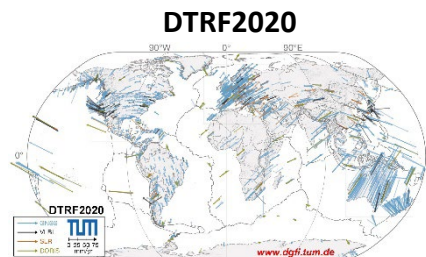
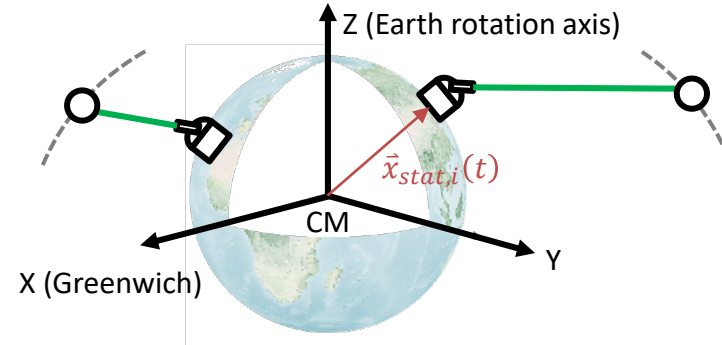


Assessment of Different ITRF Realizations Using Satellite Laser Ranging

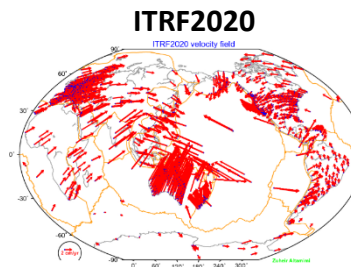
Linda Geisser¹, Andreja Susnik², Rolf Dach¹, Daniel Arnold¹, Adrian Jäggi¹

¹Astronomical Institute, University of Bern, Switzerland

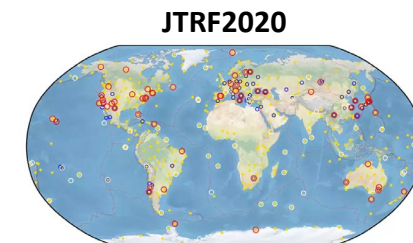
²British Geological Survey, Space Geodesy Facility, Herstmonceux, United Kingdom



[Seitz et al., 2026]



[Altamimi et al., 2023]



[Gross et al., 2023]

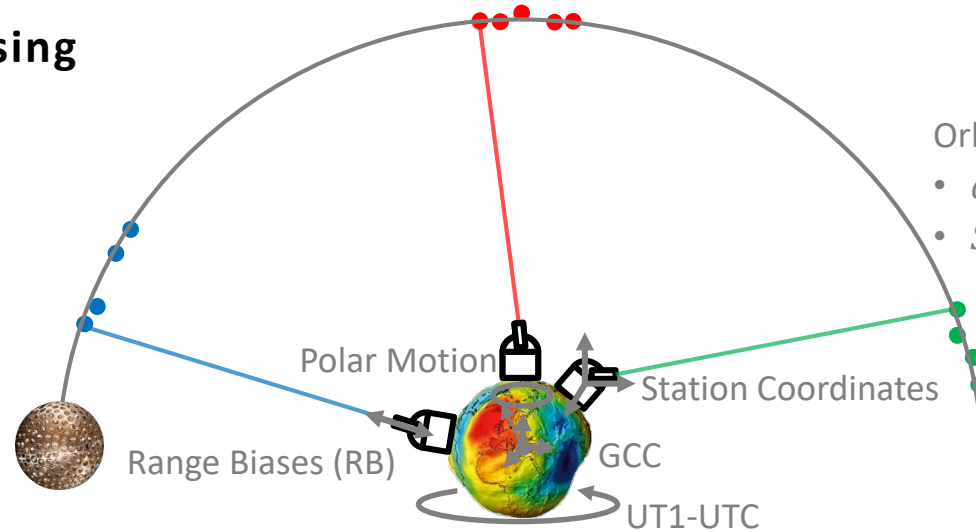
IAG Symposium Reference Frames for Applications in Geosciences, Munich, Germany, 2-4 March, 2026

Motivation

Goal:
 As part of the **IAG-IERS Joint Working Group 1.2.4**, this study analyzes the **impact** of the three different ITRF realizations (**DTRF2020**, **ITRF2020** and **JTRF2020**) on our **SLR** data processing.

- Motivation
- Methodology
- A Priori SLR Station Coordinates
- SLR Statistics
- First Results
- Summary & Outlook

• SLR data processing



Orbit Parameters [Bernese GNSS Software]:

- $a, e, i, \Omega, \omega, u_0$
- S_0, S_S, S_C, W_S, W_C

• A priori information given by the different ITRF providers (DGFI-TUM, IGN, JPL-NASA)

- Geocenter Coordinates (GCC)
- Earth Rotation Parameters (ERPs): Polar Motion, UT1-UTC
- Station Coordinates (STAT)

So far:

- No a priori introduced GCC
- IERS C04 20 EOP¹ time series

¹<https://www.iers.org/IERS/EN/DataProducts/EarthOrientationData/eop>

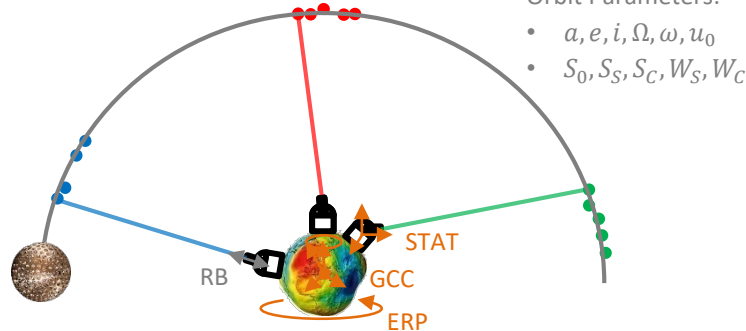
Methodology

- Motivation
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- A Priori SLR Station Coordinates
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Goal:

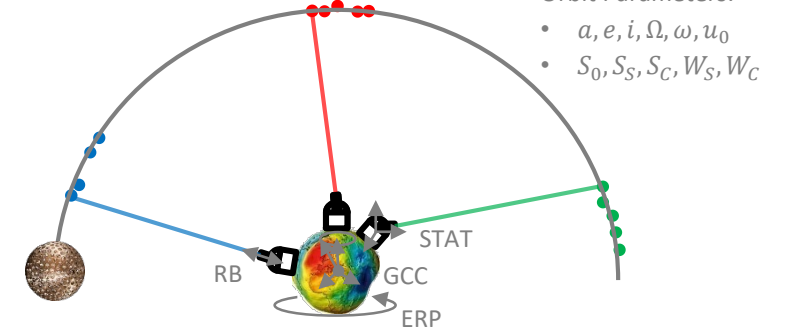
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Scenario 1



- Estimated parameters:
11 Orbit Parameters + RB
- A priori introduced (fixed) parameters:
~~ERP~~ + ~~GCC~~ + STAT provided by
DTRF2020, ITRF2020, JTRF2020
IERS C04 20 EOP time series, no GCC

Scenario 2

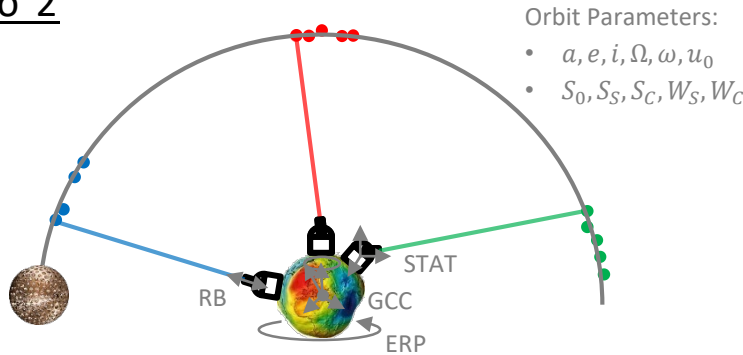


- Estimated parameters:
11 Orbit Parameters + RB + ERP + GCC + STAT
- A priori introduced parameters:
~~ERP~~ + ~~GCC~~ + STAT provided by
DTRF2020, ITRF2020, JTRF2020
IERS C04 20 EOP time series, no GCC

Estimation of Orbit + Geodetic Parameters

- Motivation
- **Methodology**
- A Priori SLR Station Coordinates
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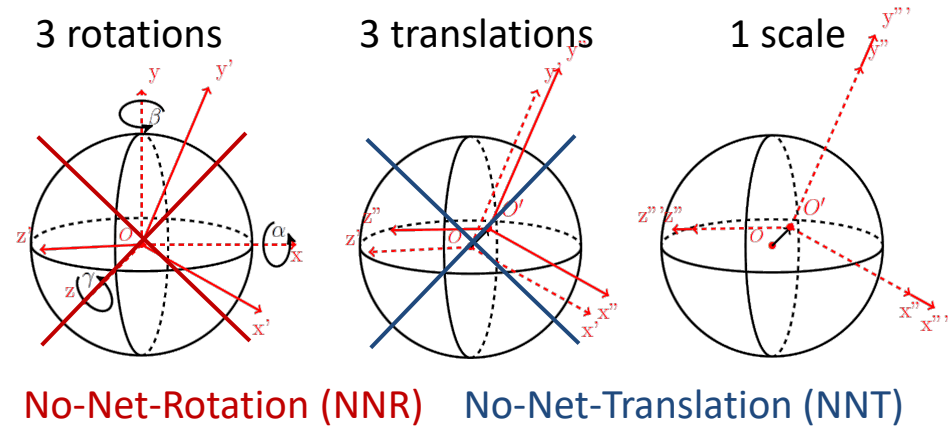
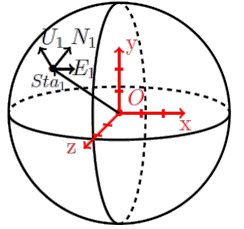
Scenario 2



- Estimated parameters:
 11 Orbit Parameters + RB + ERP + GCC + **STAT**

Datum Definition

- Loose constraints
 estimate $\{N_i, E_i, U_i\} \forall i$ stations
- Minimum constraints
 estimate 7 Helmert transformation parameters based on a subset of stations

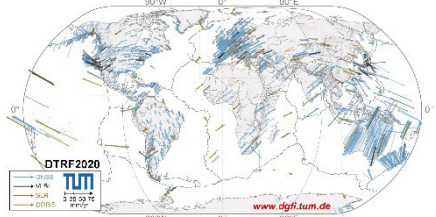


Datum Definition:
 Station coordinates are estimated using minimum constraints on a subset of **core stations**, which define a **unique solution without artificially distorting it.**

A Priori Station Coordinates

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- **A Priori SLR Station Coordinates**
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DTRF2020



[Seitz et al., 2026]

For $stat_i$ at time t :

$$\vec{X}_{stat_i}(t) = \vec{X}_{0,i}^{CF} + \vec{V}_{0,i}^{CF}(t - t_0)$$

Linear term wrt CF (SINEX)

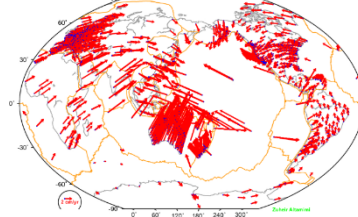
$$+ \vec{C}_{i,CF}^{NTL}(t)$$

Non-tidal loading (NTL) wrt CF
(station-specific time series)

$$+ \vec{C}_i^{PSD}(t)$$

Post-seismic deformation (PSD)
(station-specific time series)

ITRF2020



[Altamimi et al., 2023]

For $stat_i$ at time t :

$$\vec{X}_{stat_i}(t) = \vec{X}_{0,i} + \vec{V}_{0,i}(t - t_0)$$

Linear term wrt CF (SINEX)

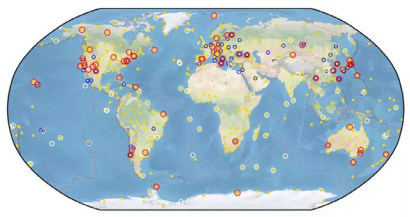
$$+ \vec{C}_{i,CF}^{ANN/SA}(t)$$

Annual (ANN) and semi-annual (SA) signals wrt
CF (station-specific ANN/SA coefficients)

$$+ \vec{C}_i^{PSD}(t)$$

Post-seismic deformation
(station-specific model parameters)

JTRF2020



[Gross et al., 2023]

For $stat_i$ at time t :

$$\vec{X}_{stat_i}(t)$$

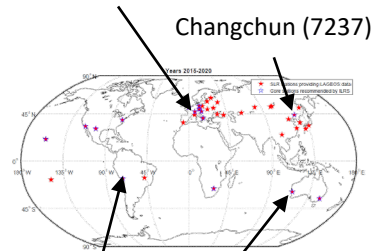
Station-specific filtered time series

Station Coordinate Time Series Comparison:

Linear term + PSD

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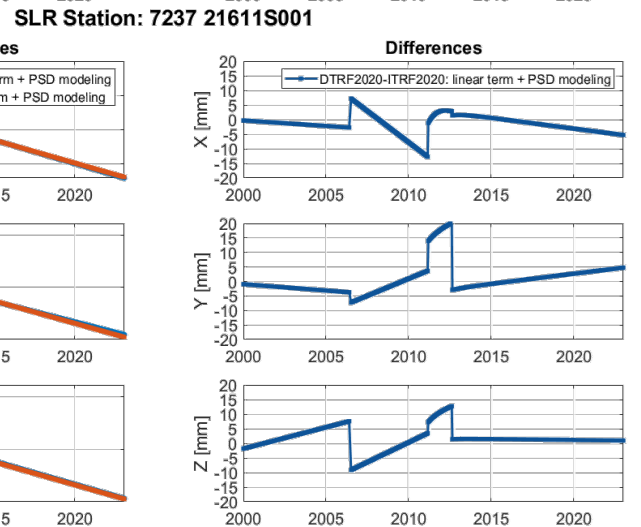
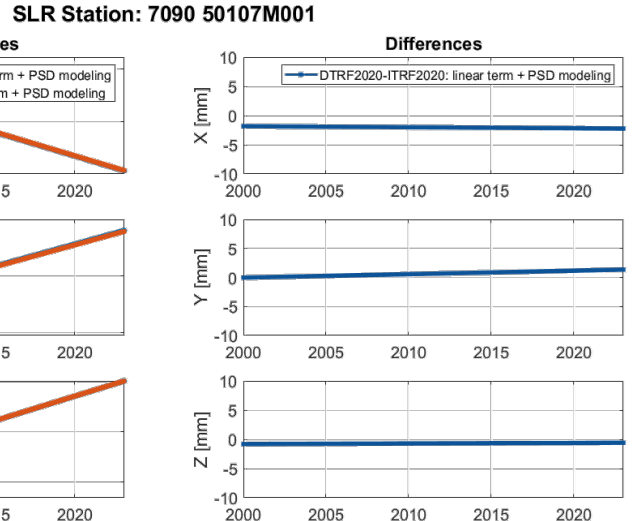
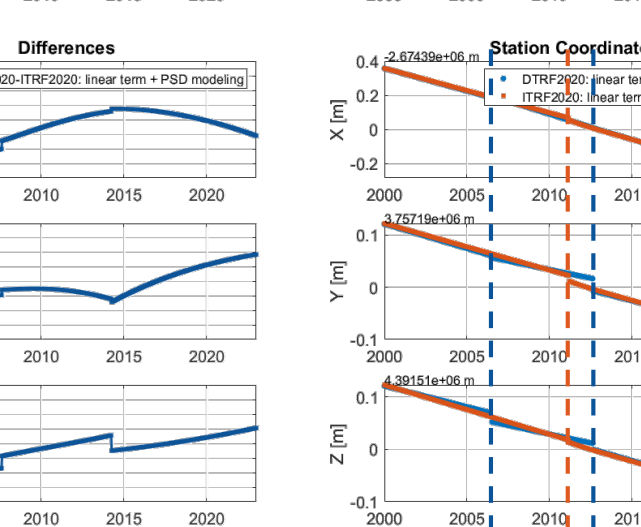
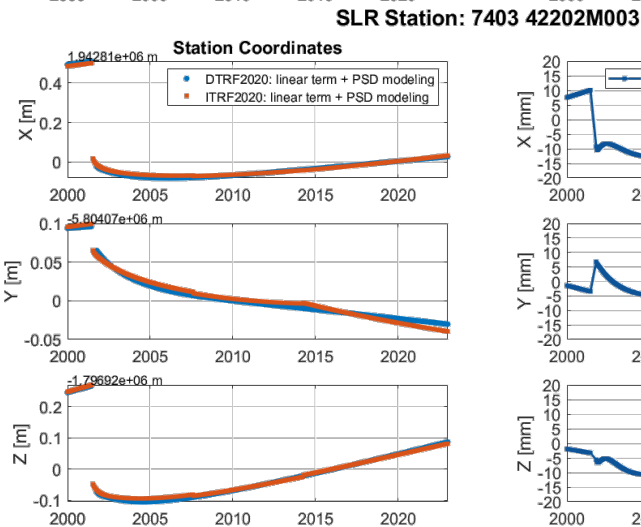
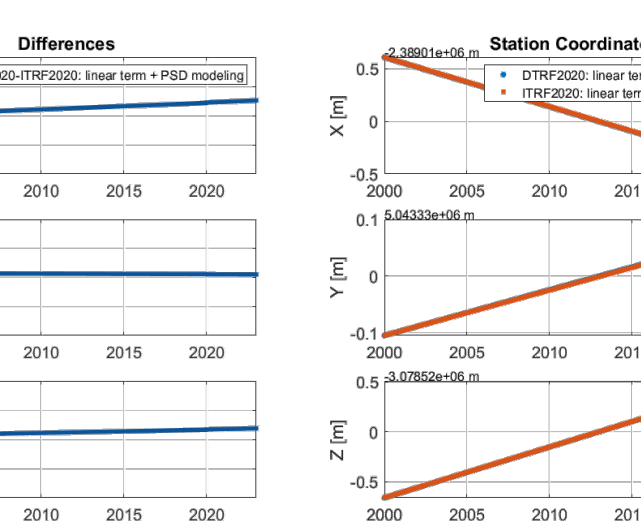
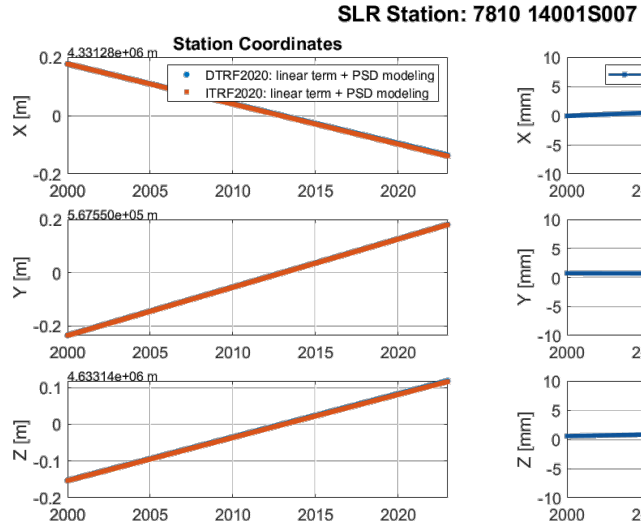
Zimmerwald (7810)



Changchun (7237)

Yarragadee (7090)

Arequipa (7403)

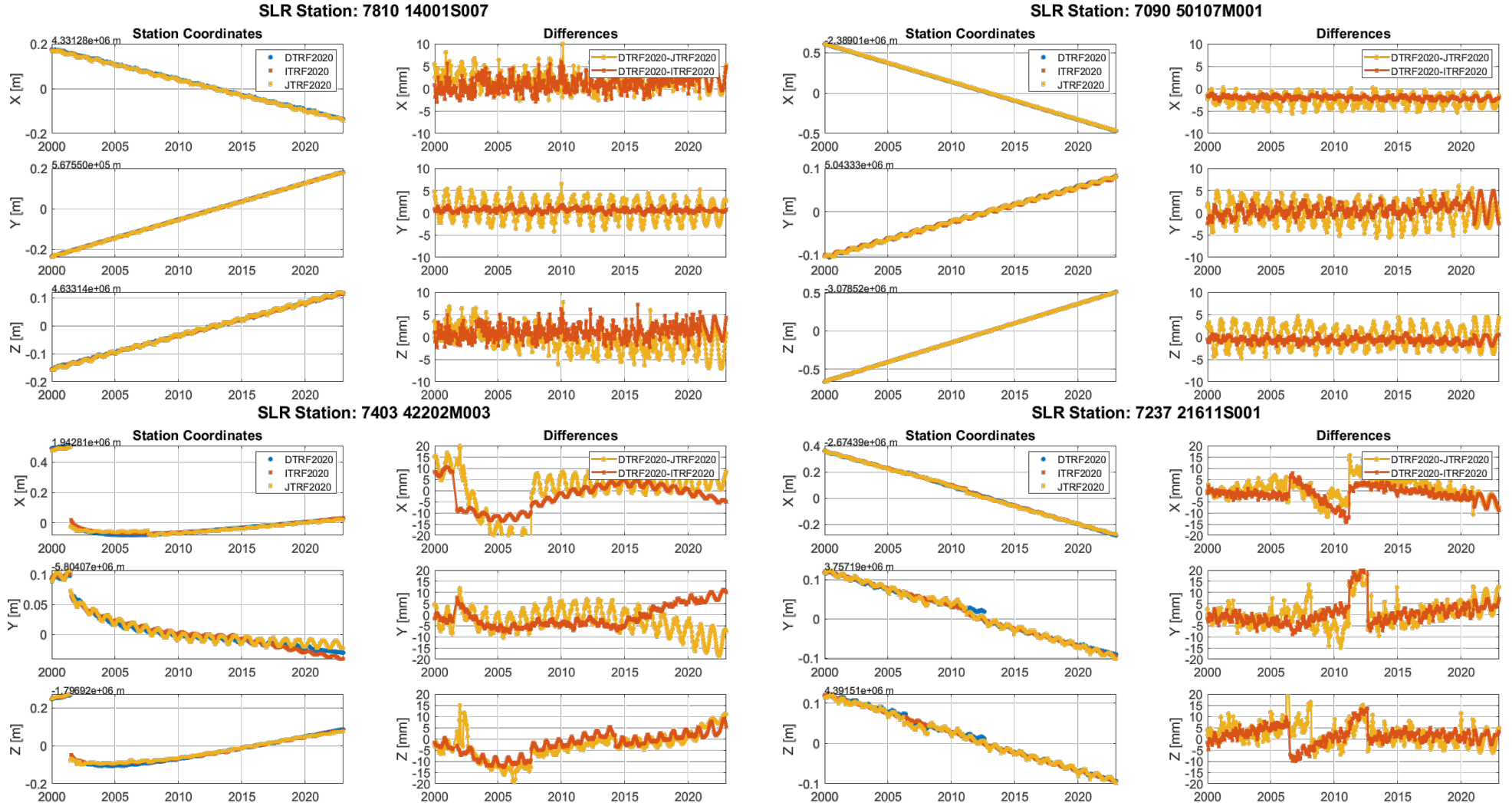
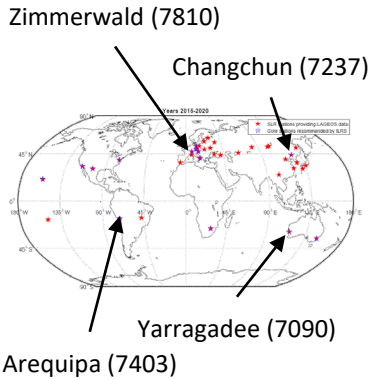


discontinuities

Station Coordinate Time Series Comparison:

Linear term + PSD + non-tidal loading / seasonal modeling

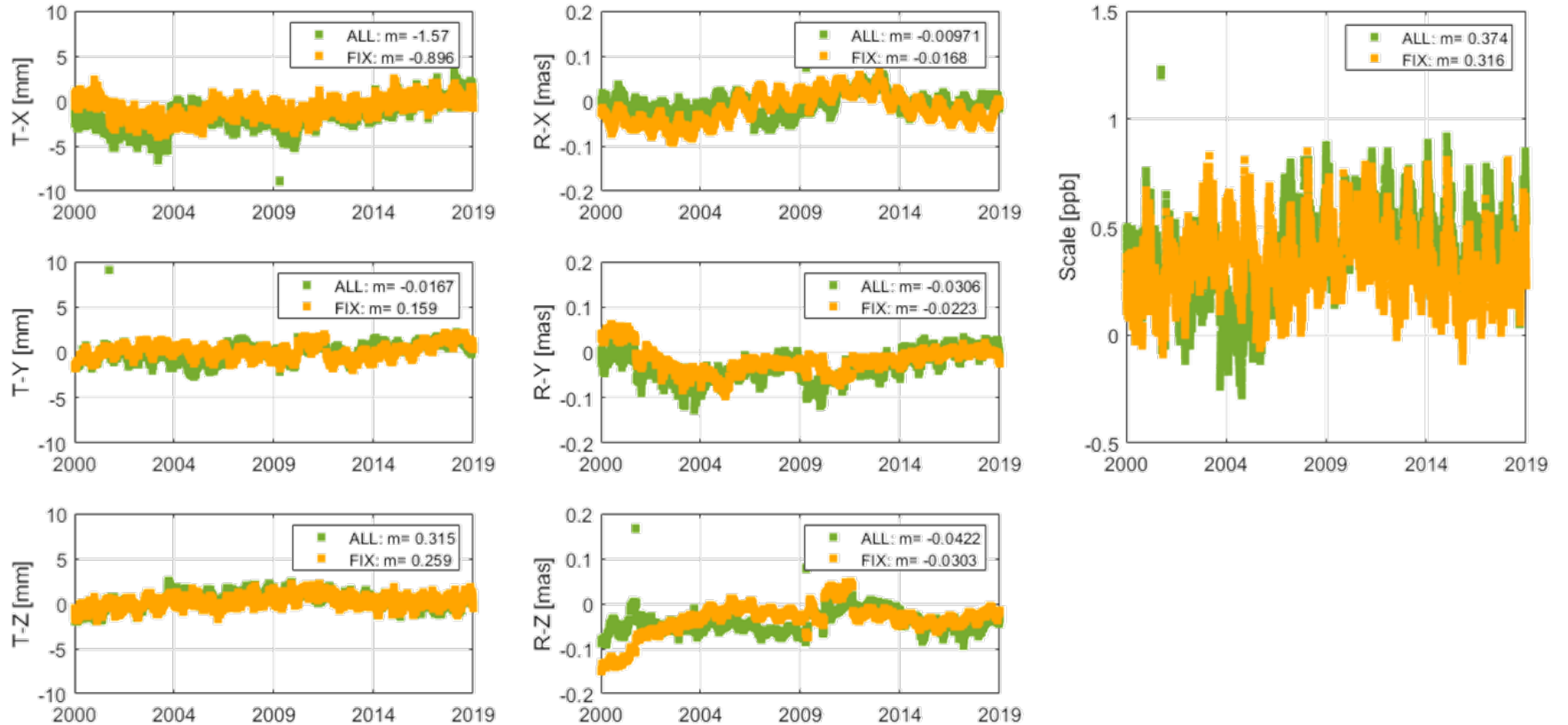
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A Priori Station Coordinate Comparisons: Helmert Transformation Parameters

- Motivation
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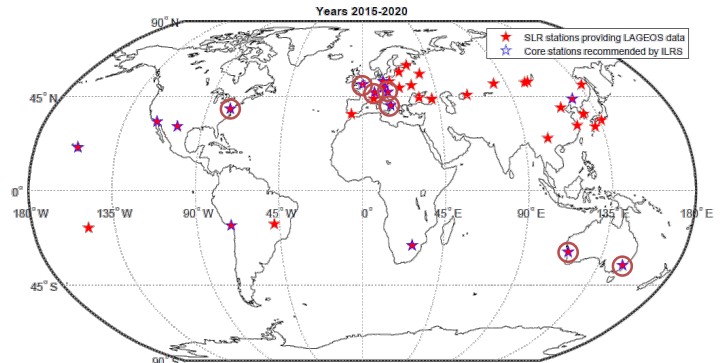
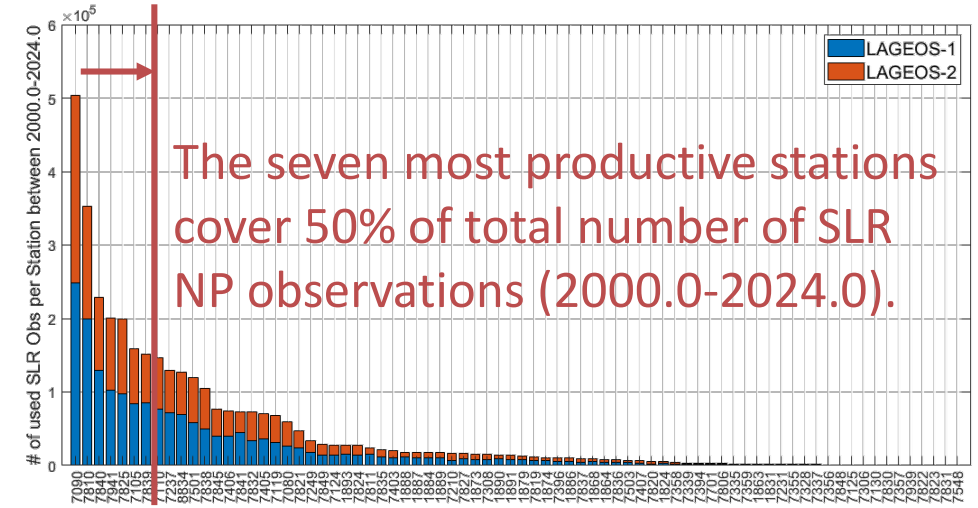
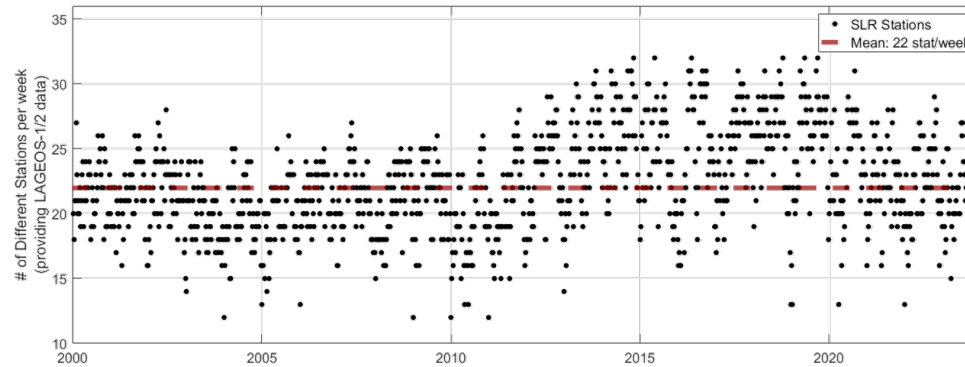
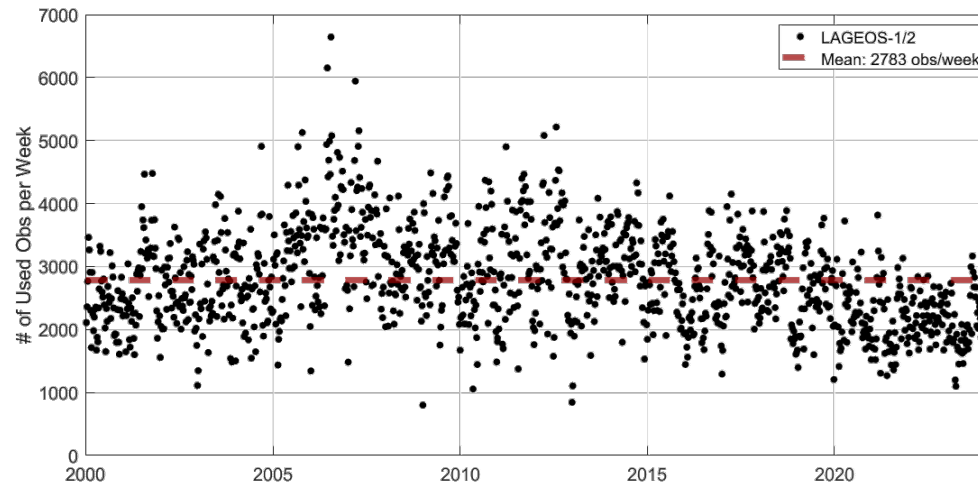
Helmert Transformation Parameters: DTRF2020 vs ITRF2020



- For the computation of the Helmert parameters either all (ALL) SLR stations are used or only the core SLR stations (based on SLRF2014).
- An annual signal appears due to differences introduced by using NTL for DTRF and a seasonal model for ITRF.

SLR Observation Statistics: LAGEOS-1/2

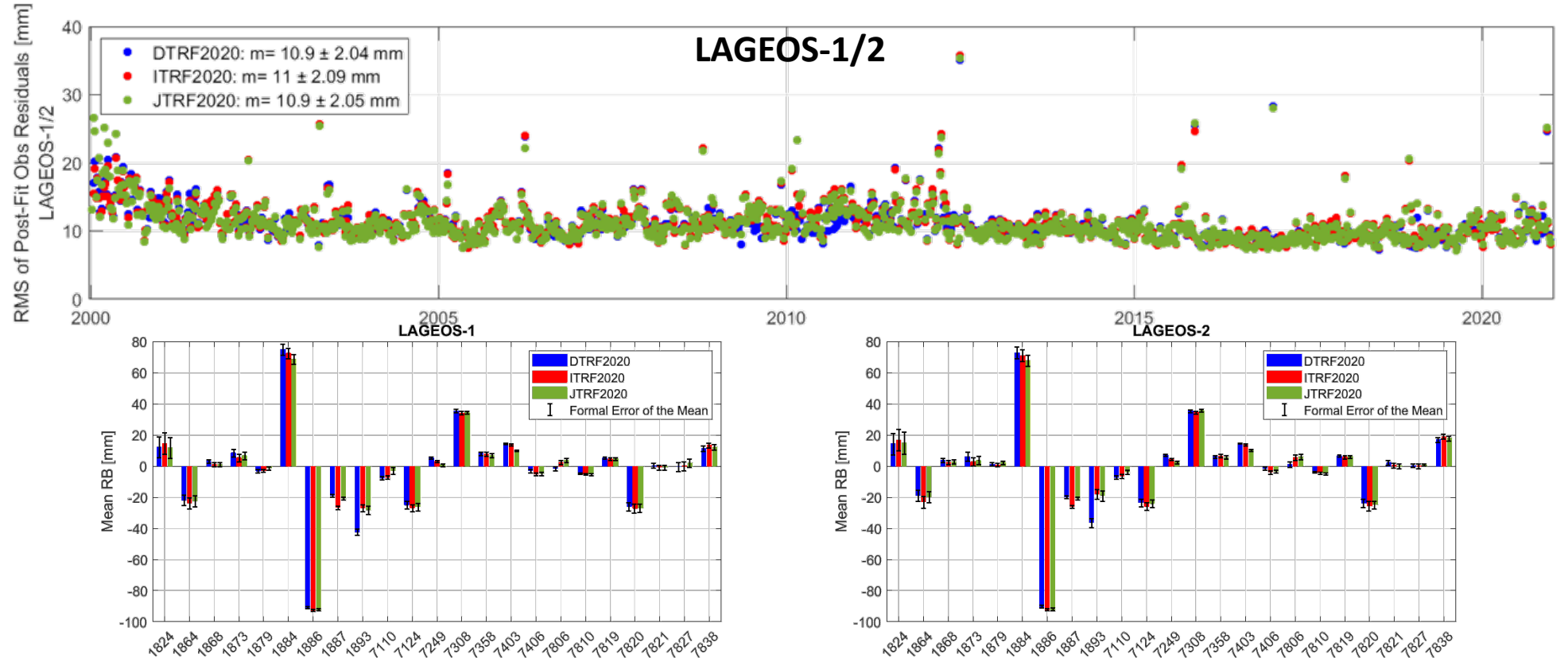
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- **Annual/semi-annual** signal in the number of SLR observations/stations.
- Number of SLR obs. decreased after 2015, while the total number of operating stations remained stable.
- **7** of 76 stations account for more than half of all LAGEOS-1/2 observations.

Scenario 1: Orbits + RB

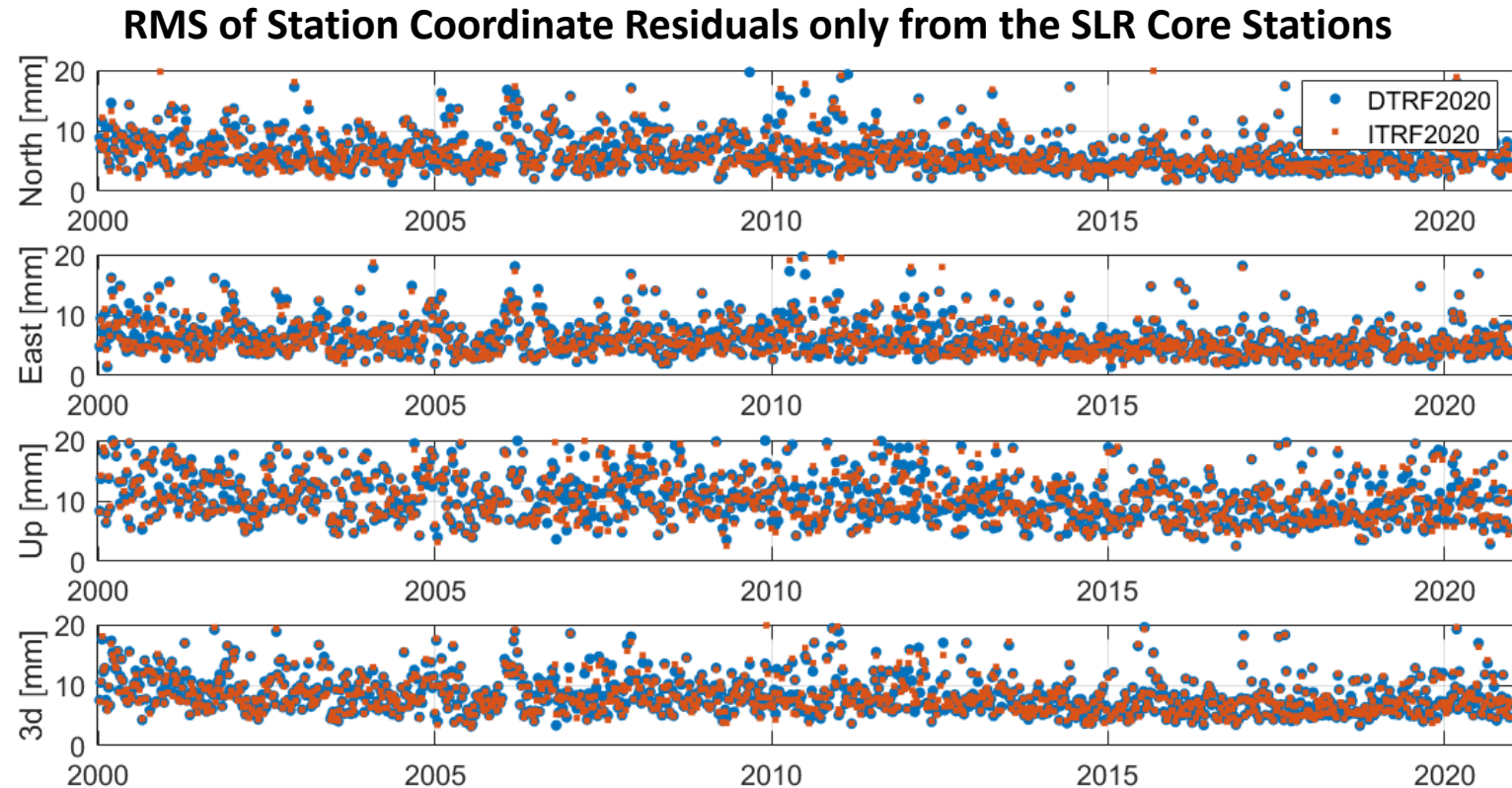
- Motivation
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 - Orbits + RB
 - Est. Geodetic Param.
- Summary & Outlook



- These results were presented at **EGU 2025**.
- The a posteriori **RMS of SLR observation residuals** are **comparable** when using different ITRF realizations.
- The mean RB for a set of selected stations reach **from several mm up to cm** (max. **8 mm between ITRFs**) and agree between LAGEOS-1 and LAGEOS-2.

Scenario 2: Orbits + RB + Geodetic Parameters

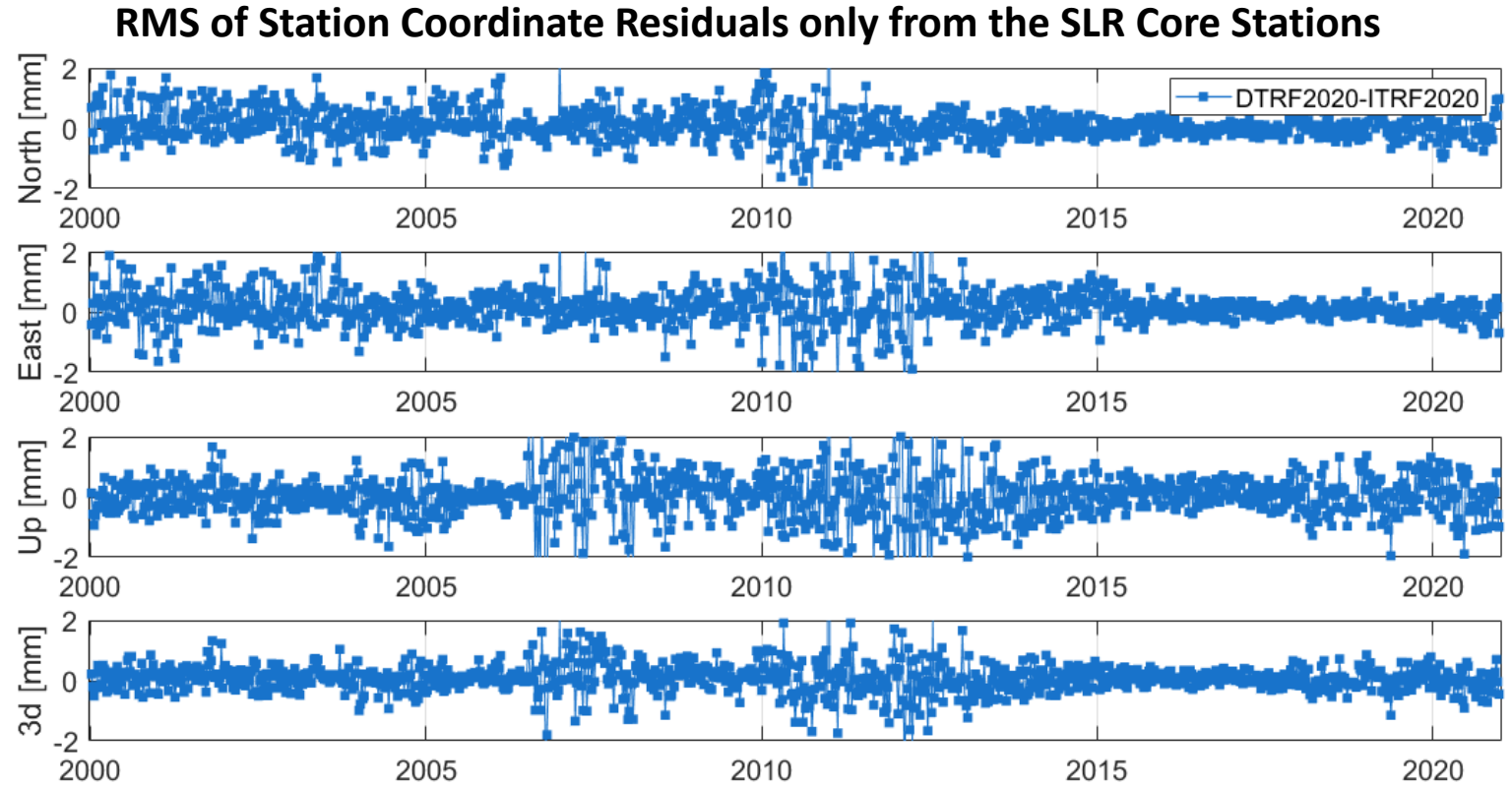
- Motivation
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- **First Results**
 - Orbits + RB
 - **Est. Geodetic Param.**
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- These time series show the RMS of the **estimated station corrections** in each direction across the **core stations**.
- Increased **variability** in the differences of the time series is observed **between 2006 and 2014**.

Scenario 2: Orbits + RB + Geodetic Parameters

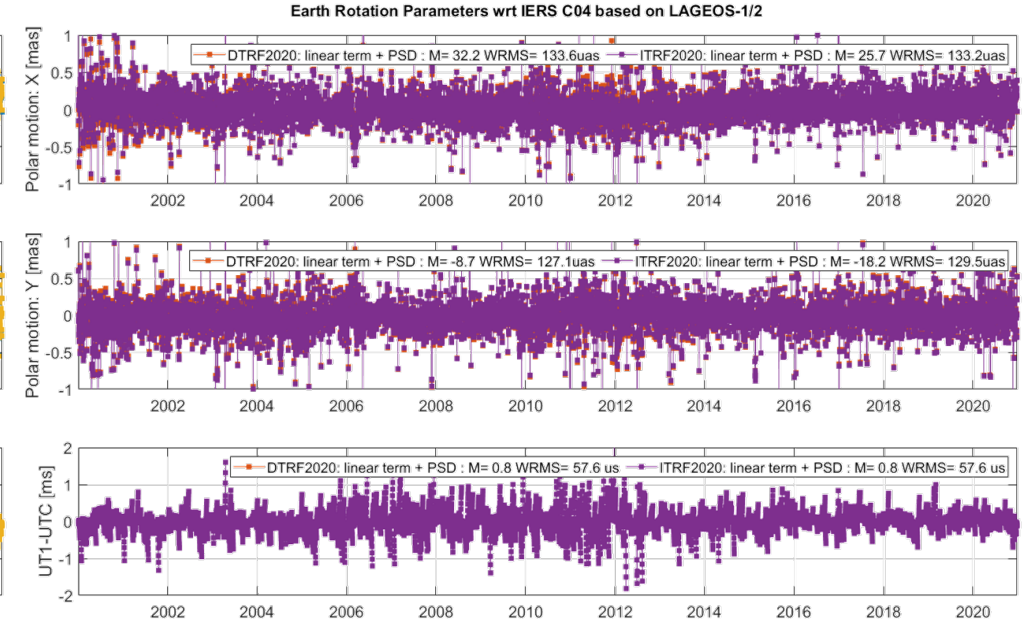
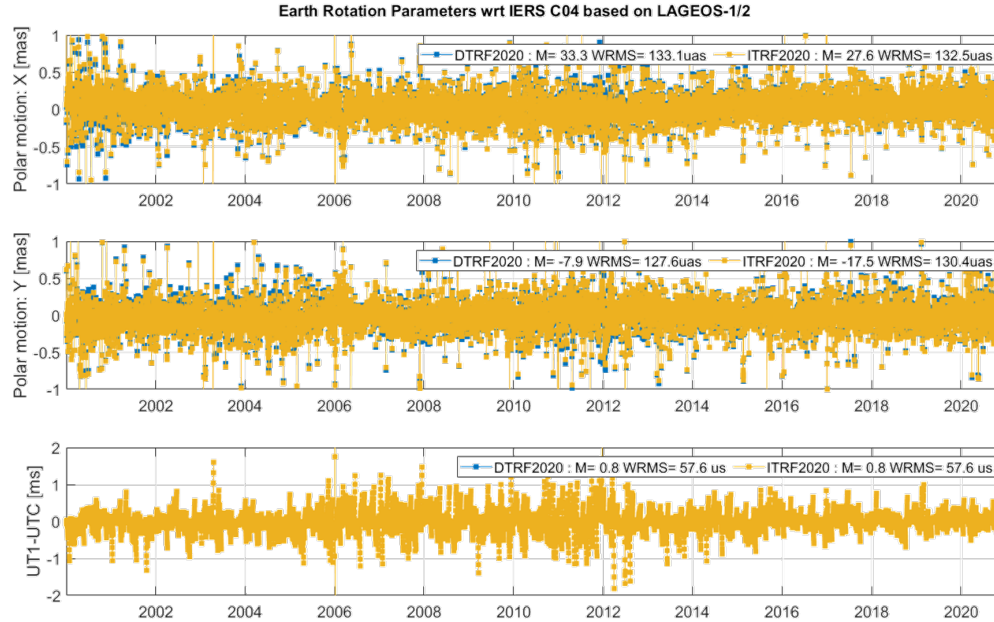
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Scenario 2: Orbits + RB + Geodetic Parameters

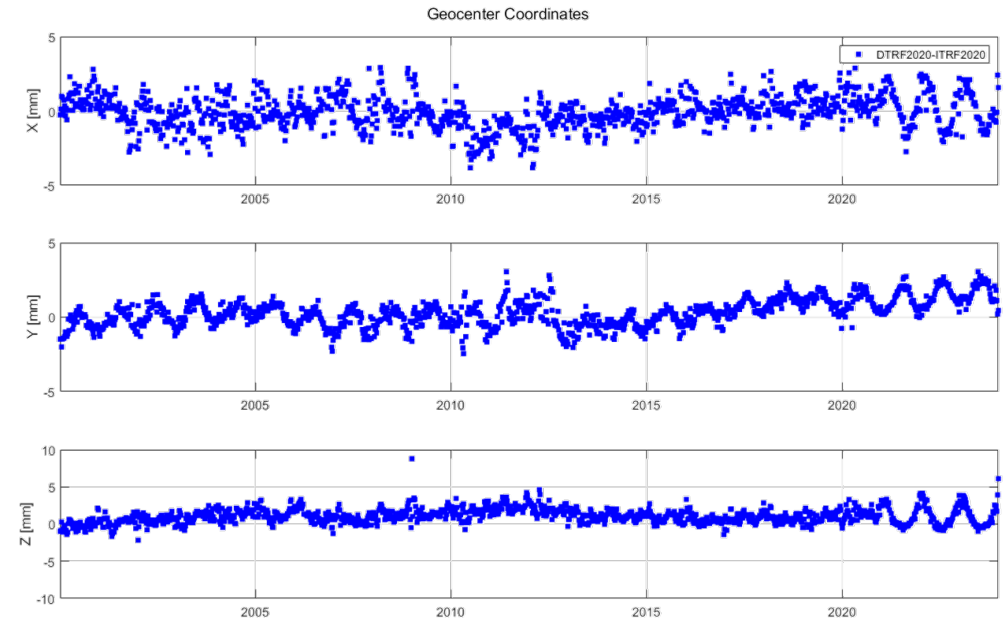
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- The estimated ERPs wrt the IERS 20 C04 time series show **similar scatter**, with only a **slight difference in the offset**.
- UT1–UTC/LOD are practically **identical**.

Scenario 2: Orbits + RB + Geodetic Parameters

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- An **annual signal** is again visible in the comparison of the geocenter time series.
- The NNT/NNR constraints to different sets of a priori station coordinates (ITRF2020 or DTRF2020) forces **the ERP and GCC to absorb the differences in the station network.**
- The strong annual signal after 2020 is due to the **absence of any NTL** corrections, whereas the seasonal periodic corrections from ITRF2020 can still be modelled.

Summary & Outlook

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- **Summary & Outlook**

- **Summary:**

- Annual signal in the station coordinate differences between ITRF2020 and DTRF2020 due to different handling of semi-annual/annual signals.
- The a posteriori RMS of the SLR observation residuals is comparable between the usage of a priori station coordinates from different ITRF realizations: DTRF2020, ITRF2020, JTRF2020.
- Periodic differences in the station coordinates are directly transferred into ERP and GCC when an NNT/NNR condition is applied.

- **Outlook:**

- Make use of the updated ITRF2020 products.
- Introduce GCC and ERPs from the corresponding ITRF provider to increase the consistency.
- Use Helmert iteration approach to define the SLR core station set, when using different ITRF realizations.

Take-Home Message (at least for me):
It is necessary to choose where specific effects are modelled/applied, and therefore which signals are carried by which parameters.

Thank you for your attention!

Contact: linda.geisser@unibe.ch

