# Updating JTRF2020

Claudio Abbondanza[1], Toshio M Chin[1], Richard S Gross[1], Michael B Heflin[1]

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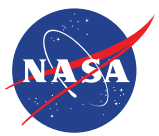
[1] Jet Propulsion Laboratory - California Institute of Technology

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# 1. Outline

- JTRF2020 is the most recent TRF solution computed at JPL by assimilating frame input data submitted by the IVS, ILRS, IGS and IDS for the ITRF2020 [1].
- Determined with a Square-Root Information Filter (**SRIF**) and Dyer-McReynolds Smoother (**DMCS**) algorithm, JPL frame products, such as JTRF2020, lend themselves to being updated rather easily as long as frame inputs consistent with the frame-defining data sets are available.
- In this presentation, we test **SREF** (**S**quare-root **R**eference frame **E**stimation **F**ilter) updating capabilities and report on the current analyses which will lead to generate the first update of JTRF2020.

# 2. Frame Inputs Used throughout Our Tests

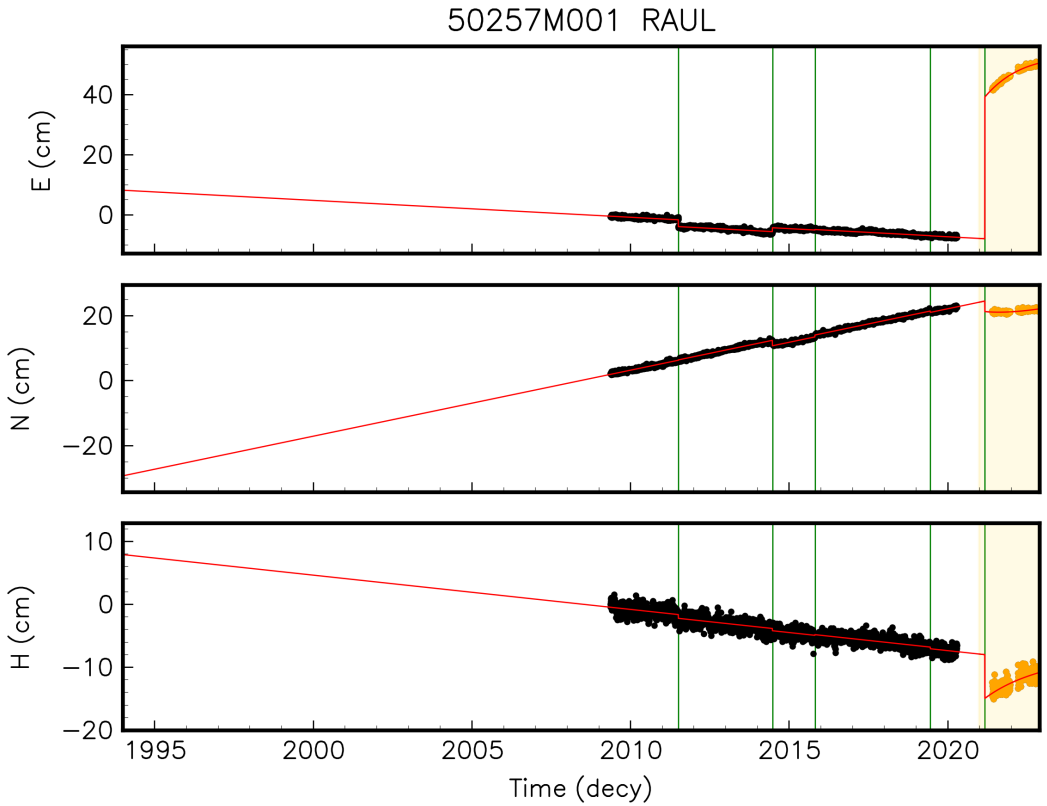
To *test* the JTRF2020 UPDATE analysis pipelines, we are using:

1. **(P) GNSS** IGSR3-igR3.atx. Extended IGS Repro3 combination expressed in the IGSR3 frame and consistent with igsR3.atx [6]. (695 daily SNX files)
2. **(R) VLBI** ivs2020a & gsf2023a. **Operational** IVS combination ivs2020a and **GSFC** solution gsf2023a used to restore Non-Tidal Atmospheric loading (NTAL). (241 session-wise SNX files)
3. **(L) SLR** ilrsa v85. Official ILRS Combination product compliant with the ITRF2020 Update CfP [3]. (159 weekly SNX files)
4. **(D) DORIS** wd21. Official IDS Combination product [4]. (131 weekly SNX files)

# 3. Gearing Up for the JTRF2020 UPDATE

- Priors of post-seismic displacement (**PSD**) models, (e-folding times & amplitudes of exp basis functions) were **updated** based on the analysis of station position time series [see Sld 4] .
- Station position & velocity discontinuities were also **updated**.
- The **data editing** pipelines formulated for JTRF2020 were applied to the frame inputs described in [Sld 2] :
  - *Outlier detection* ($7\sigma$-level) is based on *SREF Intrinsic Stacks* (with linear station motion model & PSD) of the frame inputs.
- Note that *no additional stations* will be introduced in the JTRF2020 UPDATE besides those already included in the JTRF2020 solution.
- To maintain consistency with the JTRF2020 frame inputs, the IVS **operational** products [see Sld 2] **must** be **pre-processed** [see Sld 5] prior to any SREF assimilation test.
- Although SREF is designed to generate updates from operational products, for the JTRF2020 UPDATE plans are in place to fully switch to the set of frame inputs compliant with the ITRF2020 Update CfP (P: IGSR3-ig20.atx, R: tbd, L: ilrsa-v85, D: ids-wd22)

# 4. Station Position Time Series from the Edited Frame Inputs

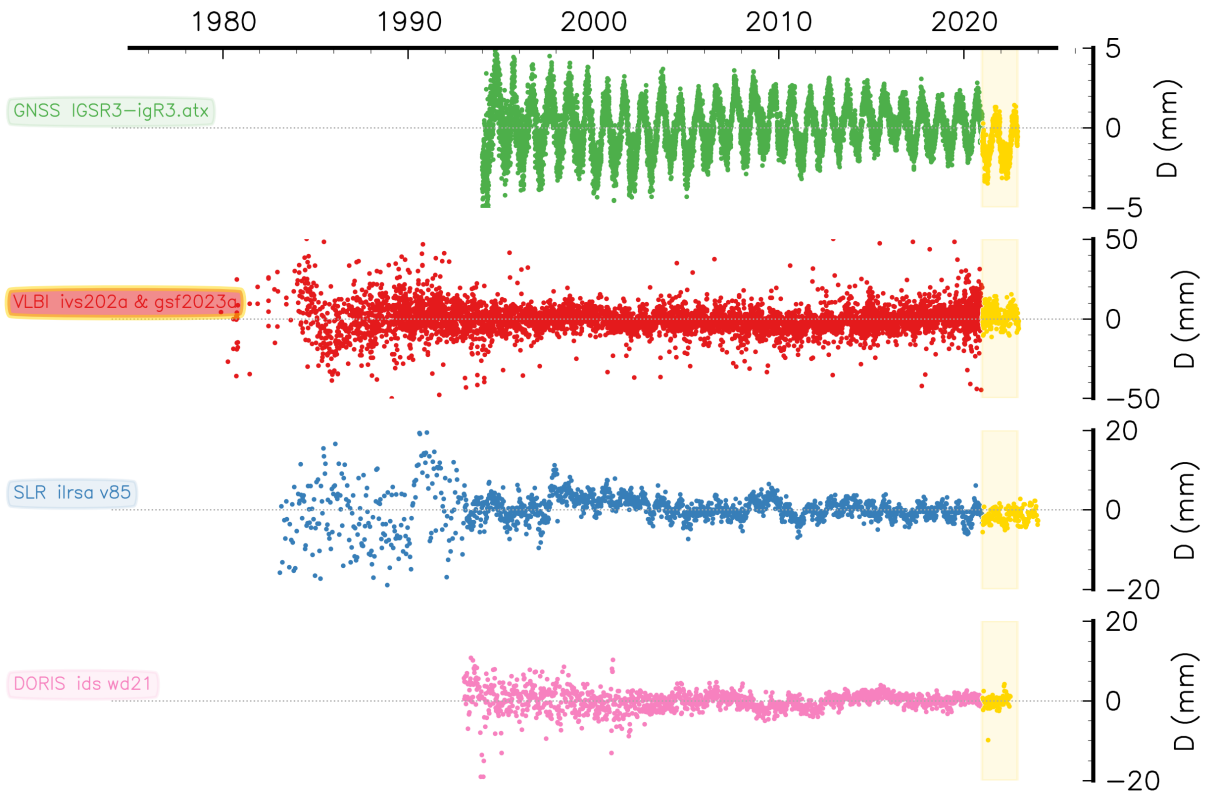



Station Position Time Series of RAUL (GNSS) derived from an intrinsic stack of the edited IGSR3-igR3.atx frame inputs (black/orange dots). Vertical green lines mark position discontinuities. Post-seismic relaxation in the yellow-shaded update interval is markedly evident. The SREF-estimated state is in red/gold.

# 5. Pre-processing of the Operational IVS Inputs

- Unlike the IVS submission to ITRF2020, the extended **operational ivs2020a** series was combined from single Analysis Center (AC) contributions wherein
  - NTAL was removed from the observing station positions
  - the geodetic parameters, generally *interpolated at noon*, were reported at *mid-session*.
- In our pre-processing of the ivs2020a series:
  - the NTAL elastic displacements were restored back into the station positions at the Normal Equation level [see e.g. 2] by using the `CALIBRATION` blocks reported in the **GSFC** SINEX files (**gsf2023a**)
  - The EOPs were interpolated at noon:
    (i) The long-period UT1/LOD tidal model by [5] was removed from the ivs2020a mid-session UT1/LOD, (ii) the UT1/LOD residuals *linearly interpolated* and (iii) the UT1/LOD model restored.
- The intrinsic IVS scale derived from accumulating the *edited* JTRF2020 IVS2020 frame inputs (in red) along with the *ivs2020a & gsf2023b* series (in gold) is shown in [Sld 6] .

# 6. Intrinsic Scales from the Edited Frame Inputs



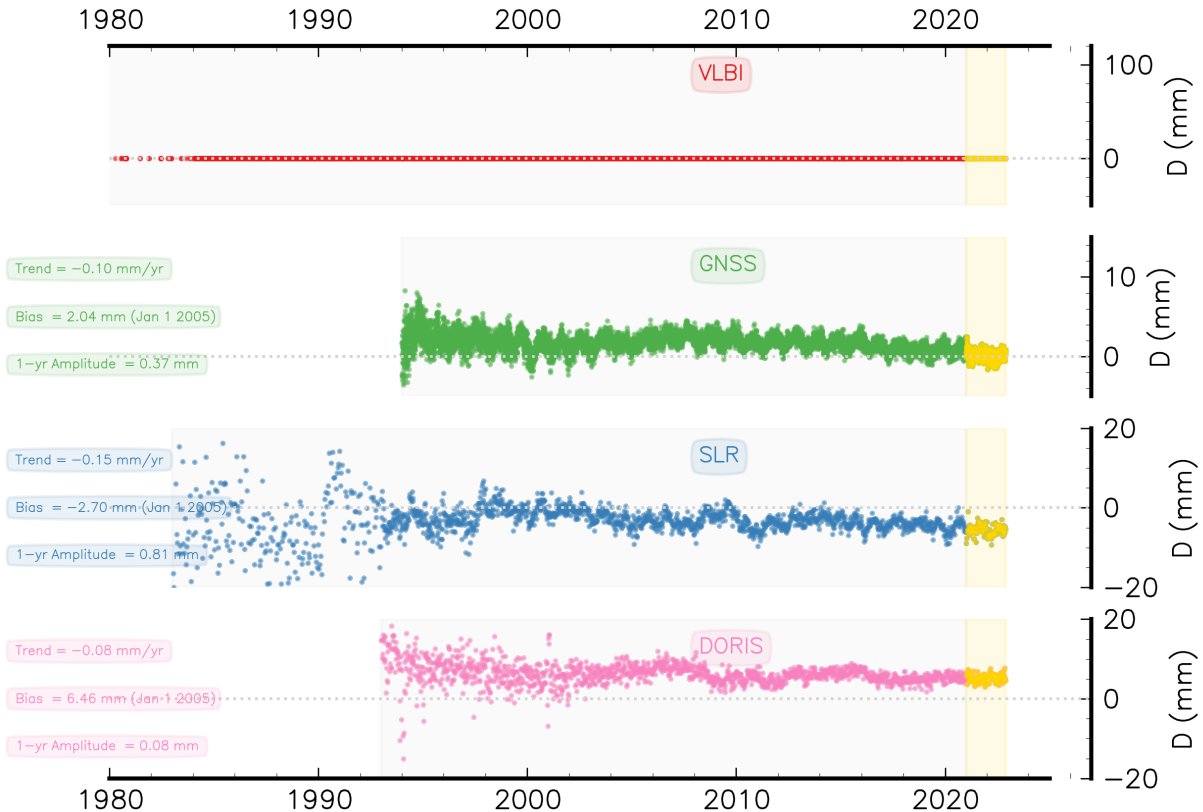

Intrinsic scale time series generated by SREF-stacking single-technique **extended frame inputs** via linear + PSD station motion model. The dotted curves represented in gold denote the scale parameters of the updated series discussed in [Sld 2].

# 7. JTRF2020 UPDATE - Preliminary SREF Tests

We discuss **uRW1b**, the SREF **update** results [Sld 8, 9 & 10] generated by restarting **RW1b**, a simplified JTRF-like solution:

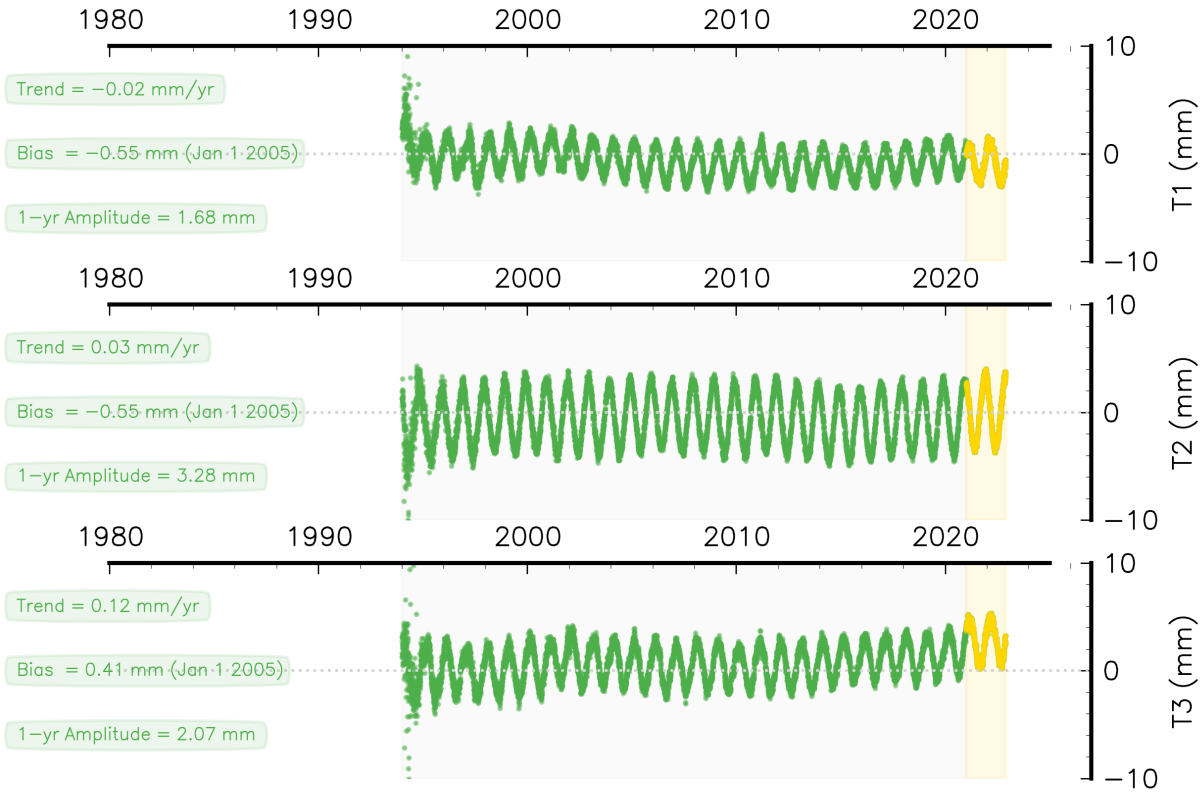
- Adopting the JTRF2020 *frame calibrations* (tie weights, co-motion constraints) on a *reduced network* of 593 stations, **RW1b** assimilates all of the JTRF2020 frame inputs through the end of 2020 and smoothes them back with a weekly time step to produce a JTRF-like solution whose (i) *origin* is at the instantaneous CM given by SLR, (ii) *scale* is given by VLBI and (iii) the *orientation* is realized via NNR to ITRF2014.
- **uRW1b** uploads **RW1b**'s last smoothed state and square-root covariance and updates them by assimilating the extended frame inputs of [Sld 2] . In **uRW1b**, SREF filters the *new data* till the end of 2023 and smoothes them backward in time up to the end of 2020.
- SREF state parameters include, in both runs, linear trends, 1 cpy oscillators, PSD & first-order auto-regressive processes, plus EOP's, and Helmert transformation parameters.

# 8. Scale Biases relative to VLBI



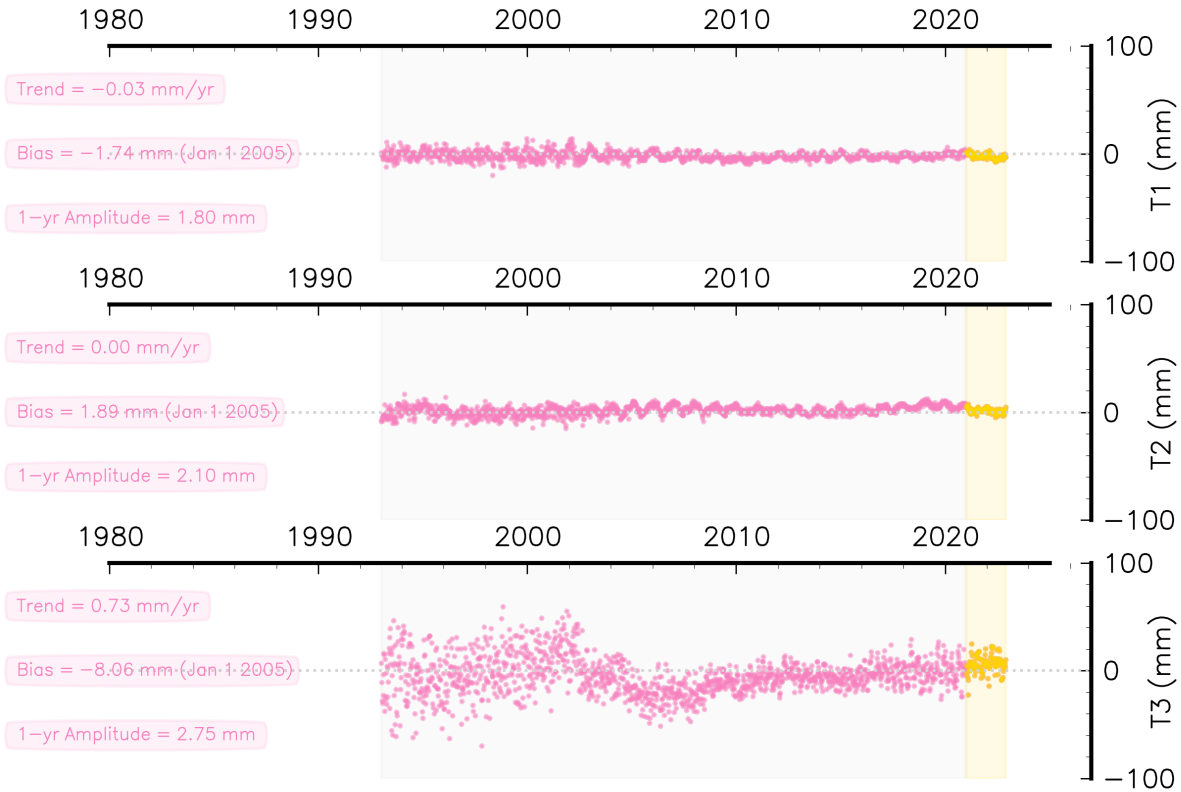

Time-variable scale biases relative to VLBI extracted from the SREF state for **RW1b** (gray-shaded areas of the plots before 2021) and **uRW1b**, the update run, plotted in gold. Values in the boxes are estimates of a least-squares fit to the time series obtained by joining **RW1b** and **uRW1b** under the assumption that no discontinuity exists between the two series.

# 9. GNSS Origin Biases relative to SLR




Time-variable translations linking GNSS to SLR as extracted from the SREF state for **RW1b** (gray-shaded areas of the plots before 2021) and **uRW1b**, the update run, plotted in gold. Values in the boxes are estimates of a least-squares fit to the time series obtained by joining **RW1b** and **uRW1b** under the assumption that no discontinuity exists between the two series.

# 10. DORIS Origin Biases relative to SLR




Time-variable translations linking DORIS to SLR as extracted from the SREF state for **RW1b** (gray-shaded areas of the plots before 2021) and **uRW1b**, the update run, plotted in gold. Values in the boxes are estimates of a least-squares fit to the time series obtained by joining **RW1b** and **uRW1b** under the assumption that no discontinuity exists between the two series.

# 11. JTRF2020 UPDATE - Next Steps

- *Assimilate* the special set of frame inputs compliant with the ITRF2020 Update CfP, by switching to GNSS:IGSR3-ig20.atx, VLBI:(tbd), and DORIS:ids-wd22.
- *Produce* a SREF UPDATE solution by replicating the two-step procedure used to generate JTRF2020:
  1. **RD1b**, the JTRF2020 first-step solution generating a TRF whose the scale is given by VLBI, and its update, **uRD1b**, will be used to infer the VLBI-to-SLR **time-variable** scale bias and determine the time-variable scale correction to apply to the **ilrsa v85** frame inputs.
  2. With the SLR scale correction determined at Step 1, the JTRF2020's last smoothed state and square-root will be uploaded and, by applying SLR scale correction determined at Step 1, we'll determine the JTRF2020 UPDATE solution.
- *Assess* the existence of potential discontinuities in the frame-defining parameters when the updates start.
- *Quantify* the degree to which the updated frame-defining parameters change in relation to the JTRF2020 predictions.

# 12. Acknowledgements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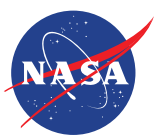
- We wish to acknowledge the crucial contributions provided by the Technique Services (IVS, ILRS, IGS, IDS) and their tremendous efforts put into the re-analyses of the space-geodetic databases.

- For any comment, question or specific request, please feel free to contact us at jtrf@jpl.nasa.gov.

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