ITRF2020 Updates – Impact on EOPs

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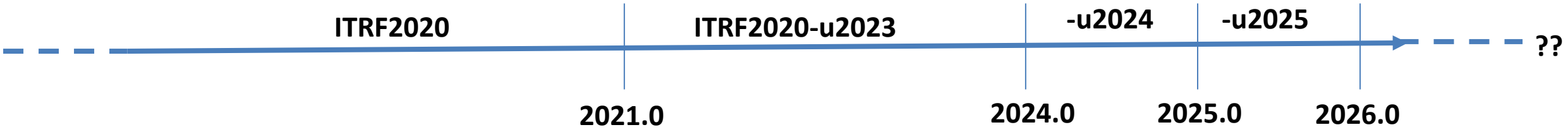
1. Timeline of ITRF2020 Updates
2. Focus on uncertainty evaluation: Consistency between ITRF2020 and its updates and :
   - EOPs
   - IERS C04
3. Conclusion

On the analysis strategy of ITRF2020 updates

Input Data / Timeline



Specifications for the ITRF2020 updates:
Alignment to ITRF2020 over 42 parameters
Advantages:

- **Minimum constraints approach**
- **All technique time series to freely adjust**
- **==> uncertainty evaluation**

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:**

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

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

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

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

ITRF Combination model (CATREF Software)

Station positions, velocities, transfo parameters & periodic terms

$$
\begin{cases}
\begin{pmatrix} x_s^i \\ y_s^i \\ z_s^i \end{pmatrix} = \begin{pmatrix} x^i \\ y^i \\ z^i \end{pmatrix} + (t_s^i - t_0) \begin{pmatrix} \dot{x}^i \\ \dot{y}^i \\ \dot{z}^i \end{pmatrix} + T_k + D_k \begin{pmatrix} x^i \\ y^i \\ z^i \end{pmatrix} + R_k \begin{pmatrix} x^i \\ y^i \\ z^i \end{pmatrix} \\
\quad + (t_s^i - t_k) \left[\dot{T}_k + \dot{D}_k \begin{pmatrix} x^i \\ y^i \\ z^i \end{pmatrix} + \dot{R}_k \begin{pmatrix} x^i \\ y^i \\ z^i \end{pmatrix} \right] \\
\quad + \sum_{j=1}^{n_f} \left[\begin{pmatrix} a_x^i \\ a_y^i \\ a_z^i \end{pmatrix} \cos[\omega_j (t_s^i - t_0)] + \begin{pmatrix} b_x^i \\ b_y^i \\ b_z^i \end{pmatrix} \sin[\omega_j (t_s^i - t_0)] \right] \\
\begin{pmatrix} \dot{x}_s^i \\ \dot{y}_s^i \\ \dot{z}_s^i \end{pmatrix} = \begin{pmatrix} \dot{x}^i \\ \dot{y}^i \\ \dot{z}^i \end{pmatrix} + \dot{T}_k + \dot{D}_k \begin{pmatrix} x^i \\ y^i \\ z^i \end{pmatrix} + \dot{R}_k \begin{pmatrix} x^i \\ y^i \\ z^i \end{pmatrix}
\end{cases}
$$

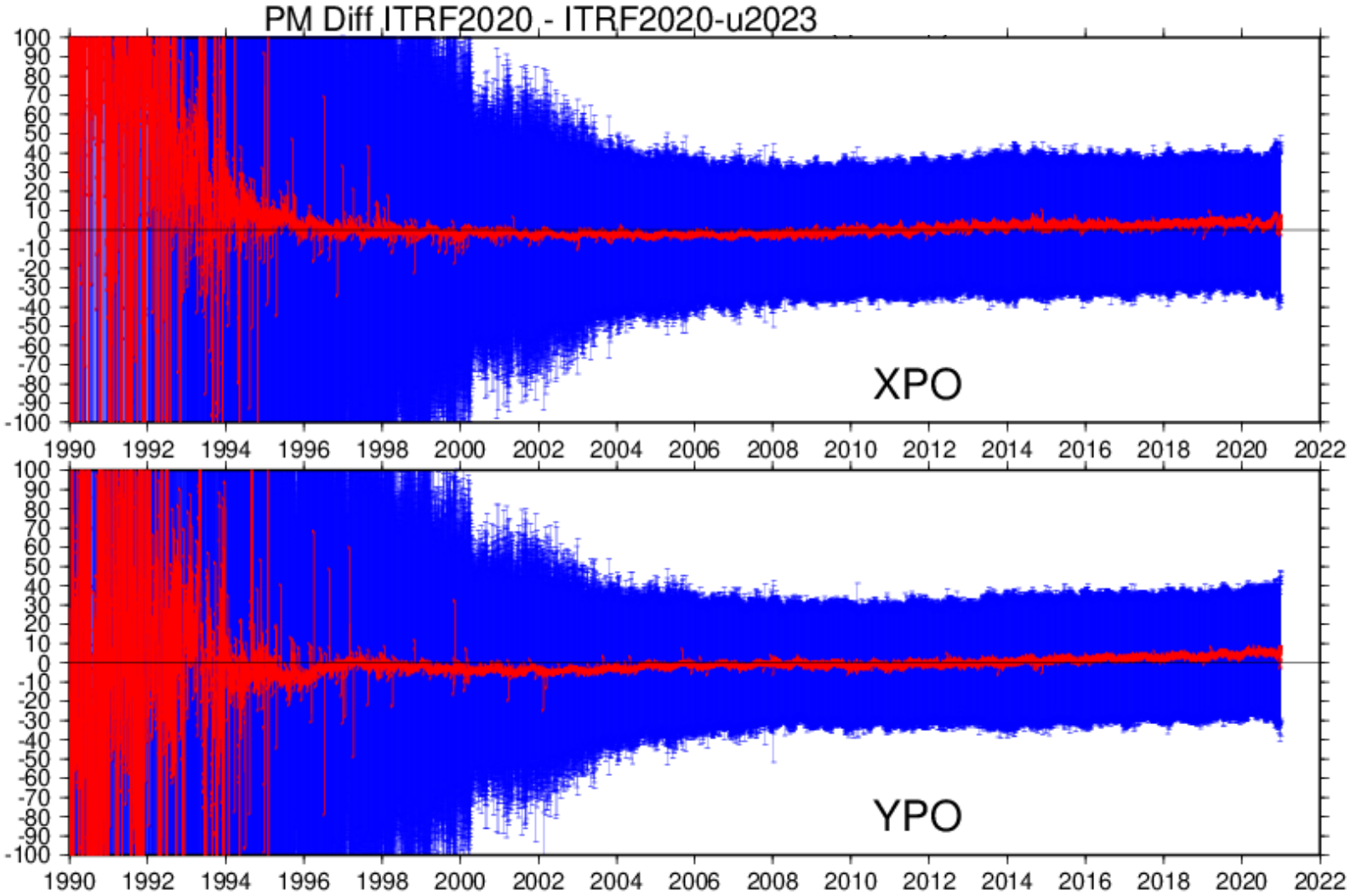
Earth Orientation Parameters

$$
\begin{cases}
x_s^p = x_c^p + R2_k \\
y_s^p = y_c^p + R1_k \\
UT_s = UT_c - \frac{1}{f} R3_k \\
\dot{x}_s^p = \dot{x}_c^p \\
\dot{y}_s^p = \dot{y}_c^p \\
LOD_s = LOD_c
\end{cases}
$$

PSD: applied as a correction model before stacking

$$
\delta L(t) = \sum_{i=1}^{n^l} A_i^l \log(1 + \frac{t - t_i^l}{\tau_i^l}) + \sum_{i=1}^{n^e} A_i^e (1 - \mathrm{e}^{-\frac{t - t_i^e}{\tau_i^e}})
$$

Polar motion diffs ITRF2020 - ITRF2020-u2023 (in µas)

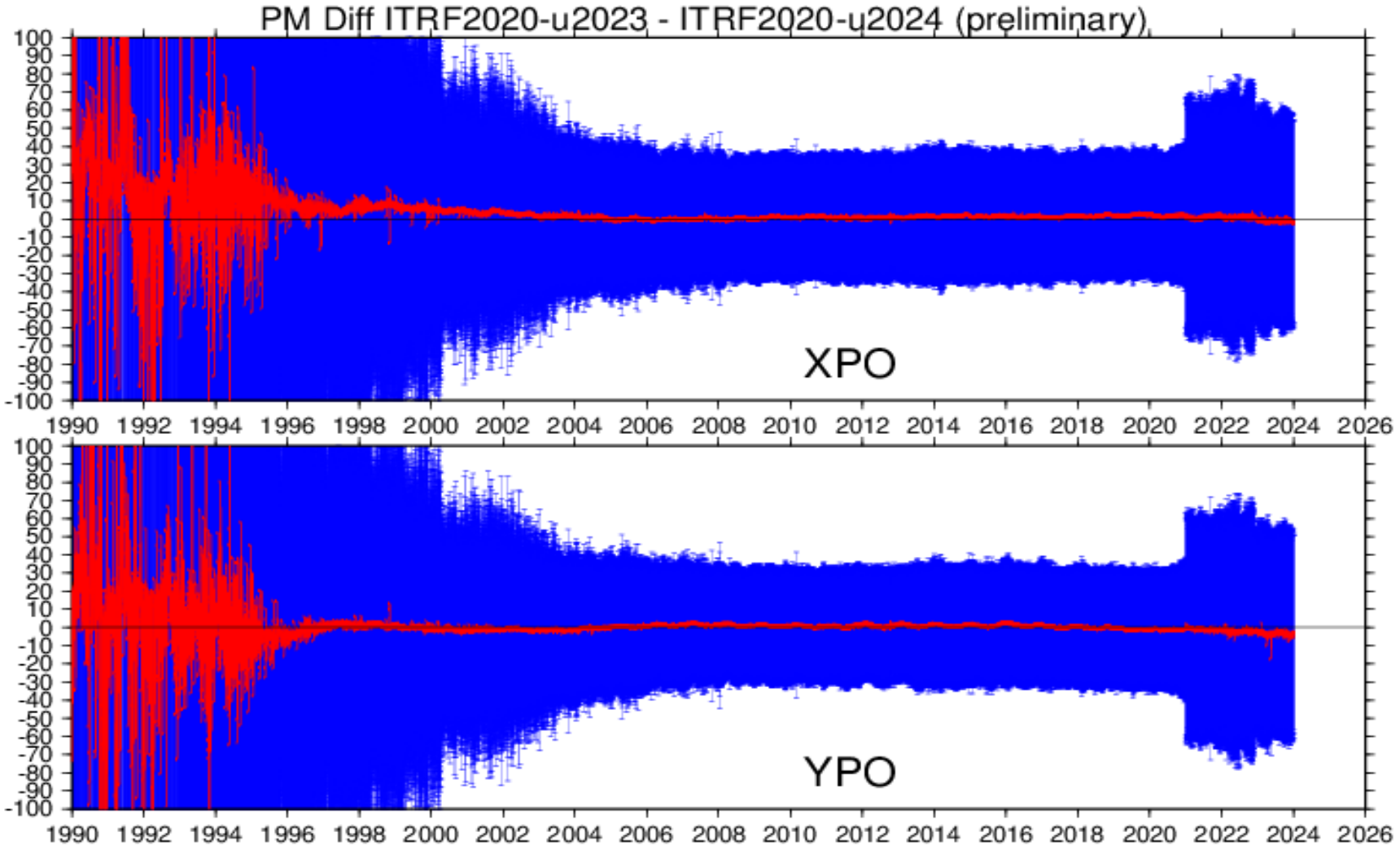


Offset at 2015.0 = 1.7 µas
Drift = 0.4 µas/yr

Offset at 2015.0 = 1.6 µas
Drift = 0.4 µas/yr

Uncertainty of Polar Motion alignment to ITRF2020 **~2 µas and 0.5 µas/yr**

Polar motion diffs ITRF2020-u2023 - ITRF2020-u2024 (Preliminary)



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

- **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

- **Advantages of ITRF2020 updates:**
  - Zero transformation parameters between ITRF2020 and its update, including orientation: ==> Frame and EOP consistency
  - Allows for more frequents IERS C04 updates and therefore ensures consistency of the most used IERS products
  - Time needed to determine the update: ~6 months

Backup