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SLR-based TRF Contributing to the ITRF2000 project

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Abstract

The 10-year TRF solution constructed by Communications Research Laboratory contributed to the ITRF2000 project as one of SLR solutions. Our solution used LAGEOS-1 and -2 data to derive the position and velocity vectors of 60 worldwide stations.

The ITRF2000 final solution released in March 2001 adopted the newly defined datum based on SLR and VLBI. The SLR-based TRFs had a great advantage in the precise determination of the origin (a few mm) and the scale (~1 ppb).

1. Introduction

Along with VLBI and GPS, satellite laser ranging (SLR) has contributed to space geodesy for decades. Currently, the instrument error in good SLR observatories has been reduced to a few millimetres. SLR has also benefited from the well-modelled tropospheric correction model of optical wavelength compared with microwave-based techniques. The greatest advantage of SLR is in the determination of the gravitational scale of the Earth (GM) and the origin and scale of the terrestrial reference frame (TRF) [1] [2].

The International Terrestrial Reference Frame (ITRF) is used worldwide as a standard set of TRF. It is a combination of solutions from multiple space geodetic techniques including VLBI, GPS, SLR, LLR and DORIS. The International Earth Rotation Service (IERS) has assembled the latest version, ITRF2000, from more than 30 contributions [3].

At CRL, we gained experience in analysing orbit determination from developing our own software package CONCERTO [4]. We constructed a TRF, SSC(CRL)00L02, from global satellite laser ranging data obtained over the last ten years, and made our first submission to the ITRF2000 project.

2. Construction of SSC(CRL)00L02

The following set of satellite laser ranging data was reduced in CONCERTO:

- LAGEOS-1 and LAGEOS-2
- ILRS 2-minute normal-point
- MJD 47000-51500 (roughly 1990.0 to 2000.0)
- 60 stations at 48 sites

Since it was impossible to solve all the parameters at once, we divided the whole sequence into two stages (Fig. 1). First, we prepared 73 observation data sets of 50-day spans so that the whole data covered ten years. In each of the 50-day spans, the satellite orbits, EOPs, range biases and station coordinates were loosely solved for. The Java version of CONCERTO with models mostly compatible with IERS Conventions [5] was used. We obtained 73 sets of solutions of station positions. We then assembled the 73 sets and derived three-dimensional positions and velocities for the 60 stations, again applying loose constraints: 10 m for positions and 1 m/y for velocities. The solution, SSC(CRL)00L02, was submitted to the ITRF2000 project in April 2000.

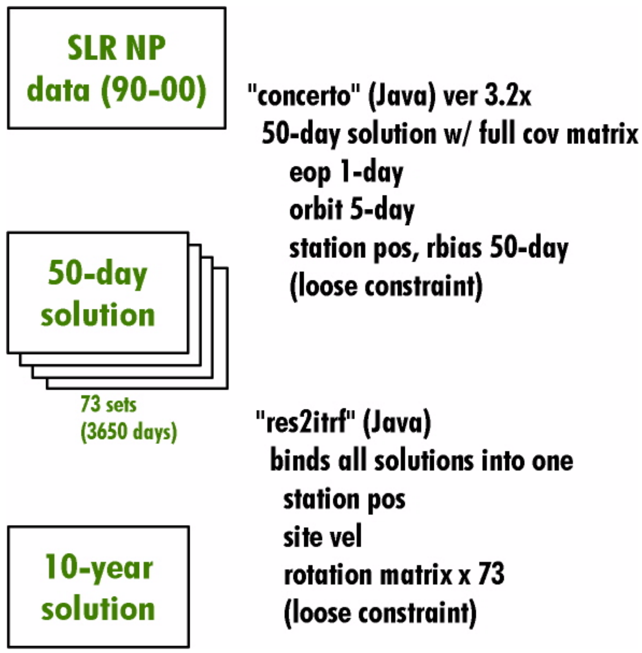

Figure 1. SSC(CRL)00L02 data flow.

3. Quality of SSC(CRL)00L02

A loosely estimated solution rotates freely and is not suitable for measuring the formal error or for direct comparison with other TRFs. We therefore constructed a tightly constrained TRF SSC(CRL)00L01.

For "good" laser ranging stations that have consistently yielded high quality data, the formal errors of the estimated positions were 0.5-0.8 mm for horizontal and 1.5-2.0 mm for vertical components. Velocity errors were 0.2-0.3 mm/y for horizontal and 0.3-0.8 mm/y for vertical components.

We compared the TRF SSC(CRL)00L01 with the former standard ITRF97 and the new standard ITRF2000. The horizontal and vertical velocity vectors of the major stations are shown in Fig. 2. For the "good" stations located at a collocation site, the average differences of position between ours and ITRF2000 were < 3 mm for horizontal and about 8 mm for vertical components, and those of velocity were 1.5 mm/y for horizontal and 2.5 mm/y for vertical components, which is not as good as VLBI and GPS solutions but comparable with other SLR solutions. Considering the estimated error, no significant vertical motion was detected in any of these laser ranging stations. Owing to the recent improvement in Chinese and Russian laser ranging stations, we got a more realistic assessment of their horizontal motion than that in ITRF97, which was reflected in

ITRF2000.

Of the nine SLR solutions submitted to the ITRF2000 project, seven were included in the final ITRF2000 solutions, and five (CGS, CRL, CSR, DGFI and JCET) were used to establish the newly defined datum. The CRL solution was one of the five. The scale of the Earth is defined by the three VLBI solutions (50%) and the five SLR solutions (50%), and the origin is defined by the five SLR solutions (100%). The CRL solution sits around the centre of the five solutions for both scale and origin (see IERS [6] for details).

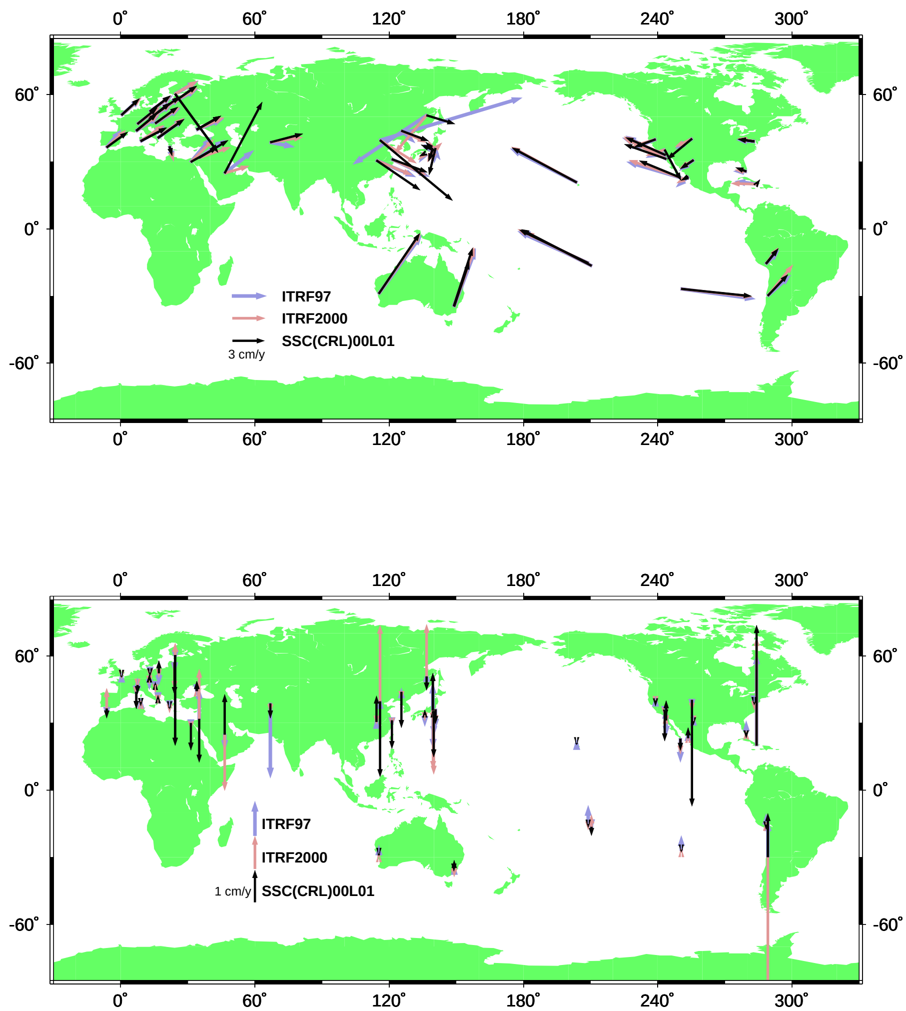

Figure 2. SSC(CRL)00L02 velocity field in comparison with ITRF97 and ITRF2000. Top: horizontal components. Bottom: vertical components.

4. Conclusions

We contributed to the ITRF for the first time. The ITRF2000 project showed that CRL's ten-year solution was comparable to other good solutions and it was actually used to define the new datum (scale and origin). This suggests that our software CONCERTO is reliable for constructing long-term TRFs.

The Analysis Working Group of the International Laser Ranging Service (ILRS) is working hard to establish a scheme to routinely generate the best combined solution from several local solutions. CRL, as an associate analysis centre of ILRS, has contributed to all of the pilot projects.

SLR is expected to provide the most accurate scale of the Earth, but the SLR solutions are scattered by $\pm$ 1 ppb, which is larger than the scatter of VLBI solutions, in the ITRF2000 project. Analysts need to overcome the error sources currently degrading the scale of the Earth, such as the atmospheric correction model and the centre-of-mass correction of geodetic satellites.

References

[1] Smith, D. E., R. Kolenkiewicz, P. J. Dunn, M. H. Torrence, Earth scale below a part per billion from satellite laser ranging, Geodesy beyond 2000, IAG General Assembly, Springer, 3-12, 1999.

[2] Eanes, R., Corrections to the Marini-Murray refraction model that affect the scale of the SLR station solutions and GM, Proceedings of 12th International Workshop on Laser Ranging, 2000 (in print).

[3] Altamimi, Z., The accuracy of ITRF2000, European Geophysical Society XXVI General Assembly, G6, 2001.

[4] Otsubo, T., H. Kunimori, B. Engelkemier, F. Takahashi, Error control of numerical integration in SLR analysis software CONCERTO, Journal of the Geodetic Society of Japan, 40, 4, 347-355, 1994.

[5] IERS, IERS Conventions (1996), IERS Technical Note 21, 1996.

[6] IERS, ITRF2000 website, http://lareg.ensg.ign.fr/ITRF/ITRF2000/, 2001.