MONITORING THE INTERNATIONAL TERRESTRIAL REFERENCE FRAME 2000 BY SATELLITE LASER RANGING IN 1993–2003

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ABSTRACT. Monitoring of terrestrial reference frames in the long time periods is important task for control of the correctness of the stations coordinates. The laser technique give the absolute positioning which permit detection of all instabilities of each station on the Earth surface. The paper presents results of determination of positions and velocities of all SLR stations in comparison to ITRF2000 in the five years period 1999-2003. The coordinates were determined individually for each station from one month orbital arcs of Lageos-1 and Lageos-2 satellites for first day of every arc and for epoch 1997.0. The stability of station coordinates determined for the same epoch 1997.0 in the five year period varied from 5 mm to 7 cm. In the period of study two real position changes were detected; for station Tateyama in 2000 and Arequipa in 2001. The orbital RMS and range bias separately for Lageos-1 and Lageos-2 were determined for each station. The results for both satellites for the most stations were in very good agreement which confirm correctness of orbital analysis. The stations velocities as result mainly of tectonic plate motion were determined by regression analysis from five years period. For the most stations is a good agreement with model of tectonic plate motion NUVEL1A. Several stations had significant differences in comparison to position and velocity in ITRF2000.

1. INTRODUCTION

The paper presents results of monitoring of the satellite laser ranging (SLR) station positions and velocities determined from satellite laser observations performed in the period 1999-2003. All results were compared with ITRF2000. The calculations included all SLR data in the period of study with exception five stations with too small number and quality of data. The positions of 50 SLR points and stations for epoch 1997.0 were determined for the period from 1^{st} January 1999 to 31^{st} December 2003. The velocities of the SLR stations were determined for 29 stations including only points with time span longer then two years.

2. ORBITAL ANALYSIS

The calculations were performed in Borowiec Analysis Centre (BAC) by NASA orbital program GEODYN-II (McCarty et al. 1993). The program included the following models and parameters: Earth gravity field: EGM96 (Lemoine et al. 1998) or EIGEN-GRACE02S (Reigber et al. 2005) 20x20, polar motion IERS C04, arc length 1 month, satellites LAGEOS-1 and LAGEOS-2, 15–17 reference stations in ITRF2000 (Boucher et al. 2004) for orbit determination; estimated parameters: satellite state vector, station geocentric coordinates, acceleration parameters along-track, cross-track and radial at 5 days intervals.

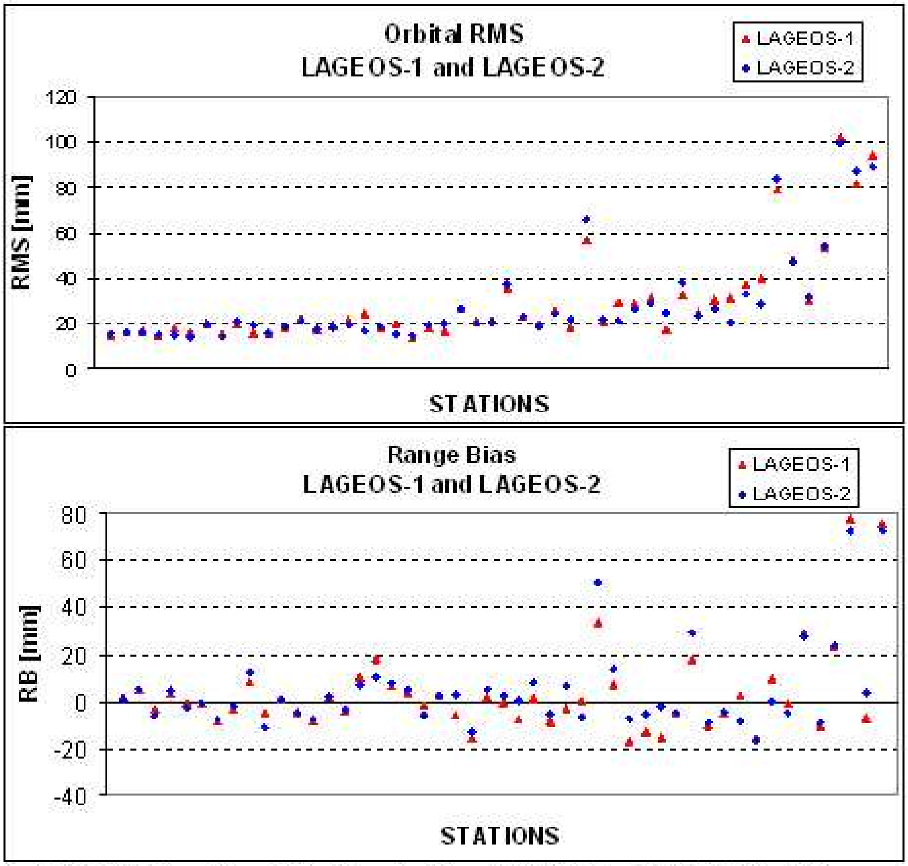

Figure 1: Orbital RMS and Range Bias determined from LAGEOS-1 and LAGEOS-2 satellites for all SLR stations in 1999-2003

The influence of observations data on the quality of the orbit determination is presented in Fig.1. The orbital RMS-of-fit and Range Bias for each station were determined independently from orbit of LAGEOS-1 and LAGEOS-2. High agreement of the results for both satellites indicate that sources of errors are mainly from SLR stations. The improvement of accuracy of the orbital analysis was achieved by change of used models: polar motion from model IERS C01 to IERS C04 (Schillak, 2005-2) and gravity field model from model EGM96 to model EIGEN-GRACE02S (Fig. 2). The mean orbital RMS-of-fit for 5 years was equal to 15 mm.

3. STABILITY OF STATION COORDINATES

The stability of 50 stations and points were calculated from scatter of positions determined per each month. The real change of position due to earthquake were detected for two stations: Tateyama (7339), 4.5 cm in June–August 2000 (Schillak et al. 2005) and Arequipa (7403), 62 cm in 23 June 2001 (Schillak and Wnuk, 2002). The results for two stations: Zimmerwald and Concepcion were calculated independently for two colors: blue-423 nm and infrared-846 nm. The best station stability was on the level 5 to 10 mm (16 points and stations). The stability of the most stations (30) was in the range 1-3 cm. Several stations had significant technical problems.

36 stations had coordinates ITRF2000. The differences of the station positions between

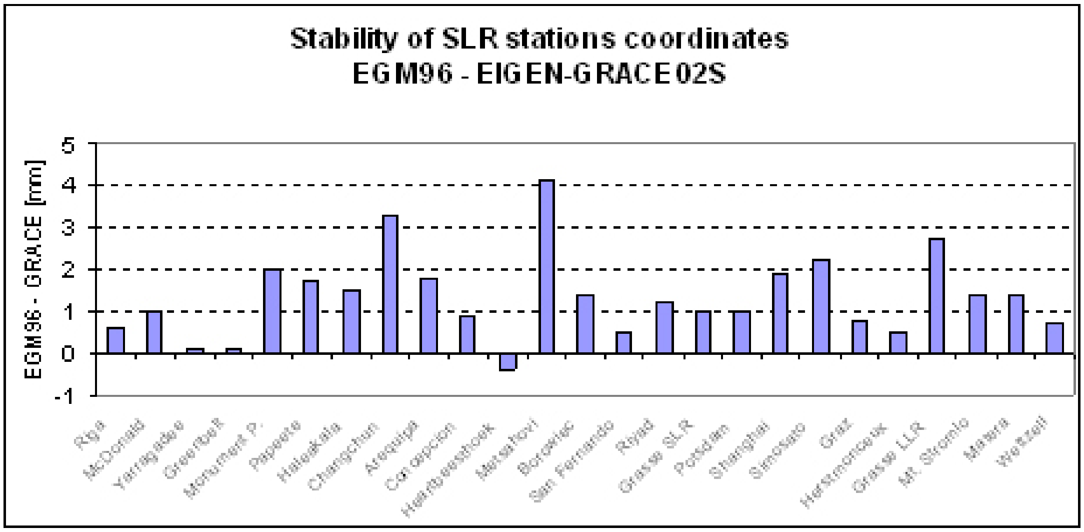

Figure 2: Stability of the SLR station coordinates for gravity field EGM96 and EIGEN-GRACE02S in 1999-2003

ITRF2000 and results of Borowiec Analysis Centre (BAC) were in the range 3-15 mm. Some stations had incorrect ITRF2000 coordinates, specially Riyad (7832), several stations had significant technical problems in the period of study (Maidanak-2, Beijng, Cagliari, Kunming, San Fernando, Simosato) or too small number of observations (Tokyo, Helwan).

4. STATION VELOCITIES

The station velocities were determined only for stations with data time span longer than 20 months, it means for 29 stations and points. The best accuracy of station velocities determination was obtained for span of 5 years. The accuracy for two years is three times lower. The difference of station velocities between ITRF2000 and the results of BAC were in the range 0-5 mm/year. Only for four stations differences were significant (Maidanak-2, Beijng, Arequipa after earthquake and Riyad). The comparison of station velocities with tectonic plates motion model NUVEL1A shows similar agreement with exception of Arequipa, Concepcion, Shanghai and Simosato. The model NUVEL1A is insufficient for South America plate and Japan.

5. CONCLUSIONS

The paper shows a good agreement between positions and velocities of the SLR stations determined by Borowiec Analysis Centre and ITRF2000 and tectonic plate motion model NUVEL1A. The ITRF2000 position and velocity of Riyad station need a correction. The station position stability for the best station achieve 5 mm in the 5 year period of study but for the most stations is in the range 1-3 cm and need improvement of the quality of SLR data of these stations. The determination of the SLR station velocities is possible with sufficient accuracy only for periods longer than two years, the longer time period significantly improve results. The long time series are very important for velocity determination. The velocities of South America tectonic plate and Japan (Arequipa, Concepcion, Simosato) and wave character changes in vertical component for several station should be explain. The positions and velocities of new points in Tateyama and Arequipa after earthquakes should be included in the new ITRF2005 solution. The near-real time monitoring of the SLR station coordinates is necessary for quick detection of real position changes and stations instrumental systematic errors. The improvement of accuracy of stations coordinates need further upgrading of the orbital programs: new or improved models of satellite and station position perturbations (atmosphere, loading effects, new models of Earth gravity field, geocenter motion...), new International Terrestrial Reference Frame (ITRF2005), new precession-nutation model (IAU2000), new celestial and terrestrial reference system (IAU2000).

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