

ITRF2020

Call for participation

Background

Starting with ITRF2005 and continuing with ITRF2008 and ITRF2014, the International Terrestrial Reference Frame (ITRF) construction used time series of station positions and Earth Orientation Parameters (EOPs): weekly from DORIS and SLR, daily from GNSS and session-wise from VLBI. Time series are essential for the ITRF to account for not only station nonlinear motions and discontinuities but also to evaluate the stability over time of the physical frame parameters, namely the origin and the scale, which are critical for Earth science applications. The ITRF rigorous combination provides a self-consistent series of EOPs, including Polar Motion from VLBI and satellite techniques, and Universal Time and Length of Day from VLBI only.

While the ITRF2014 marked considerable innovations compared with previous versions of the ITRF, by modeling nonlinear station motions (periodic signals and Post-Seismic Deformation –PSD- for sites subject to major earthquakes), some weaknesses and systematic errors have been identified in the individual technique solutions that were used as well as in their co-locations. New stations have been installed since then, but also geophysical processes (large earthquakes, slow slip events, ice unloading, etc) have deformed large areas over continental regions. Because of these issues an ITRF2020 becomes necessary that will benefit from the expected improvement of the reprocessing efforts being undertaken by the Technique Centers (IVS, ILRS, IGS, IDS).

ITRF2020

Since the release of the ITRF2014 the following improvements can be noted:

- Six years of additional observations will become available at the end of 2020;
- New sites have been added to the ITRF network;
- New co-location sites and new local ties are now available;
- The processing strategies of the individual techniques have improved and self-consistent reprocessed solutions are expected to be available;
- A rigorous PSD modeling of sites subject to major earthquakes will be operated, as for ITRF2014;
- Periodic signals observed in the station position time series will be modelled in order to estimate robust station velocities, and eventually combined at co-location sites;
- Nonlinear station motions caused by slow earthquakes or recent ice melting will need to be appropriately modelled.

In order to take advantage of these new developments, the ITRS Center, together with the ITRF CCs, is planning to generate a new ITRF solution (ITRF2020) and solicits input from the IERS Technique Centers (TCs). The TCs are requested to provide time series that are as long as possible and preferably covering the full history of observations of each technique, such as for instance VLBI and SLR data since the eighties.

In their reprocessing efforts, the TCs are encouraged to consider, to the extent possible, model updates and effects that are listed in the appendix of this CfP, as well as tidal load and other displacements for which models are given in the IERS Conventions, and its updates (<http://iers-conventions.obspm.fr/>, or <http://maia.usno.navy.mil/conventions>.)

It is envisaged that the individual TC solutions will be corrected for non-tidal loading effects during the ITRF generation, using a unique loading model provided by the IERS Global

Geophysical Fluid Center (GGFC), including atmospheric, oceanic and hydrological effects. The pertinence of applying such a global loading model will be evaluated and its impact on the ITRF2020 solution will be assessed.

Long Time Series Contributions

Contributed time series (daily/weekly) solutions to be included in the ITRF2020 should be provided in SINEX format and comply with one of the following constraint categories:

- Solutions with removable constraints;
- Loosely constrained solutions (constraint level: $\sigma > 1$ m);
- Free singular normal equations.

The SINEX files must conform to the SINEX Version 2.02 format standard and should contain for one day — a session in the case of VLBI — or one week (Sunday to Saturday), station positions, a set of EOPs for each day (offsets and rates fitted over 24-hr intervals for polar motion, UT1 and LOD, where only VLBI provides UT1). Requested time series are daily solutions from GNSS, session-wise from VLBI, and weekly solutions from DORIS and SLR. IVS is highly encouraged to provide nutation offsets and quasar coordinates for future studies by the combination centers. If the SINEX files contain a variance-covariance matrix, all constraints applied to the solution should be given in the a priori variance-covariance matrix. If a non-tidal loading model is applied, then the contribution of the non-tidal loading corrections to the right-hand side of the normal equation should be provided in the SINEX files.

All solutions should conform to the IERS Conventions, including its updates.

Whenever departures from the recommendations of the IERS Conventions are used, it is requested that the effects of those deviations be documented, and discussed beforehand with the ITRS Center. Among the model updates and effects to be considered, as listed in the appendix, some specific model updates are strongly requested:

- The IVS is encouraged to consider modeling the gravitational deformation for as many antennas as possible, and possibly refining the modeling of the thermal expansion of the VLBI antennas, provided that no net artefactual scale offset/drift is introduced;
- Appropriate modeling of SLR station range biases is needed to improve SLR scale determination;
- The most up to date GNSS force models to minimize orbit mismodeling and its impact on station positions;
- Appropriate DORIS analysis strategy, and model updates, to minimize possible scale discrepancies between ACs.

Solicited solutions to be considered in the ITRF2020 combination are official single-technique combined time series from the Technique Centers.

Solutions that result from a combination of various techniques *at the observation level* may be submitted. These solutions will be analyzed and evaluated against ITRF2020 after its release. It is important that these solutions should comply with the guidelines of this call, the IERS Conventions are strictly followed, common parameters between techniques other than EOPs (e.g. troposphere parameters, orbit parameters of multi-technique satellites) are combined, the full history of technique observations of common time-span are used and no terrestrial local ties should be introduced.

A summary file describing the strategy adopted to generate the time series (a priori models but also combination strategy) should be submitted together with the SINEX files, as well as a recommended station position discontinuity file.

Local Surveys at Co-location Sites

The local ties available at the ITRS Center for a certain number of co-location sites are now old by up to 20 years. The owners of co-location sites are solicited and highly encouraged to consider conducting new local tie surveys using the most up to date survey methods. The results of least squares adjustments of the survey observations should be provided to the ITRS Center in the form of SINEX format, with full variance-covariance information. It is further recommended NOT to remove the IGS GPS/GNSS antenna during the survey, in order to avoid undesirable possible discontinuity in the position time series when the antenna is restored back to its original marker. The position of the GNSS antenna reference point should then be determined by indirect methods. It is desirable to receive new local tie SINEX files as early as possible, but before the start of the analysis of ITRF2020 input data in February 2021. It is also advised to contact the ITRS Center (itrf@ign.fr) before beginning the survey in order to discuss specific details of individual sites.

ITRF2020 Analyses and Results

The general analysis strategy planned by the ITRF CCs will follow the procedure used for ITRF2020 and will consist of the following steps:

- Remove original constraints (if any);
- Possibly apply non-tidal effects corrections;
- Identify and reject outliers and properly handle discontinuities, using break-wise approach;
- Identify the most appropriate post-seismic deformation model when needed
- Perform per-technique combinations (TRF + EOP) of each individual time series: stacking/accumulating the weekly/daily time series. The outputs of this step will be full SINEX file per technique, containing station positions, velocities, periodic displacements and daily EOPs;
- Combine the per-technique combinations adding local ties in co-location sites. During this step, a proper weighting will be applied, by rescaling the individual variance-covariance matrices. This global combination will constitute the ITRF2020 solution.

The main expected ITRF2020 results include:

- Positions, velocities, and possibly seasonal displacements for a global network of tracking stations and related markers of the four techniques (VLBI, SLR, GNSS, DORIS), with full variance-covariance information provided in SINEX format;
- Fully consistent EOPs: daily polar motion and their rates, UT1 and LOD;
- Per-technique solutions of station positions, velocities, possibly seasonal displacements and daily EOPs, with full variance/covariance information provided in SINEX format;
- Output discontinuity files for each technique;
- Post-Seismic Deformation parametric models with full variance/covariance information provided in SINEX format;
- Residual time series as result from the per-technique time series combinations;
- Geocenter offset and scale time series.

Instructions

The Technique Centers and individual Analysis Centers that intend to contribute their long time series of SINEX files should submit these series by February 10, 2021 at the latest. Earlier submissions are most welcome and are very much encouraged.

To submit a time series of SINEX files please send an e-mail to:

ITRS Center itrf@ign.fr

and

IERS Central Bureau central_bureau@iers.org

The e-mail should contain the detailed instructions on where the solutions can be downloaded, their present naming convention, etc. The submitted SINEX files will be archived by the ITRS Center and in the IERS information and database system.

Schedule:

January 10, 2019	Dissemination of the Call for Participation
February 10, 2021	Deadline for solution submissions by Technique Centers. Earlier submissions are welcome.
April 2021 Until end of May, 2021	First and early results to be shared and discussed with the TCs. Inter comparisons of the ITRF CCs solutions
June, 2021	Preliminary ITRF2020 solution available for evaluation by the Technique/Analysis Centers
Sep-Oct, 2021	Final ITRF2020 solution released by the ITRS Center.

Appendix

Handling of technique systematic errors and needed model updates, in preparation for ITRF2020.

All Techniques:

- Implement linear mean pole model
- Develop and implement diurnal-subdiurnal tidal EOP models based on Desai-Sibois (2016) approach -- model fits to geodetic data will only redistribute technique systematic errors
- [except VLBI] Adopt post EGM2008 static gravity field based on ~all GRACE & GOCE data
- [except VLBI] Highest-fidelity time-variable gravity (TVG) model (degrees >1) using GRACE + SLR + geophysical fluid models for full space geodetic era, consistent with GRACE + GOCE standards
- [for GNSS mostly] New seasonally fitted TVG model (up to at least 3x3) derived from above
- If a loading model is applied [but preferably not], (1) ensure consistency with TVG model, (2) ensure the same loading model is used by all techniques and all ACs, and (3) provide contribution of loading corrections to the right-hand side of the normal equation in SINEX.
- Find cause of 13.63/13.66 d signal in GNSS time series & fix tide model responsible
- Derive and implement models for instrument/monument thermal 3D effects for all techniques; validate present VLBI model
- Collect metadata needed to implement instrument/monument thermal effect models
- IERS Conventions updates to document all the above
- Any other effects worth considering by any or all of the 4 techniques?

DORIS:

- Improve SRP modelling to reduce draconitics
- Minimize the SAA effect

GNSS:

- Research near-field signal multipath & develop methods to calibrate in-situ position biases at all reference frame stations
- Investigate methods to mitigate pervasive draconitic signals
- Improve radiation force modeling, especially associated with attitude changes during eclipse
- Try harder to minimize equipment- and local-induced position offsets

SLR:

- Add estimation/handling of station Range Biases (RB)
- Use updated CoM offsets
- Add estimation/handling of Time Biases (TB)
- Include applied RB & TB in SINEX file for next contribution to ITRF with their constraint information

VLBI:

- Validate Nothnagel model for VLBI thermal effects
- Structural gravitational deformation: Update software to apply models to as many antennas as possible
- Relativity: Evaluate extra terms (<~1 ps) in trial basis in calc/solve, and check with formulation of Soffel et al., 2016.
- Source Structure: Better/improved strategy

GGFC to provide:

- Individual and full loading models for all three contributions (atmosphere, ocean and hydrology) in both CF and CM frames for all sites of the ITRF2020
- Geocenter time series based on the total of global geophysical fluid