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# A comparison of ITRF2014, DTRF2014 and JTRF2014 using SLR

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**Most recent ITRS realizations**

The International Terrestrial Reference Frame (ITRF) is the realization of the International Terrestrial Reference System (ITRS). The most recent ITRF solutions have been computed by the ITRS Combination Centres (CCs) of the International Earth Rotation and Reference Systems Service (IERS), namely

- **ITRF2014** (IGN, Paris, France),
- **DTRF2014** (DGFI-TUM, Munich, Germany), and
- **JTRF2014** (JPL, Pasadena, USA).

The three ITRF solutions are based on identical input data but differ w.r.t. the applied software and computation strategy (Tab. 1).

*Tab. 1: Characteristics of the three different ITRS realizations.*

| ITRF solution | ITRF2014 | DTRF2014 | JTRF2014 |
|---|---|---|---|
| Institute | IGN (Paris, France) | DGFI-TUM (Munich, Germany) | JPL (Pasadena, USA) |
| Software | CATREF | DOGS-CS | CATREF + KALMAN |
| Combination approach | Solution (parameter) level | Normal equation level | Solution (parameter) level |
| Station position | Position $X_{ITRF}(t_0)$<br>+ velocity $\dot{X}_{ITRF}(t_0)$<br>+ PSD models | Position $X_{DTRF}(t_0)$<br>+ velocity $\dot{X}_{DTRF}(t_0)$<br>+ NT-L models<br>+ SLR origin<br>+ residual station motions | Weekly positions $\tilde{X}_{JTRF}(t_i)$ |

To validate the ITRS realizations, two different time intervals are defined:

- **Interpolation time period** (1993.0 – 2015.0),
- **Extrapolation time period** (2015.0 – 2017.0).

The JTRF2014 is only available in the interpolation time period. With the DTRF2014 solution, all station coordinates (including those of stations affected by post-seismic deformations) can be extrapolated with the conventional (linear) velocities.

Due to the different approaches, the final ITRS realizations differ to a certain extent. Fig. 1 shows the estimated height components of four selected satellite laser ranging (SLR) stations w.r.t. common mean values within the interpolation interval. The ITRS realizations differ by up to several cm w.r.t. each other. Moreover, they show significant discrepancies in the extrapolation interval which accumulate with time.

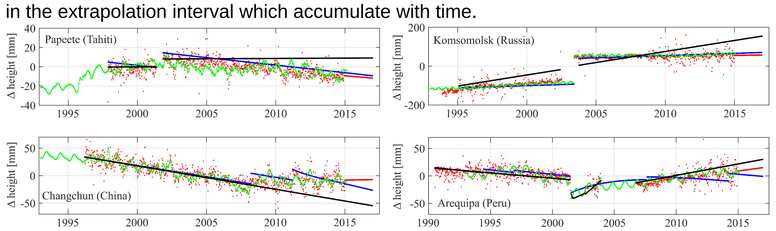


*Fig. 1: Residual height time series of Papeete (Tahiti), Changchun (China), Komsomolsk (Russia) and Arequipa (Peru) for the interpolation interval (1993.0 – 2015.0) and the extrapolation interval (2015.0 – 2017.0) from four different ITRS realizations: most recent SLRF2008 (black), ITRF2014 (blue), DTRF2014 (red), and JTRF2014 (green).*

**Validation within the interpolation time period**

To evaluate the quality of the different ITRS realizations, we use satellite laser ranging (SLR) observations and analyze weekly estimated range biases for stable (core) stations of the SLR network. Within the analysis, the stations are fixed to the respective ITRS realization. Fig. 2 shows the mean weekly biases for the core stations of the International Laser Ranging Service (ILRS). The largest mean biases are obtained for the SLRF2008 whereas the results of the other three ITRS realizations are comparable.

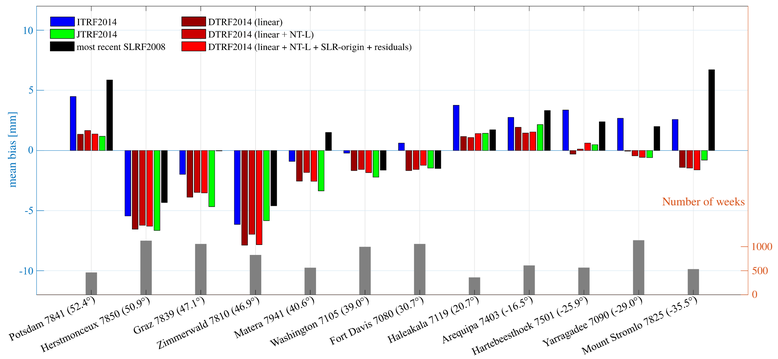


*Fig. 2: Estimated mean station-specific weekly range biases for different ITRS realizations in the interpolation time period for LAGEOS-1. In addition, the number of processed weeks is shown for each station.*

Besides the obtained range biases, also the estimated orbits based on the ITRS realizations can be compared. Therefore, Fig. 3 summarizes different estimated empirical accelerations as well as the resulting orbit fits of all stations and the ILRS core stations only. The DTRF2014 (linear + NT-L) solutions performs worst in the case of the orbit fits as well as in the case of the empirical accelerations. The DTRF2014 (with all models) as well as the JTRF2014 cause a significant offset in the once-per-revolution cross-track sine term. In all other empirical components, the ITRS realizations perform nearly equal. In the period 2005.0 – 2015.0, all ITRS realizations perform nearly equal in all components.

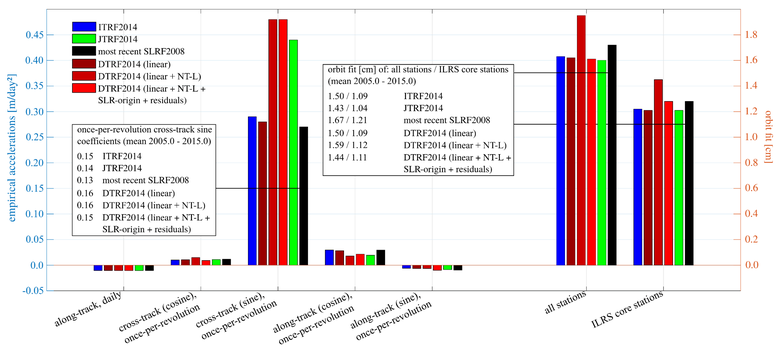


*Fig. 3: Estimated mean empirical accelerations (daily along-track and once-per-revolution along/cross-track) of LAGEOS-1 within the interpolation time period for different ITRS realizations and resulting orbit fits of all stations and the ILRS core stations only.*

**Validation within the extrapolation time period**

Within the extrapolation time period, only the conventional linear station motion model is available for the DTRF2014 solution. This means, the linear DTRF2014 is compared to the ITRF2014 (linear + PSD model) and the most recent update of the SLRF2008. As well as for the interpolation time period, mean weekly biases for the core stations are shown for the extrapolation time period in Fig. 4. The diverse velocities of Arequipa (Fig. 1) clearly affect the estimated range biases.

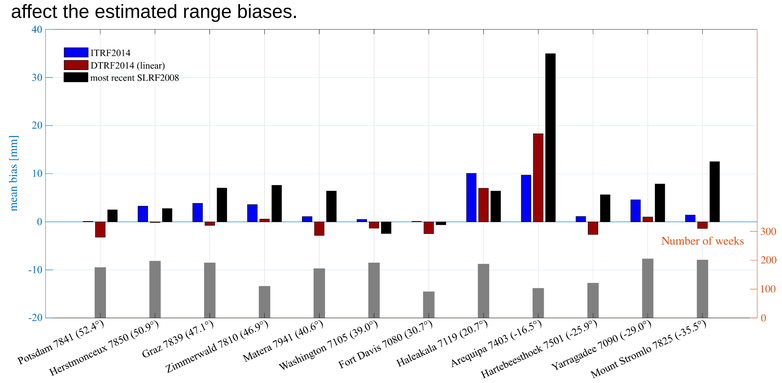


*Fig. 4: Estimated mean station-specific weekly range biases for different ITRS realizations in the extrapolation time period for LAGEOS-1. In addition, the number of processed weeks is shown for each station.*

In general, the SLRF2008 causes the largest range biases. The comparison of the ITRF2014 and DTRF2014 results shows that the DTRF2014 solution causes some smaller biases in Europe whereas the ITRF2014 performs slightly better on the southern hemisphere.

As shown in Fig. 1, the estimated velocities for Komsomolsk (Russia) differ significantly after 2015.0. Fig. 5 shows the pass-wise estimated range biases for the three ITRS realizations. Whereas the mean offset between ITRF2014 and DTRF2014 is still below 1 mm, the offset w.r.t. the SLRF2008 already increased to 4-6 cm within the two years of the extrapolation time period.

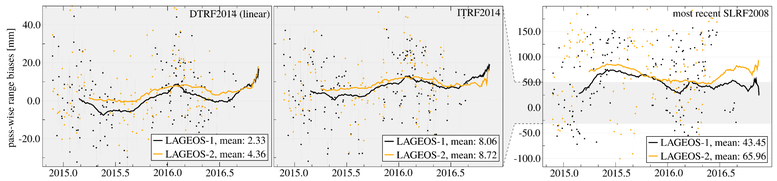


*Fig. 5: Estimated pass-wise range biases of Komsomolsk (Russia) for different ITRS realizations in the extrapolation period.*

The comparison of the three ITRS realizations using SLR shows large discrepancies within the interpolation time period (1993.0 - 2015.0). Especially the differences in the height component cause systematic differences in estimated range biases of stations.

In the extrapolation time period, the estimated velocities of the ITRF2014 and DTRF2014 solution already cause differences of several cm. This systematic effect will increase until a next ITRS realization is computed.