EUROPEAN LASER STATION POSITIONING FROM LAGEOS LASER RANGING

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ABSTRACT

This paper presents some results of the analyses of global full-rate laser ranging measurements of LAGEOS, acquired during the 1983/1984 MERIT campaign, and global quick-look LAGEOS data, obtained from January to July 1986 in the first WEGENER-MEDLAS campaign. It focusses in particular on the computation of precise LAGEOS orbits, the modeling of surface forces acting on this satellite and the determination of precise European laser station positions and interstation baselines. The analyses, primarily based on 1-week data arcs, have shown that the consistency of baselines computed from full-rate data is not basically different from that computed from quick-look data: the scatter in independently derived baseline solutions amounts to about 5 cm. The baselines between three collocating laser systems in Southern Italy, obtained from quick-look data in a 10-week data arc, agree to better than 2 cm with the surveyed values. The analyses have also disclosed some deficiencies of the dynamic model employed, of which the mismodeling of solar eclipses by the moon was the most prominent one. It is shown that the orbit of LAGEOS was severely affected by a rare extremely lengthy solar eclipse lasting for 70 minutes on April 9, 1986.

Keywords: Laser Ranging Data Analysis, Baselines, European Laser Stations, Solar Eclipse, MERIT, WEGENER-MEDLAS

1. INTRODUCTION

The Section Orbital Mechanics of the Faculty of Aerospace Engineering at Delft University of Technology has been involved in the processing of global satellite laser range measurements for the computation of precise satellite orbits and coordinates of European laser stations for almost a decade (Ref. 1). One of the latest studies was aimed at the positioning of the relatively new European laser stations at Graz, Herstmonceux and Matera and the computation of their interstation baselines using full-rate tracking data on the LAGEOS satellite obtained during the MERIT campaign, which took place from September 1983 to October 1984. To this aim, a total of 8 suitable 1-week data arcs were selected, which showed a lot of activity by both the three mentioned European stations and the network of global laser stations.

Since January 1986 the Section also acts as the European Quick-Look Data Analysis Center (QLDAC) of the WEGENER-MEDLAS project (Ref. 2). During the laser tracking campaigns, the first of which lasted from late March to mid October 1986, the Section receives each week all global quick-look data taken on the LAGEOS satellite during the previous week. These data are processed as fast as possible to monitor the data quality of the cooperating European laser tracking systems, in particular that of the mobile systems operating in the Mediterranean area, by computing accurate LAGEOS orbits and by determining the different positions occupied by the mobile systems. At present, only a German and a Dutch Modular Transportable Laser Ranging System (MTLRS) are operational in that area, but in 1987 a US Transportable Laser Ranging System (TLRS) will join them.

The quick-look data analyses have proven that it is very well possible to derive good station positions and interstation baselines from this kind of data, with accuracies almost comparable to the results of studies involving full-rate measurements. The analyses dealt with in this paper included a total of 29 consecutive 1-week data arcs, which also provided some insight into systematic trends in recovered values of satellite-dynamics related parameters and thus into possible modeling deficiencies. In addition, the data were analyzed in long arcs with periods of up to 10 weeks, with the objective to minimize the aliasing of tracking and/or modeling errors into the few adjusted parameters. This allows an investigation of these errors by evaluating the resulting measurement residuals. Both analysis types have led to the discovery of specific problems related to the dynamics of the LAGEOS satellite.

2. MERIT FULL-RATE DATA ANALYSIS

General information on the 8 selected 1-week data arcs is listed in Table 1, which clearly shows the large amount of available passes, averaging at 110 per week. The full-rate data were analyzed in the form of 2-minute normal points, provided by the NASA Goddard Space Flight Center. The average number of normal points per pass amounts to about 10. A few general aspects of the computation model applied in this study are summarized in Table 2. The primary goal of the full-rate analyses was the recovery of accurate positions for the Graz, Herst-

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Table 1. General information on the selected LAGEOS global 1-week full-rate data arcs.

arc id.	Start (yymmdd)	Stop (yymmdd)	Stations	Passes	Normal points
1	831024	831031	16	107	1014
2	840416	840423	19	93	779
3	840423	840430	19	126	1276
4	840514	840521	18	119	1171
5	840528	840604	16	124	1298
6	840611	840618	18	95	975
7	840827	840903	19	128	1311
8	840903	840910	18	90	910

monceux and Matera stations in Europe. In addition to those, also the coordinates of a few other stations had to be adjusted, because they were not yet present in the a priori station coordinate solution adopted in this study as the reference system or lacked sufficient accuracy. These stations are Zimmerwald, Shanghai and Dionysos, and the locations of mobile laser systems at Quincy (TLRS-1) and Kootwijk (MTLRS-1) which occupied these sites in the period covered by the analyses. The few passes from Santiago and Cerro Tololo were deleted altogether from the solutions because there were no suitable a priori coordinates available at that time. The observations from Metsahovi, finally, were also not processed due to a suspected flagging error.

Prior to the final multi-arc analysis, in which the 8 arcs were combined into one very-precise parameter solution, 8 separate preliminary solutions were obtained for the state-vectors at epoch, the solar reflectivity (C_R), the along-track acceleration (A_T) and the station coordinates. Although some of the coordinate solutions from these 1-week arcs were based on a very small number of passes, the resulting interstation baselines between the selected European stations of interest proved to be very stable. As can be seen from Figure 1, the variation in all solutions for each baseline is less than 30 cm. Disregarding unrealistic solutions for Graz and Matera in the second arc and the solution for Herstmonceux in the fourth arc (based on only one pass), the standard deviations of the single-arc solutions for the baselines Graz-Herstmonceux, Graz-Matera and Herstmonceux-Matera were found to be only 5, 7 and 10 cm, respectively.

Table 2. Computation model summary.

Dynamic and measurement model

PGS 1680 gravity field (a_e = 6378.14411 km; GM = 398600.448 km^3/s^2); c = 299792.458 km/s; solar and lunar attraction; solar radiation pressure; frequency-independent solid-earth tides (k_2 = 0.29; φ_2 = 2.018 deg); ocean tides not applied; UT/CSR LSC 84.02 tracking station coordinates; tracking station displacement (h_2 = 0.6; ℓ_2 = 0.075).

Estimated parameters

State-vector at epoch; solar reflectivity; along-track acceleration (1 parameter in 1-week data arcs; at 14-day intervals in long data arc); pole position and A1-UT1 difference at 5-day intervals (at 1-day intervals in long data arc); k_2 and φ_2 tidal parameters (long data arc only); station coordinates of Graz, Herstmonceux and Matera plus selected stations (full-rate data arcs); station coordinates of MTLRS-1 and MTLRS-2 plus selected stations (quick-look data arcs).

Observations

2-Minute normal points; 20 deg cut-off elevation.

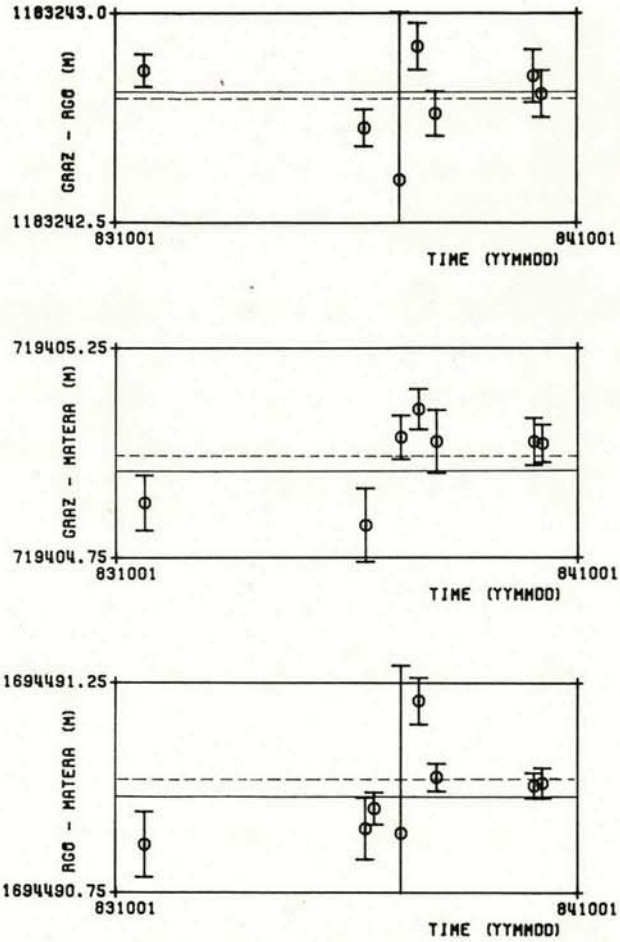

Figure 1. Solutions for the baselines of interest and corresponding standard deviations, obtained from single 1-week full-rate data arcs. The solid lines represent baseline values according to the UT/CSR LSC 84.02 coordinate solution, whereas the dotted lines represent the solutions of the multi-arc analysis.

The European station positions that were obtained in the multi-arc solution, in which all information of the 8 individual 1-week data arcs is accumulated, are presented in Table 3. These coordinates represent the positions of the optical centers of the laser tracking systems. The standard deviations were obtained by scaling the formal standard deviations with the rms of fit of the data for the corresponding stations. The solutions for Graz, Herstmonceux and Matera are based on a total of 35, 65 and 61 passes, respectively. Generally, they agree to better than 10 cm with the corresponding coordinates in the University of Texas' UT/CSR LSC 84.02 solution (Ref. 3), which provides the reference frame and from which the a priori coordinates were taken. A single exception is the height of the

Table 3. Optical center coordinate solutions for Graz, Herstmonceux and Matera and corresponding standard deviations, obtained in the full-rate multi-arc solution. The coordinates refer to the UT/CSR LSC 84.02 reference system and are given in meters.

	X	Y	Z
Graz	4194426.833 ± 0.007	1162693.949 ± 0.007	4647246.446 ± 0.005
Herstmonceux	4033463.930 ± 0.008	23662.322 ± 0.008	4924304.963 ± 0.005
Matera	4641965.291 ± 0.011	1393069.981 ± 0.010	4133262.243 ± 0.007

Table 4. Full-rate multi-arc baseline solutions and corresponding standard deviations, a priori values and NASA, ESOC and Telespazio solutions for the baselines of interest. All values are in meters.

	Graz-Herstmonceux	Graz-Matera	Herstmonceux-Matera
Multi-arc solution	1183242.800 ± 0.017	719404.996 ± 0.016	1694491.022 ± 0.013
UT/CSR (Ref. 3)	1183242.815	719404.958	1694490.978
NASA (Ref. 4)	1183242.736	719405.027	1694490.982
Telespazio (Ref. 4)	1183242.767	719404.988	1694490.961
DGFI (Ref. 4)	1183242.771	719405.008	1694490.974
ESOC (Ref. 5)	1183242.767	719404.988	1694490.961

Matera station: this has increased by 14.4 cm with respect to the a priori height of 528.773 m. This 14 cm is more-or-less equal to the average of the height shifts of the 8 single-arc Matera solutions, which ranged from +6 to +24 cm. It remains unclear what is the cause of this significant difference.

Table 4 presents the interstation baselines and the belonging estimated standard deviations, recovered in the multi-arc analysis. The results agree quite well with the baseline solutions obtained by the University of Texas (UT/CSR LSC 84.02, Ref. 3), NASA (MERIT 84, Ref. 4), Telespazio (Ref. 4), DGFI (Ref. 4) and ESOC (Ref. 5). The differences between the solutions obtained in this study and those obtained by the other institutions are generally less than 5 cm.

General results of the multi-arc data analysis, concerning the computed LAGEOS orbits, are presented in Table 5. The residuals, which have rms values ranging from 8 to 11 cm, can be converted into apparent range and timing biases. These biases may then be interpreted as the errors of the computed LAGEOS orbits, at least during the times of observation. They provide an indication of the accuracy of the dynamic models, applied in the orbit computations. In particular the timing biases are very useful because they are correlated with the along-track orbital position component in which direction, generally, the largest errors occur. From Table 5 it can therefore be concluded that for a 1-week data arc, the LAGEOS position may be determined with an accuracy of 10 cm in radial and 25 cm in along-track direction during the observation periods. Also included in this Table are the solar reflectivity and the along-track acceleration parameters C_R and A_T, the recovered values of which appear to be very stable except for the solutions of C_R obtained for arcs 2 and 3. It was also found, however, that the standard deviations of these solutions exceed the usual values by factors of up to 6.

Table 5. Some results of the full-rate multi-arc orbit determination and parameter estimation analyses. Listed are the rms of fit of the normal point residuals, statistics of the apparent range and timing biases and solutions for the solar reflectivity and the along-track acceleration.

Arc id.	Rms of fit (cm)	Range bias (mean/rms) (cm)	Time bias (mean/rms) (μs)	C_R	A_T (pm/s^2)
1	9.3	-0.6/10.0	-9.4/51.6	1.160	0.73
2	10.5	0.5/10.9	-7.1/49.3	0.930	0.40
3	11.2	-0.5/10.6	0.4/44.6	0.893	-5.32
4	8.7	0.5/ 9.3	0.3/48.0	1.117	0.90
5	9.1	0.4/10.1	-6.1/43.9	1.127	-3.02
6	9.3	2.0/ 9.9	-14.0/53.9	1.133	-1.13
7	7.9	-0.7/ 6.9	-5.3/52.1	1.153	-7.72
8	9.4	-0.8/17.2	-2.4/52.5	1.116	-1.30

Generally, these results support the conclusion that there were no serious problems left in the data used in this analysis and that the overall model applied was sufficiently accurate to allow a precise positioning of the laser stations at Graz, Herstmonceux and Matera.

3. QUICK-LOOK DATA ANALYSIS: ORBITAL ASPECTS

The weekly analysis of quick-look data at Delft University's QLDAC is primarily aimed at quality control of the ranging data obtained by the mobile laser systems participating in the WEGENER-MEDLAS campaign. They are deployed at several sites in the Mediterranean area where they remain for relatively short periods of time, of the order of 6-8 weeks. In this paper only some aspects of two different methods of quick-look data analysis will be discussed. The principal difference between the two methods is the length of the data arc analyzed. The first method relies on single 1-week data arcs, while the other is based on single arcs with lengths which may become as large as the total time that a mobile station remains at one location, i.e. 6 weeks or more. The computation model applied in these analyses is basically the same as the one adopted for the full-rate analyses presented in the previous Section. Its major characteristics are summarized in Table 2. It must also be mentioned here, that the quick-look data are screened and converted into 2-minute normal points before they are processed. The results which are discussed below are always based on these normal points.

In a 29-week period since the start of the operations of QLDAC, the two MTLRS systems have operated at three different sites each in the Mediterranean area. During the months January, February and March both systems were deployed near the fixed Matera station in Italy for a final collocation (Ref. 6-7). The consecutive locations of MTLRS-1 and -2 are listed in Table 6 and are illustrated in Figure 2 (cf. Ref. 8). Table 7 presents an overview of the begin- and end-dates of the three analysis periods, the number of global laser stations from which data were received in these periods, the number of passes they provided and the number of normal points contributing to the orbital solutions.

In contrast with the 8 scattered 1-week data arcs selected for the full-rate analysis the 1-week quick-look data arcs represent a continuous series. The results of the consecutive analyses therefore provide a nice contiguous string of solutions of several model parameters with a relatively high temporal resolution, facilitating the detection of possible modeling problems.

Table 6. General information on the sites successively occupied by the European mobile laser systems during the first WEGENER-MEDLAS campaign. The time-span covered by the three periods ranges from January 5 to July 27, 1986.

	MTLRS-1	MTLRS-2
1	7540 (Matera, Italy)	7541 (Matera, Italy)
2	7520 (Karitsa, Greece)	7550 (Basovizza, Italy)
3	7510 (Askites, Greece)	7517 (Roumelli, Greece)

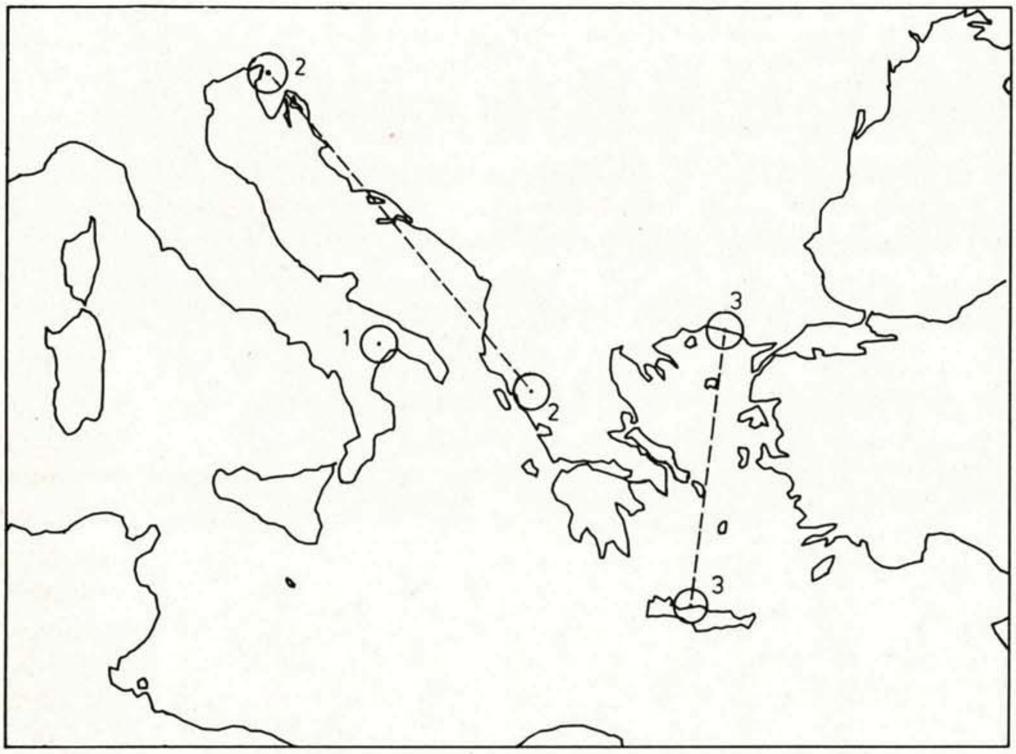

Figure 2. The sites at which the European mobile laser systems were deployed during the first half of 1986: Matera (collocation, period 1), Karitsa and Basovizza (period 2) and Askites and Roumelli (period 3).

The weekly solutions for the solar reflectivity C_R are plotted in Figure 3 (top) as a function of time. Also included in this Figure are solutions which were earlier obtained for the second half of 1985 during the testing of the quick-look data analysis system which started in August 1985. So the weekly solutions for the solar reflectivity cover a period of almost one complete year. The Figure shows two distinct features. First, the scatter in the consecutive solutions is relatively large in the beginning and at the end of the timespan, but the behavior of this parameter appears to be rather stable during the first months of 1986. Although not depicted, the larger scatter is accompanied by significantly larger standard deviations. Both effects seem to be correlated with the position of the sun relative to the orbital plane. A possible explanation for these phenomena is, that as the orbital effects of solar radiation pressure become smaller when the angle between the earth-sun line and the orbital plane increases, it becomes harder to recover the parameter that determines the scale of these effects, i.e. the solar reflectivity coefficient. Or, inversely, the parameter is best determined when the sun is in or near the orbital plane, which was the case in the beginning of 1986.

Table 7. General information on the periods during which the European mobile laser systems occupied different sites in the Mediterranean area. Start- and stop-times listed here were employed in the DUT quick-look analyses; the actual occupation periods may have started a few days later or ended a few days earlier. Only stations and passes contributing to the orbit determination and parameter estimation are included in this Table. The normal points were computed from the quick-look data.

	Start (yymmdd)	Stop (yymmdd)	Stations	Passes	Normal points
1	860105	860316	20	892	11619
2	860330	860525	21	674	8445
3	860525	860727	18	633	8199

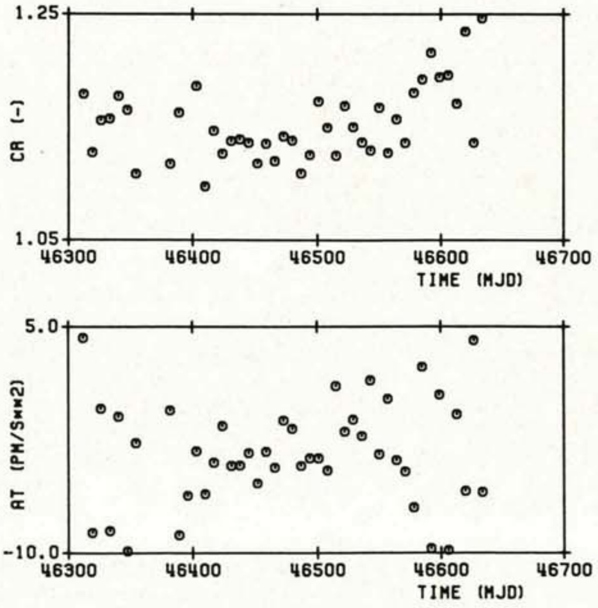

Figure 3. Solutions for the solar reflectivity and along-track acceleration parameters, obtained from 1-week quick-look data arcs. The depicted solutions cover the period August 1985-July 1986.

The second remarkable feature of this Figure is the apparent structure in the weekly solutions: the average value at the beginning and at the end of this 1-year period appears to be somewhat larger than in the middle of this period, i.e. the first months of 1986. It can be argued that this behavior is caused by imperfections in the dynamic model. A possible candidate for this is the simple frequency-independent tide model which was used in the analyses. As was mentioned above, the solar reflectivity is less well-determined during certain periods so that it may pick-up errors from another origin. Something similar can be observed for the along-track acceleration which is depicted in the bottom plot of Figure 3 and which acts as a garbage parameter by its virtue. It has been verified that a proper modeling of the tidal forces generally results in more realistic solutions for the force scaling parameters C_R and A_T. Although the model imperfections may have led to unrealistic solutions for the solar reflectivity and the along-track acceleration, the adjustment of these parameters by itself enabled a fairly consistent quality of the orbital solution to be achieved: generally, the residual rms of fit of the normal points to the computed orbit remained at about 10 cm.

The other method of quick-look data analysis at QLDAC consists of the processing of the data in a single, continuously growing data arc, the ultimate length of which equals the period that the mobile laser systems are deployed in a specific configuration. Unlike the 1-week data arcs whose relatively short length does not allow the orbit errors due to model imperfections to build up significantly, the long arcs will exhibit more effects of these errors. As there are relatively fewer solve-for parameters to absorb these errors, the modeling imperfections will be reflected in the residuals of the processed ranging data.

A very good illustration of this is the 8-week arc covering the entire second period, with MTLRS-1 deployed at Karitsa and MTLRS-2 at Basovizza. The timing biases, which are computed from the residuals on a pass-by-pass basis after convergence of the parameter estimation process, are presented in Figure 4. The rms value of these timing biases, which are strongly correlated with the along-track orbit errors of LAGEOS, corresponds to more than 1 m in this direction. More important, however, is the fact that the variation of the timing biases with time shows a discontinuity on April 9. It turned out that on this very date the sun was eclipsed by the moon as viewed from LAGEOS. The apparent path of the moon's center over the sun, as seen from LAGEOS, is depicted in Figure 5, revealing that LAGEOS crossed the shadow cone twice, and almost through the center. During the eclipse LAGEOS was subjected to a lower level of solar radiation pressure. The analysis software employed by QLDAC at that time, however, did not check on the occurrence of solar eclipses by the moon, and therefore applied the full radiation pressure throughout the entire period. In the 1-week data arc during which this event occurred, the resulting effect mostly disappeared into the along-track acceleration, which took the anomalous value of -23 pm/s^2. The inherent stability of the 8-week orbit, however, did not allow this phenomenon to be absorbed by one or more adjusted parameters so that it manifested itself in the residuals. The cause of the anomalous results was verified after modification of the analysis software. The 1-week analysis of the pertaining week was repeated and resulted in an acceptable value of the along-track acceleration of -1.2 pm/s^2.

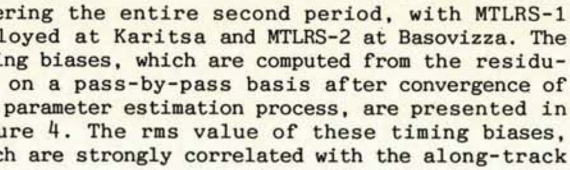

Figure 4: Apparent timing biases of the LAGEOS passes over the global laser stations, computed from range residuals after fitting an 8-week satellite orbit through the quick-look normal points acquired during the period March 30 to May 25, 1986. The arrow indicates the solar eclipse of April 9.

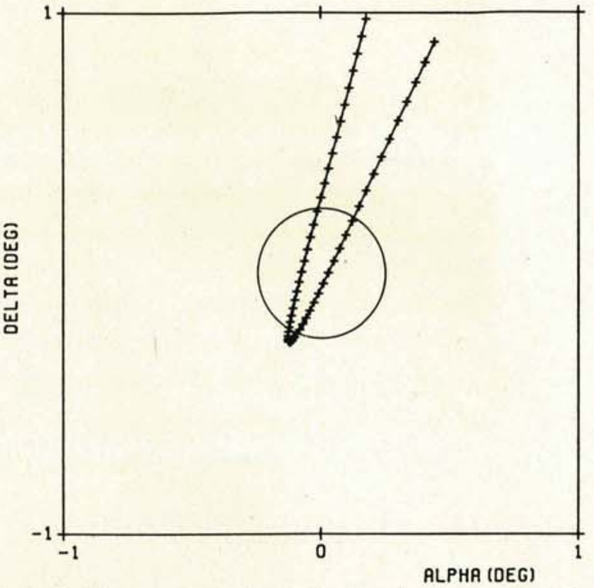

Figure 5. The apparent path of the moon's center over the sun as viewed from LAGEOS during the eclipse of April 9, 1986. Tic marks are interspaced by 100 s.

The effect of not accounting for the eclipse is dramatically illustrated in Figure 6. Here, the differences between two computed 1-week satellite ephemerides with and without a proper modeling of this eclipse are presented. Since the sun is situated close to the orbital plane, the most significant effect is in the radial and along-track directions. Over this relatively short period of 1 week, the total difference generally remains well below the 50-cm level, however, except for the final day, a Saturday with hardly any tracking data available, when it rises to almost 1 m.

The total length of the eclipse, of course, is a very important factor for the magnitude of the orbital perturbations. This particular eclipse was a rare and extremely long one (the longest up to the present), which lasted for 70 minutes and during which 88 percent of the sun was obscured by the moon at maximum. As a matter of fact, another eclipse occurred on May 8, but this one lasted for only 12 minutes with a maximum coverage of 6 percent which is too short and too small to result in significant orbit perturbations.

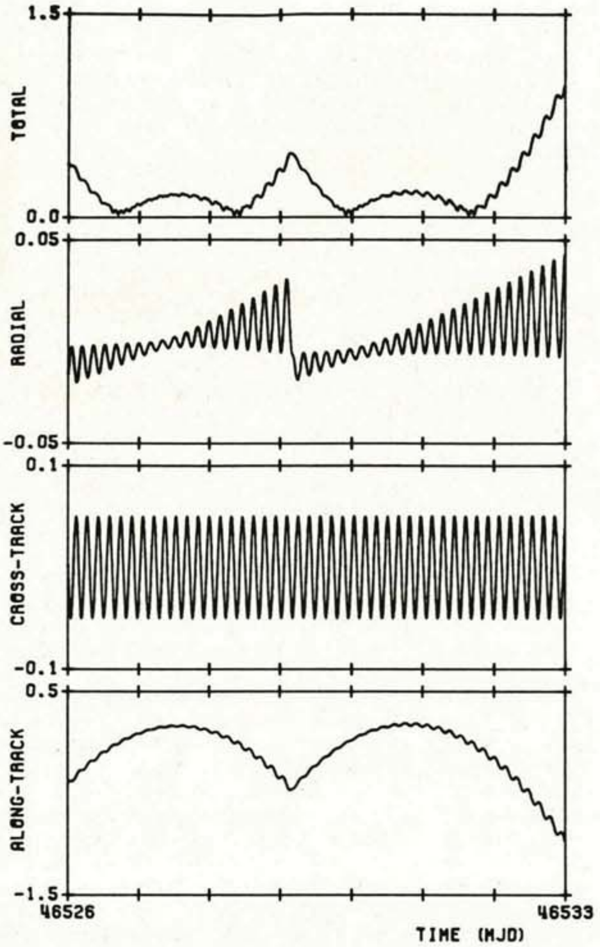

Figure 6. The time-history of the differences between the LAGEOS orbits computed with and without a proper modeling of solar eclipses by the moon. The quick-look data arc covers the week from April 6 to April 13, 1986. All values are in meters.

4. QUICK-LOOK DATA ANALYSIS: STATION POSITIONING

An important monitoring tool of the quick-look analysis system is the solution of the coordinates of the mobile laser systems and of other stations of interest. Generally, the a priori positions of the mobile laser systems are not known very accurately, precluding a simple method of detecting systematic data problems. Monitoring of successive solutions for the positions derived from regularly replenished datasets, however, does facilitate this. Systematic ranging errors, for example, will be partly or even completely absorbed in the derived laser system positions. Unless these are permanent errors, they will betray themselves by sudden changes in the solutions, which may be detected if the effects are large enough. In fact, the comparison of independently obtained solutions for station coordinates or interstation baselines often is the only way to assess the quality of these solutions. An exception is the Matera collocation period, during which MTLRS-1 and -2 were deployed near the fixed laser system. Then, the recovered positions and interstation baselines could easily and very accurately be verified against the results derived from local surveys. For this period both the baselines resulting from the 1-week and the long data arcs will be presented in this paper. For the other two occupation periods only baseline results obtained from independent 1-week data arcs will be presented.

An overview of the weekly solutions for the baseline between MTLRS-1 and -2 during the Matera collocation is presented in the top plot of Figure 7. During the final weeks, the weather conditions were not too favorable and therefore, only during very few passes measurements were obtained. The resulting poor baseline solutions are not included in this Figure. In spite of the sometimes small number of passes, the computed baselines are very stable, averaging at 16.640 m. This is very close to the nominal value of 16.622 m, obtained from the local survey. The unweighted rms of the differences of the weekly solutions with respect to the nominal value amounts to 9.8 cm, but this result is strongly affected by the solution for the fifth week. Disregarding this outlier, the rms becomes only 2.0 cm.

The baseline recovered from the 10-week data arc analysis amounted to 16.613 m, differing from the nominal value by only a fraction of the corresponding standard deviation of 2.3 cm. This standard deviation was obtained by scaling the formal standard deviation with the overall rms of fit of the arc. In this analysis the coordinates of the stationary Matera laser system were also solved for, and this resulted in another two very good baseline solutions. For the interstation baseline MTLRS-1 to

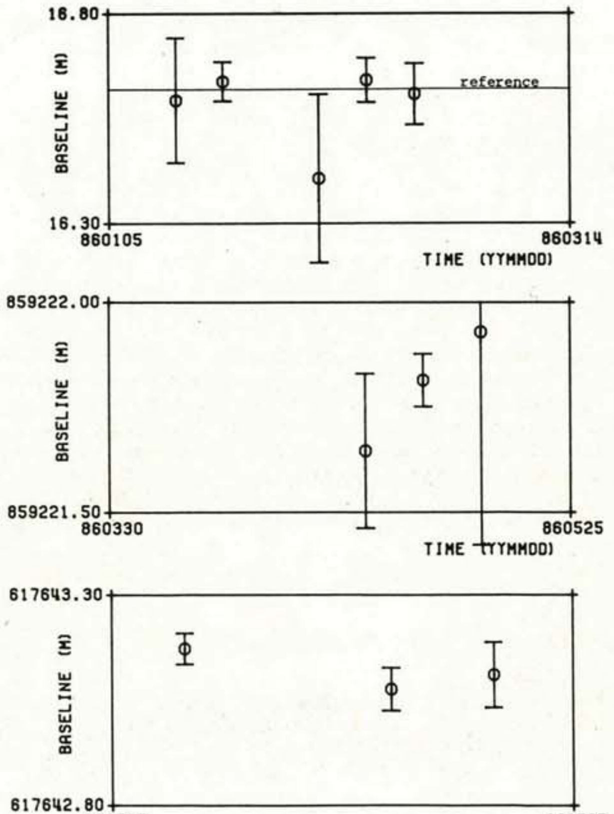

Figure 7. Solutions for the baselines between the European mobile laser systems, obtained from 1-week quick-look data arcs. MTLRS-1 and -2 were deployed at Matera for a collocation (top), at Karitsa and Basovizza (middle) and at Askites and Roumelli (bottom). The reference value was obtained from local surveys.

Matera a value of 38.922 m was derived (standard deviation 1.8 cm), the nominal value being 38.940 m. For the baseline MTLRS-2 to Matera the difference with the surveyed value was again very small: 49.980 m (standard deviation 1.5 cm), as compared to the nominal value of 49.971 m.

Weekly baseline solutions for the second period, when MTLRS-1 and -2 were deployed at Karitsa and Basovizza, respectively, are presented in the middle plot of Figure 7. The data yield of MTLRS-2 was rather small unfortunately, since this system encountered some technical problems and did not start operation until the fourth week. The quick-look data analysis for this period, therefore, resulted in only three independent weekly baseline solutions, averaging at 859221.786 m. Although the interpretation of the results is somewhat hampered by this limited number of solutions, they are not basically different from the results of the first period. The rms of the differences between the depicted baselines and their mean value amounts to 11.7 cm.

Finally, the bottom plot in Figure 7 gives an overview of the interstation baselines recovered during the third period, with MTLRS-1 deployed at Askites and MTLRS-2 at Roumelli. This time, due to problems with the data communication links, many of the passes were received too late at QLDAC to be included in one of the 1-week data arcs. No more than four baseline solutions could be derived, the final one being based on only one pass over MTLRS-2. The baselines average at 617643.135 m, and again the quality of these solutions appears to be similar to that of the results obtained during the Matera collocation: the rms of the differences with respect to the weighted mean amounts to 4.3 cm.

Figure 7 clearly illustrates that during half of the overall period of the quick-look data analyses, no weekly baselines have been computed, mainly because one of the mobile systems did not provide observations in those weeks due to bad weather or technical or data communication problems. The tracking information obtained by the other, active system can still be used for the computation of an interstation baseline, however, by simply accumulating all the weekly coordinate solutions for either station. This is done by combining the normal equations of these solutions resulting in weighted averages for the coordinate solutions, from which more accurate baselines can be obtained. These results are summarized in the lower part of Table 8. This Table also presents some statistics of the weekly baseline values as compared with reference values or with the baselines obtained in the way just described. The rms of the differences with respect to the baselines of the averaged coordinate solutions ranges from 2 to 12 cm.

5. CONCLUSIONS

All results for baselines, derived from combinations of independent 1-week data arcs, are summarized in Table 8. This Table includes baselines computed from both full-rate data from the MERIT campaign and quick-look data from the first WEGENER-MEDLAS campaign. It provides an up-to-date estimate of the baselines between three relatively new fixed European stations, based on a set of 8 carefully selected data arcs of one week length. The results compare favorably with early solutions from other authors and may be an improvement because a potential height error in the UT/CSR LSC 84.02 position of Matera of 14 cm was identified. The Table also provides an indication of the potential of quick-look data to supply accurate interstation baselines because it shows that the consistency of 1-week data arc baseline solutions derived from quick-look data is not basically different from that obtained from full-rate data. If a sufficient number of tracking passes with sufficient lengths over the stations whose coordinates are adjusted is available, individual baselines computed from single weeks of tracking data appear to exhibit a mutual consistency of the order of 5 cm. Since the differences between the results obtained with full-rate and quick-look data are very small, it must be concluded that it is primarily the computation model employed which determines the accuracy of the interstation baseline solutions.

The 1-week length of the data arcs seems to be very favorable from the point of view of the dynamic model imperfections. Even in the case of a severe deficiency like the lack of modeling of solar eclipses in the computation of the effects of solar radiation pressure, the overall results for the 1-week arc are hardly affected. A disadvantage is that due to weather and equipment problems it is often very hard to find suitable 1-week arcs with tracking by the systems of interest.

Table 8. Some statistics of the interstation baselines derived from 1-week data arcs. The average baseline values were computed from individually averaged station positions. For the baselines computed with full-rate data, the values according to the UT/CSR LSC 84.02 coordinate solution were taken as reference; for the baseline between the sites 7540 and 7541, the surveyed value was used for this purpose.

Measurement type	Baseline	Average (m)	Standard deviation (cm)	Rms difference with reference (cm)	Rms difference with average (cm)
full-rate	Graz (7839) - Herstmonceux (7840)	1183242.808	1.8	5.9	6.2
full-rate	Graz (7839) - Matera (7939)	719405.002	1.8	8.9	6.8
full-rate	Herstmonceux (7840) - Matera (7939)	1694491.031	1.5	10.8	10.5
quick-look	Matera (7540) - Matera (7541)	16.607	2.0	9.8 (2.0)*	9.2 (2.1)*
quick-look	Karitsa (7520) - Basovizza (7550)	859221.807	2.6	-	11.7
quick-look	Askites (7510) - Roumelli (7517)	617643.202	3.1	-	9.9

* The values in parenthesis apply after removal of 1 suspected outlier.

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