SLR residuals to GPS / GLONASS and combined GNSS-SLR analysis

D. Thaller, K. Sośnica, R. Dach, A. Jäggi, C. Baumann
(Astronomical Institute, University of Bern, Switzerland)

1. Behavior of coated and uncoated GLONASS LRAs in the SLR residual analysis

As regards the question whether coated or uncoated corner cubes are better suited for the SLR tracking of GNSS satellites, we analyzed the SLR residuals to the CODE (Center for Orbit Determination in Europe) microwave orbits for GLONASS for the time span June 2003 to October 2012. The mean bias and the RMS of the SLR residuals are shown in Fig. 1. As the GLONASS satellites with uncoated laser retro-reflector arrays (LRAs) are quite new, there is only one satellite with a big amount of tracking data (i.e., 729 corresponding to glonass-115), whereas the others have a comparably small amount of data until now. From the results shown in Fig. 1 we may conclude that the RMS of the SLR residuals is smaller for those satellites with uncoated corner cubes, which would be an argument in favor of using uncoated corner cubes in future.
At a first glance it is striking that the mean residuals for the uncoated LRAs are larger than for the coated LRAs, i.e., about 2-3cm instead of 1-2cm. Taking into account that the mean SLR residuals for the two GPS satellites are at the level of 3cm, the biases seen for the uncoated GLONASS arrays are closer to the biases for the GPS satellites, which would be an indication that the consistency between GPS and GLONASS is increased when uncoated corner cubes are used (although GPS carries coated corner cubes).
When looking at the station-specific SLR residual statistics the above conclusions are confirmed. Nevertheless, an extension of the residual time series for satellites with uncoated corner cubes is needed in order to approve the conclusions drawn above by a larger amount of SLR tracking data.

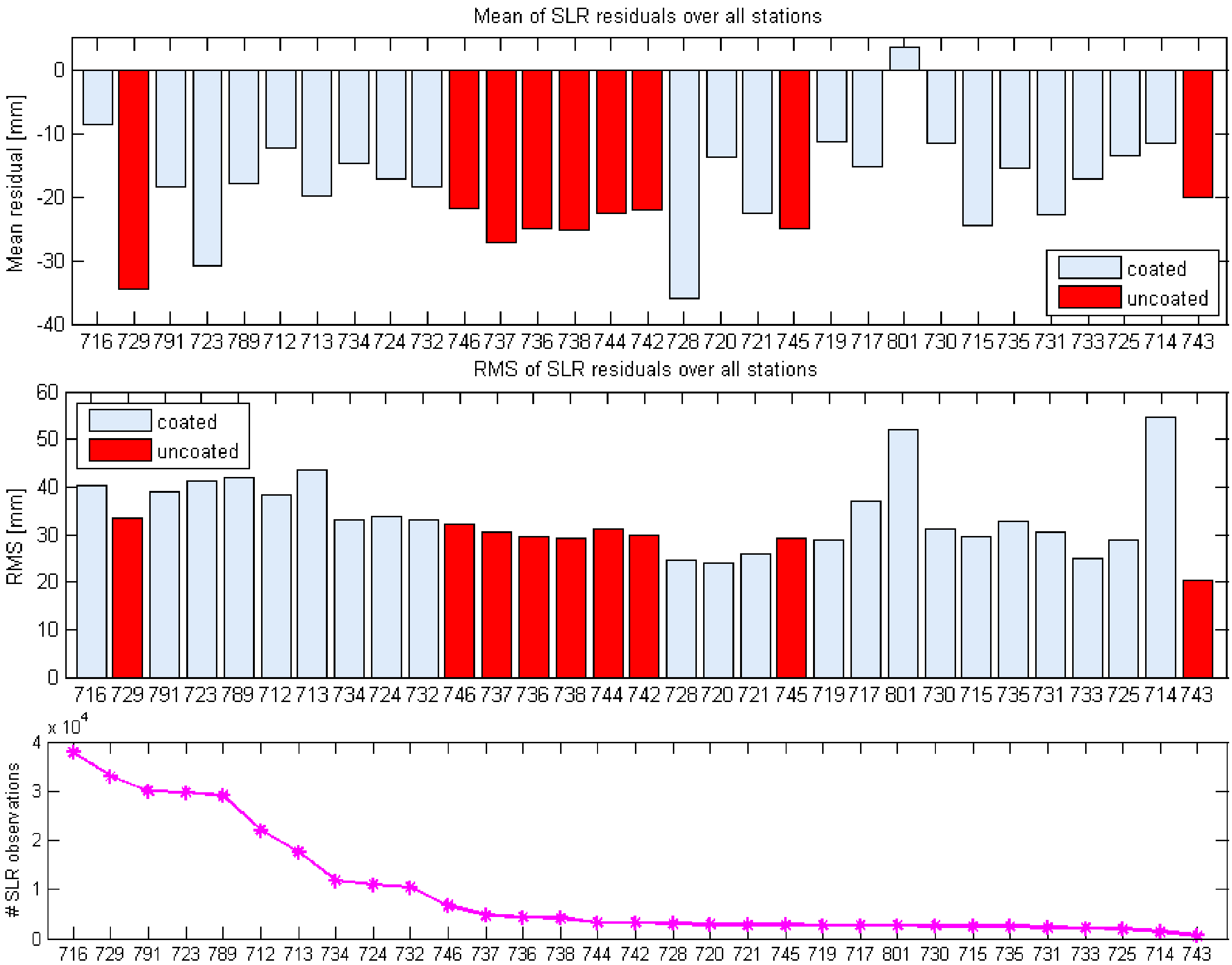

Figure 1: SLR residual analysis for GLONASS satellites with coated and uncoated LRAs. The satellites are sorted in descending order of the amount of SLR data. Satellite numbers are Russian GLONASS numbers.

2. Combined GNSS-SLR solutions

The goal of a combined solution is to make use of the strength of each individual technique. As regards the combination of GNSS and SLR, the strength of SLR is the definition of the scale and the geocenter, whereas GNSS provides a densified terrestrial reference frame and stable Earth rotation parameters (ERPs). The procedure for a combination using the satellite co-locations on GNSS satellites have been described in Thaller et al. (2011). This procedure has been extended by the inclusion of LAGEOS and Etalon data in order to stabilize the SLR station coordinates and the geocenter. Combined solutions have been computed for the time span 2000-2010. All geodetic parameters of interest are estimated together in one solution: station coordinates, ERPs, geocenter coordinates, satellite orbits for GNSS and spherical satellites, corrections to the microwave satellite antenna offsets (SAOs) and LRA offsets, and several technique-specific parameters (e.g., troposphere parameters for GNSS and range biases for SLR).
The advantage of the combination for the weekly geocenter estimation has been demonstrated by Thaller et al. (2012a). The scatter in the z-geocenter is reduced from 10.7mm in a GNSS-only series to 7.6mm in the combined series, which must be attributed mainly to the fact that the artifactual signals related to the draconitic GNSS periods vanish or are greatly reduced by the inclusion of SLR data to LAGEOS. The scatter in the combined series is close to that of the SLR-only series (i.e., 6.4mm).
Regarding the scale, we estimate the microwave SAOs in order to adopt the scale from SLR (see Thaller et al., 2011 and Thaller et al., 2012b). The mean SAO corrections w.r.t. the igs08.atx values (Schmid, 2012) amount to -86.1mm and -110.4mm for GPS and GLONASS, respectively, which corresponds to a scale difference between GNSS and SLR of 0.67ppb and 0.86ppb. Figure 2 demonstrates that the scale of the combined solution is driven by SLR (as desired): There is no systematic scale difference between the SLR network in the combined and in a LAGEOS-only solution, whereas there is a clear scale bias for the GNSS network between the combined and a GNSS-only solution. This scale bias is -0.67ppb, thus, corresponds exactly to the corrections estimated for the SAO. This result emphasizes that such type of combined GNSS-SLR solution is well suited to transfer the scale from SLR to the GNSS network and to consistently estimate microwave SAO for the GNSS satellites.

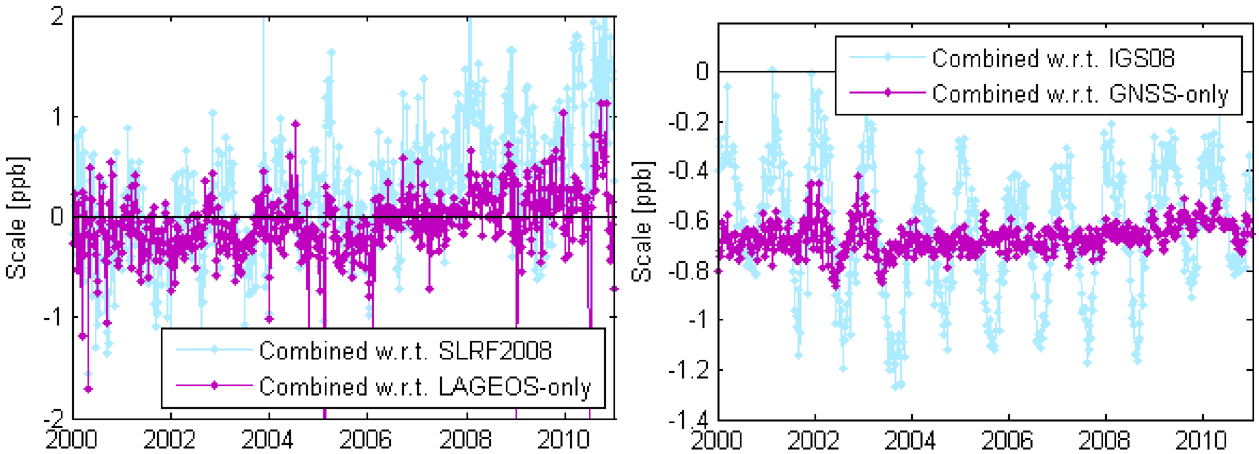

Figure 2: Verification of the scale in the weekly combined solutions. Left: scale of the SLR network; right: scale of the GNSS network.

References

Schmid R (2012): IGS Antenna Working Group. In: Meindl M, Dach R, Jean Y (eds) IGS Technical Report 2011, Astronomical Institute, University of Bern.

Thaller D, Dach R, Seitz M, Beutler G, Mareyen M, Richter B (2011): Combination of GNSS and SLR observations using satellite co-locations. J Geod 85(5):257–262. doi: 10.1007/s00190-010-0433-z.

Thaller D, Sośnica K, Dach R, Jäggi A, Beutler G, Mareyen M, Richter B (2012a): Geocenter coordinates from GNSS and combined GNSS-SLR solutions using satellite co-locations. IAG Symposia Series, Vol. 139, Proceedings of the IUGG General Assembly 2011, Melbourne.

Thaller D, Sośnica K, Dach R, Jäggi A, Baumann C (2012b): The space tie between GNSS and SLR. Proceedings of the International Technical Laser Workshop 2012 (this volume).