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Description of DTRF2020 preliminary solution

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1. Input data

Space-geodetic techniques

GNSS/IGS	1994-2021.0	daily solutions: free NEQ (rank deficiencies w.r.t. origin and orientation) reconstructed from SINEX
VLBI/IVS	1979-2021.0	session-wise NEQ (rank deficiencies w.r.t. origin and orientation)
SLR/ILRS	1984-2021.0	weekly, fortnightly solutions; loosely constrained; the loose constraints remain on the NEQ reconstructed from SINEX
DORIS/IDS	1993-2021.0	weekly solutions; datum conditions not booked in SINEX; rank deficiencies w.r.t. origin, orientation and scale are restored by setting up seven parameters of a similarity transformation per input NEQ

Local ties

- Local ties provided for ITRS 2020 and previous ITRS realizations

Non-tidal loading (NTL) displacements

- Provided by IERS GGFC
- Including atmospheric (ATM), hydrological (HYD) and oceanic (OCN) loading displacements with different temporal resolutions
- Based on the following models
    - ERA5 IB
    - ERA5 TUGO-m
    - ERA5 hydro
- Station-wise CM-related loading time series per components [ATM, HYD, OCN] and [North, East, up]. CM-related values are applied for all techniques. The choice of the origin (CM/CF) for the corrections is free for VLBI, GNSS and DORIS as their NEQs are singular w.r.t. origin.

2. Parameters

Parameters provided by the different techniques and parameters of the DTRF2020 solution.

	Station positions	Station velocities	x/ypole	x/ypole rate	LOD	dUT1	Nutation X/Y
GNSS	x		x	x	x	x	x
VLBI	x		x	x	x		x
SLR	x		x		(x)		
DORIS	x		x				
DTRF2020	x	x	x	x	x	x	x

(x) SLR LOD series is not used in the combination, because it shows significant tidal signals w.r.t. the other techniques and the latest IERS series, IERS 08 C04 and IERS 14 C04.

3. DTRF2020 solution

Reference epoch: 2010.0

Combination strategy

- Combination of NEQs
- Reduction of epoch-wise mean NTL displacements and post-seismic deformation (PSD) from epoch-wise (daily, weekly, session-wise) NEQs
- Identification of discontinuities and outliers
- Computation of a TRF solution (NEQ) per technique by applying intra-technique velocity conditions (equating velocities of consecutive solution number of one station and of co-located instruments of one technique as far as they do not differ significantly)
- Combination of TRF-NEQs (resulting from the previous step) taking into account relative weights (see below)
- Introduction of local ties and velocity conditions (equating velocities of co-located sites) as pseudo-observations
- DTRF2020P datum realization

Consideration of NTL and PSD

- NTL time series are converted to the temporal resolution of the input NEQs (daily, fortnightly or weekly), tailored to the individual station observation time span and detrended
- PSD is approximated per station and component by combinations of exponential and logarithmic functions (Note: for the GNSS station TSK2, a small offset caused by a discontinuity shortly after the earthquake is included in the approximation)

- NTL and PSD are reduced from input NEQs on daily, weekly or session basis

Weighting strategy

- Consideration of a-posteriori variance factors
- Considering weighting factors obtained by relating estimated formal errors and formal errors obtained for a mean station position from station time series analysis (VLBI, SLR and DORIS)
- For GNSS we analyzed time series of a selected set of stations by applying suitable noise models for their non-linear station motions in order to adjust the over-estimation of GNSS velocity precisions. We applied the HECTOR software for this. We obtained an over-estimation of the precision in particular for the velocities of stations with a long observation history with a factor of about 20-24. This factor was not considered in the GNSS weighting factor applied in the combination as it would lead to an unjustified down-weighting of the GNSS station positions and the consistently estimated GNSS EOP. Therefore, we accept the over-estimation of GNSS velocity precisions within the combination. We will provide the obtained factor as additional information to the users.

Datum realization

- Origin: the DTRF2020P origin is realized from the full set of SLR data provided by ILRS
- Scale: the DTRF2020P scale is realized from the full set of VLBI and GNSS data provided by IVS and IGS, respectively. SLR does not contribute to the DTRF2020 scale because of a small scale offset and drift w.r.t. VLBI and GNSS. The SLR scale shows a very stable intrinsic time series and thus no scale parameters are set up for each SLR weekly/fortnightly NEQ but only one scale offset and scale drift for the combined SLR TRF NEQ. This ensures that SLR benefits from its high internal scale stability.
- Orientation: the DTRF2020P orientation is realized by no-net-rotation conditions w.r.t. DTRF2014 using a subset of GNSS stations

DTRF2020P solution comprises

- ~ 97600 parameters
- Coordinates of 3200 individual station position solutions (solution numbers)
- EOP (see table above): ~76800

4. DTRF2020P data set

- SINEX files of DTRF2020P solution per technique with full variance-covariance matrix (please note, that there is a list of GNSS stations without DOMES numbers)
- EOP file of DTRF2020P solution in IERS 20 C04 format

- NTL corrections in [xyz] and [North/East/up] applied in DTRF2020P as time series per station
    - Directory: NTL/${technique}/means/
- Mean offsets and drifts removed from individual NTL correction time series before using them in DTRF2020P (for atmospheric, hydrological and oceanic effect and the sum) in [xyz] and [North/East/up]
    - Directory: NTL/${technique}/
- PSD corrections in [xyz] applied in DTRF2020P as time series per station showing a significant post-seismic deformation. For solution numbers with a data end at 20:365:00000 in DTRF2020 preliminary solution, long time series are provided up to epoch 2031-01-01.
    - Directory: PSD/${technique}/
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