

Simulation of realistic SLR observations to optimize tracking scenarios

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Introduction

The list of laser ranging targets supported by the International Laser Ranging Service (ILRS) is continuously increasing, raising the question how to cope with the growing number of trackable targets. Currently, the ILRS proposes a priority list but each station runs their schedules and target selection independently. Between August 2014 and October 2015 three dedicated tracking campaigns lasting between two and four months were organized by the ILRS. For these time frames the stations were asked to focus on selected targets of the Global Navigation Satellite System (GNSS). Each pass of a target was separated into disjoint sections and a minimum number of normal points (NPs) had to be acquired for each section of a pass. The common results of these campaigns showed that the network was able to handle tracking all the required satellites for now, however, only a few stations were able to fulfill the campaign requirements at all times and that there is a request for more daylight data. There is no answer yet determining the optimal number of NPs and their distribution within a pass nor how the tracking scenario influences the results of a data analysis.

Simulation

Aiming to address these questions, a capable tool for simulating realistic satellite laser ranging (SLR) observations to satellites equipped with retroreflectors was established. The synthetically generated observations are supposed to be used to compare and optimize SLR tracking scenarios with respect to station and geocenter coordinates as well as Earth rotation parameters (ERPs).

Analyzing the observations submitted to the ILRS since 2012, a tracking profile for each station

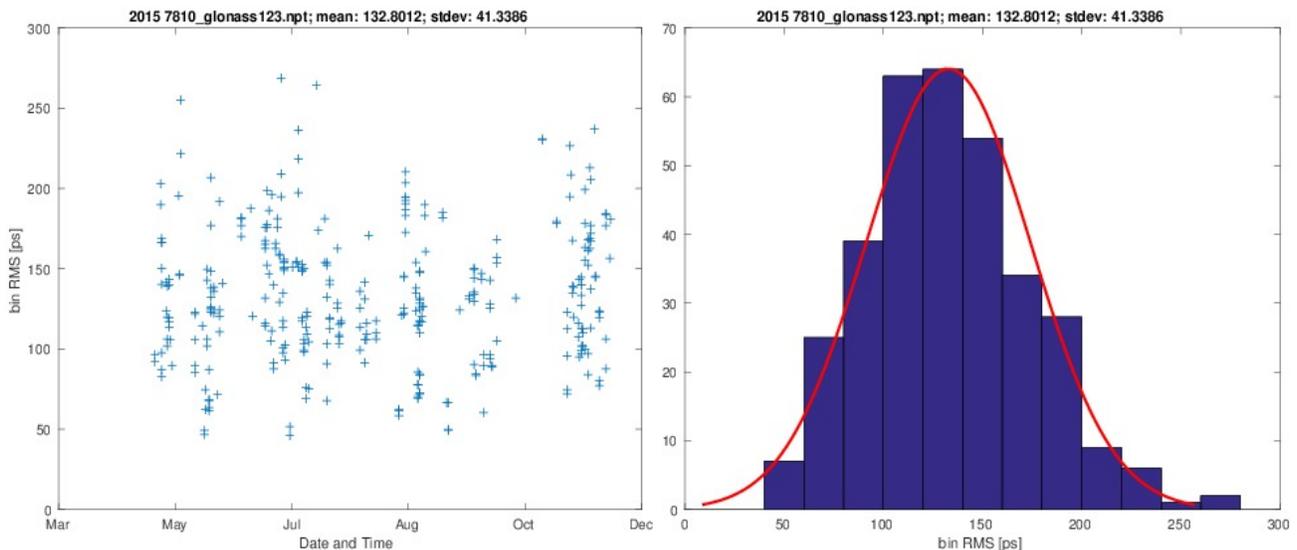


Figure 1: Modelling the noise characteristics of measurements from station 7810 (Zimmerwald) to GLONASS-123. This was done for each station-satellite pair.

was established resembling the respective target priorities. This takes into account typical downtimes due to maintenance, limitations due to weather conditions or restricted operation times as well as the altered priorities during the ILRS tracking campaigns. Furthermore, the measurement noise characteristics of each station with respect to the different satellites were studied and are embedded within the simulation. For this purpose the distribution of bin RMS given in the NP files was modelled via an appropriate normal distribution for each station-satellite pair, as demonstrated in Figure 1.

The simulation is based on the geometric distances derived from the station-satellite geometry including the typical corrections for tropospheric refraction, relativistic effects and so on. All time and range biases are assumed to be zero for the simulation. On top of the distance a pseudorandom, white noise function is added that is rescaled according to the derived noise characteristics of the station-satellite pairs.

A key feature of the simulation procedure is that the pseudorandom noise function is handled independent from the selected observation scenario. It means that a simulated observation between a station i and a satellite k will get the same return from the white noise function for a certain epoch t disregarding the selection of other potential measurements. This feature allows the full comparability of different observation scenarios. Of course it is also possible to initialize the white noise function in a different way in order to obtain a new scenario regarding the stochastic behavior of the assumed SLR measurements.

First results

In order to verify the assumed noise characteristics from the simulation tool, we first tried to replace the observations to GNSS satellites submitted to the ILRS between January 2013 and January 2016 by synthetic measurements. For each existing observation from a station i to satellite j at epoch t , a synthetic

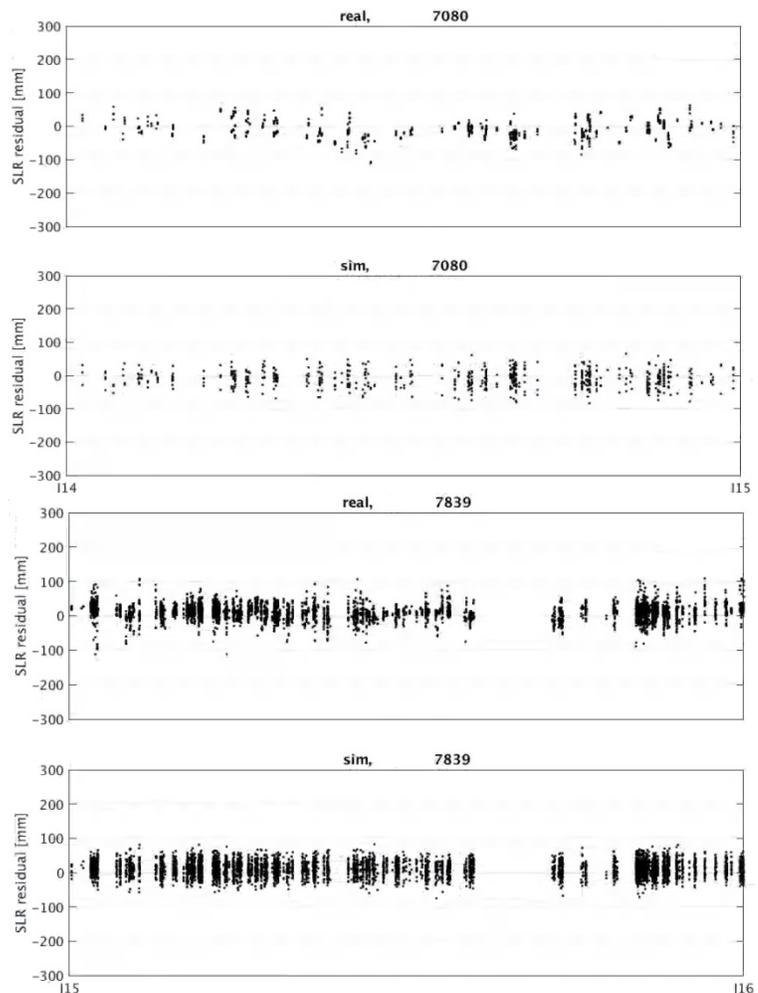


Figure 2: Comparison between the residuals of the real observations and the simulation results for the year 2014, stations 7080 (McDonald Observatory) on the top and 7839 (Graz) on the bottom.

measurement was produced. The assumed geometry is based on the CODE final orbit products submitted to the IGS and the SLRF2008 station coordinates. Having a coinciding simulation result for each real observation allows us to perform an in-depth comparison of the residual characteristics between the real and simulated measurements. Given as example, Figure 2 compares the residuals for two selected stations taking into account all observations of the year 2014. Primarily, the residuals of the simulation are of similar magnitude and variance as the ones belonging to the real observations. However, the latter ones show a seasonal variation. It is not clear whether they result from deficiencies in modelling the SLR measurements (e.g., in the troposphere model) or from the introduced GNSS satellite orbits. For that reason they have not been considered for the rescaling of the noise function in the simulation.

Summary and outlook

The basis for further simulations and in-depth analysis of different tracking scenarios was established. In the first step we have demonstrated that the residuals of the simulated observations are comparable to the ones of the real observations. In a further step this simulation tool will be applied to generate synthetic observations that resemble different tracking scenarios by replacing the targets of the SLR stations at those epochs when real measurements exist, thus we know the station was operational.

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