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Quality assessment of SLR data-related products

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Abstract. *We analyse SLR data – related products that are computed from Lageos-1 and Lageos-2 data acquired by the ILRS network. We analyze time series of post-fit residuals for both satellites, biases and space stations coordinates (SSCs), that are deduced following the recommendations provided by the Analysis Working Group. We compute the same kind of products, with a GRGS updated version of SLRF2008. Finally, we propose a change in the operational strategy to improve the accuracy of the products delivered by the ILRS.*

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, worldwide, and interconnected by co-locations of different observing techniques. The requirements to be followed in the framework of the Global Geodetic Observing System (GGOS) 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, in particular but not only, a sea level rise measurement coherent with the altimetric data precision (Plag and Pearlman, 2009).

Following the operational analysis scheme of SLR data, that we perform over the period 1998-late 2013 from all the measurement acquired by the ILRS network (Pearlman and Degnan, 2002), we compute for the Lageos-1 and Lageos-2 satellites weekly arcs with (i) the current version of SLRF2008 (ii) a GRGS-updated version. Then, we analyze the sets of orbital parameters (in terms of weekly rms), of Earth Orientation Parameters (EOPs), and especially of Station Coordinates (SSCs). We aim at analyzing the 2013 relevance of the SLR-rescaled version of ITRF2008, SLRF2008, in view of the preparation of ITRF2013.

1. Orbit computation and methodological approach

The orbital modelling that we used follows the Analysis Working Group (AWG) guidelines, except for the loading effects that are accounted for as well. 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), gathering up a total of 2000 to 3000 normal points per week and per satellite. The main characteristics of the computation are shown Figure 1 for Lageos 2 (similar comments can be formulated for Lageos 1): a total of NPs more or less constant, even over the last few years, and a weekly residuals level a little bit larger at the end of the period.

Several computations were carried out, the first one using SLRF2008 as a « SLR version » of ITRF2008 (Altamimi et al., 2011), and seen as a reference for a priori SSC, the other ones being seen as possible improvements. The levels of magnitude of weekly residuals are very similar (Figure 2), even if a slight difference can be seen over the period 2009-2013, which corresponds to the period that was not used to generate ITRF2008.

As a test of the consistency of the bias adjustment recommendation provided by the AWG, we first follow a scheme where all the corrections written in the ILRS Data Handling File are accounted for, except for the range bias that are estimated for each station, including the core stations (which is not, of course, the approach to be followed by each AC when delivering the operational products). The period under consideration is 5th January 2003 – 13th Nov 2012. The data are eliminated by applying a 6-sigma criterion. We can then solve for positions and velocities of each station over the whole period, the range bias per station and satellite, as well as a translation for the whole network. Except for stations with a too low number of acquired NPs, each position and velocity is estimated, as well as the geocenter motion ; the constraints are loose contraints for the whole network, with position and range bias constraints at the level of 1m, and 1cm/yr for the velocities and the geocenter. To investigate the role played by the geocenter motion, we performed another test by fixing the station velocities and the geocenter motion to the a priori values (SLRF2008 and zero, respectively).

2. ITRF2008 features

Only one Set of Station Coordinates is estimated over the whole period.

Some differences may be noticed between the operational version of the coordinate file, and the updated version that we propose. For example, there exists a vertical velocity of 1 mm/yr for the Yarragadee station, whereas this value is zero in SLRF2008 (Figure 3). The difference between the free and estimated velocity cases shows the geocenter motion as an annual signal. Moreover, it appears that, based on a frequency map analysis, the amplitude of the annual term on the vertical coordinate is higher when the geocenter is fixed, than in the case where it is adjusted: it seems, as expected, that estimating the geocenter simultaneously with the station coordinates removes the part of the variations due to the global network change.

When investigating the evolution of SLRF2008 over the last few years, it appears that two groups of features can be noticed: errors in positions, errors in velocities. These features have of course to be identified as well by other ACs within the AWG before adopting a new official set for an updated version of SLRF2008.

For these stations, there exits a drift in the coordinates, meaning that the components of the velocity could be improved : Riga (1884), Komsomolsk (1868), Altay (1879), Yarragadee (7090), Chania (7830), Tanegashima (7358), San Juan (7406), Arequipa (7403), Concepcion (7405), Monument P. (7110).

Concerning the coordinates, a special care should be focused on the improvement of the vertical component for these stations: Mount Stromlo (7825), Graz (7839), Grasse (7845).

Morover, some features were identified after big earthquakes, such as in Concepcion (Figure 4), or in Koganei, where the instability of time series dramatically increases after the big earthquake that took place on March 2011.

3. Suggestion for a methodological improvement

Our suggestion is to use a time-dependency of the weight of each station in the normal system to be inverted following the Cholevsky algorithm along the least square adjustment of the trajectory to tracking data. It could be a way to account for features (such as earthquakes or methodological evolutions of the stations) affecting the stability of data provided by each station, to get a kind of a dynamical weighting of the stations. With such an approach, the rms values provided jointly with the coordinates and velocities in ITRF2008 could be inserted in the computation only as *a priori*, and not as definitive ones. It could be of interest for stations that are not that stable, or for stations providing a number of NPs strongly varying with time.

Up to now, in the operational scheme followed by the ACs, weigthing data acquired by a station is only based on the value σ_{ITRF} provided in ITRF for each station: $\sigma_{ITRF} = \sqrt{\sigma_X^2 + \sigma_Y^2 + \sigma_Z^2}$. This weight could be changed to $\sigma_{ITRF} = \sqrt{\sigma_X^2 + \sigma_Y^2 + \sigma_Z^2 + \Delta\sigma^2}$, $\Delta\sigma$ being an additional factor obtained from the weekly residuals of a satellite performed only over a given station: $\Delta\sigma$, as a time-dependent parameter, could be seen a the way to over- or underweight a station w.r.t. to ITRF-fixed value. Moreover, several iterations on the $\Delta\sigma$ computation should be scheduled in the method, to derive an optimal value for each station.

Figure 5 shows the global improvement that is expected following that method, after 3 iterations and starting from values of σ_{ITRF} that are the same for all stations of the network. Obviously, the improvement is small (even if clearly visible), but not without any interest as far as the goal is to reach a millimetric accuracy for the SLR data analysis by the next few years. For some stations, especially those not providing a large amount of data or those not that stable over time, it would be worth changing their ponderation from one week to another (as shown Figure 6 in the case of the Arkhyz (1886) station). A further analysis is required to clearly understand the changes induced by such a time-dependent weighting, in particular concerning the effect on the LOD determination from SLR data, and will be the subject of a forthcoming paper.

Conclusions

We analyzed recent evolution of the SLR part of ITRF2008. Based on an evaluation in terms of Helmert parameters and 3D wrms of the coordinate residuals, it is clear that a new set of SSC should be useful to account for recent features in ITRF2008 such as earthquakes or discontinuities due to technological evolutions. Let us note, as well, that at least a part of the rise in the level of weekly residuals for Lageos-1 and Lageos-2 is not only due to the natural degradation ITRF2008 with time : issues linked to non gravitational effects affecting their trajectories should be kept in mind.

Additionally, Let us note that since ITRF retrieves coordinates and velocities from coordinate time series, under the assumption of linear station motion, all the realizations are affected by earthquakes, as the one that occurred near Concepcion, on spring 2010. From that point of view, it should be interested to use a time dependency-ponderation of the stations, determined by the level of residuals over each station, once the orbit is adjusted from the whole set of data acquired by the entire network. We showed preliminary results on such an approach.

ITRF2013, the new realization of the ITRS, in now in progress, and the ILRS contribution should be delivered to the ITRS product center by the middle of 2014.

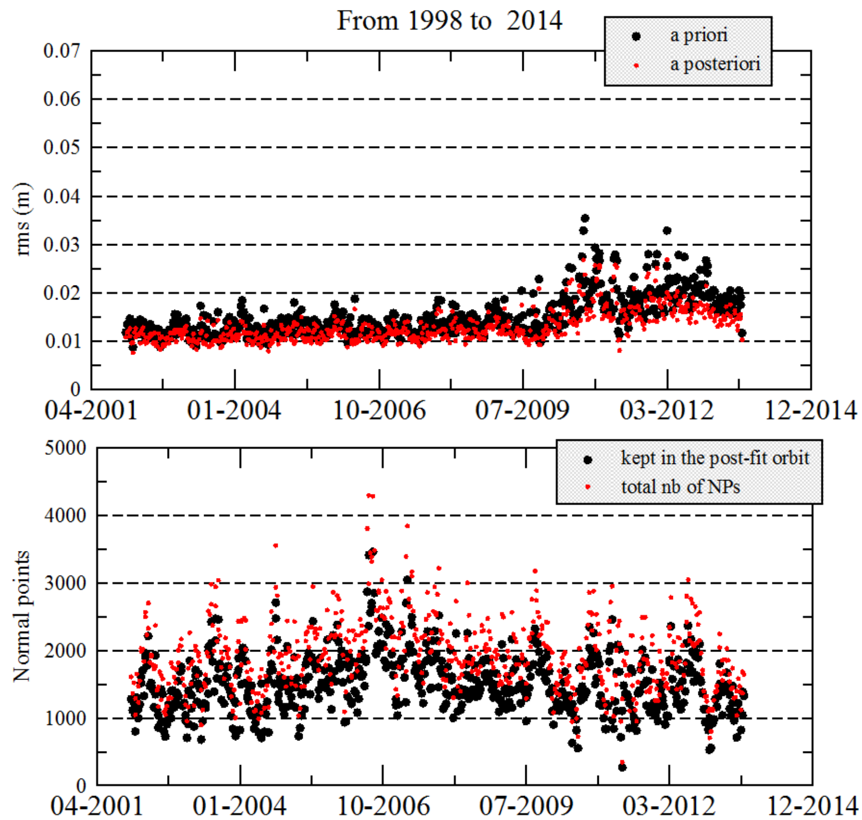

Figure 1. Lageos-2 weekly arcs residual assessment, over the period 2001-late 2013.Top: a priori and a posteriori weekly rms between adjusted orbit and NPs acquired by the whole ILRS network. Bottom: Total number of NPs available per week, and NPs kept in the orbit computation

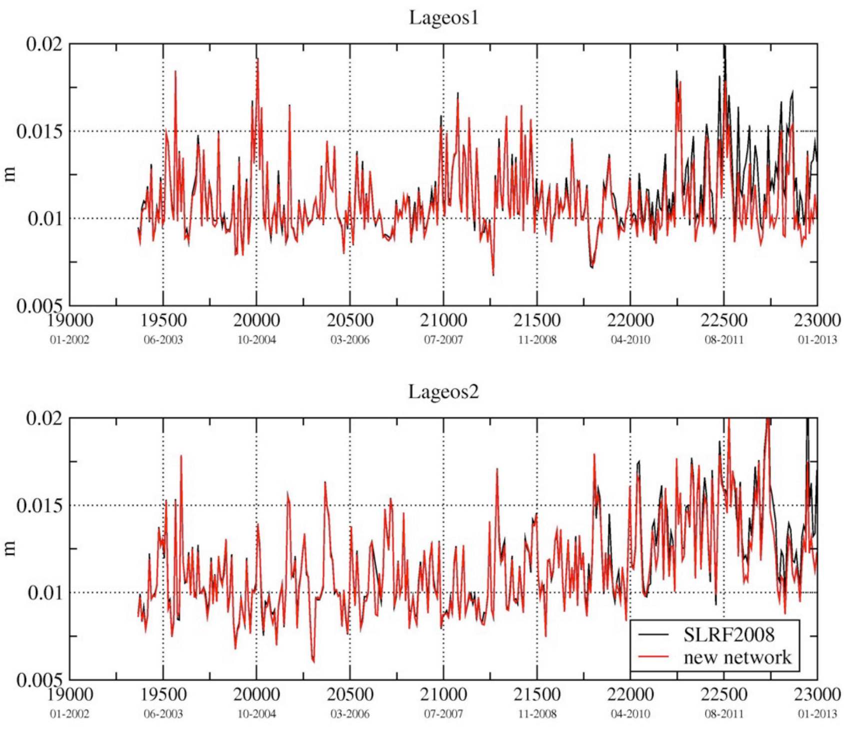

Figure 2. Lageos-1 and Lageos-2 weekly residuals, using the operational set of SSCs (SLRF2008, up-to-date late 2013), or an updated version based as well on SLR data acquired over the last few years, with stations recently affected by some features (e.g. earthquake) in ITRF2008.

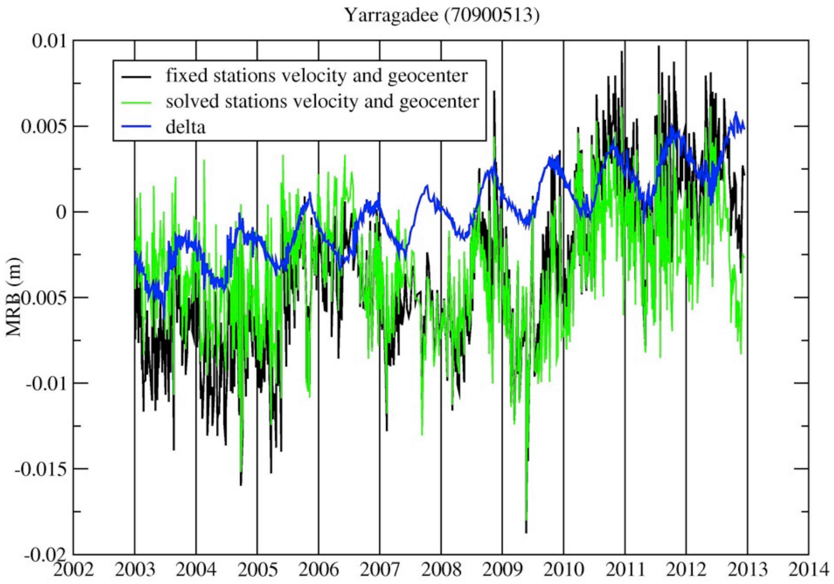

Figure 3. A possible methodological improvement for the next ITRF, shown in the case of the Yarragadee station (7090) Mean Range Bias (MRB) time series. One set of coordinates is adjusted per station over the whole period under investigation ; one MRB every 10 days.

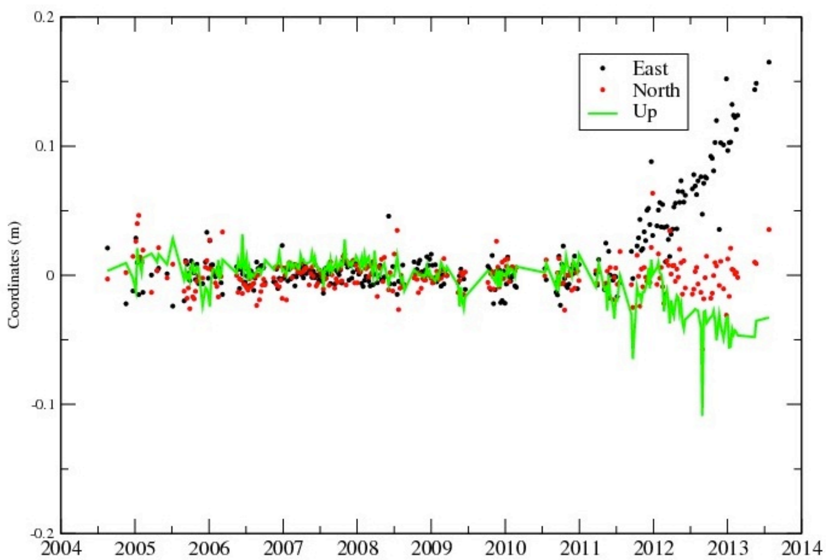

Figure 4. Example of the effect of "big" earthquake in ITRF2008: Concepcion (7405). Weekly residuals with respect to the SLRF2008 coordinates (East, North, Up).

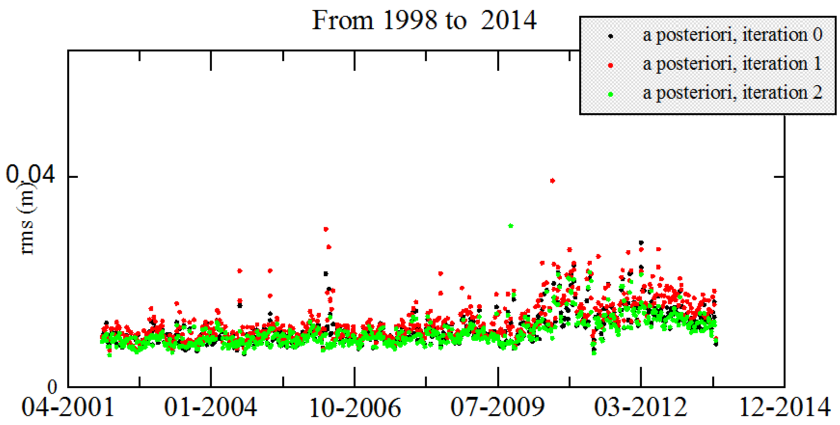

Figure 5. Impact of the weight of SLR data per station on the global results: Lageos-1 weekly arcs

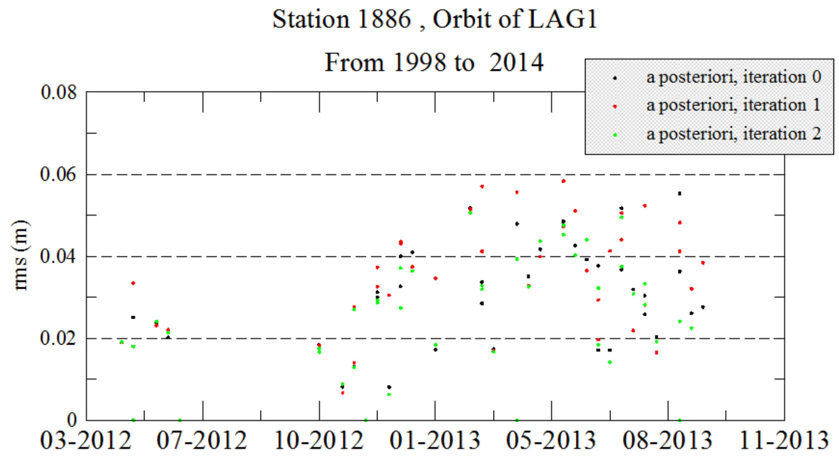

Figure 6. Time evolution of the 1886 (Arkhyz) station rms of Lageos-1 NPs, depending upon the a priori value used to weight the station observations in the global least-square adjustment.

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