DORIS contribution to the ITRF2020 Updates

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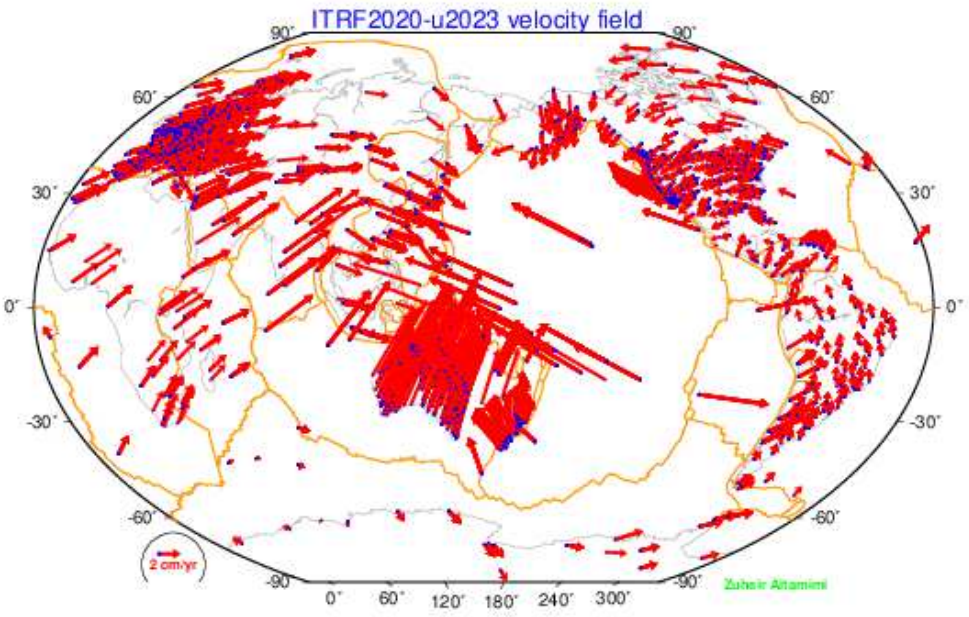
- Brief Introduction to the analysis strategy of ITRF2020 and its updates
- Motivation of regular (yearly) updates of ITRF2020
- Some results from ITRF2020-u2023 and ITRF2020-u2024
- Focus on some DORIS Results
- Conclusion



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Analysis Strategy of ITRF2020 & its updates

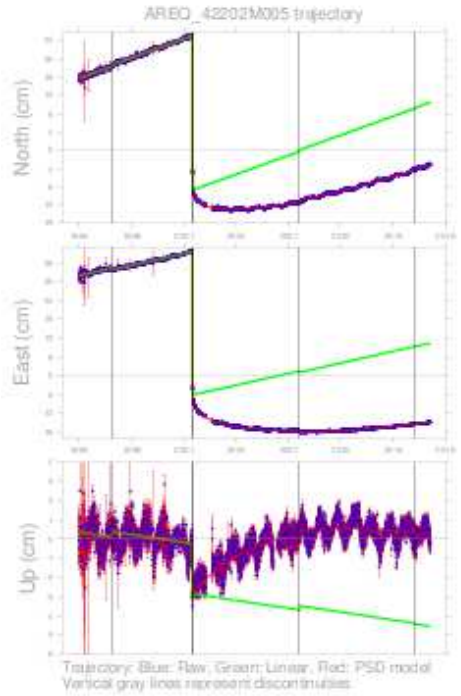
Input data: Time series:

- **DORIS/IDS weekly**
- **GNSS/IGS daily**
- **SLR/ILRS weekly**
- **VLBI/IVS: Session-wise**

- **Local ties**

Additional constraints at colocation sites: Equality constraints for

- **Station velocities**
- **Station seasonal signals**



Time series analysis & stacking of the 4 technique time series all together + Modeling of nonlinear station motions:

- **Periodic signals**
- **Post-Seismic Deformation**

ITRF2020 Specifications:
Origin: SLR
Scale: SLR & VLBI
Orientation: Alignment to ITRF2014
ITRF2020 updates: Alignment to ITRF2020

ITRF2020

$X, \dot{X}, \delta X_{PSD}$, *Seasonal Signals and EOPs*

Motivations for regular (yearly) updates of ITRF2020

- The stability of the ITRF long-term origin, evaluated to be at the level of or better than 5 mm and 0.5 mm/yr for its time evolution,
- The agreement in scale between VLBI and SLR, at the level of 1-2 mm, with no drift,

- The growth of extrapolation errors of the ITRF2020 coordinates beyond the end of the ITRF2020 input data,
- Changes in the positions of certain ITRF2020 stations (due to, e.g., earthquakes and equipment changes) that occurred after the end of the ITRF2020 input data.

Specifications of ITRF2020 updates

- Include 3 years (2021.0 – 2024.0) for the first update, and 4 years (2021.0 – 2025.0) for the second update

- Same analysis strategy as for ITRF2020: Accumulate the full 4 technique time series all together, adding local ties and co-motion constraints

- Align each ITRF2020 update to ITRF2020 for both the long-term frame and seasonal signal (CM Frame) defining parameters (origin, scale, and orientation)
- Adding new post 2021.0 discontinuities when necessary
- Updating PSD parametric models

Alignment of ITRF2020 updates to ITRF2020: 42 degrees of freedom

- **14 parameters for the TRF definition (origin, scale, orientation):**

$$(A^T A)^{-1} A \left(X_{ITRF2020} - X_{update} \right) = 0$$
$$(A^T A)^{-1} A \left(\dot{X}_{ITRF2020} - \dot{X}_{update} \right) = 0$$

- **28 parameters for the annual and semi-annual signals:**

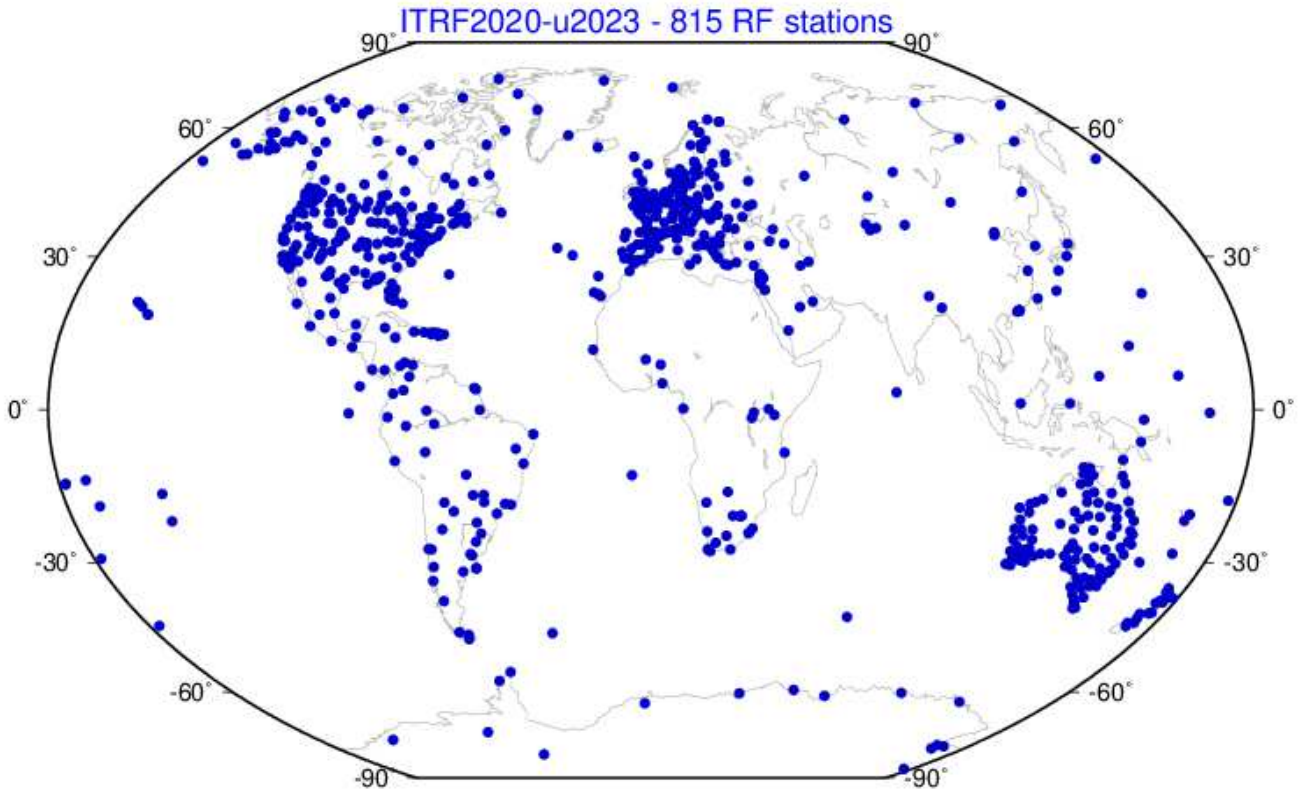
$$(A^T A)^{-1} A \begin{pmatrix} a^i_{x\_ITRF2020\_CM} - a^i_{x\_update} \\ a^i_{y\_ITRF202\_CM} - a^i_{y\_update} \\ a^i_{z\_ITRF202\_CM} - a^i_{z\_update} \end{pmatrix} = 0$$

$$(A^T A)^{-1} A \begin{pmatrix} b^i_{x\_ITRF2020\_CM} - b^i_{x\_update} \\ b^i_{y\_ITRF202\_CM} - b^i_{y\_update} \\ b^i_{z\_ITRF202\_CM} - b^i_{z\_update} \end{pmatrix} = 0$$

$$A = \begin{pmatrix} . & . & . & . & . & . & . \\ 1 & 0 & 0 & x^i_0 & 0 & z^i_0 & -y^i_0 \\ 0 & 1 & 0 & y^i_0 & -z^i_0 & 0 & x^i_0 \\ 0 & 0 & 1 & z^i_0 & y^i_0 & -x^i_0 & 0 \\ . & . & . & . & . & . & . \end{pmatrix}$$

In short : No net translation, no net scale and no net rotation between ITRF2020 and its updates

815 RF stations used in the alignment of ITRF2020-u2023 to ITRF2020



838 RF stations used in the alignment of ITRF2020-u2024 to ITRF2020

WRMS of the alignment

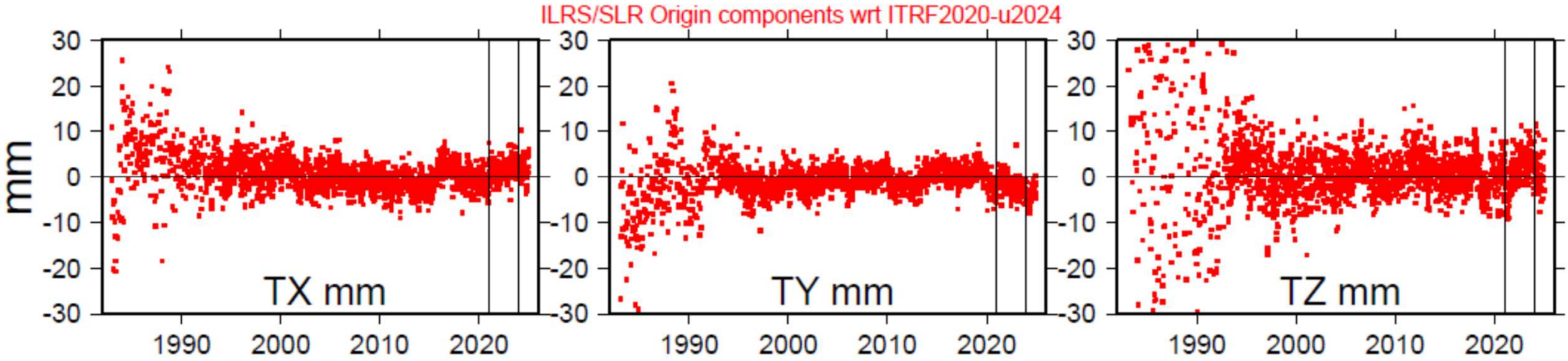
ITRF2020-u2023

	East	North	Up
positions @ 2015.0	0.11 mm	0.10 mm	0.28 mm
velocities	0.02 mm/yr	0.02 mm/yr	0.05 mm/yr
annual signals	0.05 mm	0.05 mm	0.15 mm
semi-annual signals	0.03 mm	0.02 mm	0.06 mm

Similar numbers for ITRF2020-u2024

Some results with uncertainty evaluation

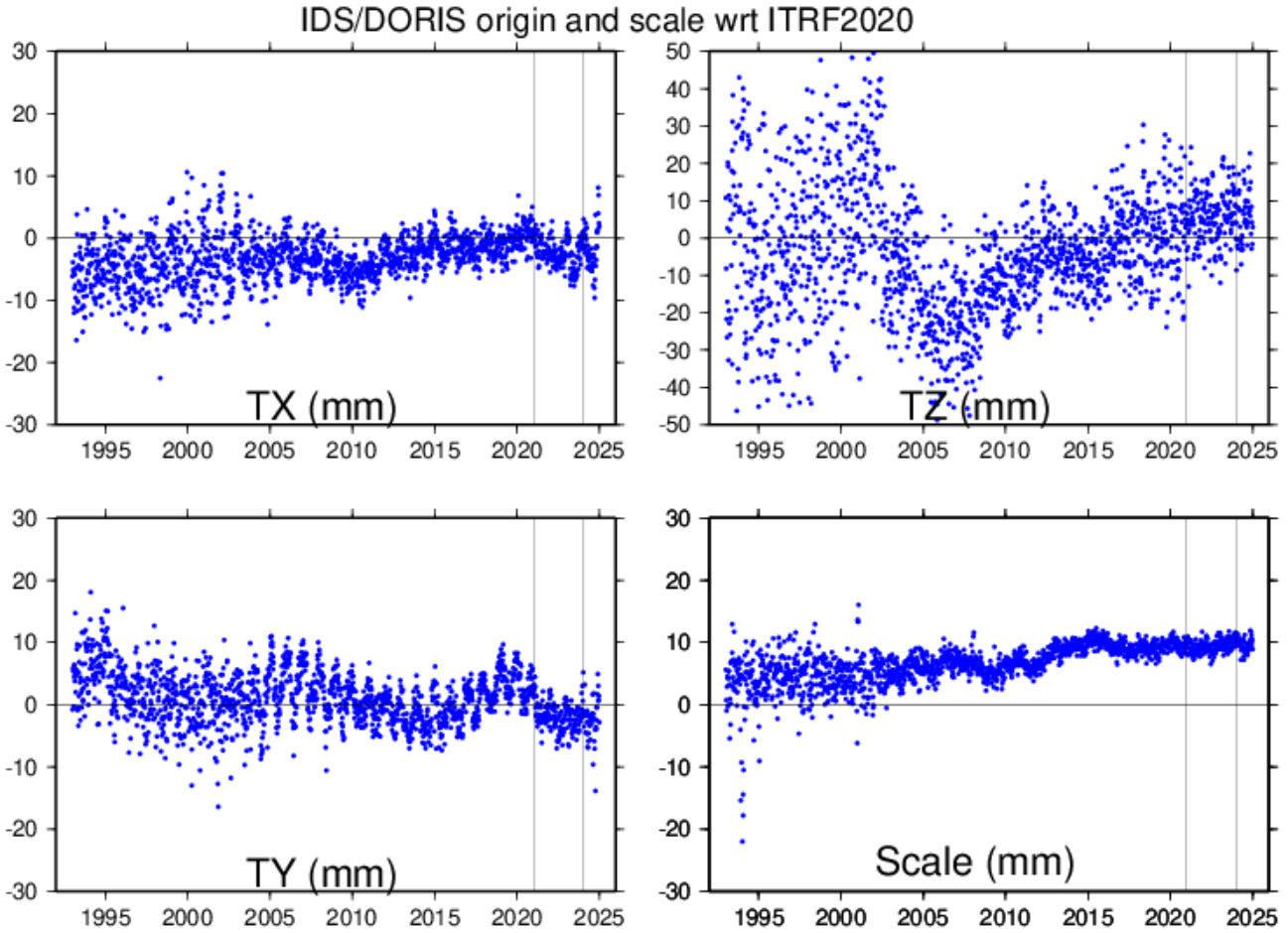
ILRS/SLR Origin components wrt ITRF2020-u2024 uncertainty evaluation (in mm)



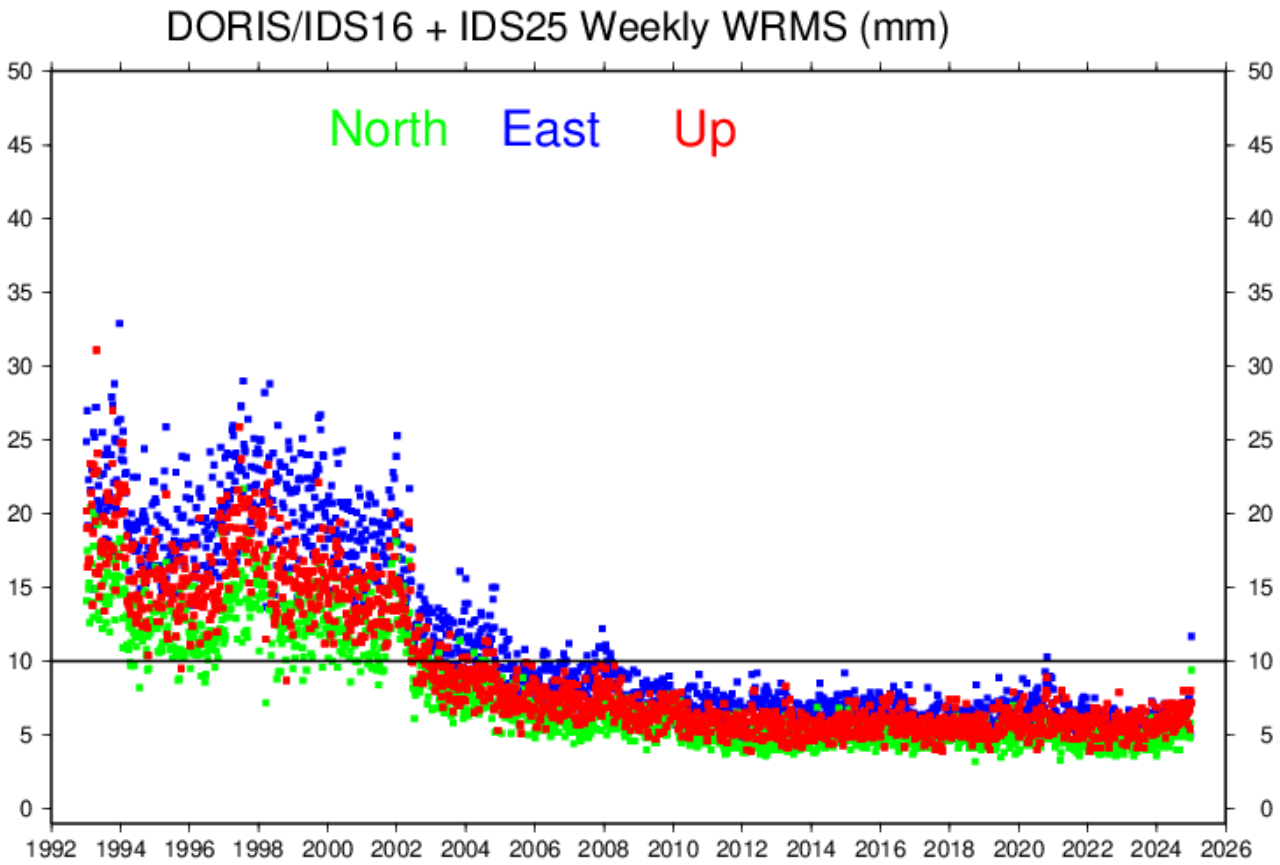
Offset (mm) at 2015.0	**0.23**	**-0.78**	**0.87**
Drift (mm/yr)	**-0.03**	**-0.01**	**-0.01**

- **Origin uncertainty at the level of 1 mm at 2015.0 and better than 0.1 mm/yr**

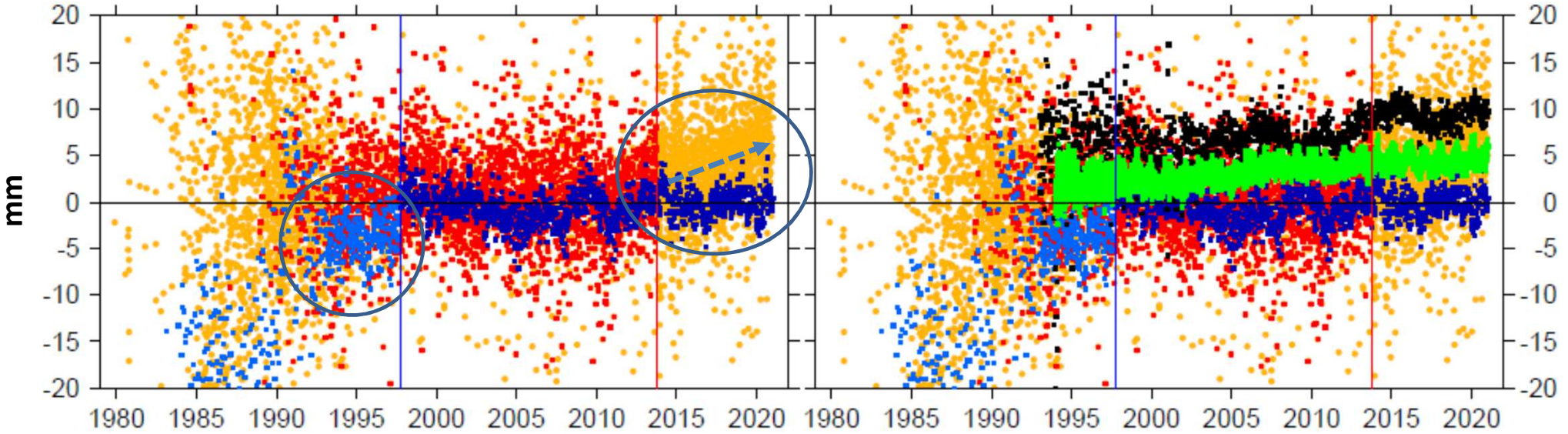
ITRF2020-u2024 IDS Origin and Scale



ITRF2020-u2024 IDS WRMS time series



Scales with respect to ITRF2020



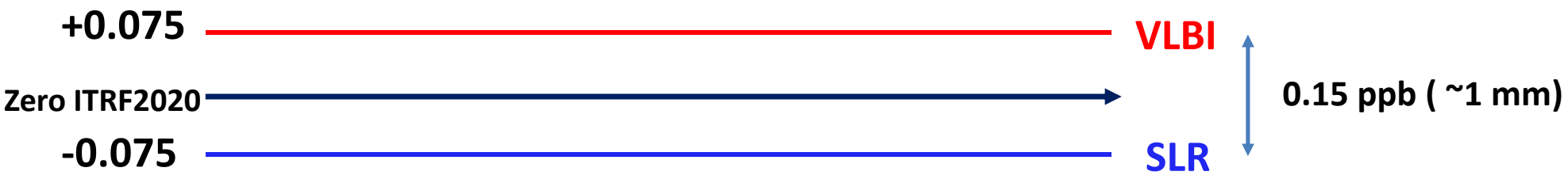
- Orange: all VLBI Sessions
- Red: Selected VLBI Sessions (convex hull volume ≥ 10^{19} m^3)
- Light blue: all SLR time series
- Dark blue: Selected SLR time series
- Green: GNSS/IGS/Repro3
- Black: DORIS

Solution	Scale at 2015.0 (ppb)	Scale rate ppb/yr
IGS/GNSS	0.682 ±0.018	0.018 ±0.001
IVS/VLBI	0.075 ±0.040	0.000 ±0.003
ILRS/SLR	-0.075 ±0.038	0.000 ±0.004
IDS/DORIS	1.386 ±0.037	0.028 ±0.003

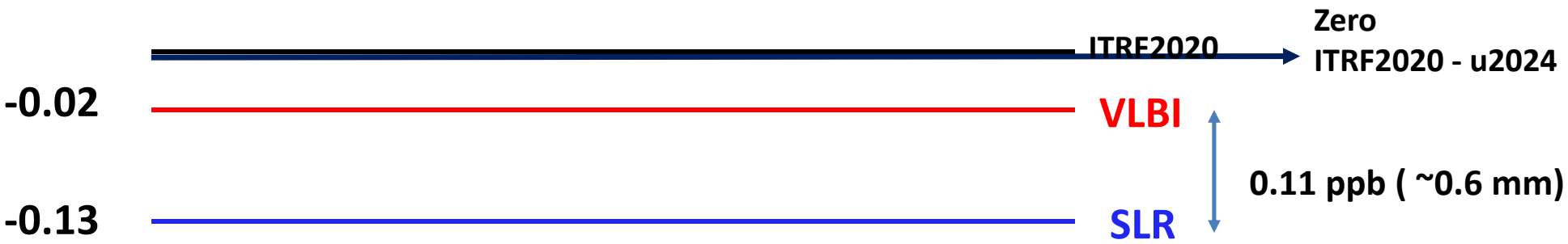
ITRF2020 scale: Average of red (VLBI) and dark blue (SLR)

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

Scale uncertainties (in ppb): ITRF2020



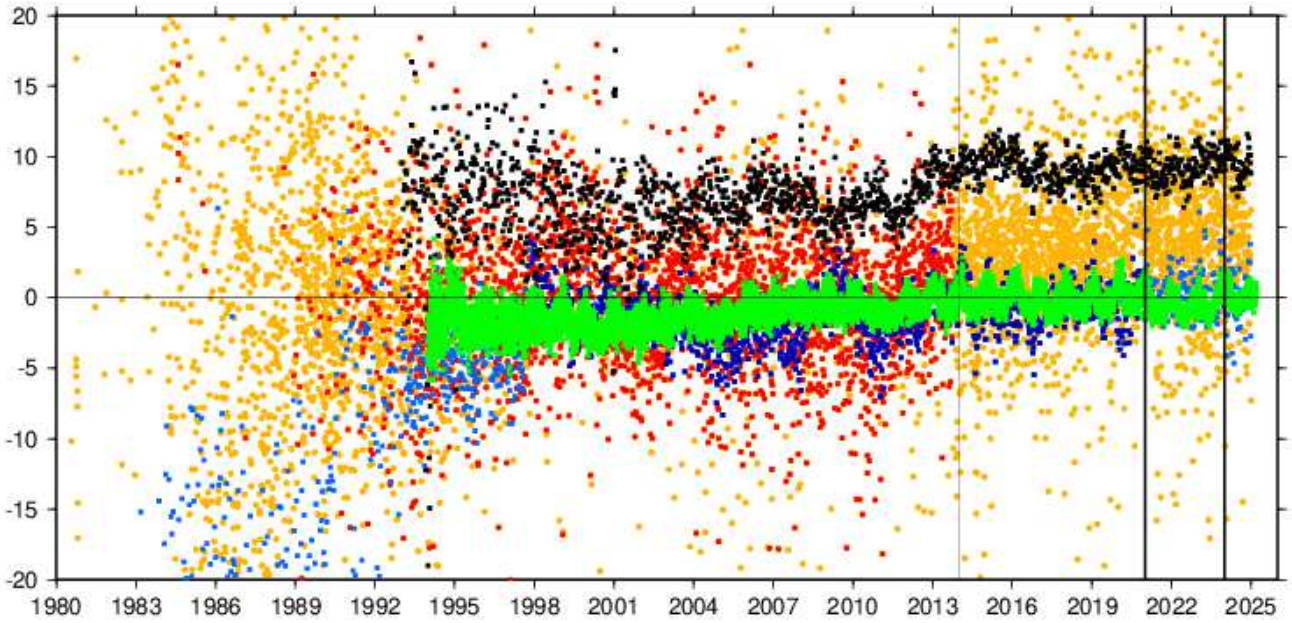
Scale uncertainties (in ppb): ITRF2020-u2024



VLBI scale change: ~ -0.10 ppb
SLR scale change : ~ -0.06 ppb

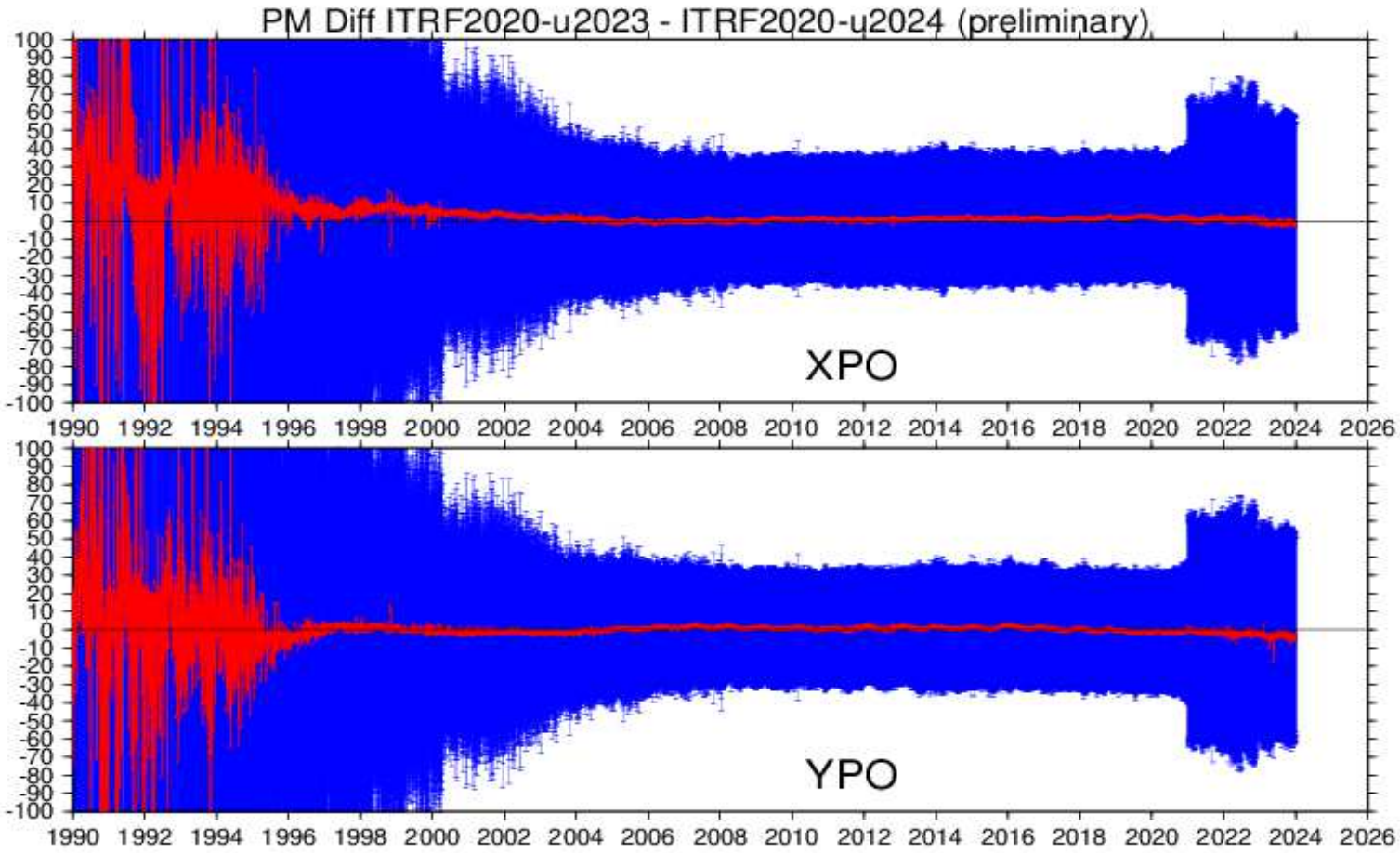
Rough ITRF2020-u2024 scale alignment uncertainty: ~0.1 ppb (~0.6 mm)

Relative scales : ITRF2020-u2024



- Orange: all VLBI Sessions
- Red: Selected VLBI Sessions (Solid Volume ≥ 10^{19} m^3)
- Light blue: all SLR time series
- Dark blue: Selected SLR time series
- Green: IGS/Repro3/Operational (compatible with igs20.atx)
- Black: DORIS

Polar motion diffs ITRF2020-u2023 - ITRF2020-u2024



Offset at 2015.0 = 1.0 µas
Drift = -0.06 µas/yr

Offset at 2015.0 = -0.2 µas
Drift = 0.04 µas/yr

Uncertainty of Polar Motion alignment to ITRF2020 ~1 µas and 0.1 µas/yr

Conclusion

- Alignment of ITRF2020 updates to ITRF2020 over 42 parameters
  - no change to the defining parameters of the long-term frame and seasonal signals (same origin, scale and orientation)
- Uncertainty evaluation:
  - Origin (SLR) : at the level of 1 mm at 2015.0 and 0.1 mm/yr
  - Scale (SLR + VLBI) : at the level of ~1 mm with no drift
  - Polar Motion: better than ~2 µas and 0.5 µas/yr
  - Stability of the DORIS/IDS scale over the past 10 years, but off by 1.3 ppb wrt ITRF2020
  - Variability of the DORIS/IDS TY geodenter component ?
- Adding 4 years more data impact the transfer of origin and scale between techniques at the level of 1 mm