Quick analysis using orbitNP.py of full-rate SLR data submitted to the ILRS in 2018

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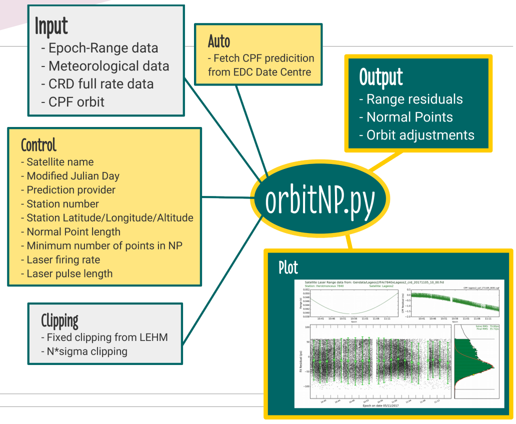
Introduction

As of January 2018, all ILRS stations are requested to submit, in addition to normal points, full-rate data containing all successful laser returns to the ILRS Data Centres. Most stations have responded and now routinely send full-rate data for all ILRS satellites. A PYTHON progrram called *orbitNP.py*, developed at the SGF, Herstmonceux, was used here to investigate the quality and consistency of full-rate data from stations in the ILRS network and some irregularities are highlighted.

OrbitNP.py Software

OrbitNP.py originates from FORTRAN code used at the SGF, which was translated in to PYTHON. It reads full-rate data files along with a corresponding CPF orbit prediction file to produce flattened range residuals by solving for time bias and range bias. The residuals are plotted for inspection and normal points are formed. This can be done for any satellite pass from any ILRS station. OrbitNP.py can alternatively process raw epoch-range data with local meteorological data and can be used as example source code for reducing SLR ranges by applying an orbit fit. Included are two routines for clipping flattened residuals. The first is an iterative mean that removes outliers. The second fits a Gaussian curve to the front of the residual distribution to identify the leading-edge-half-maximum (LEHM) and fixed clipping is applied from this point.

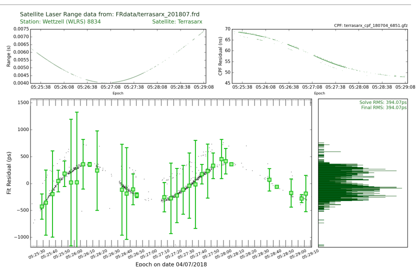


Full-rate Data

Full-rate data offers a clear picture in to the pass data that went in to forming the normal point observations. It can differ from a uniform spread of points due to changes in signal strength during the pass, pointing and tracking difficulty, variable atmospheric transmission and turbulence and variations in the satellite target response. Presented here are some irregular passes submitted to the ILRS as processed with orbitNP.py.

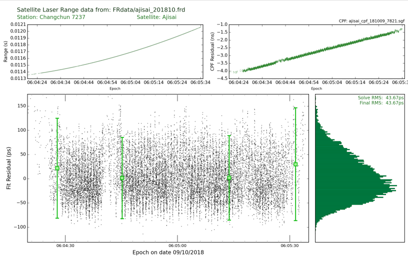
Calibration not applied

The full-rate data examined from the Wettzell station (8834) could not always be flattened using orbitNP.py and resulted in a large range bias. The CRD flag indicates that the system calibration was applied to the data but it was necessary to apply the calibration to get flat residuals for all satellites.



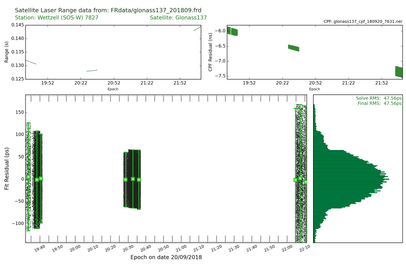
Range variations

What looks like a cyclical change in the range can be seen in this plot of an Ajisai pass from the Changchun station. The distribution is narrow for this satellite and so perhaps it is sampling the front of the satellite at high return rate. This behaviour was not seen for other satellites.



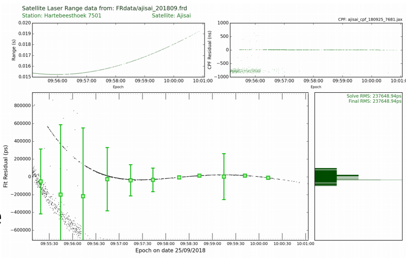
Normal point clipping

This plot shows a Glonass-137 pass from the Wettzell SOS-W station. The data is clipped on a normal point basis, this removes more noise around periods of denser track. It is particularly effective for GNSS satellites that have an elevation dependency for normal point RMS.



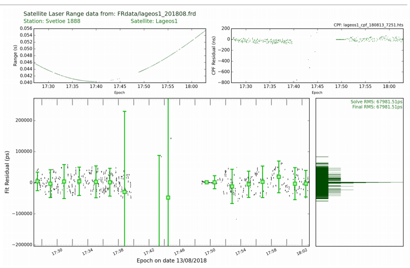
Non-SLR data included

Full-rate data files should ideally only contain successful SLR records. Plotted here is a Hartebeesthoek Ajisai pass that includes data that should have been excluded. Monument Peak, Greenbelt, Haleakala and Arequipa also send under-clipped full-rate data. These outliers were removed in the normal point formation.



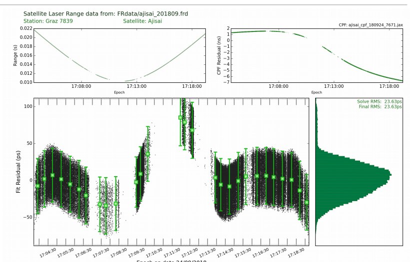
Not filtered in time

The times in a pass when the satellite is not being tracked should not be included in the full-rate data. This plot shows a Lageos 1 pass from Svetloe, Russia that contains SLR results at about 17:50. No normal points were submitted with the full-rate data. The Zelenchukskya station submits similar data files.



Conflict with polynomial/clipping

Many stations flatten SLR ranges using a polynomial fit before clipping the data. This alternative method can conflict with the orbit fit and consequently some passes from some stations do not result in flattened residuals. This plot shows an Ajisai pass from the Graz station which was clipped at the front edge.



Conclusions

Each SLR station can treat range measurements differently in the process of forming normal points. Some insight in to this can be gained by looking at the full-rate data.

Non-SLR noise points should be eliminated from full-rate data files as much as is possible.

Clipping of flattened residuals should be consistent from pass to pass and should remove non SLR returns.

This is not an exhaustive analysis of the 2018 full-rate data set. The reader can explore ILRS full-rate data by downloading *orbitNP.py* through the ILRS.

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