Rapid quality checks within the EUROLAS cluster

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Abstract

The EUROLAS Cluster of Satellite Laser Ranging stations collects annually some 40% of the observations made by the world-wide SLR Network. On behalf of the Eurolas Cluster we have set up a quality checking process which exploits the clustering of the stations by analysing SLR observations of the Lageos satellites made simultaneously by two or more of the stations. We find that there is a core set of very accurate stations whose observations agree at the mm level, and we use these observations in a short-arc orbital improvement scheme to judge the accuracy of other stations in the cluster that are tracking the same satellite at the same time. We have fully automated this quality-check procedure, and present daily on the WWW the results in the form of graphs of range residuals, and numerical estimates of stations' time and range bias values. We have also used this short-arc technique to analyse some sets of range observations of ERS-2 made by the Cluster, and find that orbital arcs can be determined to a precision of a few cm.

We conclude that observations from the EUROLAS Cluster of SLR stations and the continuing quality check procedure together will make an effective tool for calibration of for example the ENVISAT altimeter.

1 Introduction

The existence of a cluster of European satellite laser ranging stations (EUROLAS) provides an opportunity to monitor the precision and accuracy of the observations routinely carried out by a group of high-precision systems. In this paper we review the methods that we have developed on behalf of EUROLAS to provide rapid feedback on observational quality to the stations. An experimental scheme was initially developed by Appleby [1], based on the RGO SLR Analysis package SATAN [5], and using a short-arc orbit improvement method devised by Sinclair [4]. However, the operation of this experimental system has been completely upgraded and automated by the first author. Here we outline the methods used in this automatic quality-check system, which is presented in more detail by Hausleitner [3]. We then use the short-arc orbit improvement method to carry out a constrained orbit adjustment for some arcs of the ERS-2 satellite that were tracked quasi-simultaneously by several EUROLAS stations, noting that such techniques are likely to be important for calibration of future altimeter missions, such as ENVISAT [2].

2 Analysis method and automated system

The overall system divides logically into three major parts:

The **data acquisition** part covers the following tasks:

- Tracking data acquisition which daily downloads normal point observations from a data server (currently NASA/CDDIS) via FTP and organizes these data on a local archive.
- Earth rotation parameter acquisition which continuously downloads the latest IERS Earth Orientation Bulletin-A from the United State Naval Observatory (USNO).
- Weekly acquisition of Lageos quicklook analysis reports from the University of Texas / Center of Space Research (UT/CSR) for comparisons with the local solutions.

The normal point **quality check** part mainly performs:

- A 6-day long-arc orbit integration for Lageos-1 and -2 and fitting to a global set of the most accurate SLR stations. The orbit is fitted by adjusting an initial state vector, a solar radiation coefficient, and an along-track acceleration and also by solving for Earth rotation parameters. In this way a post-fit RMS of about 3 cm is achieved for both Lageos satellites.

- A short-arc process which detects periods of simultaneous tracking and computes short-arc corrections in along-track, across-track and radial directions constrained by the global orbit. In this way residual orbital errors are removed but the global reference frame defined by the long-arc orbit is maintained. Range and time biases for all contributing stations are then deduced from the short-arc residuals.
- Local archiving of the daily results of the analyses.

Observations from passes tracked simultaneously by the SLR stations Graz, Herstmonceux, Postdam and Wettzell (core stations) are used to compute short-arc corrections.

The **information feedback** utility consists of two programs:

- A mailing service compares each computed value of time and range bias to predefined threshold values and generates appropriate messages which are then sent automatically to the observing station.
- Another information feedback program manages the presentation of the quality check results on the World Wide Web. A history of results including all relevant information is maintained and updated continuously. The results are placed daily on the NERC SLR Facility website at

  `http://mtfiles.nerc-monkswood.ac.uk/nercslr`

This automatic SLR normal point analysis service has been implemented at the NERC Satellite Laser Ranging Facility, Monks Wood, UK and operates on a daily basis. The analyses are scheduled to begin at 0100 GMT and use six-day orbits for each satellite. Because of the existence of up to a few days delay in the normal point availability at the Data Centres, the daily analyses are carried out such that data up to four days old can be included in any one daily solution.
The program control system was developed in PERL (Practical Extraction and Report Language).

2.1 Results

Using the six-day orbits fitted to the global best stations we can check the quality of data from the whole network of contributing stations. To do this we compute range residuals for each station with respect to the fitted orbits, and present the results in the form of scatter-plots. These plots readily show the existence of bias and outliers at a level of about 5cm.

Subsequent short-arc solutions using observations of the Lageos satellites confirm that the majority of the stations in the EUROLAS cluster produce very precise and accurate data, with any systematic effects being below the cm level. This is illustrated in the two plots of Figure 1, where in each case range observations from stations 7839 and 7840 are used to compute constrained along-track, across-track and radial corrections to six-day global orbits. The precision of the improved orbit is better than 1 cm radially, and residuals from these improved orbits are computed and plotted for all contributing stations.

However, these plots also demonstrate that some stations do produce data which is biased in some way, either in range or in observational epoch. Such observations are readily identified by this technique, since their range residuals stand off from the zero position. In practice we find some stations have fixed bias values, while others have bias that varies from pass-to-pass. We must emphasise that these solutions are carried out using ITRF96 station coordinates, and that any readjustment of the station coordinates will certainly alter the bias values.

3 Use of this technique for orbit determination of ERS-2

We compute 5-day orbits of ERS-2 using the global set of SLR data. With a solution for multiple drag coefficients, we obtain a post-fit residual rms of about 10 - 15 cm.

The short-arc solution, constrained by the long-arc orbit, and using data from at least three stations that were tracking quasi-simultaneously yields a post-fit residual rms of about 1 cm. Residuals for two such determinations are presented in Figure 2.

We can also solve for observational bias if our Lageos results indicate that this may be required. This was necessary for the data for one of the stations contributing to the short arc results shown in Figure 2.

4 Conclusion

We have outlined our automatic system for quality checking the Lageos range data from the EUROLAS cluster. Results are displayed daily on the web pages of the NERC Satellite Laser Ranging Facility at

`http://mtfiles.nerc-monkswood.ac.uk/nercslr`

We have experimented with a short-arc orbital improvement scheme to compute precise orbits for the ERS-2 satellite. This precision orbital arc determination based on observations of the EUROLAS cluster of stations, together with the routine normal point quality check procedure, points to very promising future applications such as the calibration of, for example, the ENVISAT altimeter.

References

[1] **Appleby, G. M.**: *Quality checks within the EUROLAS Cluster*. Proc. 10^{th} Int. Workshop on Laser Ranging Instrumentation, Shanghai, China, 1997

[2] **Francis, R. and M. Roca**: *RA-2 In-Orbit Calibration Plan: Range* . ESTEC, Noordwijk, The Netherlands, December 1997

[3] **Hausleitner, W.**: *The establishment of an automatic on-site SLR normal point quality check service*. SLR Technical Note 13, Royal Greenwich Observatory, Cambridge, UK, 1997

[4] **Sinclair, A. T.**: *The determination of station coordinates and baselines from the 1986 and 1987 WEGENER/MEDLAS data by global and short-arc solutions.* Fourth Int. Conf. on the WEGENER/MEDLAS Project, Schevenin, 1989

[5] **Sinclair, A. T. and G. M. Appleby**: *SATAN: Programs for determination and analysis of satellite orbits from SLR data*. SLR Technical Note 8, Royal Greenwich Observatory, Cambridge, UK, 1988

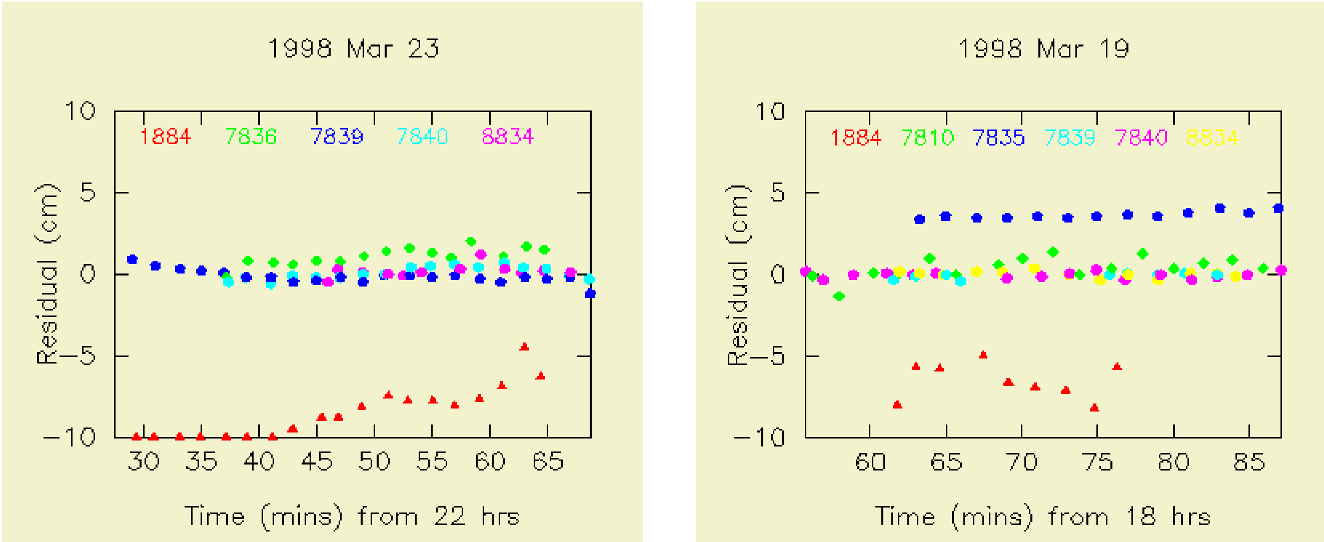

Figure 1: Observational residuals of Lageos short-arcs

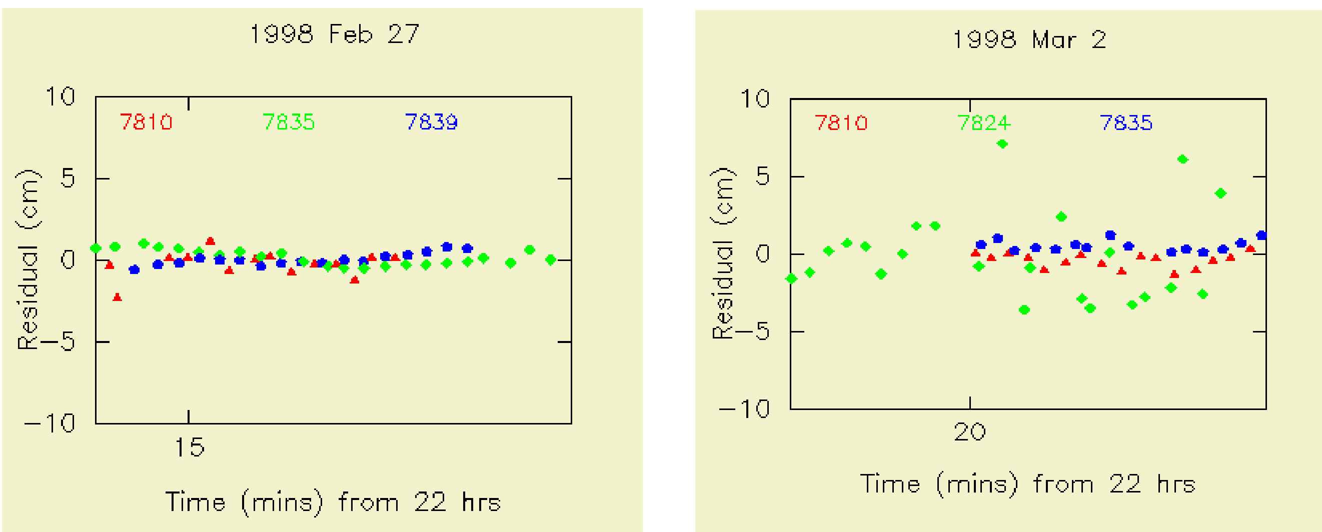

Figure 2: Observational residuals of ERS-2 passes after short-arc correction