Joint Working Group on the Consistent Realization of TRF, CRF, and EOP (CRTCE)

IAU Commission A2 joint with IAG Sub-Commission 1.4 and IERS

Member list (alphabetical order)

We acknowledge the dedication of the JWG members and correspondents.
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Objectives

The objectives of the working group are to

- quantify the consistency of the current conventional reference frames and EOP as well as to
- assess the consistency of reprocessed and predicted EOP.

The JWG strives to achieve this purpose through the computation of multi-technique CRF-TRF solutions together with EOP in one step, which can serve as reference solutions for comparisons. The JWG will

- investigate the impact of different analysis options, model choices and combination strategies on the consistency between TRF, CRF, and EOP. It will
- study the differences between multi-technique and VLBI-only solutions,
- study the possible contributions to EOP and frame determination by the LLR technique,
- study the differences between EOP derived by VLBI solutions at different radio wavelengths,
- study the effects on the results, when different data time spans are considered, and to
- compare the practically achievable consistency with the quality requirements deployed by IAG GGOS.

Progress

In the time period 2021-2023 progress has been achieved on the following topics

- Earth Orientation Parameters and station coordinates from Lunar Laser Ranging (LLR)
  L. Biskupek, V.V. Singh, J. Müller and M. Zhang
  Since the operations of the infra-red system at OCA (Cote d'Azur Observatory, Grasse, France) started, the number of LLR normal points approximately doubled and the accuracy of the observations increased. IR-LLR also enables a better distribution of observations across the synodic month in comparison to e.g. green laser. RMS of x_p / y_p are specified to be 1.4 mas / 1.8 mas and 18.6 µs for ΔUT1 in the time frame 2000 – 2022. The determination of nutation terms significantly improved as well. In comparison to results based on data until 2018, repeatabilities improved by about a factor of two or three for the 13.6 d period, respectively.
- K-band and Ka-band VLBI improved significantly
  A. de Witt, C. Jacobs, D. Gordon, H. Krásná
  Since the ICRF3, K-band based VLBI results improved in practically all aspects making this technology a very good comparison for EOP and reference frames. In 2022, the authors report four more years of data, an increase of recorded bandwidth by a factor of two, more than three times the number of observations, about 25% more radio sources than for ICRF3 leading to median scaled errors at the level of 48.4 µas (α) and 83.2 µas (δ). For EOP, the authors report formal errors of 0.1 mas for x_p and slightly more for y_p as well as 7.5 µs for ΔUT1 in the time frame after 2015. For Celestial Pole Offsets (CPO) about the same level of precision or slightly better than EOP 14 C04 is reported (Krásná et al., 2022).
  This means uncertainties comparable to those of S/X bands. Concluding high-frequency

VLBI will in future provide very precise means of comparison for S/X and VGOS-derived geodetic VLBI results.
Krásná et al. (2023a) carried out a study which allowed to better understand the systematic differences between the available S/X and K-band observations, such as the need for an external ionospheric calibration by the K-band data, or the lack of a uniform global terrestrial network causing a non-optimal observation geometry.

- Multi-technique solutions on the observation level involving a variety of ties
  J. Wang, M. Ge, S. Glaser, R. Heinkelmann, H. Schuh
  With the example of a GNSS – VLBI observation level combination, the authors demonstrate significant improvement for polar motion with weighted standard deviations of below 40 µas for x_p and a bit more than 40 µas for y_p. Whereas the WSTD of ΔUT1 of about 10 µs and CPO do not seem to benefit a lot from the combination with GNSS. The effects of tropospheric ties on the combination will remain in the focus of the studies.
- VGOS results for EOP and reference frames
  A. Walenta ne Girdiuk, D. Thaller et al.
  Preliminary results have been presented by the BKG IVS AC on the analysis of VGOS data for reference frames and EOP. As the report has been given before the release of ITRF2020, no prior VGOS VLBI station coordinates were available consistent with ITRF releases and therefore one could observe small but significant biases in results obtained by VGOS data. Already first benefits of VGOS could be demonstrated previous to ITRF2020 by the author team. In future as more VGOS data will become available these studies will be demonstrated with more statistical significance and employing ITRF2020 as prior information the VGOS to S/X inter-system biases will become considerably smaller.
- DTRF2020 release
  M. Seitz, F. Seitz
  The ITRS realization of the ITRS Combination Centre at DGFI was finalized and released in 2023 (Seitz et al, 2023). In DTRF2020, the VGOS station network is combined with the legacy S/X network on normal-equation (NEQ) level based on common parameters (station coordinates of antennas observing in both modes, station velocities, EOP) mixed-mode sessions, special session linking the Onsala telescopes and local ties. Further innovations of DTRF2020 are: i) atmospheric, oceanic and hydrological non-tidal loading corrections, consistently modelled and provided by IERS GGFC, are reduced on NEQ level, ii) the DTRF2020 scale is realized from the VLBI and the GNSS scale contribution, iii) post-seismic deformation is considered.
- ITRF2020 release
  Z.Altamimi, P. Rebischung, X. Collilieux, L. Métivier, K. Chanard
  ITRF2020 was published in June 2022. Similar to ITRF2014, consistent combined EOPs series have been provided with ITRF2020 station coordinates. In addition to an enhanced combination strategy, GPS spurious draconitic signals have been filtered out from the input GNSS station coordinate series which benefited the ITRF2020 EOPs. ITRF2020 orientation has been aligned to ITRF2014 to avoid introducing any significant bias and trend with the previous combined series of ITRF2014 and IERS EOP C04. More details can be found in Altamimi et al. (2023).
- Consistent estimation of TRF, CRF and EOP
  M. Seitz, D. Thaller
  The IVS-AC at DGFI-TUM worked on a consistent estimation of TRF, CRF and EOP based in a first step on VLBI data only but including for the first time VGOS sessions. Comparisons with DTRF2020, ITRF2020, ICRF3 and EOP reference series show a good agreement. The work prepares a TRF/CRF/EOP solution which is based on the combination of all four space geodetic techniques that contributed to DTRF2020 and will be calculated in collaboration of ITRS Combination Centre and IVS AC at DGFI-TUM and the IVS Combination Center at BKG/DGFI-TUM.
  Krásná et al.
  The IVS-AC VIE computes a consistent TRF, CRF and EOP from VLBI sessions on a regular basis (Krásná et al., 2023b). Two kinds of solutions are provided: the pure S/X

solutions include only the legacy S/X 24-hour sessions provided through the IVS data centers, and the other solutions combine the S/X with VGOS sessions. These reference frames are substantial improvement of the official international terrestrial and celestial reference frame, since they include the latest VLBI sessions provided through the IVS data centers.

References:

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