

# ITRF2020 and the IVS Contribution

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**Abstract** The ITRF2020 is provided in the form of an augmented reference frame. In addition to station positions, velocities, and Earth Orientation Parameters (EOPs), parametric functions for both Post-Seismic Deformation (PSD) for stations subject to major earthquakes and seasonal (annual and semi-annual) signals expressed in the Satellite Laser Ranging (SLR) center-of-mass and the center-of-figure frames are also provided to the users. At the time of writing, a full article on ITRF2020 results is under preparation [1]. However, this paper provides an extended summary of ITRF2020, with a special focus on the IVS/VLBI contribution, in particular the level of the scale agreement of the four techniques as well as their variations and behavior over time.

**Keywords** VLBI, ITRF, ITRF2020

## 1 Extended Summary

The reader may refer to the full article on ITRF2020, which is under preparation by the same authors [1]. However, we provide here the main features of ITRF2020, focusing on the contribution of the International VLBI Service for Geodesy and Astrometry [2, 3]. The ITRF2020 is characterized by the following key points:

- The input data to the ITRF2020 are in the form of the time series of station positions and EOPs,

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provided by the four technique services of the International Association of Geodesy: weekly solutions for IDS/DORIS and ILRS/SLR, daily solutions for IGS/GNSS, and session-wise solutions for IVS/VLBI.

- 253 local tie vectors between GNSS and the three other technique reference points were used: 77 for VLBI, 53 for SLR, and 123 for DORIS. These tie vectors were actually used in the form of station coordinates provided in SINEX format with full variance-covariance information.
- An innovative and new analysis strategy was adopted for the ITRF2020 computation, that is, rigorously accumulating the full time series of the four techniques all together and adding local ties and co-motion constraints at co-location sites (equating station velocities and seasonal signals).
- The Post-Seismic Deformation (PSD) parametric models for sites subject to major earthquakes were refined using the ITRF2020 extended data. As an example, Figure 1 exhibits the trajectory of the VLBI station at Concepcion, Chile, before and after the 2010 mega earthquake where the PSD parametric model determined by IGS/GNSS data fits perfectly the VLBI station position time series.
- The number of the IVS/VLBI session-wise solutions included in the final ITRF2020 combination is 6,178, spanning in total 41 years of observations, involving 154 stations at 117 sites, with only 14 sites in the southern hemisphere. The majority (86%) includes a small number of stations, ranging between three to nine stations. 842 (13%) sessions involve ten to 19 stations; eight sessions have 20 stations, while one session exceptionally includes 31 stations. In addition to station positions, the solutions include the full set of EOPs.

- The scale of the ITRF2020 long-term frame is determined using internal constraints in such a way that there are zero scale and scale rate between ITRF2020 and the scale and scale rate averages of VLBI selected sessions up to 2013.75 and SLR weekly solutions covering the time-span 1997.7–2021.0, as depicted in Figure 2. This is the first time in ITRF history where the intrinsic SLR and VLBI scales agree at the level of 0.15 ppb at epoch 2015.0 (equivalent to 1 mm at the equator), with zero drift. The reasons for the scale offset before 1997.7 for SLR and the scale drift after 2013.75 for VLBI are unknown to the authors and are under investigation by the ILRS and IVS. The noisy and scattered scale before 1993.0 for SLR are due to the weak observation of the LAGEOS I satellite. Figure 2 (bottom panel) illustrates the IDS/DORIS and IGS/GNSS scale time series that exhibit significant offsets and drifts with respect to ITRF2020:  $\approx 1.4$  and  $\approx 0.7$  ppb at epoch 2015.0 and  $\approx 0.03$  and  $\approx 0.02$  ppb/yr for IDS/DORIS and IGS/GNSS, respectively.

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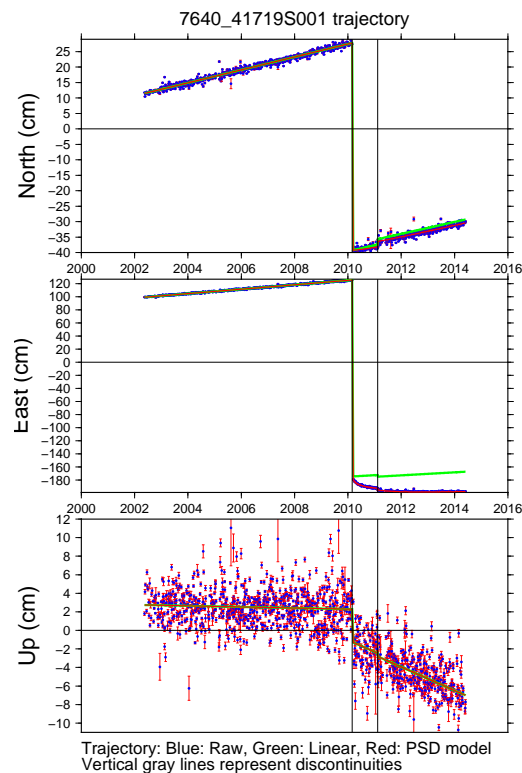


Fig. 1 Trajectory of TIGOCONC station in ITRF2020.

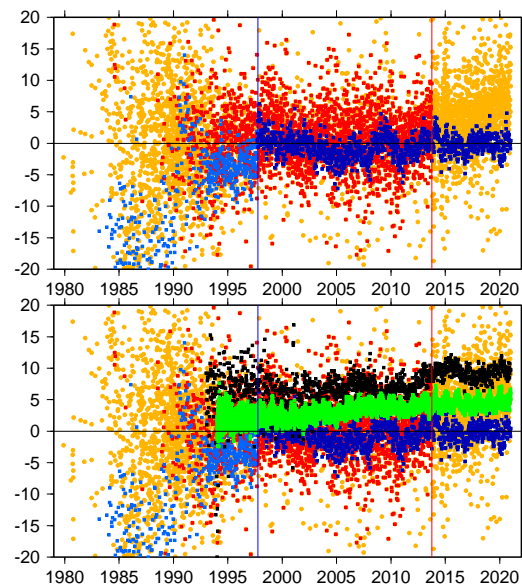


Fig. 2 SLR and VLBI scale time series with respect to ITRF2020 (top), adding DORIS and GNSS (bottom), in mm. Light blue and orange: all SLR and VLBI time series; dark blue and red: selected series whose average defines the ITRF2020 scale; black: DORIS; and green: GNSS.