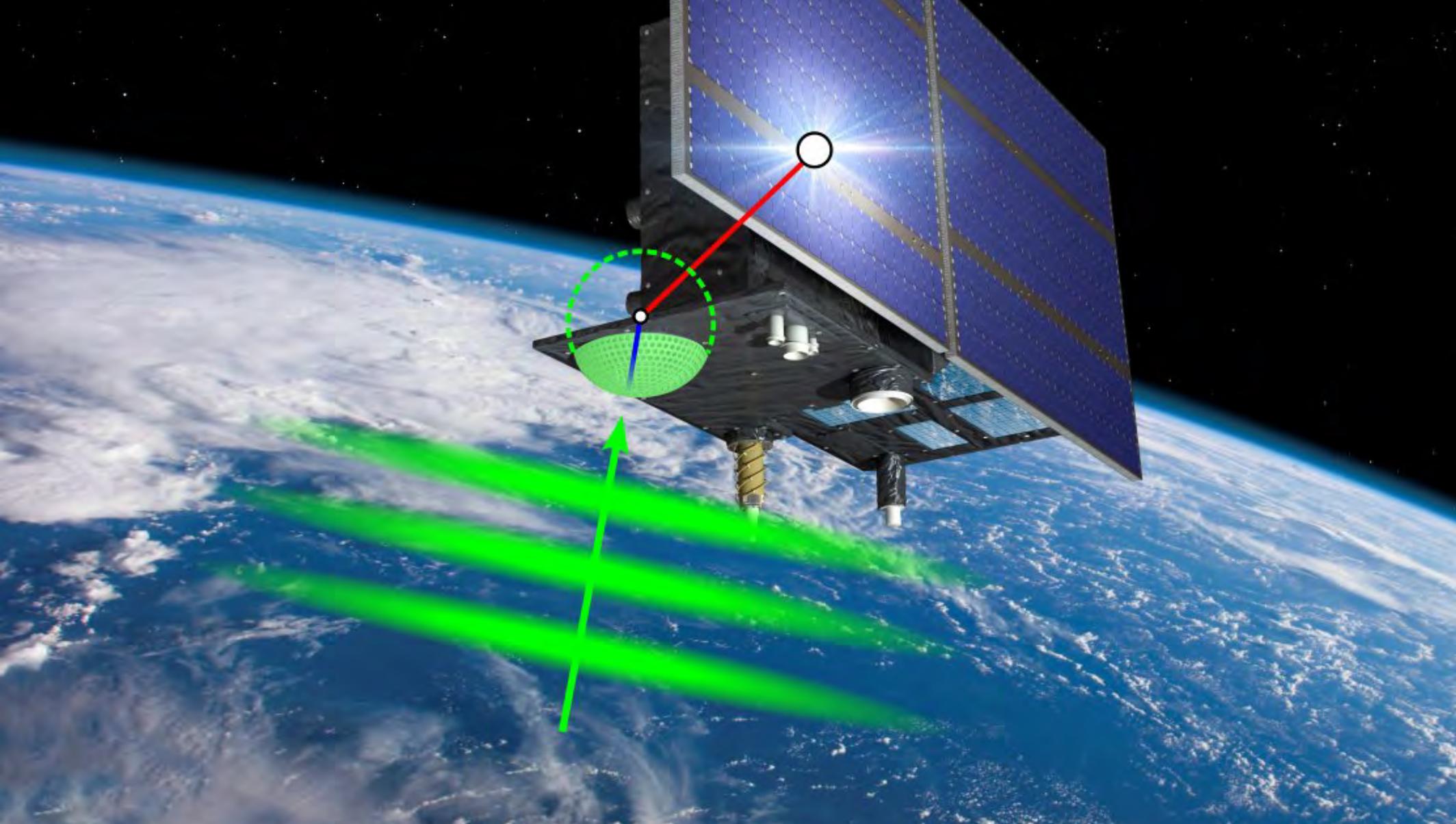
The basics

- First-gen SLR systems had low sensitivity to the optical properties of targets:
    - Very long laser pulses (nanoseconds).
    - Slow detection devices (signal smearing).
    - Multi-photon detection (bias to first photons received).
- The advent of faster detectors made target signatures relevant.
- **Target signature**: optical distortion of the laser pulses by the retroreflector array (LRA).
    - Determined by the array geometry and reflectors' characteristics.
    - Orientation dependent.
    - *Not* an error.
- Different SLR systems "see" a different target signature.
- Different processing choices change the time of flight.

Time of flight   Distance to centre
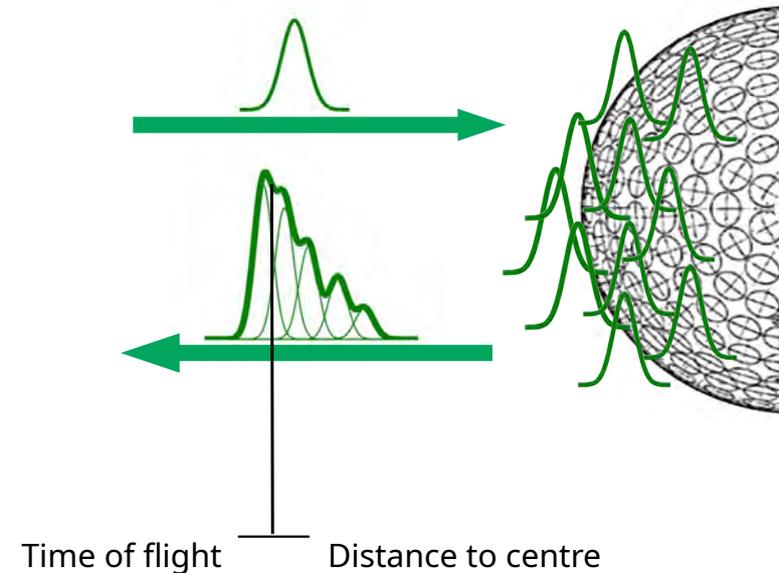
The basics

- Factors that determine the "CoM":
  - Satellite LRA (target signature)
  - Detection system
  - Operational conditions
  - Data reduction and calibration

- The computation of optical offset corrections ought to include all these effects.

Pre-launch testing

- For LAGEOS and LAGEOS-2, extensive pre-launch optical testing conducted:
  - Usefulness limited to detection systems tested (NASA-like stations).
  - Uncertain applicability to real-world systems.
  - No extrapolation to other detection setups.
- All these meant that the practical usefulness of the tests was limited.
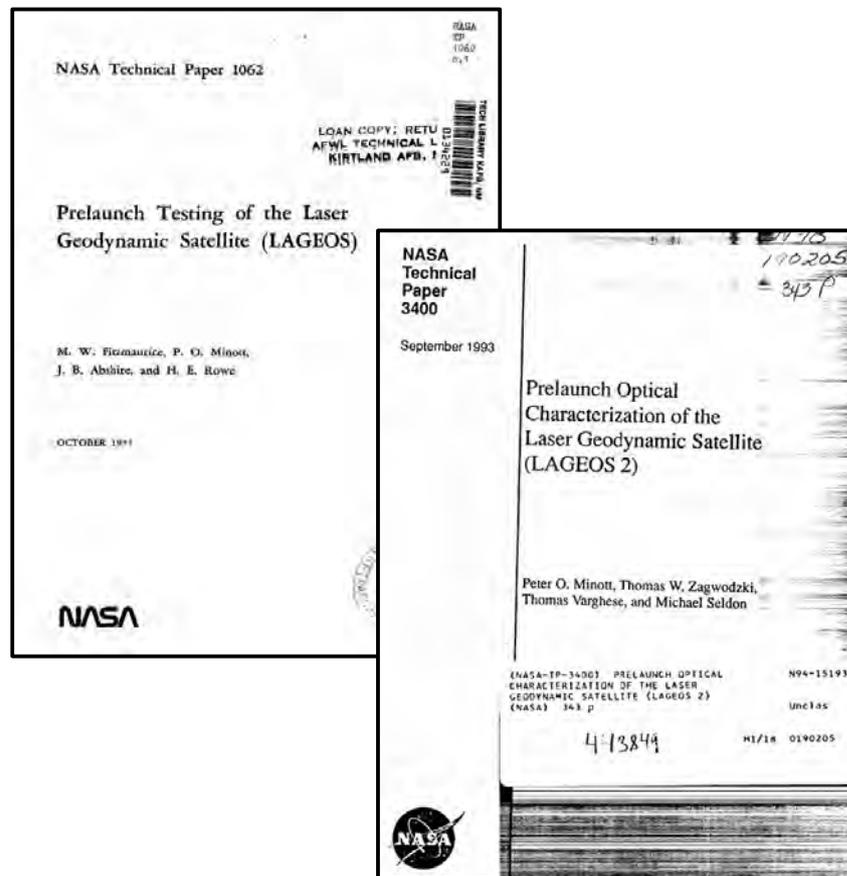
"CoM" corrections for SLR spheres

- T.Otsubo and G.Appleby (2003): method to compute satellite- and station-dependent CoM corrections.

- Beyond the methodological considerations, one must compute the corrections for every satellite-system combination.
  - Taking into account system changes.
  - Operational mode.
  - Data reduction and calibration.

- For instance, if a station changes detector, laser, mode of operation, or data reduction strategy, the CoM correction is liable to change → a static snapshot of the network has a time-limited validity

Otsubo & Appleby, JoG 2003 (LAGEOS, Etalon, Ajisai)

Otsubo et al, JoG 2014 (LARES, Starlette, Stella)

Rodríguez, Otsubo, Appleby, JoG 2019 (improved modelling 6 targets)

Rodríguez, IWLR 2023 (LARES-2)

How we do all this

1) Compute ideal **optical response** of retroreflector array (family of functions).

2) Determine **best fit to single-photon** observations.

**3)** **Compute CoM** according to system specifications, station performance and data reduction method.

Single-photon ranging: return rate limited so that each received satellite pulse contains no more than an individual photon on average.

- Takes rid of electronic biases
- Stable operation regardless of atmospheric conditions, satellite distance and elevation, LRA
- Discards observations required to lower return rate to ≤10%

Key: distribution of laser echoes is a faithful representation of the target optical response.

Example LAGEOS pass

(flattened residuals [cm])
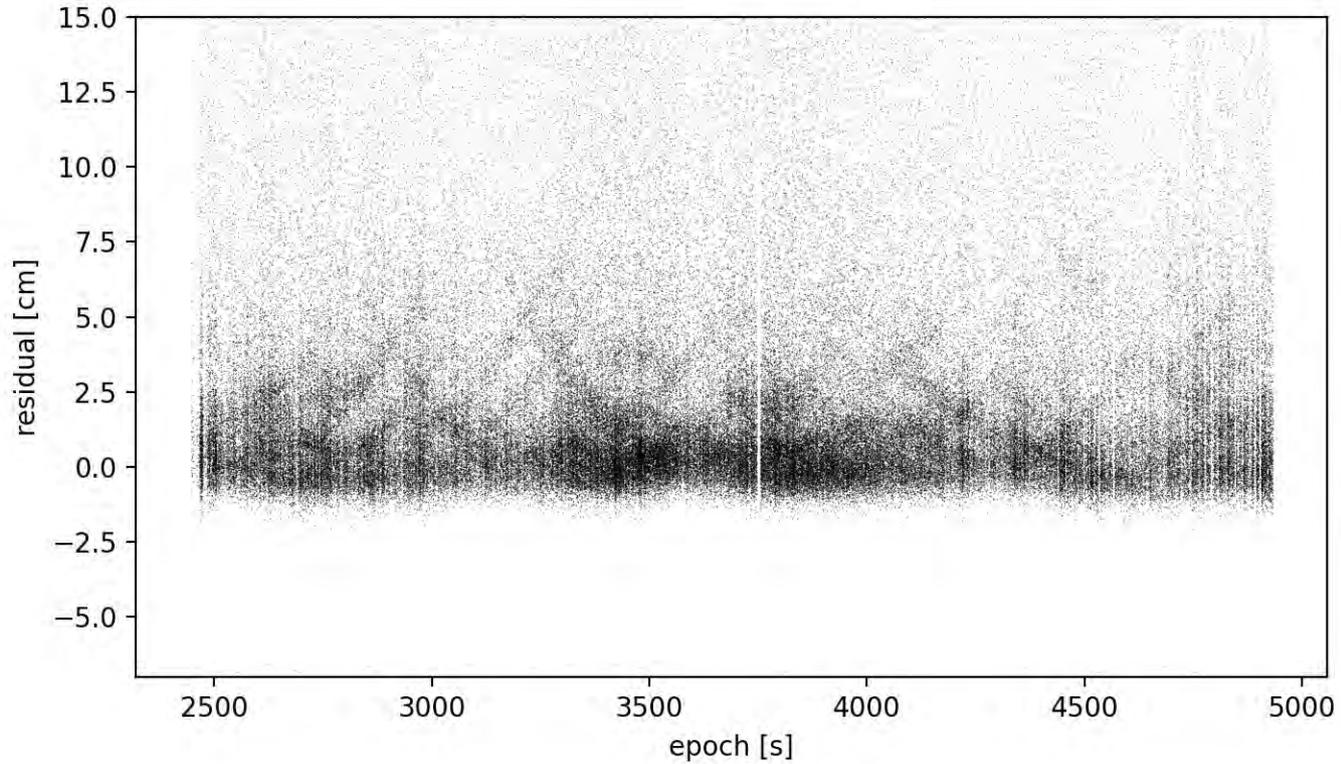
LAGEOS	
Diameter	60 cm
Mass	407 kg
#CCRs	426

CoM computation I. Optical response(s)

We seek to model the **shape** of the retroreflected laser pulses.

Simplification: **average** optical behaviour of the satellite. We don't model:

- Polarisation effects
- Retroreflector dihedral angle offsets
- Thermal effects
- Velocity aberration
- Diffraction patterns

NOT ignored: implicitly included **empirically.**

The model is fitted to empirical data to determine the best match.

We take into account:

- Characteristics of reflectors (CCRs)
- CCR positions and orientations
- CCR recess and visibility
- Reflection losses
- Total internal reflection (if app.)
- Laser wavelength

CoM computation II. Fit to single-photon data

An empirical fit determines the "correct" model.

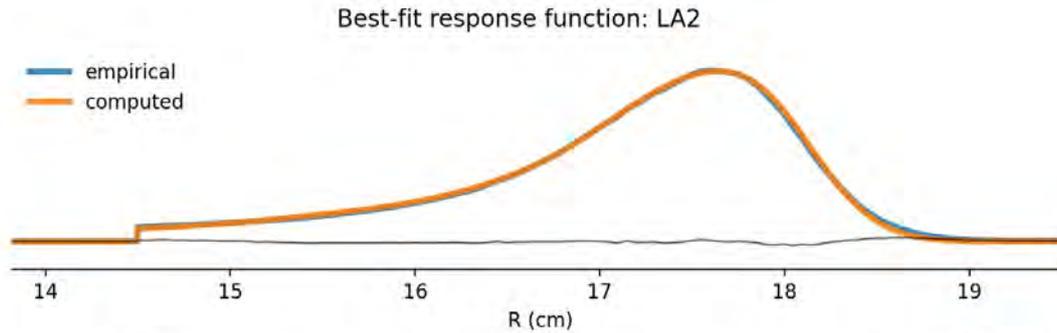For LARES-2, the input data are ~5M single-photon observations (*)

120+ passes
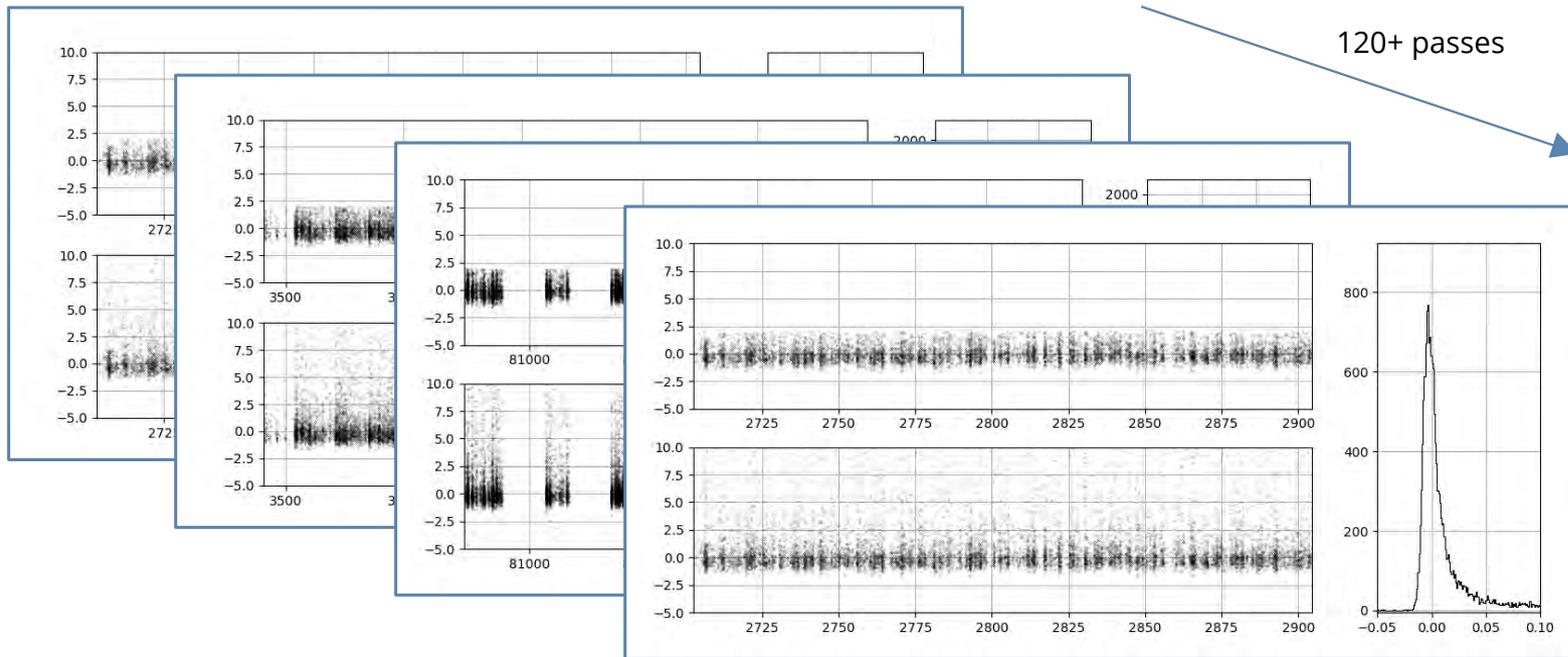
(*) Massive acknowledgment to **Herstmonceux** for their unremitting provision of world-class data.

CoM computation II. Fit to single-photon data

empirical

CoM computation II. Fit to single-photon data

Best-fit response function: LA2

- The fitted model reproduces the empirical data really well.
- Larger targets are harder to model (Etalon, Ajisai).

LAGEOS
600 mm
426 CCRs

LARES
364 mm
92 CCRs

LARES-2
424 mm
303 CCRs

CoM computation III. Derivation of CoM values

Satellite **optical** behaviour → **CoM** values

Things to consider:

- Station hardware

- Mode of operation (single/multi/mixed-photon)

- Data reduction strategy

Difficulties:

- Heterogenous network

- Uncertain/imprecise/missing information on HW used

- Uncertain/undefined mode of operation

- Unclear reduction/calibration details

- Instabilities and changes at the stations

- Tricky modelling for multi-photon/mixed-mode

CoM computation III. Derivation of CoM values

Distributions of CoM corrections for 3 satellites

Narrow **total range** (good!)

~8 mm   3 mm   3 mm

σ = 0.7 mm
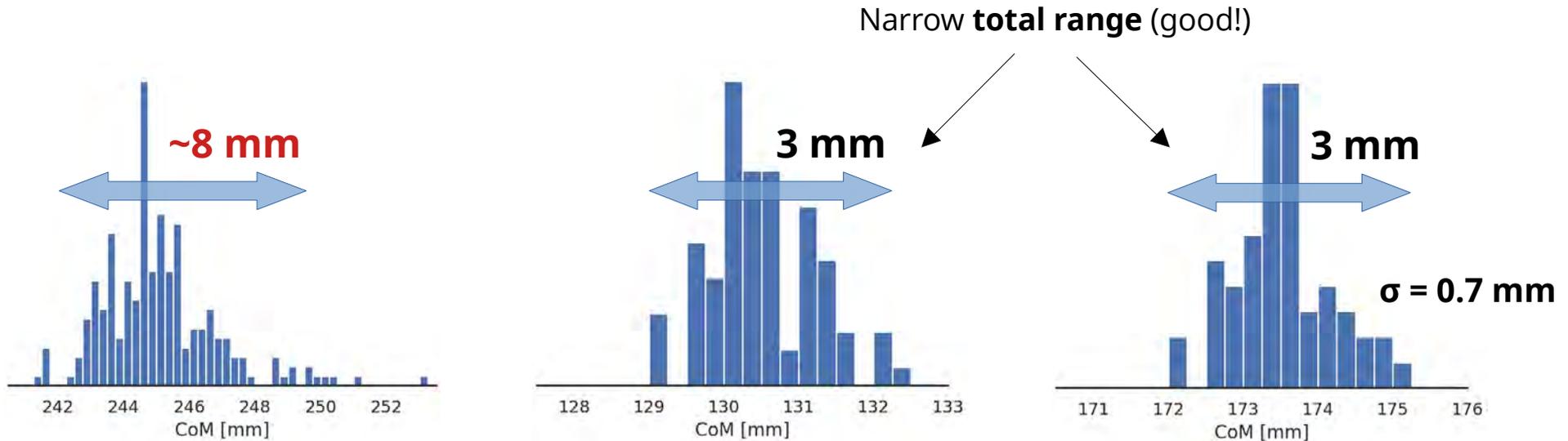
LAGEOS
Min: 241.4 mm
Max: 253.1 mm
Avg: 245.0 mm

LARES
Min: 129.0 mm
Max: 132.3 mm
Avg: 130.5 mm
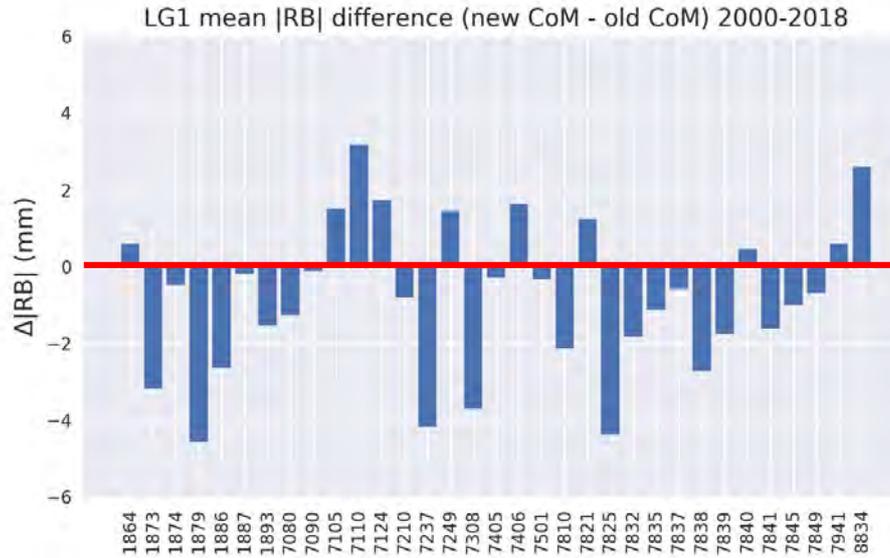
LARES-2
Min: 172.0 mm
Max: 175.0 mm
Avg: 173.5 mm

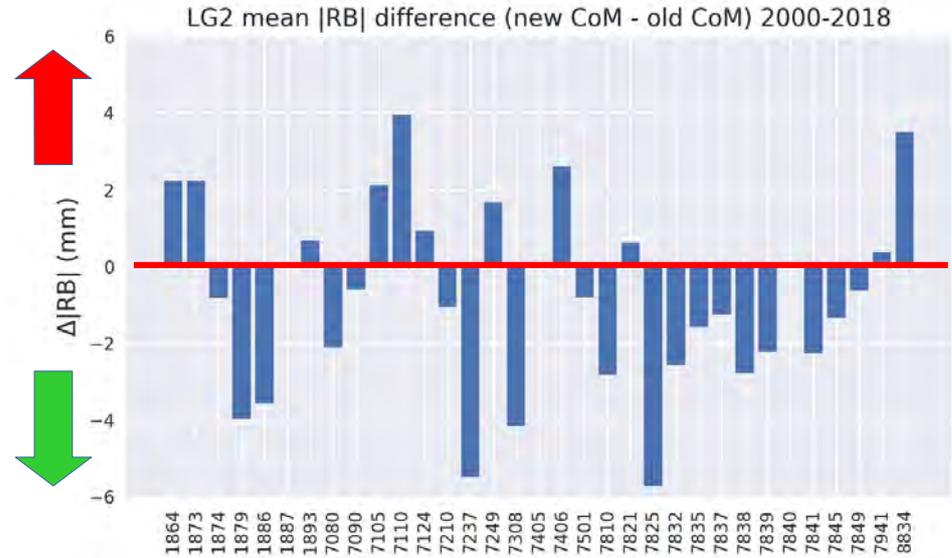# But does it work?

But does it work?

ETALON mean RB 2000-2018
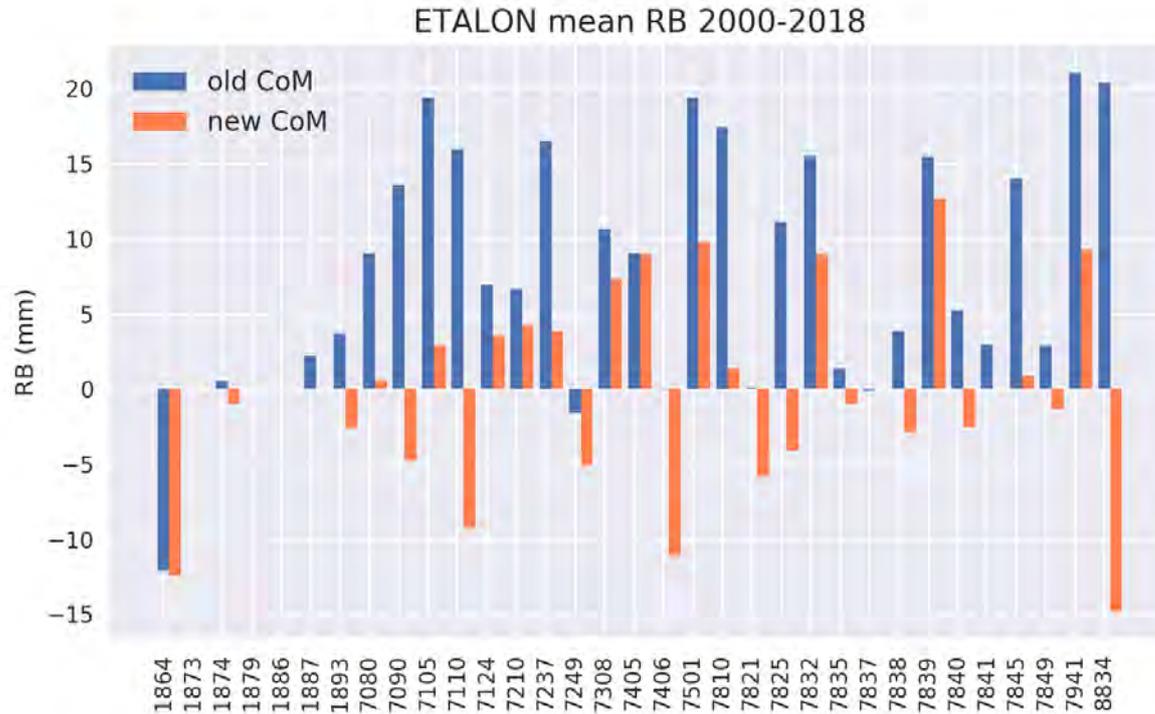
Range bias analysis suggests we did some good.

But does it work?

LG1 mean |RB| difference (new CoM - old CoM) 2000-2018

LAGEOS
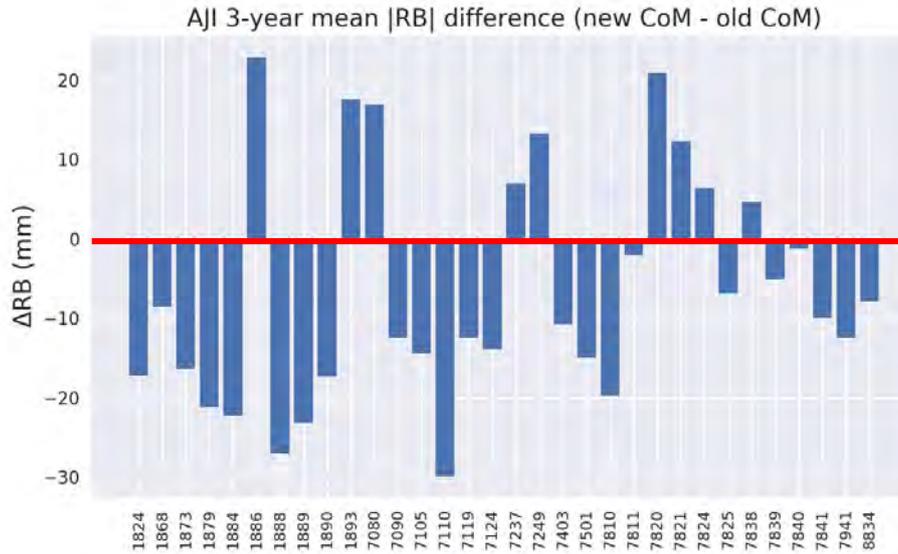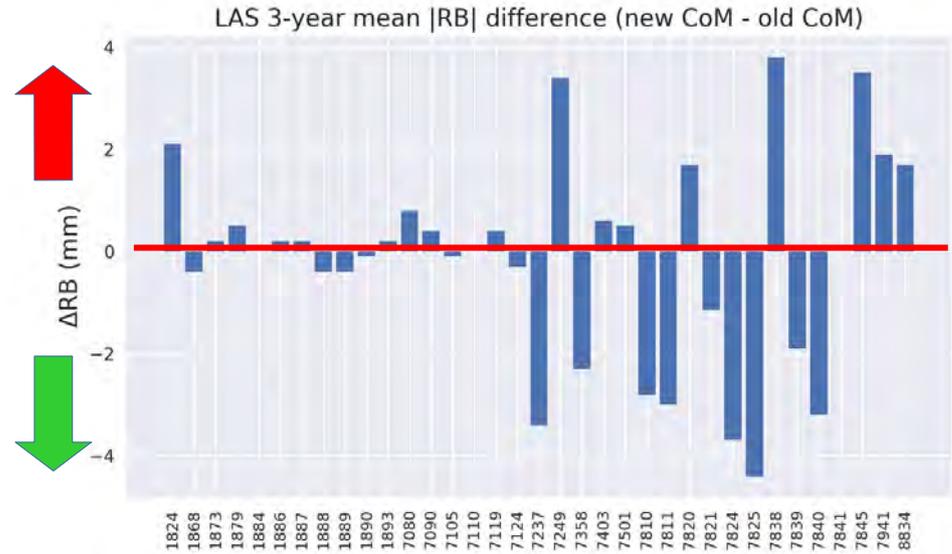
LG2 mean |RB| difference (new CoM - old CoM) 2000-2018

LAGEOS-2

Negative is "good" → bias "removed"

But does it work?

Ajisai

LARES

Negative is "good" → bias "removed"

But does it work?

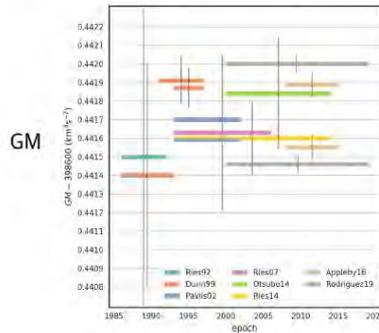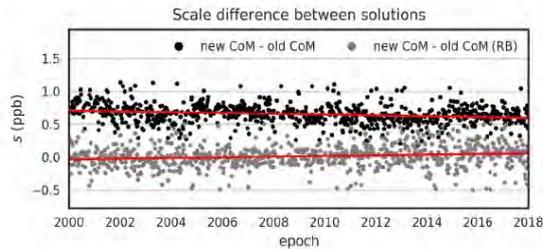J. Rodríguez: *Upgraded CoM modelling for geodetic SLR targets, accuracy, sources of uncertainty and errors*, UAW2019.

M. Seitz et al: *ITRS realization 2020: the new situation for scale realization*, EGU2020.

Some thoughts

- As far as we can tell, our modelling is sound.

- In particular, single-photon stations should be well modelled.

- We see many operational inconsistencies that impact the data.

- We have no independent comparison/validation (hi, Genesis).

- Our method requires several months of observations (strictly single-photon).

- For Genesis, it will be interesting to perform the empirical fit with several stations (Yebes, Herstmonceux, Potsdam, Wettzell, Zimmerwald...).

IGN-Yebes CoM corrections: https://datos-geodesia.ign.es/SLR/centre_of_mass_models/

Thank you

Deutsches Geodätisches Forschungsinstitut (DGFI-TUM)
TUM School of Engineering and Design
Technische Universität München

T///

Genesis data analysis – from the ILRS ASC PoV

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ESA Genesis Science Workshop, Brussels, Belgium, 13.03.2026

The ILRS Analysis Standing Committee (ASC)

- The ILRS ASC is **one out of five standing committees** the ILRS established permanently

- The **coordination** of the ILRS and, especially, **between mission operators and the tracking network** is ensured by the ILRS Central Bureau (CB)

- At the ILRS GB meeting three weeks ago, Mike Pearlman officially ended his service as CB director (~25 years) plus another 3-4 years as Secretary before…

  Mike, thank you for all you've done!

- The new director of the ILRS CB is Michael Croteau (NASA GSFC).

- The secretary of the ILRS CB is Claudia Carabajal (NASA GSFC).
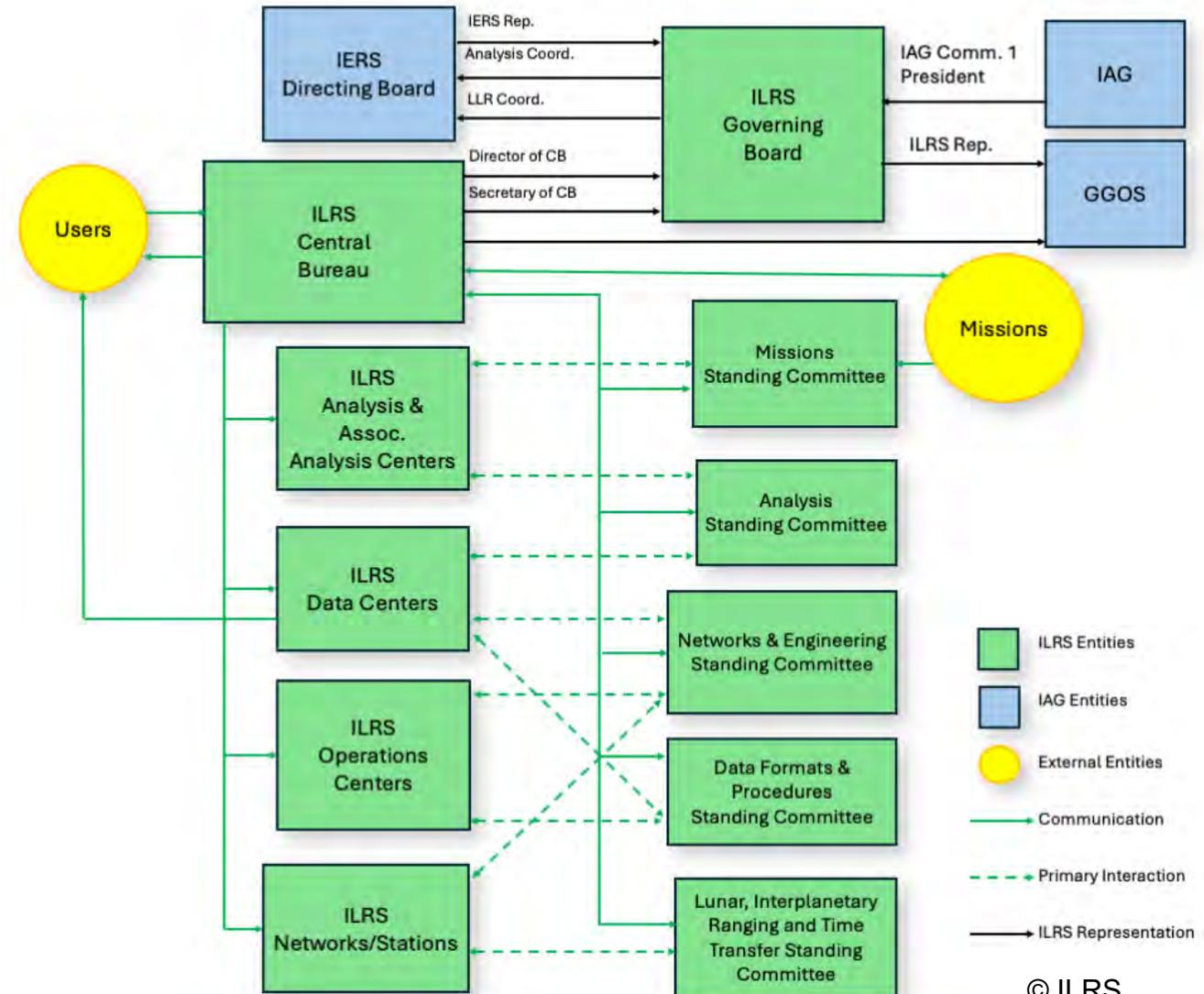
© ILRS

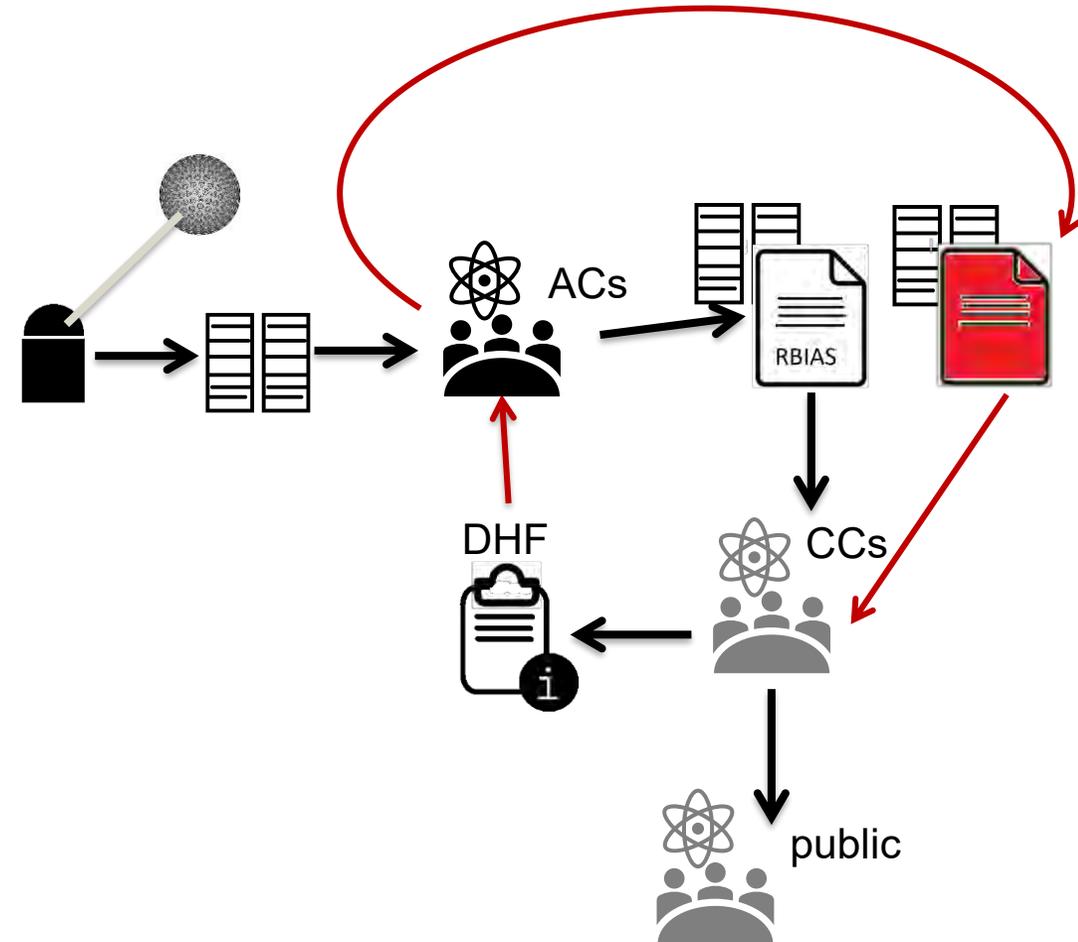# The ILRS ASC product portfolio – (operational) products

➤ All products computed by the ILRS ASC (as well as all SLR normal points) are available at two **ILRS Data Centers** (NASA CDDIS and the Eurolas Data Center (EDC) hosted by DGFI-TUM)

➤ Conventional orbit length for all solutions is **7 days**

➤ All following products are based on the (operational) submissions of all 8 ACs and are combined by both ILRS CCs! This data is then provided to the user via the ILRS Data Centers.

➤ **Combined orbits**
- orbits of LA-1/-2, LR-2 and ET-1/-2 are computed together with the weekly operational products
  - combined (averaged) SP3c-based orbits
  - temporal resolutions: 60s (LA-1/-2), 120s (ET-1/-2)

➤ **ILRS metadata files** (accessible via ILRS website and EDC)
- ILRS-specific ITRF2020 version SLRF2020
  - occasionally updated for new stations and station updates
  - currently realized as ITRF2020 + SLR-specific updates + ITRF2020-u2024 PSD model
- ILRS eccentricity file
  - occasionally updated for new stations and station updates

The ILRS ASC product portfolio – (operational) products

- ILRS Data Handling File (DHF)
  - frequently updated for new stations and range/time/pressure bias (RB/TB/PB) updates
  - based on a weekly RB product (v280/v330) where ACs/CCs derive long-term mean RBs for LA-1/-2, LR-2 and combined ET → **latency: 9 days**
  - when using xTRF2020 or later, the ILRS DHF must be used within SLR data analysis (or RBs must be determined)

- ILRS target signature model
  - computed by J. Rodriguez (cf. presentation before, accessible via IGN website and EDC)
  - model for variations of LRA optical phase center (currently satellite- and station-dependent)

- ➤ **TRF and EOP products**
- daily
  - v180 (LA-1/-2, ET-1/-2) and v190 (v180 + LR-2) SINEX files
  - **daily 7-day solutions** computed on the day right after the solution interval → **latency: 1 day**

- weekly
  - v80 (LA-1/-2, ET-1/-2) and v90 (v80 + LR-2) SINEX files
  - **weekly 7-day solutions** computed every Tuesday with a one-week buffer period → **latency: 9 days**
  - loose-constrained TRF+EOP solution (~1m constraint on TRF) as well as TRF-fixed EOP solution
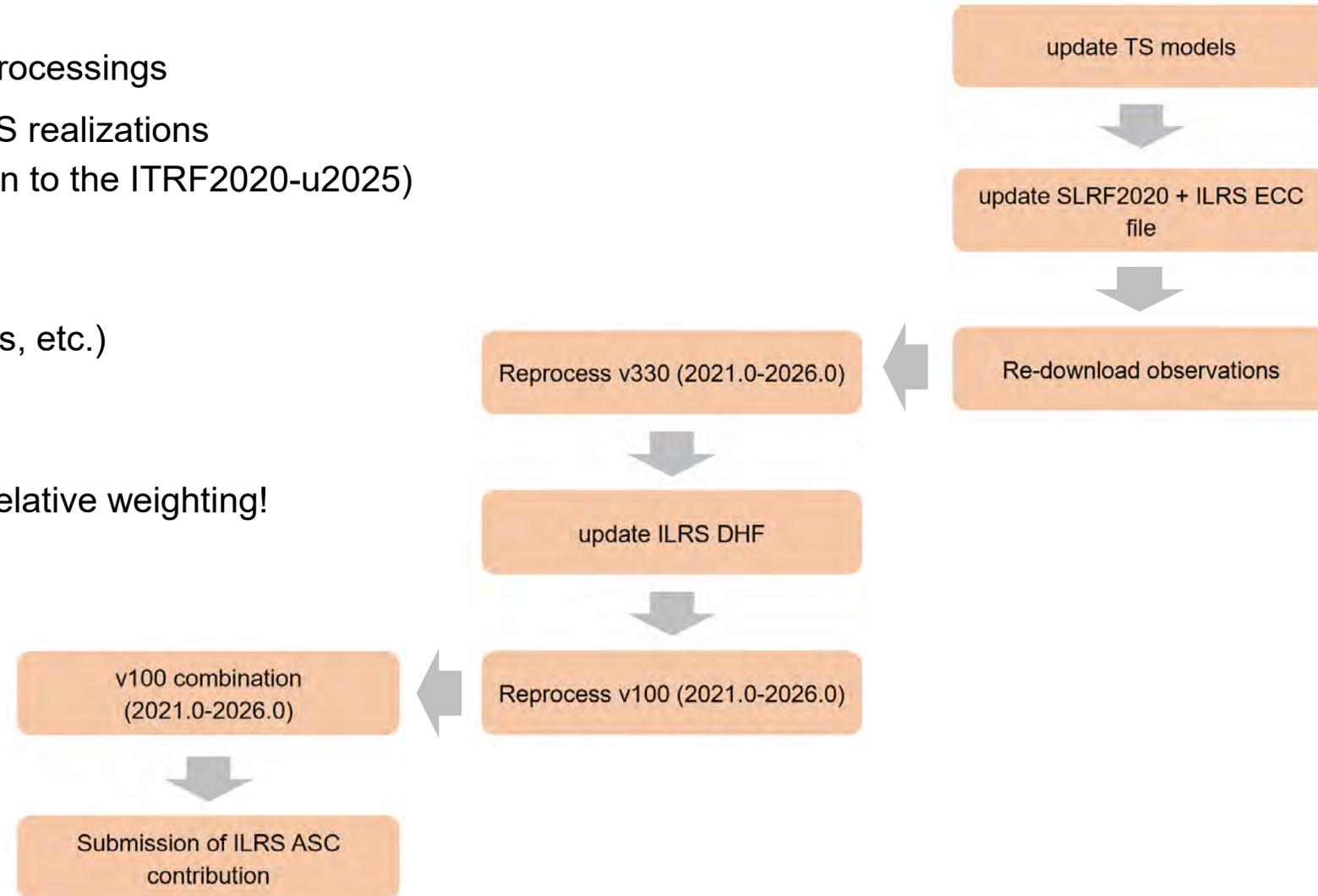
Moving from 4 to 5 satellites in the operational products

➤ Updating target signature model for LR-2

➤ Ad hoc (weekly) product with estimation of all RBs per station and satellite (incl. LR-2) together with EOP and station coordinates

➤ Validation of RB estimates:
  ▪ <u>inter-satellite</u>: comparison of long-term mean RBs for LA-1/-2 with LR-2 per station within 5-satellite product
  ▪ <u>inter-product</u>: comparison of long-term mean RBs for all shared satellites (no LR-2) between 4- and 5-satellite products

➤ Update ILRS DHF with validated long-term mean RBs for LR-2

➤ 5-satellite operational-like products: daily, weekly and RB monitoring, including orbit determination

➤ Finally, discontinuation of daily/weekly 4-satellite products

➤ This procedure is also required for new data releases, target signature model changes, etc. (cf. ITRF2020-u2025 reprocessing)
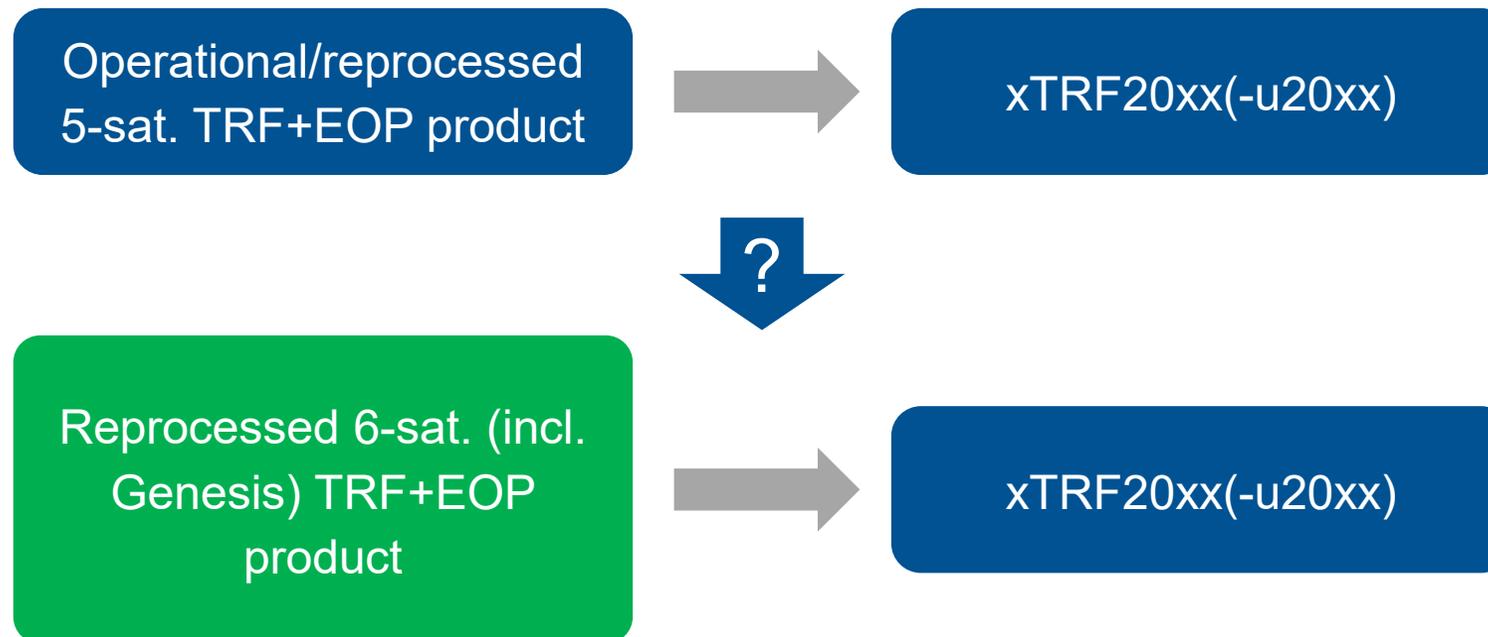
The ILRS ASC product portfolio – reprocessings

➢ The ILRS ASC is frequently involved in reprocessings

- several reprocessings in the past for ITRS realizations
- currently ongoing: v100 (ILRS contribution to the ITRF2020-u2025)
  - Revised target signature model
  - new stations
  - updated station metadata (eccentricities, etc.)
  - new data releases
  - LR-2 inclusion
  - change of number of ACs → different relative weighting!

update TS models

⬇

update SLRF2020 + ILRS ECC file

⬇

Re-download observations

⬅

Reprocess v330 (2021.0-2026.0)

⬇

update ILRS DHF

⬇

Reprocess v100 (2021.0-2026.0)

⬅

v100 combination (2021.0-2026.0)

⬇

Submission of ILRS ASC contribution

The ILRS ASC product portfolio – pilot projects

➢ Pilot projects (PP) are defined to introduce new developments into the ILRS operational products

- ▪ Last successful PP: station-systematic error monitoring project → development of ILRS DHF

- ▪ Ongoing PPs:

  - – Low-degree spherical harmonic determination (estimation of gravity field coefficients, required for inclusion of LR-1)

  - – **Analysis of SLR data to ESA's Genesis** (or other non-spherical satellites)

```
┌─────────────────────────┐              ┌─────────────────────────┐
│ Operational/reprocessed │    ───▶      │    xTRF20xx(-u20xx)     │
│ 5-sat. TRF+EOP product  │              │                         │
└─────────────────────────┘              └─────────────────────────┘

                              ?
                              ▼

┌─────────────────────────┐              ┌─────────────────────────┐
│ Reprocessed 6-sat. (incl.│   ───▶      │    xTRF20xx(-u20xx)     │
│ Genesis) TRF+EOP         │              │                         │
│ product                 │              │                         │
└─────────────────────────┘              └─────────────────────────┘
```

Genesis data analysis PP

➢ Survey to assess capabilities of ACs/AACs currently ongoing

- 8 ACs/AACs provided feedback up to now (6ACs/2AACs) – still waiting for more responses

- Is your s/w capable to analyze also other geodetic space techniques than SLR? (8 answers comprise 6 different s/w packages)

- Will you join an **ILRS ASC PP (working group) on "Genesis data analysis"?**

- Would you be able to **process Genesis SLR data on an operational basis?**

➢ Other questions and tasks which need to be addressed

- ILRS CCs must be able to **combine Genesis NEQs/solutions** with operational/ reprocessed data sets! Weighting?

- How to deal with **multi-technique data sets**? Currently, no ILRS/IERS entity is responsible for this kind of data!

- **How should Genesis be observed**? Scenarios need to be simulated (frequent observations, network campaigns with increased number of NPs, campaigns coordinated with other techniques, etc.)
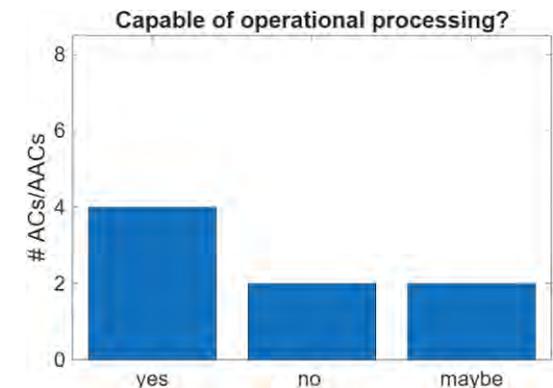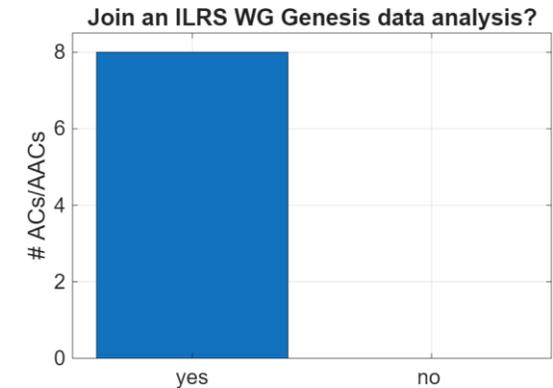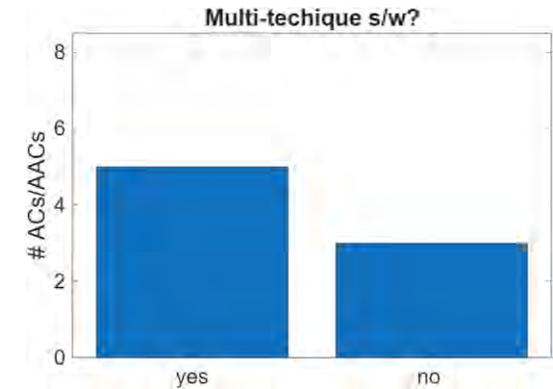
Genesis data analysis PP – next steps

➢ Establish PP at next ILRS ASC meeting (during EGU GA 2026 in Vienna, Austria)

➢ Initiate **simulations of Genesis observation scenarios**

➢ Initiate test campaign with Jason/Sentinel SLR data

▪ Develop **dataflow/workflow of SLR observations** (observations → TRF+EOP products)

▪ Assess impact of **SLR data to non-spherical satellites on TRF+EOP solution**

▪ Extend SLR data set to, DORIS/GNSS at some ACs/AACs (multi-technique pre-combined

➢ Convince ILRS ACs/AACs to somehow implement the Genesis satellite macromodel (+ self-shadowing modeling;-)

➢ Not to forget (tasks for the ESA Gensis WG5 on "SLR"):

▪ **Genesis predictions must be provided in CPFv2 format** with reasonable accuracy before observations can be done (in case of SLR and VLBI)

▪ Discuss with ESA/industry **how calibration procedure might look like** → highly accurate pre-launch LRA calibrations will partially allow to decouple satellite- and station-systematics → Genesis target signature model still accounts for other not-modeled effects (cf. previous talk by J. Rodriguez)

▪ Nevertheless, the **ILRS DHF must be extended for Genesis observations** (i.e., determine long-term mean RBs)

▪ How to deal with this new kind of SLR (or multi-technique) data at ITRS CC level (beyond scope of ILRS)?

Combination of GENESIS observations with the other Earth's Laser Ranged satellites for Optimal Estimation of Geocenter

1

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2

Francesco Vespe[2]

UNIVERSITÀ DEGLI STUDI DI NAPOLI
FEDERICO II

Content

- If GENESIS, in combination with other SLR satellites (LAGEOS type), improves the Quality of the estimate of the Geocenter

- What is the best orbit for GENESIS (60°, 95°, other…)

- Geometric Analysis based on DOP computed having an ideal observer at the center of Earth

- A more realistic analysis taking into account the performances of the SLR stations

- Some Results

- Conclusions

The SLR constellation

Satellite	h [km]	a [km]	e	i [°]	Ω [°]	ω [°]	M₀ [°]
LAGEOS-1	5900	12270	0.004	109.8	126°/yr	0	Random
LAGEOS-2	5900	12270	0.014	52.6	-227°/yr	0	Random
LARES-2	5930	12300	0.002	70.0	-126°/yr	0	Random
GENESIS 60	6000	12370	0.00	60°	-182°/yr	0	Random
GENESIS 95	6000	12370	0.00	95	31.7°/yr	0	Random

Ideal Case: a SLR station on the Geocenter!
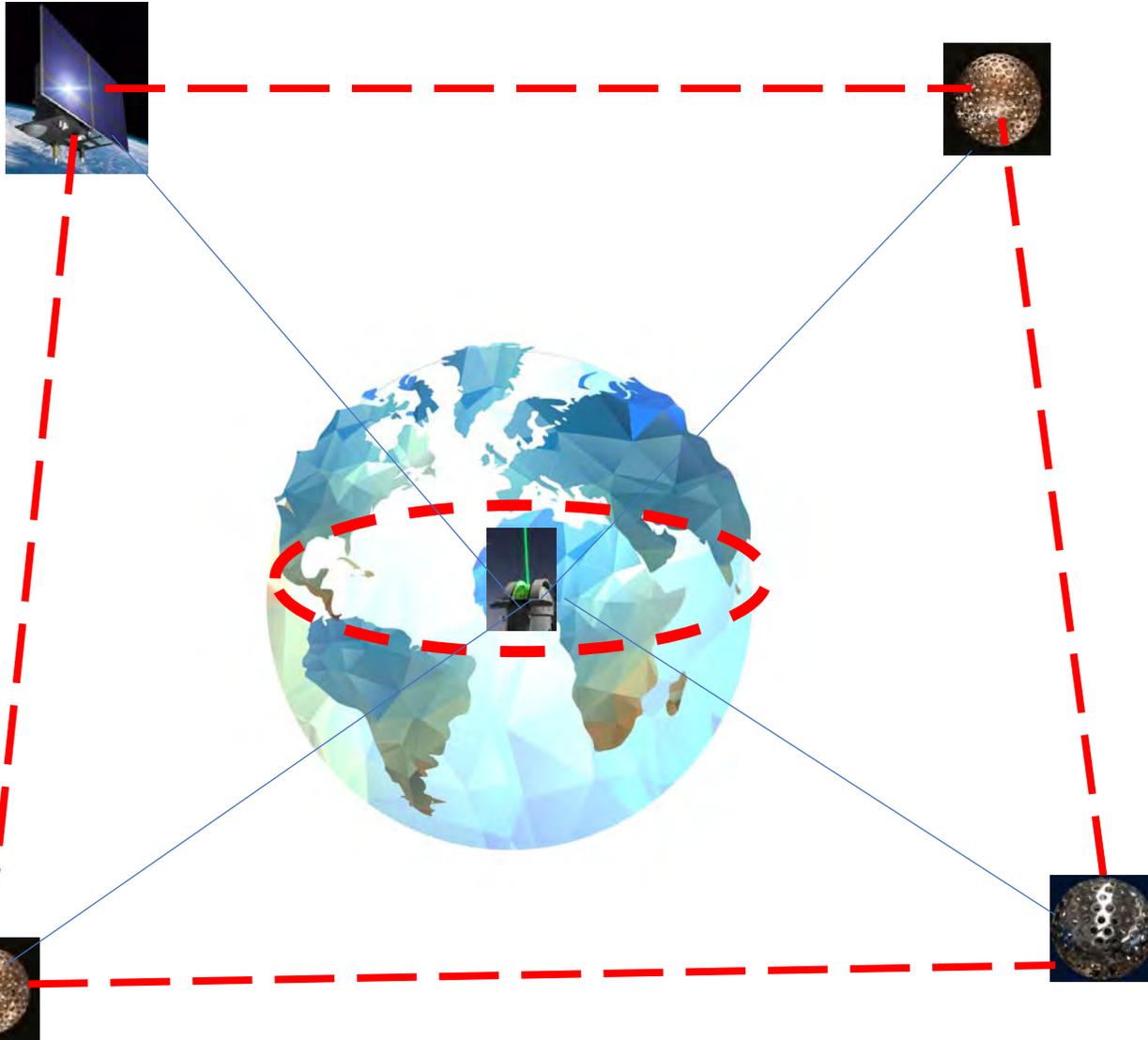
$$\bar{y} = \mathbf{H}\bar{x} + \bar{\epsilon}$$

$$\mathbf{D} = \sigma \cdot \mathbf{C}$$

$$\mathbf{C} = (\mathbf{H^T H})^{-1}$$

$$H = \begin{bmatrix} \frac{x_1-x}{R_1} & \frac{y_1-y}{R_1} & \frac{z_1-z}{R_1} & 1 \\ \frac{x_2-x}{R_2} & \frac{y_2-y}{R_2} & \frac{z_2-z}{R_2} & 1 \\ \frac{x_3-x}{R_3} & \frac{y_3-y}{R_3} & \frac{z_3-z}{R_3} & 1 \\ \frac{x_4-x}{R_4} & \frac{y_4-y}{R_4} & \frac{z_4-z}{R_4} & 1 \end{bmatrix}$$
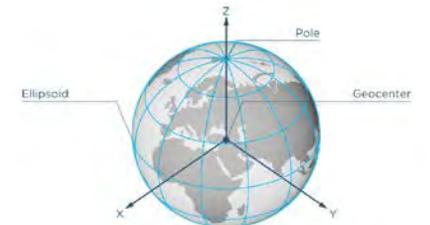
The matrix $(\underline{\underline{H}}^T \underline{\underline{H}})^{-1}$ represents the purely geometric contribution to the estimation uncertainty

$$\text{GDOP} = \sqrt{C_{xx} + C_{yy} + C_{zz} + C_{tt}}$$

$$\text{PDOP} = \sqrt{C_{xx} + C_{yy} + C_{zz}}$$

$$\text{HDOP} = \sqrt{C_{xx} + C_{yy}}$$

$$\text{VDOP} = \sqrt{C_{zz}}$$
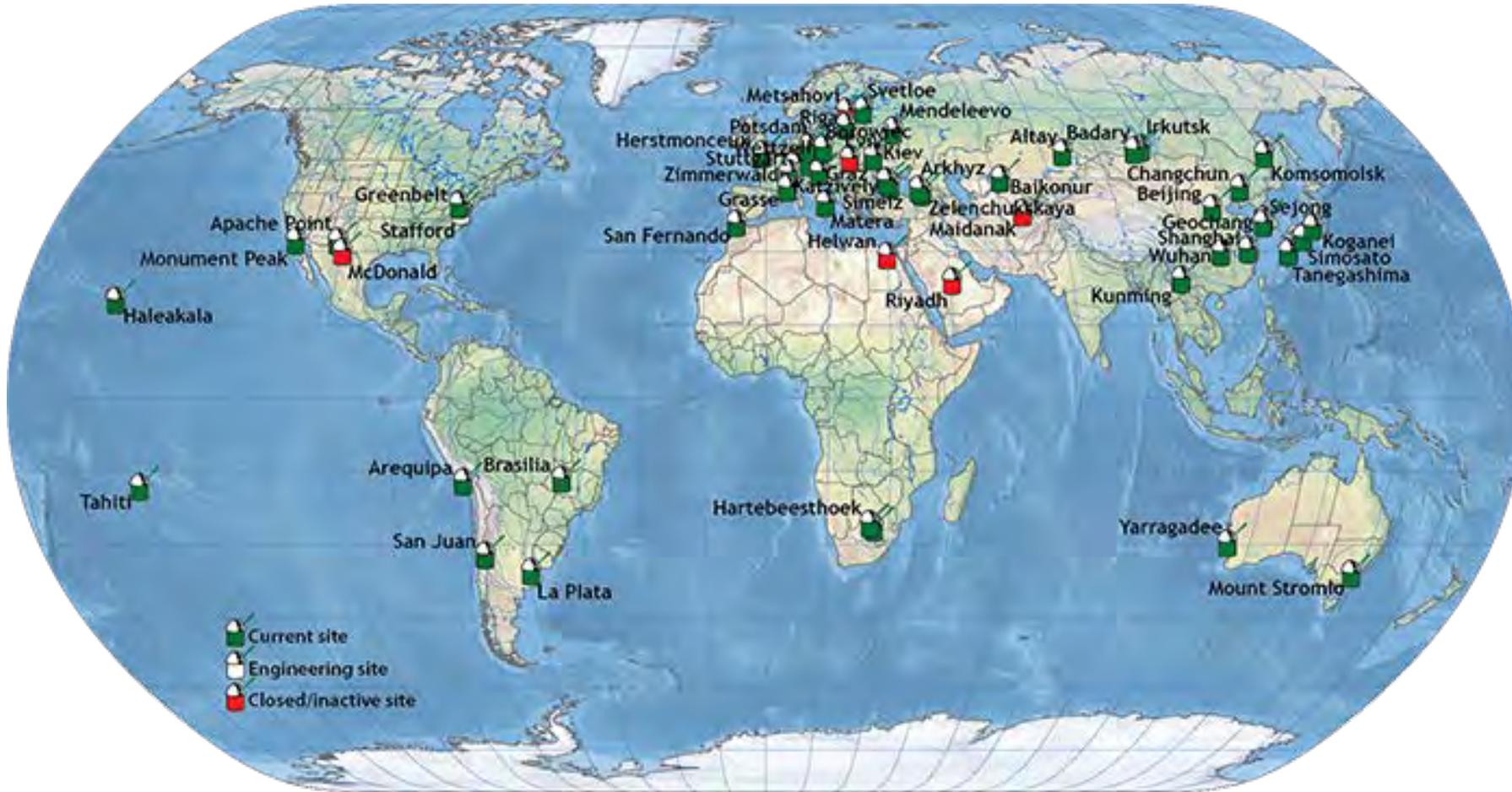
More Realistic Approach

- We associate to each satellite the closest SLR station at its Nadir point on the ground

- We weight each satellite with the station rms in the following fashion:

$$\mathbf{C_w} = \left(\mathbf{H^T W H}\right)^{-1}$$

$$w_{nn} = rms_n \cdot Sec[\varphi_n]$$
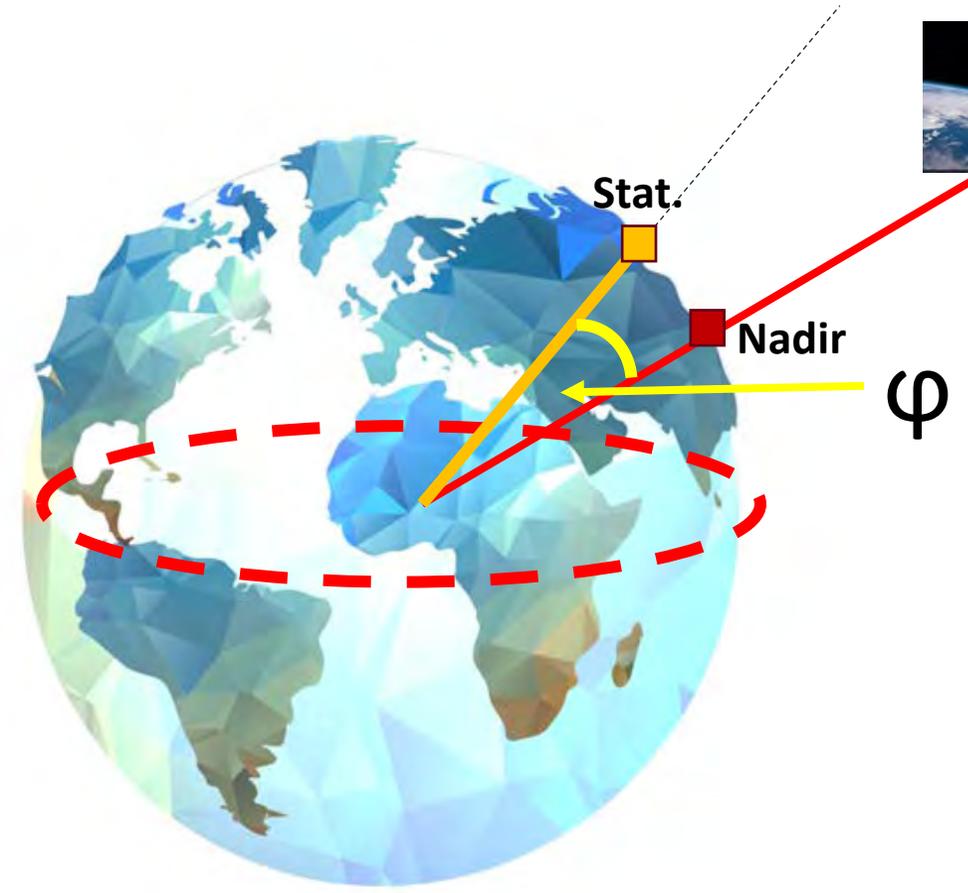
SLR Network

Station	Lat.	Long.	δ (mm)
APOL	32.78	-105.82	18.10
AREL	-16.47	-71.49	7.50
BADL	51.77	102.24	1.90
BEIL	39.61	115.89	2.10
BORL	52.28	17.07	18.60
CHAL	43.79	125.44	1.40
GLSL	50.36	30.50	5.00
GODL	39.02	-76.83	1.60
GRSM	43.75	6.92	15.80
GRZL	47.07	15.49	5.10
HA4T	20.71	-156.26	1.50
HARL	-25.89	27.69	10.00
HERL	50.87	0.34	12.20
IRKL	52.22	104.32	3.00
IZ1L	28.30	-16.51	6.00
JFNL	30.52	114.49	6.70
KTZL	44.39	33.97	9.60
KUN2	25.03	102.80	11.50
MATM	40.65	16.70	4.30
MDVS	56.03	37.22	2.80
MONL	32.89	-116.42	1.50
POT3	52.38	13.06	11.00
RIGL	56.95	24.06	3.20
SFEL	36.47	-6.21	23.20
SHA2	31.10	121.19	5.40
SIML	44.41	33.99	27.70
SISL	33.58	135.94	16.20
SOSW	49.14	12.88	10.90
STL3	-35.32	149.01	8.50
SVEL	60.53	29.78	1.80
THTL	-17.58	-149.61	2.00
TKBL	36.07	140.13	0.90
YARL	-29.05	115.35	1.50
YEBL	40.52	-3.09	5.50
ZELL	43.79	41.57	7.20
ZIML	46.88	7.47	13.00

Quality of ranging data

Matera
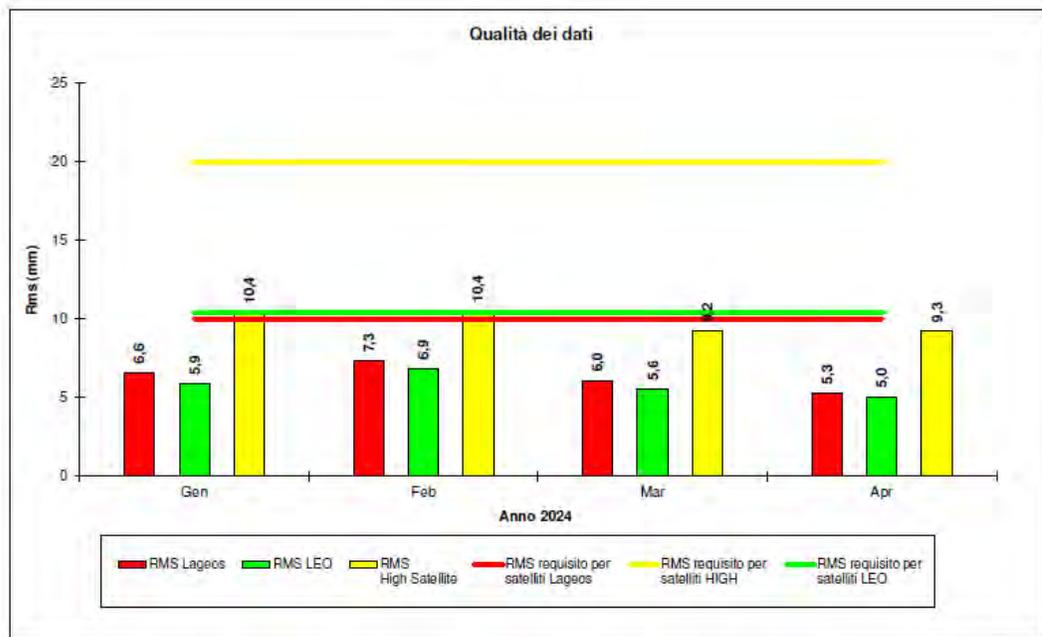
$$C_{nn} = rms \cdot Cosec[\varphi]$$
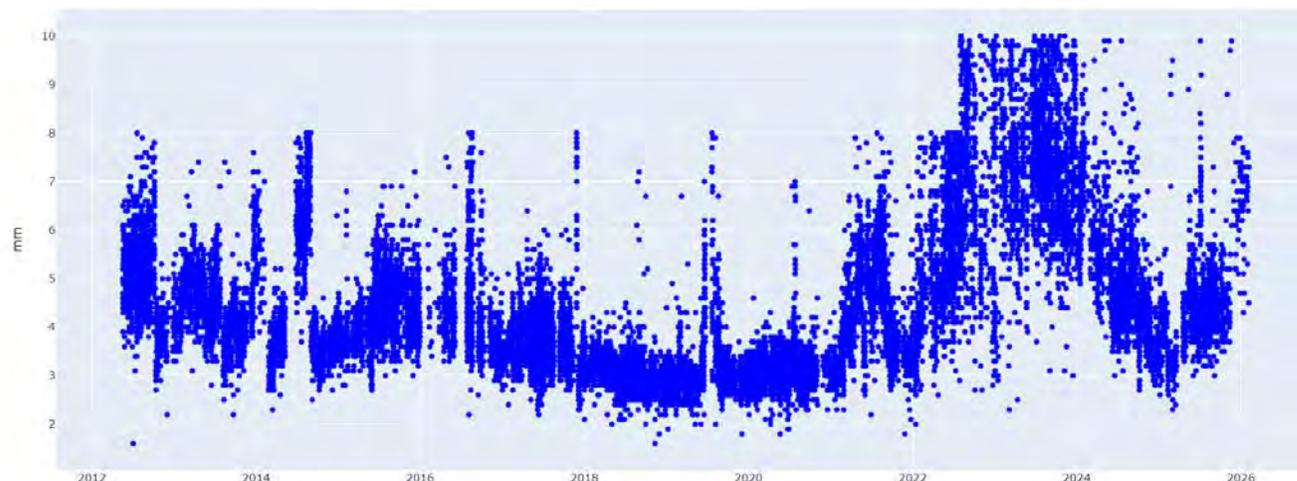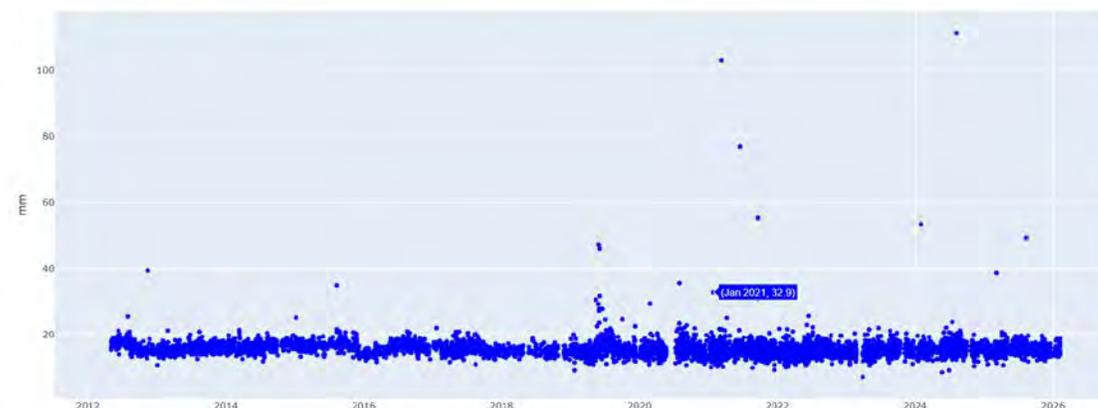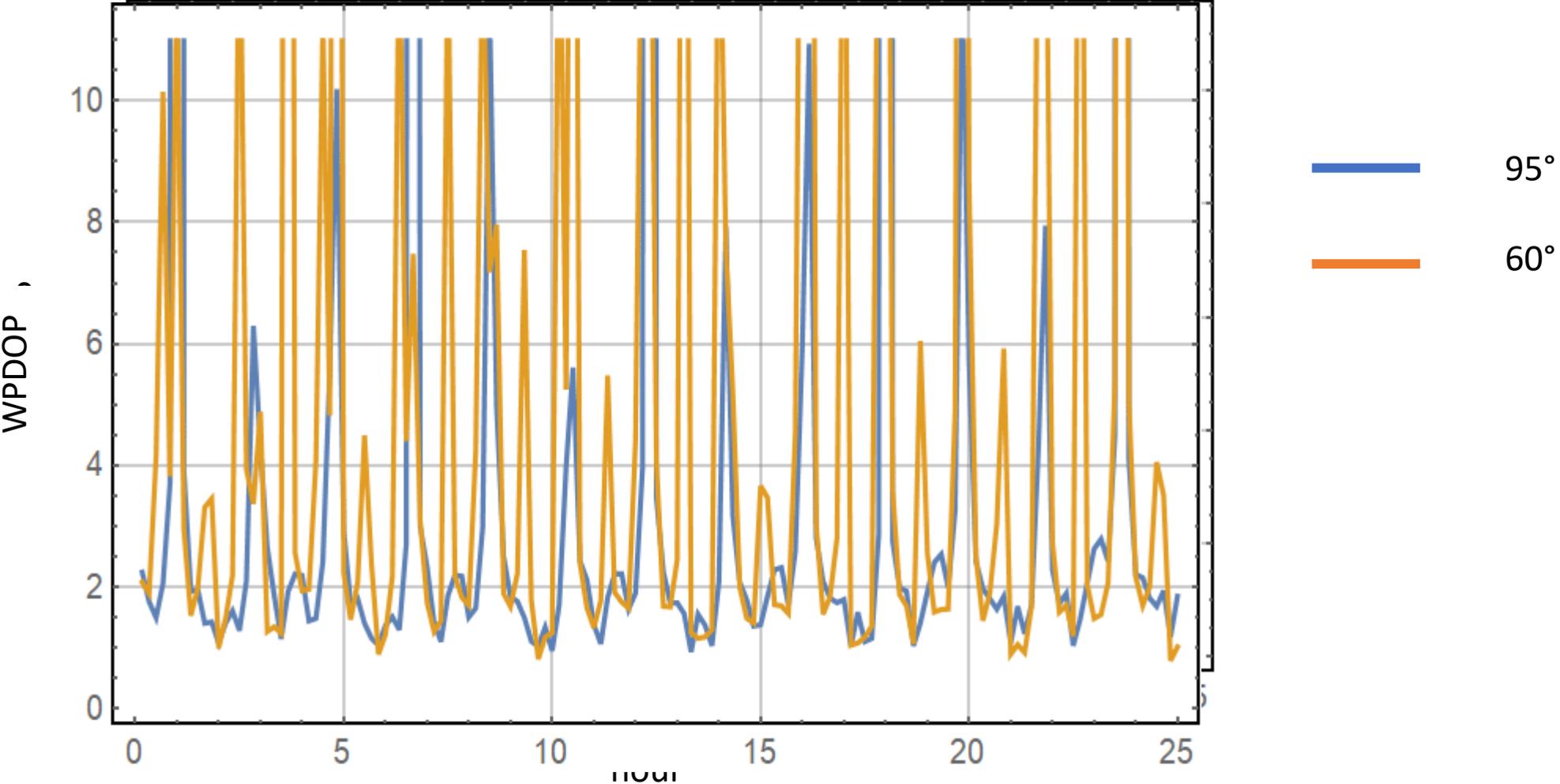
Localization of Nadir Point ant SLR stations
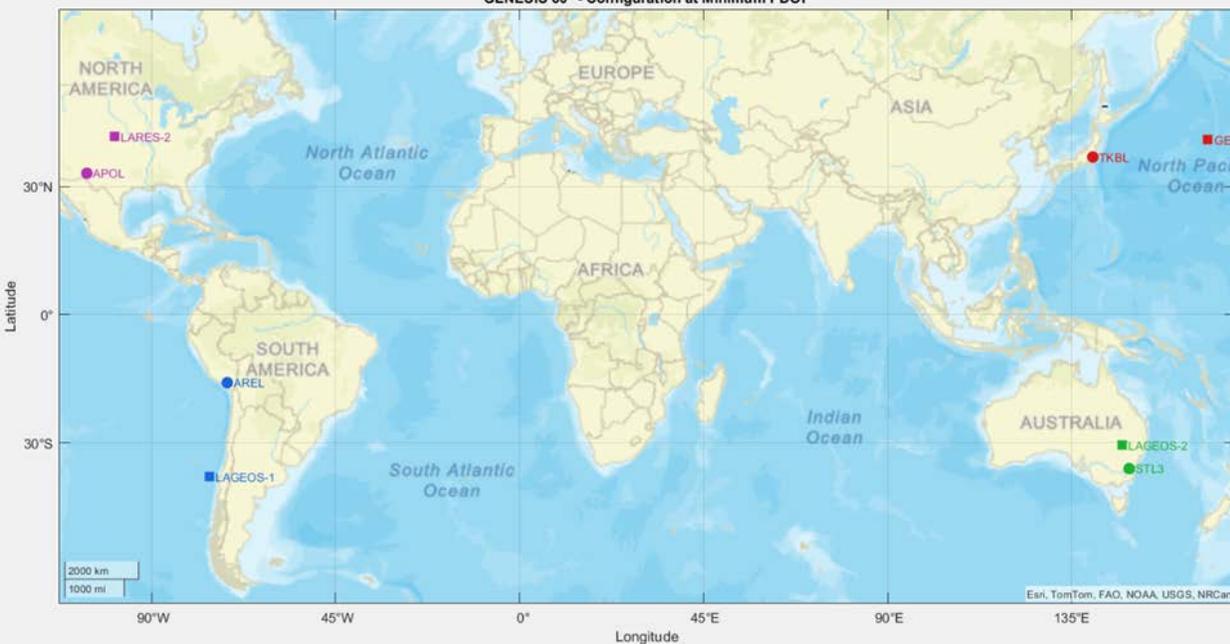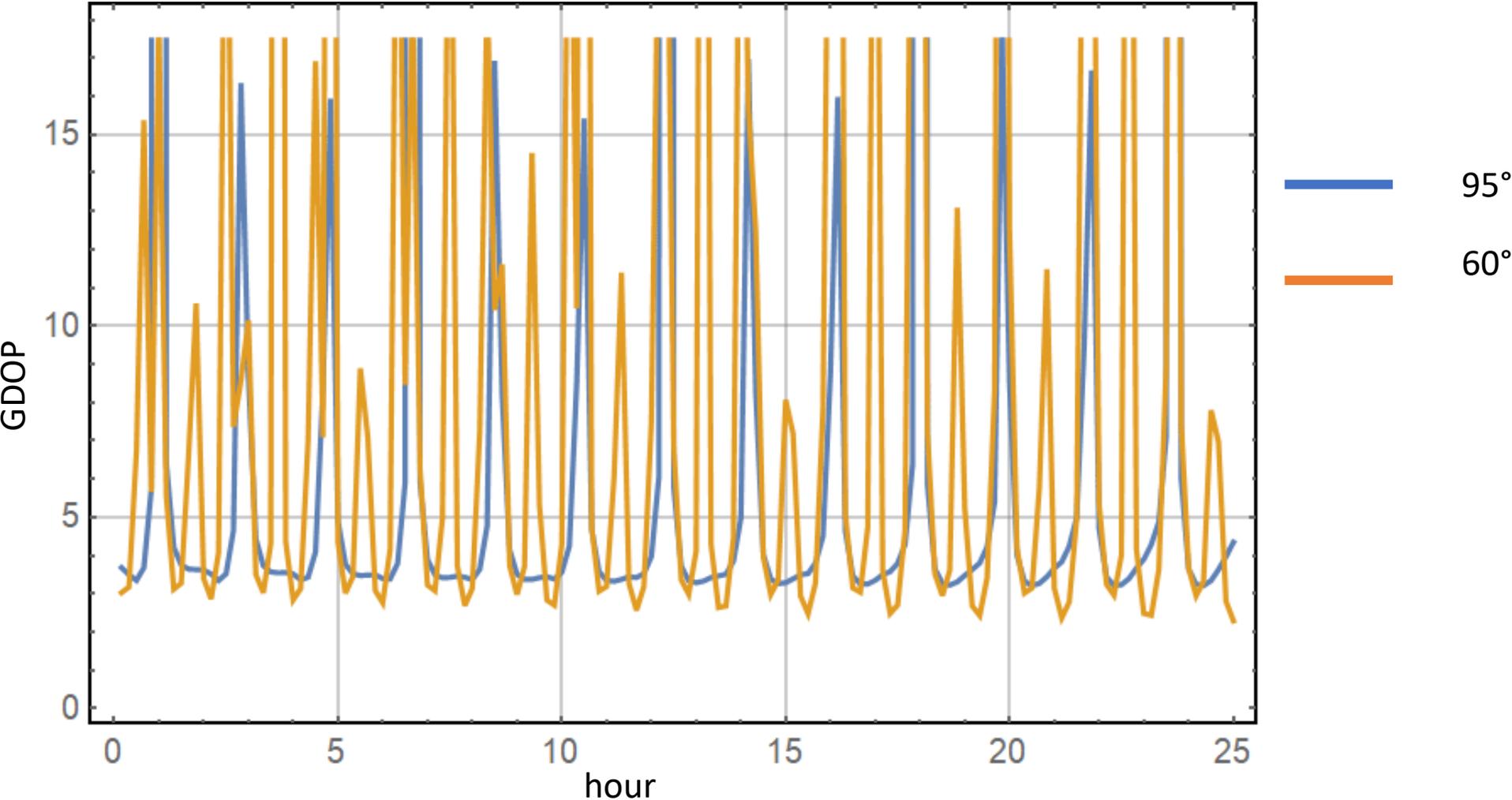
Daily Plot:GDOP

Daily Plot: WGDOP
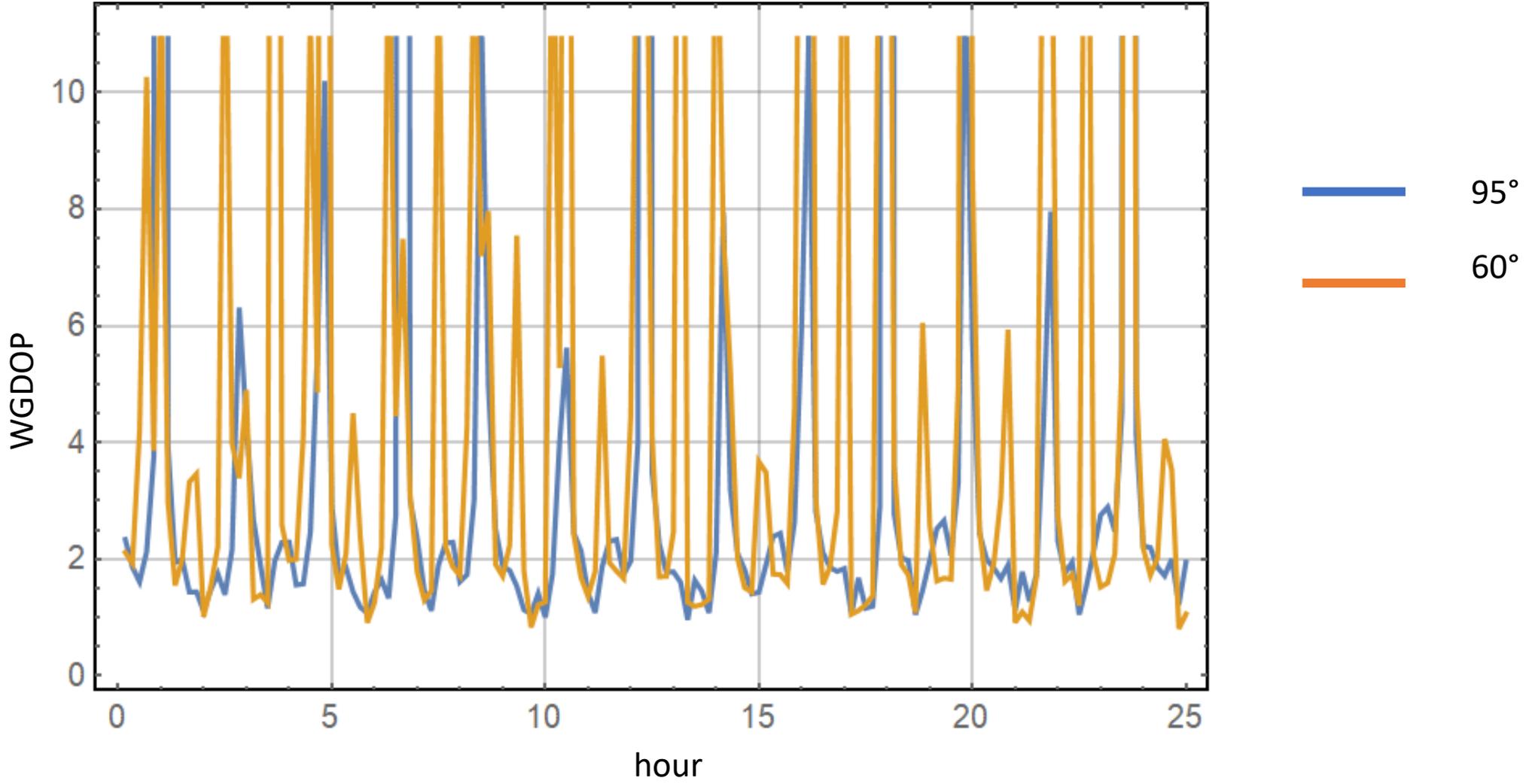
Daily Plot:PDOP

Daily Plot:WPDOP

Legend: 95° (blue), 60° (orange)
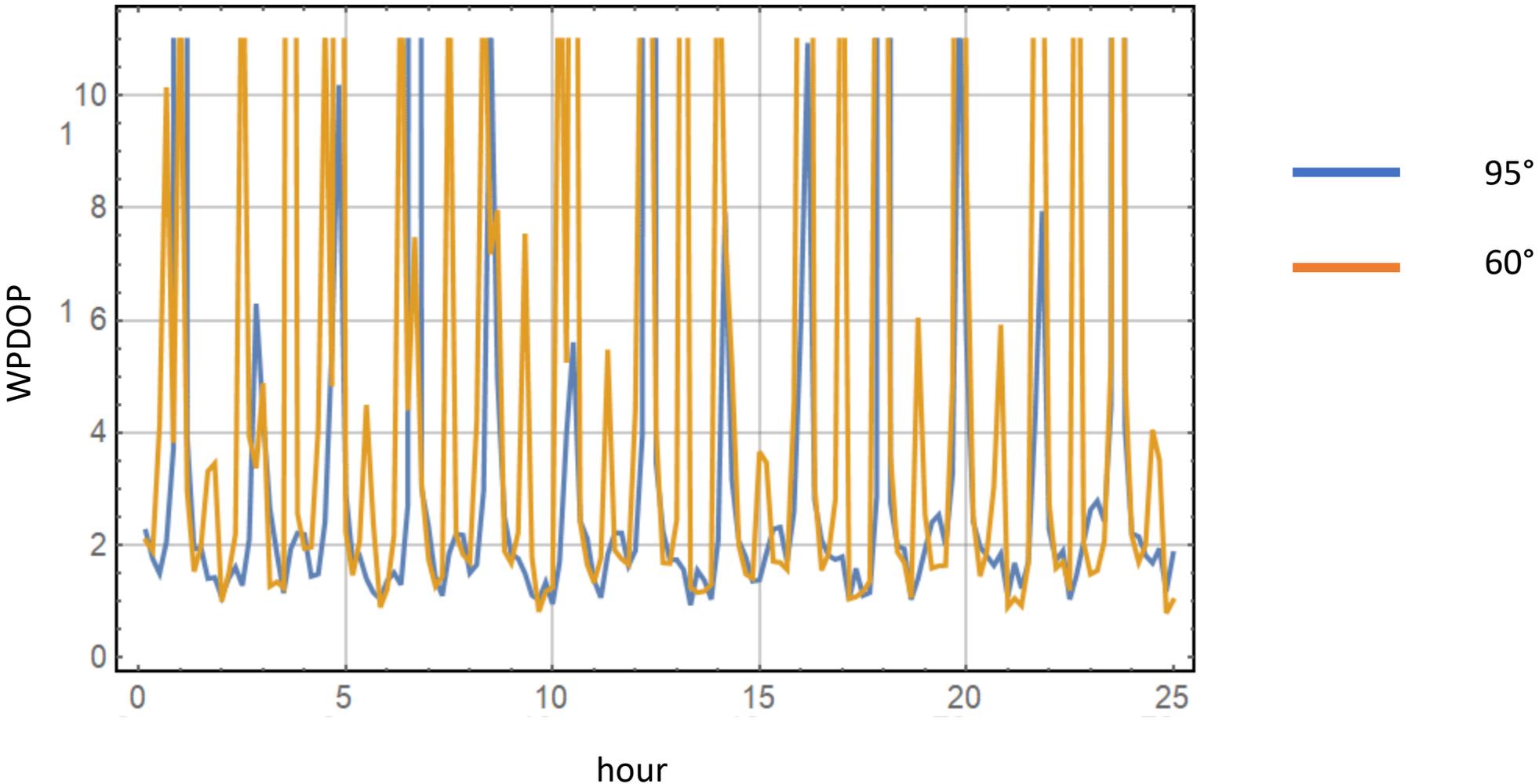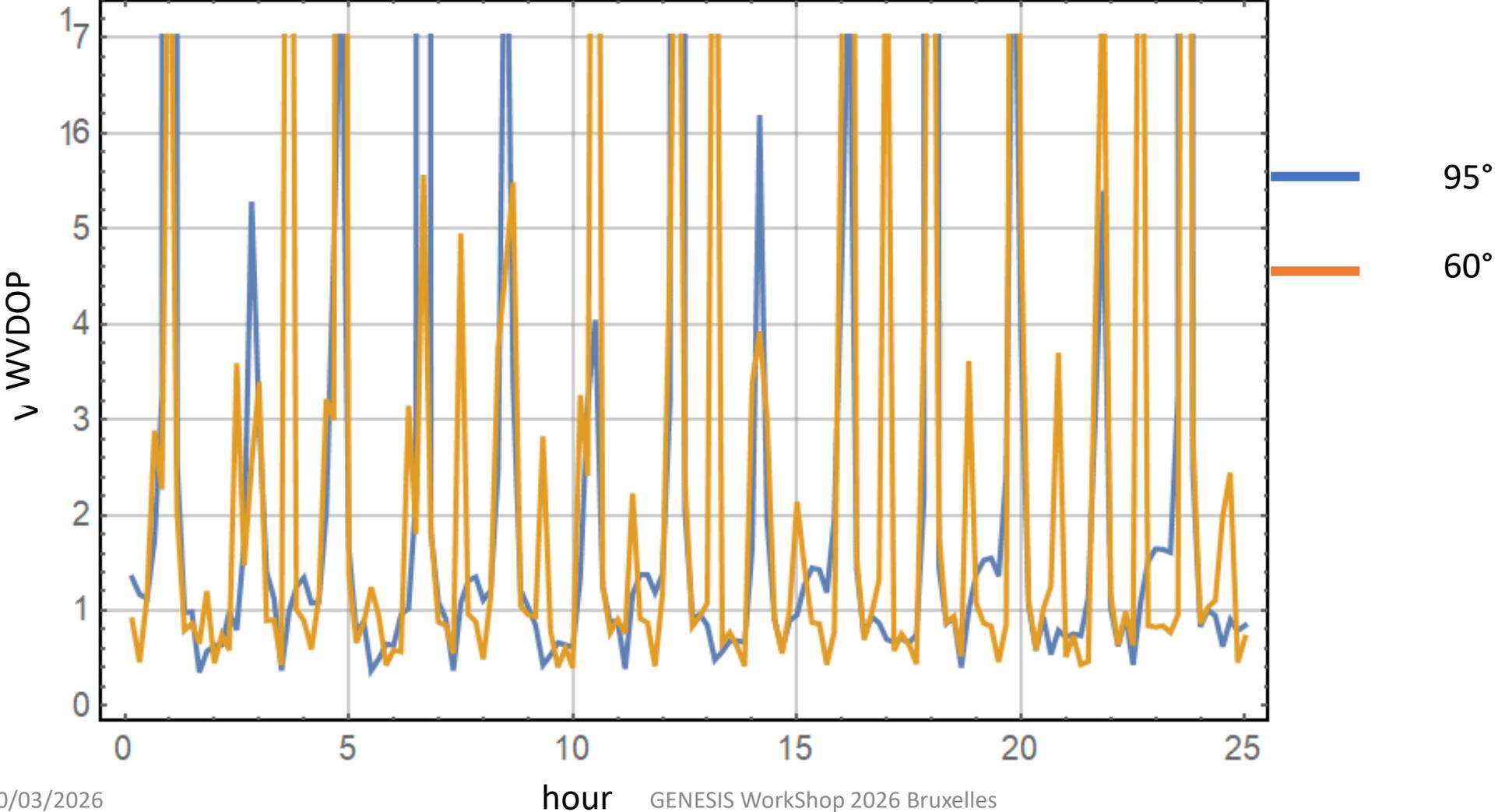
Daily WVDOP

Daily WVDOP
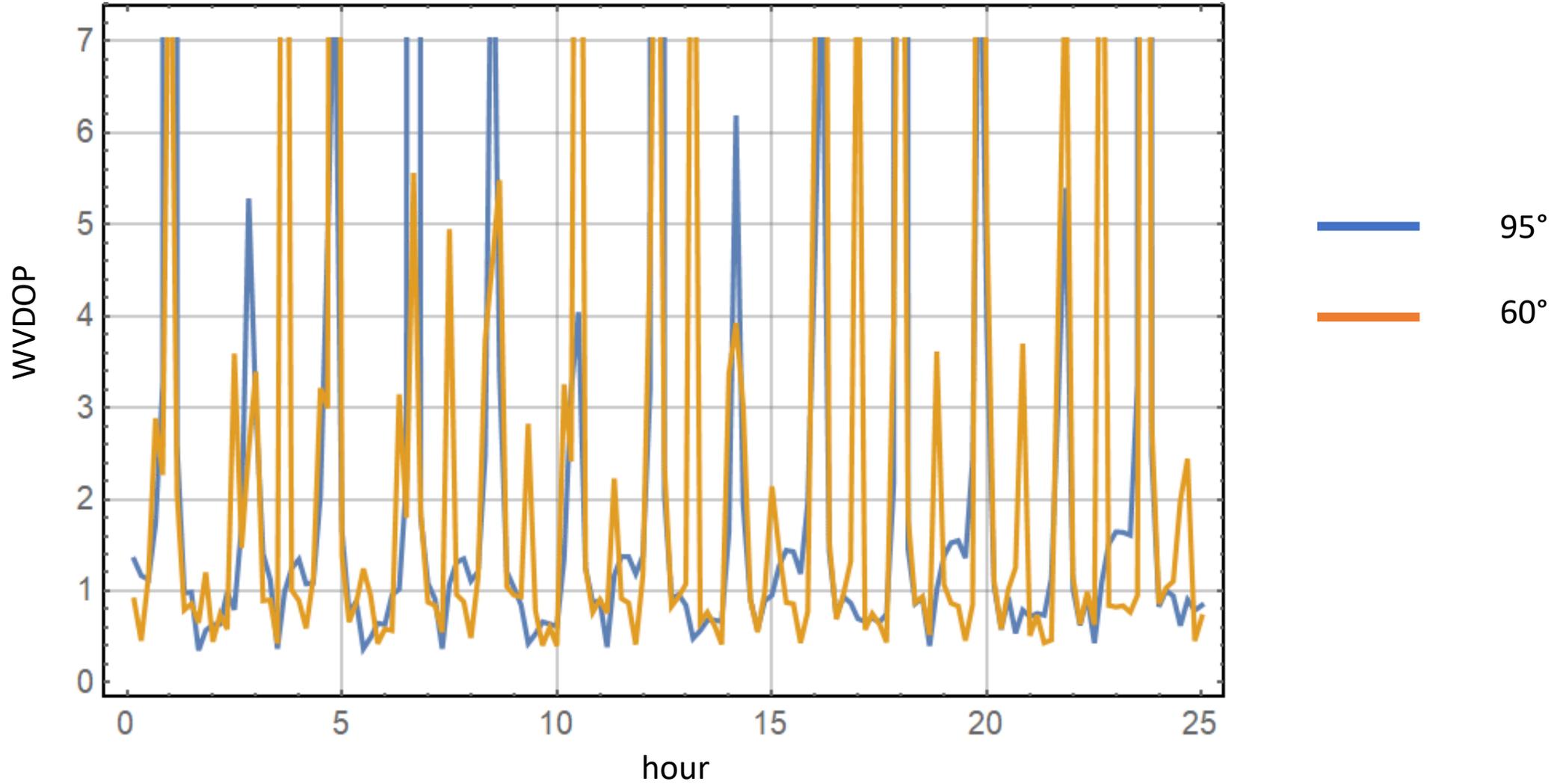
Results for Monthly computation

	Mean		Minimum	
	geom.	weighted	geom.	weighted
GDOP60	19.034	10.558	3.214	0.960
PDOP60	18.944	10.506	3.165	0.936
VOP60	13.936	7.761	1.252	0.351
GDOP95	10.604	5.800	2.293	0.808
PDOP95	10.555	5.774	2.235	0.795
VDOP95	4.936	2.691	1.095	0.400

Situation With and without GENESIS

Conf.	WGDOP		WDOP		WVDOP	
	Mean	Minimum	Mean	Minimum	Mean	Minimum
No GENESIS	15.61	2.82	14.33	1.56	8.41	1.12
GENESIS 60°	10.59	0.96	10.51	0.94	7.76	0.35
GENESIS 95°	5.80	0.81	5.77	0.79	2.69	0.40

And GENESIS with GALILEO ?
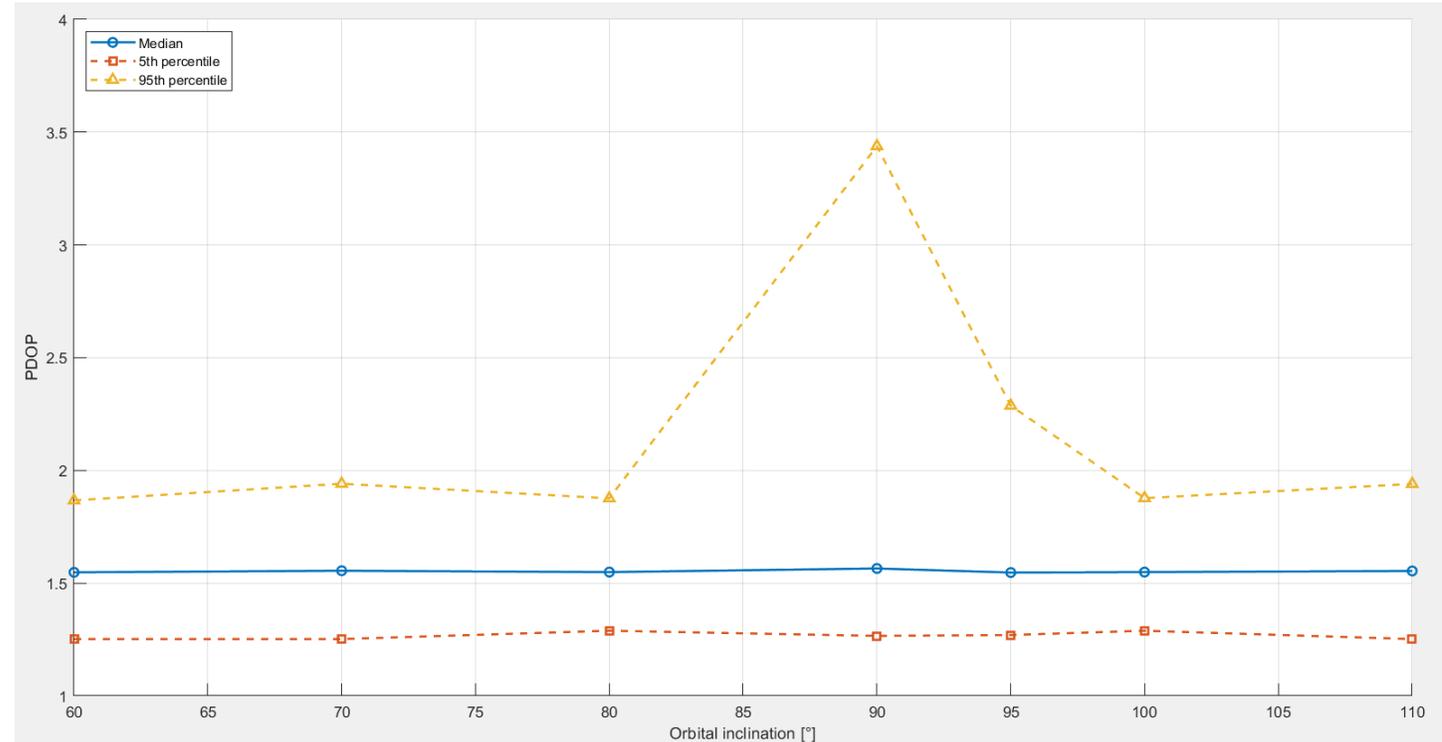
Orbital inclination	PDOP median	5th percentile	95th percentile
60°	1.548	1.252	1.867
70°	1.555	1.252	1.941
80°	1.549	1.289	1.876
90°	1.565	1.266	3.438
95°	1.547	1.270	2.287
100°	1.549	1.289	1.877
110°	1.554	1.252	1.940

1. More isotropic distribution of the satellites
2. More stable values of PDOP

Conclusions

- The impact of GENESIS in the estimation of GC is meaningful

- The Geometrical Analysis based on DOP shows that an inclination of the GENESIS orbit of 95° is more favourable than 60° one; It's a Ciufolini's fault! 😆

- The orbit of 95° is more favourable also if the DOP analysis is performed with GNSS satellites;

- POD show us on the contrary that 60° is preferable....

- An analysis to combine GNSS and SLR satellites is worthwhile to be performed