DETERMINATION OF THE STATION COORDINATES FOR QUALITY CONTROL OF THE SATELLITE LASER RANGING DATA

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Abstract

The paper presents the method of quality control of the SLR data on the base of the station topocentric coordinates. The coordinates were determined from monthly orbital arcs of satellites LAGEOS-1 and LAGEOS-2. The orbital arcs were calculated on the basis of results of 15-17 fixed stations with very good quality of coordinates in ITRF2000 system. The orbital arc RMS was on a level of 1.8 cm. The differences between topocentric coordinates obtained from orbital results and local geodetic tie were presented for three sites: Grasse (7835-7845) from 4.5-year period, Potsdam (7836-7841) from year 2003 and Maidanak (1864-1863) for the period from May 2002 to the end 2003. The differences between coordinates determination for two colors for stations Zimmerwald (7810, 6810) and Concepcion (7405, 6405) were also presented. The coordinates and velocities of Riyadh station (7832) in ITRF2000 system has been corrected and Arabian tectonic plate motion were determined. The coordinates determination and control of their stability for the new points were presented for FTLRS system: Ajaccio (7848) and Chania (7830). The example of continuous coordinates determination in the long period is Borowiec SLR station (7811). The stability of coordinates and the movement of Eurasian tectonic plate for this station were determined for the 10-year period from 1993.5 to 2003.5.

Introduction

The continuous determination of the coordinates of the satellite laser ranging stations is one of the methods for quality control of the laser ranging data. This method reflects the quality of SLR data in the form of the station position stability, especially systematic effects (range bias) in vertical component and also quantity of normal points, which decided about standard deviation of coordinates determination. The possibility of immediate comparison with results of GPS are also very important in this method. The description of the method and results of the coordinates determination of Borowiec SLR in 1999 and all SLR stations in the period 1999-2001 were presented in the previous papers of the author (*Schillak, 2000, Schillak and Wnuk, 2002), Wnuk et al., 2002*). The method needs stable terrestrial reference frame, which assures the best stations position for the same epoch. One of the best terrestrial coordinates frame is ITRF2000, which includes four space techniques, for the most SLR stations SLR+GPS. The difference between determined coordinates and ITRF2000 is result of several effects:

- real station displacement (for example Arequipa, Tateyama),
- systematic errors of the measurements (from SLR system and environment) – main source of difference,
- orbital effects from not correct or not included some perturbations of the satellite and station positions,

• systematic differences of the real position with ITRF2000 (not correct position and velocity in ITRF2000).

The advantage of this method is presentation on one graph full picture of all station errors as the effect of quality and quantity of measurements of the given station. The method includes also all hitherto parameters for estimation of station quality like orbital RMS and Range Bias. The stations coordinates were determined by using orbital program GEODYN-II. The most important parameters are presented below:

• Earth gravity field: EGM96 20x20
• polar motion: IERS C04 (every one day)
• one month arcs,
• LAGEOS-1 and LAGEOS-2 as one solution,
• 15-17 fixed stations for orbit determination: coordinates and velocities in ITRF2000,
• no weights,
• no range bias determination (range bias will be see in vertical component).

Estimated parameters:

• satellite state vector,
• one station geocentric coordinates,
• acceleration parameters along-track, cross-track and radial at 5 days intervals.

Results

The paper presents results of coordinates determination for some choice stations, especially for comparison of two SLR systems in the same site and the coordinates determination for new stations or upgrading of not correct ITRF2000 coordinates. The control of coordinates determination were performed by comparison of orbital results with local geodetic tie between two stations in Grasse; SLR (7835) and LLR (7845) from the 4.5 years of common LAGEOS-1 and LAGEOS-2 observations of both stations (Fig. 1). The determined geocentric coordinates of the LLR station 7845 were transferred to the point 7835 on the base of local geodetic tie from log file of Grasse SLR station. The differences of the coordinates between stations for common months in all components are present in figure 1. The differences are not significant and show very good agreement between orbital and ground surveying data.
The similar method was used for the two SLR stations in Potsdam (7836 and 7841) (Fig. 2). In this case the differences in East-West and vertical component are significant. It was caused by systematic errors of the local geodetic tie.
The third example of the two SLR stations in one site is Maidanak (1864, 1863) (Fig. 3). The geocentric coordinates for station 1863 were determined form observations performed in the period May, 2002 – May, 2003 and on the base of the difference with Maidanak 1864 ITRF2000, the coordinates were transferred to common point 1864. The results for the station 1863 are significantly better in comparison with 1864. The significant and variable differences between these stations in vertical component are result of systematic errors of the station 1864, probably from frequency standard walk.
The next example is comparison of the determination of coordinates from measurements of one station in two colors; blue (423 nm) and infrared (846 nm) for stations Zimmerwald (Fig.

4) and Concepcion (Fig. 5). The differences of the station coordinates determined independently for both colors are not significant.
The new station coordinates in ITRF2000 system were determined for three points; Concepcion (7405), and two FTLRS sites: Ajaccio (7848) and Chania (7830) (Fig. 6). The stability of these coordinates for three components was equal to 11.4 mm, 13.3 mm and 8.3 mm for Concepcion, Ajaccio and Chania respectively. The final values of geocentric coordinates of these points for epoch 1997.0 are present in figures 5 and 6.

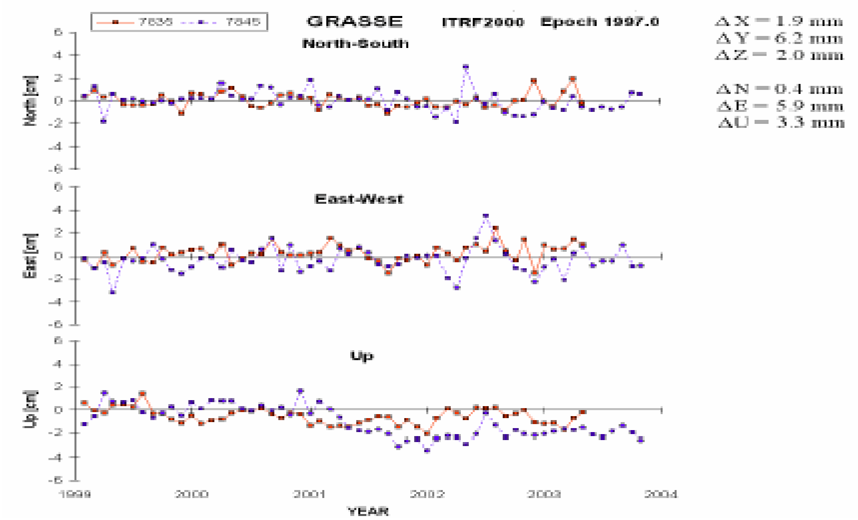

Figure 1. Topocentric coordinates of the Grasse SLR stations 7835 and 7845 in the period 1999.0-2004.0 in comparison to ITRF2000 for epoch 1997.0. The geocentric coordinates of the station 7845 were transformed to the point 7835 on the base of the local geodetic tie (Grasse log file).

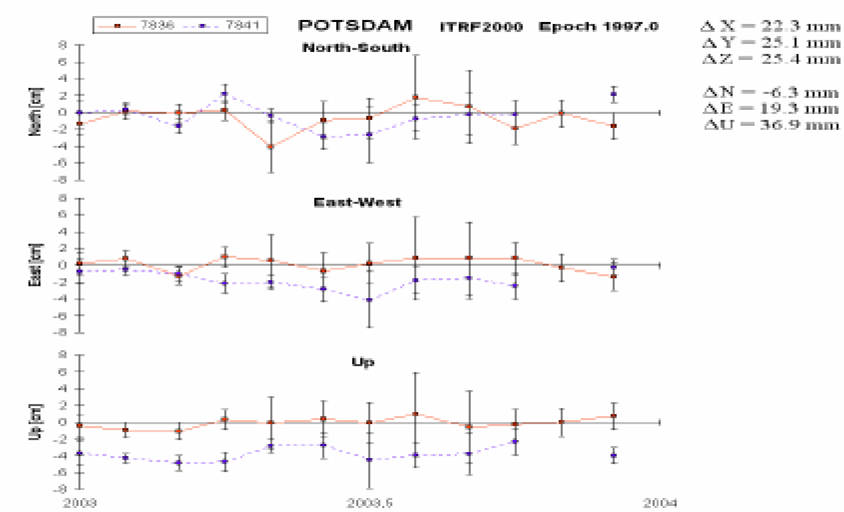

Figure 2. Topocentric coordinates of the Potsdam SLR stations 7836 and 7841 in the period 2003.0-2004.0 in comparison to ITRF2000 for epoch 1997.0. The geocentric coordinates of the station 7841 were transformed to the point 7836 on the base of the local geodetic tie (Potsdam log file).

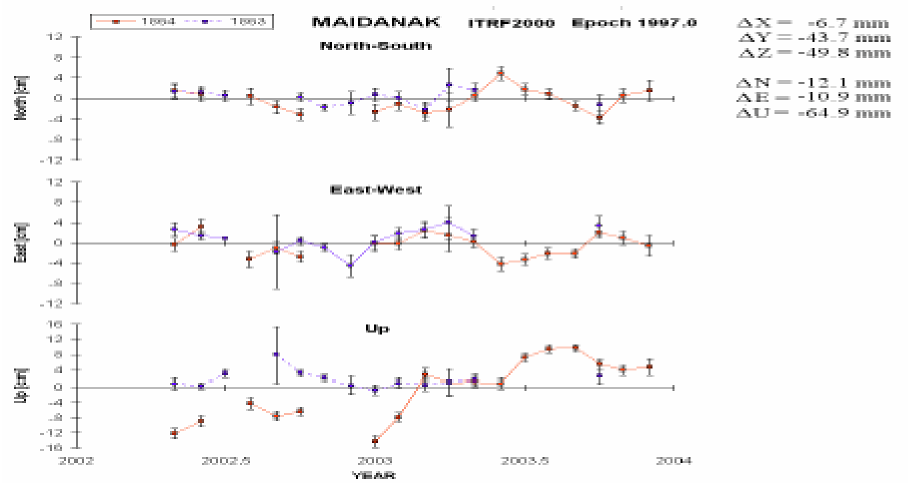

Figure 3. Topocentric coordinates of the Maidanak SLR stations 1864 and 1863 in the period 2002.0-2004.0 in comparison to ITRF2000 for epoch 1997.0. The geocentric coordinates of the station 1863 were transformed to the point 1864 on the base of the difference between geocentric coordinates of both stations.

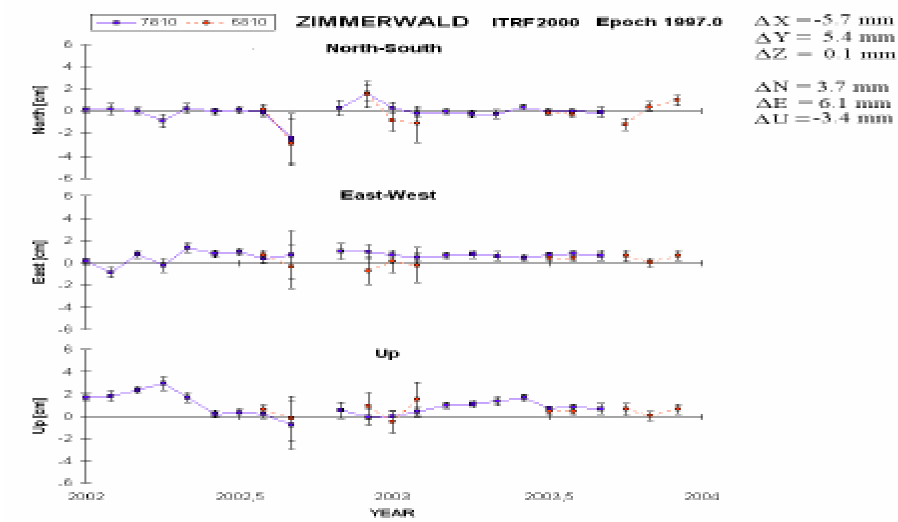

Figure 4. Topocentric coordinates of the Zimmerwald SLR station for two colors: blue (7810) and infrared (6810) in the period 2002.0-2004.0 in comparison to ITRF2000 for epoch 1997.0.

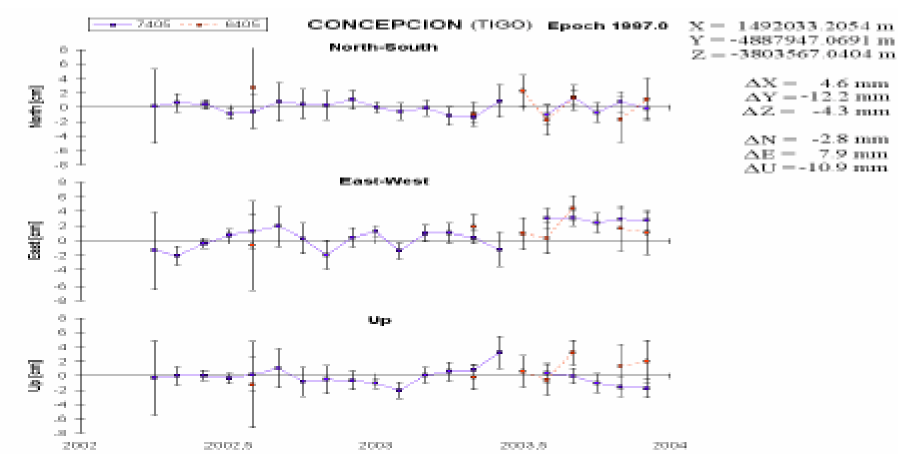

Figure 5. Topocentric coordinates of the Concepcion SLR station (TIGO) for two colors: blue (7405) and infrared (6405) in the period 2002.0-2004.0 in comparison to the new determined coordinates for epoch 1997.0.

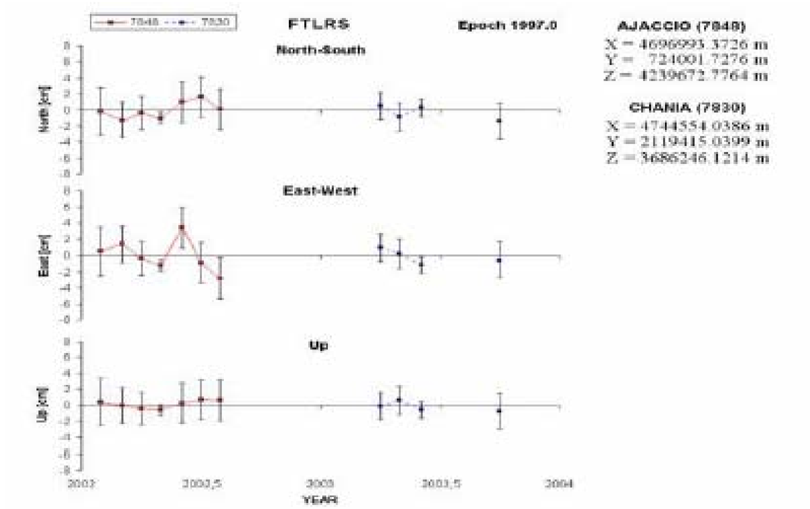

Figure 6. Topocentric coordinates of the FTLRS for two points: Ajaccio (7848) – left side, and Chania (7830) – right side, in the period 2002.0-2004.0 in comparison to the new determined coordinates for epoch 1997.0.

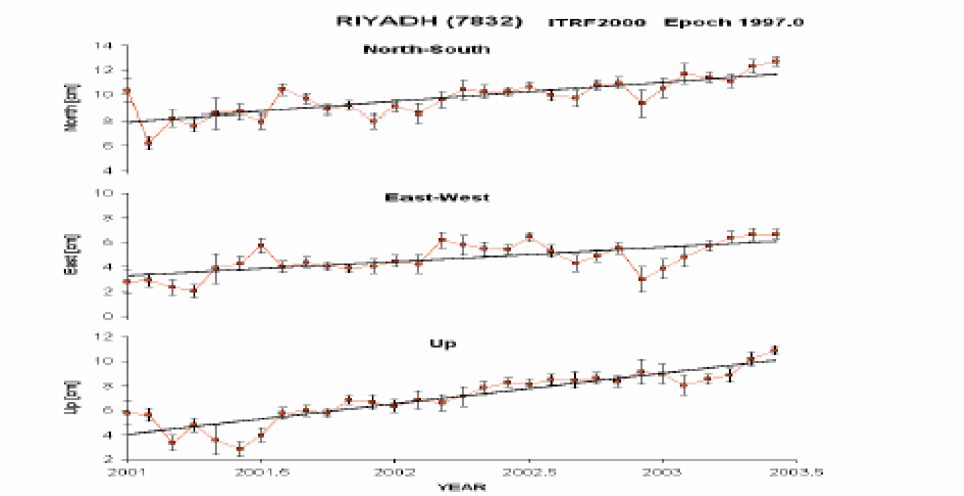

Figure 7. Topocentric coordinates of the Riyadh SLR station 7832 in the period 2001.0-2003.5 in comparison to ITRF2000 for epoch 1997.0. Non correct velocities in ITRF2000 are clearly visible.

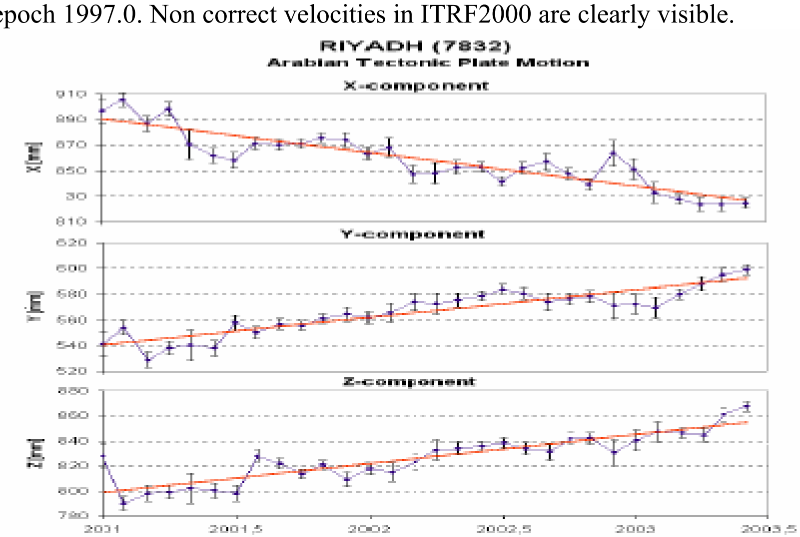

Figure 8. Geocentric coordinates of the Riyadh SLR station 7832 in the period 2001.0-2003.5 for first day of every monthly arc. Inclination of the coordinates shows Arabian tectonic plate motion.

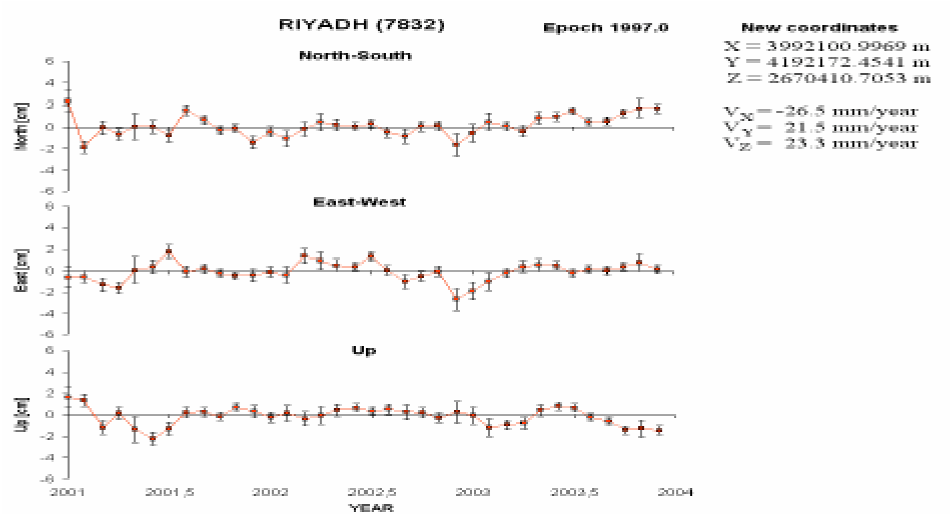

Figure 9. Topocentric coordinates of the Riyadh SLR station 7832 in the period 2001.0-2004.0 in comparison to the new determined coordinates and station velocities for epoch 1997.0.

The non correct station coordinates and velocities in ITRF2000 were detect for SLR station in Riyadh (7832)(Fig. 7). The correct coordinates and velocities for this station are very important due to its localization and high quality and quantity of results. The new coordinates and velocities of this station were determined by linear regression method from geocentric coordinates (X, Y, Z) determined for reference epoch of the every month arc (first day of the month) (Fig. 8). The new coordinates in ITRF2000 system for epoch 1997.0 attached in figure 9 are significantly better.

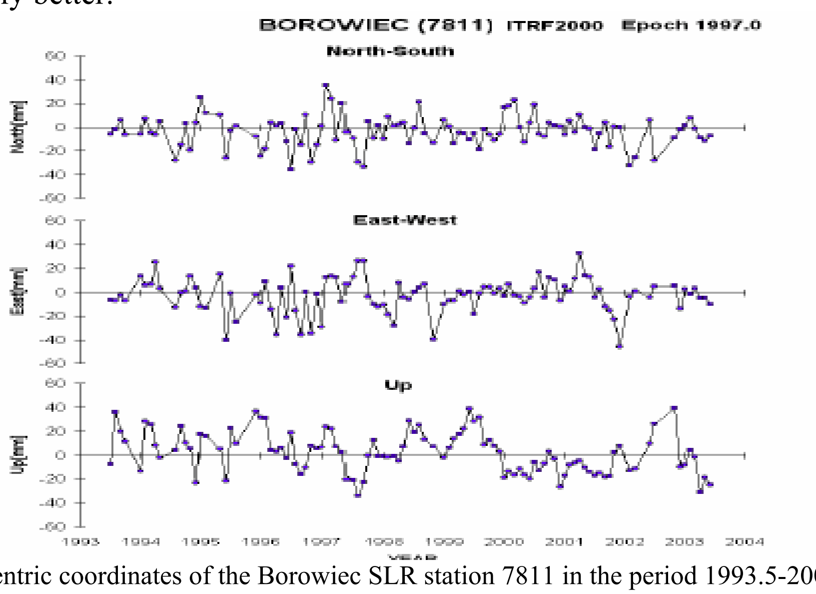

Figure 10. Topocentric coordinates of the Borowiec SLR station 7811 in the period 1993.5-2003.5 in comparison to ITRF2000 for epoch 1997.0.

The long term stability of the station coordinates are present for Borowiec SLR station (7811) (Fig. 10). Stability of coordinates in ten years period was equal to 15.4 mm. The vertical component shows some systematic effects which reflect station Range Bias. The mean value of differences with Borowiec ITRF2000 coordinates for epoch 1997.0 for North-South, East-

West and vertical components are equal to –3.9 mm, -3.4 mm and 2.3 mm respectively. These results show very good agreement with coordinates of the Borowiec GPS station (BOR1) (the coordinates of Borowiec in ITRF2000 were mainly determined from GPS results).

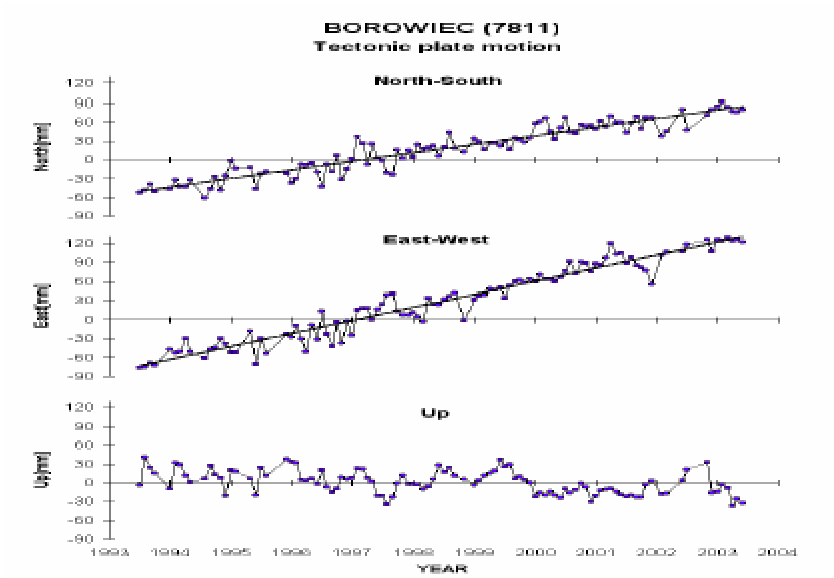

Figure 11. Topocentric coordinates of the Borowiec SLR station 7811 in the period 1993.5-2003.5 for first day of every monthly arc. Inclination shows Eurasian tectonic plate motion, the vertical component is free from this movement.

The coordinates determined for arc reference epoch (first day of every month) show the effect of Eurasian tectonic plate motion (Fig. 11). This effect is visible only for horizontal components. The vertical component is free from this movement (monthly coordinates are the same as in figure 10). The plate velocity is in very good agreement with tectonic plate motion model NNR-NUVEL1A and ITRF2000 velocities.

Conclusions and future plans

- Conclusions:

• good agreement between orbital results and local geodetic tie for 4.5 years period of GRASSE SLR stations confirm properly parameters and options of orbital program,
• the observatories which have two SLR stations (GRASSE, POTSDAM, MAIDANAK...) are asked for parallel observations of LAGEOS satellites as long as possible – good standard for control of the orbital method,
• accurate (1 mm) geodetic tie for these observatories and its periodical control is very important for verification of orbital analysis,
• important is the number of normal points per station – 50 NP/month is critical for coordinates determination,
• determination of the station velocities in ITRF2000 for new stations is possible with sufficient accuracy only for periods longer than two years,

- the presented method of QC of the SLR data illustrate variation of the quality (range bias, RMS) and quantity of results on one graph,
- very good agreement between orbital RMS and range biases for LAGEOS-1 and LAGEOS-2 for the most stations was detect (for example for stations 7835: 15.3, 15.3; 3.3, 4.7 mm, 7845: 18.5, 18.3; 5.9, 7.1 mm).

- Future plans:

- the all SLR stations coordinates for the period 5 years (1999.0 – 2004.0) are available (sch@cbk.poznan.pl),
- the station coordinates and the tectonic plate motions for the 10-year period (1993.5 – 2003.5) for the more than ten SLR stations will be prepared in the near future – this method is the good control of the long term or periodical positions changes,
- near-real time monitoring of the station coordinates is necessary for quick detection of station systematic errors or real position changes,
- the orbital program need upgrading for minimize the effects from orbital analysis
  – new or improved models of satellite and station position perturbations (atmosphere, loading effects, model of Earth gravity field…)
  – new precession-nutation model (IAU2000),
  – new celestial and terrestrial reference system (IAU2000).

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