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S. Boissier, M. Heydari-Malayeri, R. Samadi and D. Valls-Gabaud (eds)

GRGS EVALUATION OF THE ITRF2008P SOLUTION, FROM SLR DATA

F. Deleflie[1] and D. Coulot[2]

Abstract. Following Deleflie and Coulot (2009), this paper aims to analyse the preliminary version of the new realization of the International Terrestrial Reference System called ITRF2008p. We compare the quality of the products that we regularly provide as an official ILRS Analysis Center (AC) with the ones obtained using ITRF2008p instead of the ILRS Analysis Working Group rescaled version of ITRF2005. We also compare our results to those obtained by other ACs, in terms of Space Station Coordinates (SSC), Earth Orientation Parameters (EOP), translations and scale factors, following our operational analysis scheme of SLR data, that we performed over the period 1995-2010.

Keywords: SLR data, International Terrestrial Reference Frame, GRGS, space geodesy

1 Introduction

The International Terrestrial Reference System (ITRS) realizations are established and maintained with the global space geodetic networks. The network measurements must be precise, continuous, worlwide, and interconnected by co-locations of different observing techniques. The requirements to be followed in the framework of the GGOS project are to perform a global Terrestrial Reference Frame (TRF) with an accuracy of 1.0 mm, and a stability of 0.1 mm/yr, ensuring a sea level rise measurement coherent with the altimetric data precision. IGN has released during March 2010 the ITRF2008P preliminary version of the next ITRF for evaluation by the technique services. An enormous effort has been achieved by these services (IVS, ILRS, IGS, IDS) and their Analysis and Combination Centers, to provide reprocessed solutions. The quality of the ITRF2008 is certainly benefiting from these technique improved solutions. The Satellite Laser Ranging (SLR) technique is one of these techniques, organized through the International Laser Ranging Service (ILRS) (Pearlman et al., 2002). Each Analysis Center (AC) solution contains Space Station Coordinates (SSC) and daily EOP, using Lageos and Etalon data, according to ILRS/ Analysis Working Group (AWG) guidelines.

The AWG of the ILRS worked on the ITRF2008 submission during the first part of 2009. The combined solution was based on the contribution of seven Analysis Centers (ASI, DGFI, GA, GFZ, our own contribution for GRGS, JCET, and NSGF). After a few dedidated AWG meetings during spring 2009, the final contribution of ILRS for ITRF2008 was sent to IERS during August 2009.

2 Orbit computation

Two geodetic satellites, Lageos-1 and Lageos-2, were used in this study, with an orbital modelling following the AWG guidelines. In particular, we accounted for the last release of the file containing all the data corrections to be applied to SLR data. These data came from about 30 tracking stations (most of them located in the northern hemisphere, due to a well-known heterogeneity of the ILRS network), gathering up a total of 2000 to 3000 normal points per week and per satellite.
Two computations were carried out, the first one using the ILRS AWG rescaled version of ITRF2005 (SLRF2005) for a priori SSC, the second using ITRF2008p. The levels of magnitude of weekly residuals are very similar (for Lageos-1, a mean of 1.27cm $\pm$ 2.47mm for SLFR2005, and 1.18cm $\pm$ 2.02mm for ITRF2008p ; for Lageos-2, a mean of 1.26cm $\pm$ 2.47mm for SLRF2005, and 1.17cm $\pm$ 2.16mm for ITRF2008p), even if a slight difference

[1] IMCCE-Observatoire de Paris / GRGS, 77 Avenue Denfert Rochereau, F-75014 Paris
[2] Institut Géographique National, LAREG / GRGS, ENSG, 6-8 Avenue Blaise Pascal, 77455 Champs-sur-Marne, France

can be seen over the period 2007-2009. Figure 1 shows the level of weekly residuals for Lageos-2. There are no significant differences between the time series of orbital parameters deduced from the post-fit analysis with SLRF2005 or ITRF2008p (by the way, it should be worth studying to what extent such expected differences can be absorbed or not through the set of empirical parameters used to compensate the lack of non gravitational forces modelling).

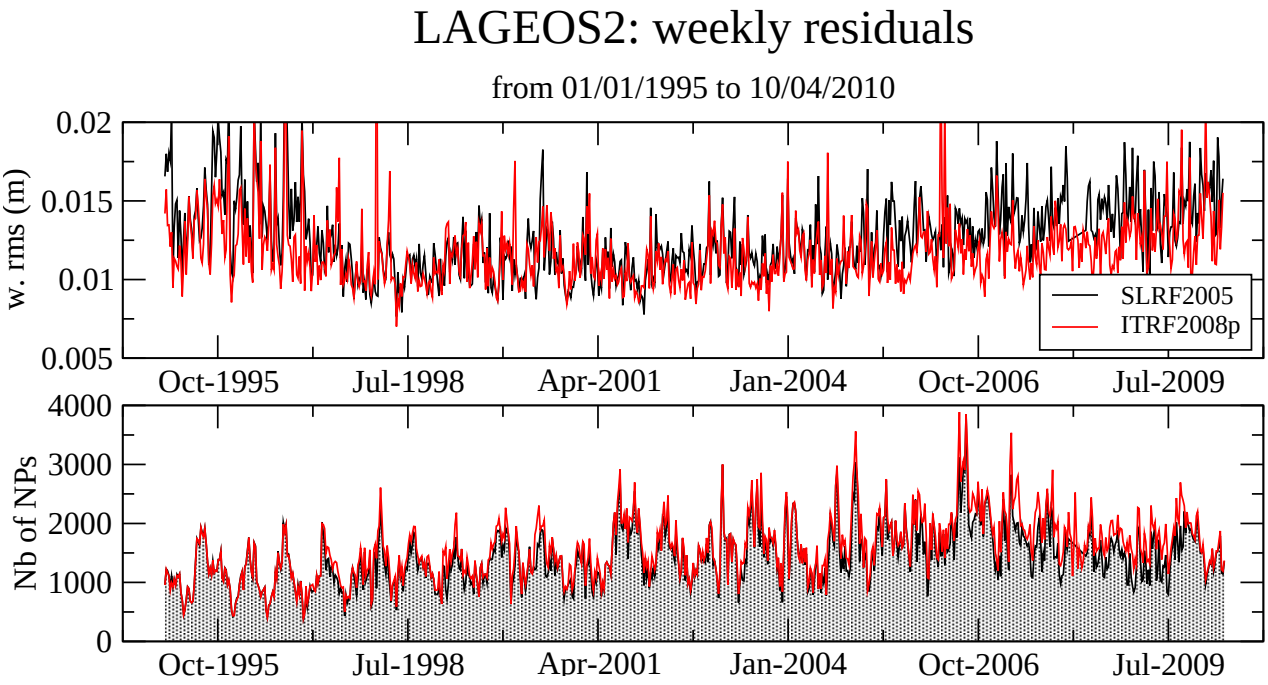

Fig. 1. Residuals of weekly arcs of Lageos-2, from 01/01/1995 to 10/04/2010, and numbers of normal points per week

3 Helmert transformation

To compare various terrestrial frames, realized as sets of SSC, a 7-parameter transformation is estimated, and described by translations (T_x, T_y, T_z), rotations (R_x, R_y, R_z), and a scale factor (D). The transformations are, for the station i, provided though two sets of coordinates (X_i^0, Y_i^0, Z_i^0) and (X_i^1, Y_i^1, Z_i^1),

$$\begin{pmatrix} X_i^1 \\ Y_i^1 \\ Z_i^1 \end{pmatrix} = \begin{pmatrix} X_i^0 \\ Y_i^0 \\ Z_i^0 \end{pmatrix} + \begin{pmatrix} 1 & 0 & 0 & X_i^0 & 0 & -Z_i^0 & Y_i^0 \\ 0 & 1 & 0 & Y_i^0 & Z_i^0 & 0 & -X_i^0 \\ 0 & 0 & 1 & Z_i^0 & -Y_i^0 & X_i^0 & 0 \end{pmatrix} \begin{pmatrix} T_x \\ T_y \\ T_z \\ D \\ R_x \\ R_y \\ R_z \end{pmatrix}$$

and for the corresponding EOP (x_p^1, y_p^1, UT^1) and (x_p^0, y_p^0, UT^0), with $f = 1.002737909350795$,

$$\begin{pmatrix} x_p^1 \\ y_p^1 \\ UT \end{pmatrix} = \begin{pmatrix} x_p^0 \\ y_p^0 \\ UT^0 \end{pmatrix} + \begin{pmatrix} 0 & -1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & \frac{1}{f} \end{pmatrix} \begin{pmatrix} R_x \\ R_y \\ R_z \end{pmatrix}$$

		ITRF2005	ITRF2008p
T_x	weighted mean	−0.83	−0.05
(mm)	weighted std. dev.	3.97	3.50
	WRMS	4.05	3.50
T_y	weighted mean	−0.13	0.05
(mm)	weighted std. dev.	3.76	3.35
	WRMS	3.76	3.35
T_z	weighted mean	1.29	0.76
(mm)	weighted std. dev.	7.35	7.03
	WRMS	7.46	7.07
scale	weighted mean	−1.91	−0.45
(ppb)	weighted std. dev.	0.69	0.42
	WRMS	2.03	0.62

Table 1. Helmert parameters between (i) ilrsa-v24 solution and ITRF2005, (ii) ilrsa-v24 solution and ITRF2008p

		ITRF2005	ITRF2008p
X_p	weighted mean	40	−2
(μas)	weighted std. dev.	228	203
	WRMS	232	203
Y_p	weighted mean	43	−5
(μas)	weighted std. dev.	222	204
	WRMS	226	204

Table 2. Differences between the pole coordinates from ilrsa-v24 solution consistent with (i) ITRF2005, (ii) ITRF2008p, and the IERS 05 C04 reference time series

4 Results and comparisons between SLRF2005, ITRF2005 and ITRF2008p

4.1 A priori values

We had a look at the differences between the observations (range) and the theoretical corresponding values (distances between the tracking stations and the satellites), computed from (i) the orbit and (ii) the SSC provided in SLRF2005 or ITRF2008p. These differences were reported before adjusting any parameter. When using ITRF2008p, we show that there is an improvement of the RMS of the a priori residuals for the great majority of the stations (for Lageos-1, improvement for 82 % of the stations, with a median improvement of 1.5 mm ; for Lageos-2, improvement for 87 % of the stations, with a median improvement of 2.0 mm). The coordinates of the station number 7810 (Zimmerwald, Switzerland), which is one of the most stable stations in the ILRS network, have ever been improved at the level of 5.7 mm for Lageos-1, and 7.8 mm for Lageos-2 (and we can as well mention the improvement for 7403 (Arequipa, Peru), at the levels of 53.1 mm and 32.4 mm respectively).

4.2 Helmert parameters between (i) ilrsa-v24 combined solution, (ii) SLRF2005, and (iii) ITRF2008p

Figure 2, Tables 1 and 2 show the comparison, for the main parameters defining a TRF and Earth's rotation, between the ilrsa-v24 ILRS combined solution and ITRF2005 and ITRF2008p. It appears that for all parameters, the differences are lower when using ITRF2008p, and that there is a better stability of time series achieved with ITRF2008p. Let us notice, moreover, that the difference for the scale of the ilrsa-v24 solution is much lower with ITRF2008p than with ITRF2005, as shown Figure 2, and Table 1.

5 Short analysis of the contribution of each ILRS AC

Table 3 shows the WRMS of Helmert parameters and of EOP and station position residuals for each individual solution contributing to the combined solution ilrsa-v24 w.r.t. this latter. These values can be seen as quality indicators of each ILRS AC contribution w.r.t. the combined solution.

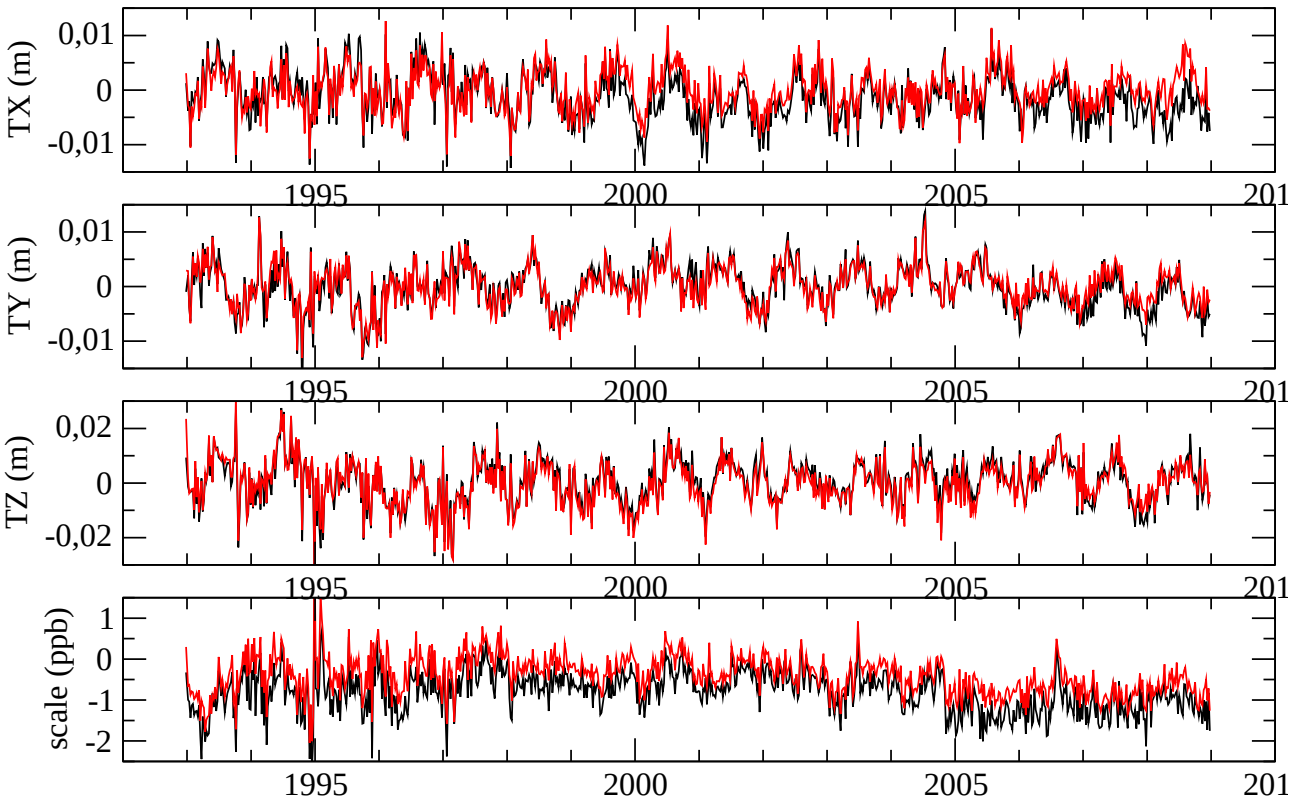

Fig. 2. Translations and scale factors (in mm) between the ilrsa-v24 solution and (i) ITRF2005 and (ii) ITRF2008p

Solution	TX(mm)	TY(mm)	TZ(mm)	D (ppb)	E (mm)	N (mm)	U (mm)	Xp (μas)	Yp(μas)
		WRMS			Median WRMS of residuals			WRMS	
		over 1993.0-2009.0			all stations (20 core stations)				
ASI-v23/ilrsa-v24	1.6	1.5	4.9	0.33	5.97 (4.41)	6.54 (5.31)	4.10 (2.97)	164	156
DGFI-v24/ilrsa-v24	4.42	3.43	7.17	0.47	12.63 (8.26)	13.07 (10.11)	8.28 (5.98)	333	310
GA-v22/ilrsa-v24	1.27	1.07	4.41	0.16	9.46 (5.59)	10.25 (5.76)	7.29 (3.97)	208	178
GFZ-v23/ilrsa-v24	2.59	2.77	6.21	0.49	8.56 (6.32)	9.53 (7.55)	6.17 (4.86)	332	316
GRGS-v24/ilrsa-v24	1.62	1.47	1.72	0.2	6.87 (4.29)	7.28 (4.51)	5.10 (3.42)	176	166
JCET-v23/ilrsa-v24	1.20	1.09	3.77	0.26	9.13 (5.79)	9.56 (6.82)	18.60 (12.66)	242	218
NSGF-v24/ilrsa-v24	4.54	5.08	9.76	0.63	14.34 (10.53)	16.76 (12.49)	11.74 (7.43)	554	466
ilrsa v24 / ITRF2008p	*3.50*	*3.35*	*7.07*	*0.62*	*10.91*	*10.63*	*8.8*	*201*	*199*

Table 3. Helmert parameters and station positions and EOP residuals for AC individual contributions w.r.t. the ILRS combined solution, and for ilrsa-v24 solution w.r.t. ITRF2008p and the IERS 05 C04 series

6 Conclusion

We analysed the SLR part of the preliminary version of ITRF2008p. Based on an evaluation in terms of Helmert parameters and 3D WRMS of the coordinate residuals, it seems that the new ITRF is performing better. Station position series WRMS have a better stability in the three components, and we noticed big improvements for SLR stations 7810 and 7403. Let us note that since ITRF retrieves coordinates and velocities from coordinate time series, under the asumption of linear station motion, all the realizations, including ITRF2008, are potentially affected by earthquakes, - as the one that occured near Concepcion, Chili, during spring 2010-: new realizations of the ITRF will still be required by the next few years. By the next few months, as an ILRS Analysis center, we will report further the official (final) ITRF2008[1] reference frame delivered by the ITRS Product Center, as well as the reference frame provided by the DGFI Combination Center, following the same protocol as in this paper.

[1]The final ITRF2008 solution can now be downloaded at the dedicated web site: `http://itrf.ign.fr/ITRF\_solutions/2008/ITRF2008.php` .

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