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LOD FIRST ESTIMATES IN 7406 SLR SAN JUAN ARGENTINA STATION

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RESUMEN

En este trabajo se presentan resultados derivados de observaciones satelitales realizadas en la estación San Juan SLR del Observatorio Astronómico Félix Aguilar (OAFA). El telescopio Satellite Laser Ranging (SLR) fue instalado a principios del año 2006, de acuerdo con un convenio de cooperación internacional entre la Universidad Nacional de San Juan (UNSJ) y la Academia China de Ciencias (CAS). El buen funcionamiento del SLR permitió, desde el año 2011, el procesamiento de los datos mediante el uso del software NAOC SLR. Este programa fue diseñado para calcular las órbitas de los satélites y las coordenadas de la estación; sin embargo, en este trabajo se empleó para la determinación de las series de tiempo LOD (Length Of Day) y de la velocidad de Rotación de la Tierra.

ABSTRACT

In this paper we show results derived from satellite observations at the San Juan SLR station of Felix Aguilar Astronomical Observatory (OAFA). The Satellite Laser Ranging (SLR) telescope was installed in early 2006, in accordance with an international cooperation agreement between the San Juan National University (UNSJ) and the Chinese Academy of Sciences (CAS). The SLR has been in successful operation since 2011 using NAOC SLR software for the data processing. This program was designed to calculate satellite orbits and station coordinates, however it was used in this work for the determination of LOD (Length Of Day) time series and Earth Rotation speed.

Key Words: astrometry — reference systems — time

1. INTRODUCTION

The rotation of the Earth is an absolutely irregular and unpredictable phenomenon. At present the laws describing the instantaneous earth rotation vector is unknown. So at some given time, it is not possible to deduce the pole's position on the Earth and to predict accurately the location of a corresponding meridian in a geographical location (Altamini et al., 2002). These irregularities, fully confirmed, can be classified as: secular variations (due to tidal friction), periodic variations (related to physical processes occurring inside the Earth) and accidental variations (produced by atmospheric displacement and seasonal variations caused by vegetation).

The study of the rotational rate of the Earth is inherently complex because the mechanisms of fluctuations are uncertain (Altamini et al. 2002). For this reason, geodetic-astronomical determinations with increasing accuracy are still being made regularly. The data resulting from these observations are subjects of continuing research (Gambis 2004). During the last half century, the OAFA has collaborated with the international services IERS, BIPM and NASA to advance the understanding of this phenomenon.

Since 2006 these determinations have been made at the OAFA with a SLR telescope, through a collaboration between the National University of San Juan and the Chinese Academy of Sciences (Weidong et al. 2011).

2. SLR DATA PROCESS

The processing of the observables of this technique, known as Normal Points (NP), is made with the NAOC SLR software allowing the estimation of the duration of the day with very good accuracy.

The difference between day length (D) determined astronomically and 86400 seconds of TAI, is called LOD (Length Of Day). Its relationship with the angular velocity of the Earth (w) is expressed by:

$$\omega = 72921151.467064 - 0.843994803\mathrm{D}$$

2.1. *LOD Determination*

The basic observable of the SLR is the measured time difference between the emission of a laser pulse and its reception at the station A after the reflection at the satellite S. Multiplying this time interval

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by the speed of light c yields the two-way distance between the station and the satellite. However, the distance obtained is not equal to the geometrical distance derived from the positions of the station and the satellite, since some correction terms must be taken into account (Pacheco and Podestá, 2010):

$$\frac{1}{2} * c * \tau_A^S \left\| R_{EOP} * \mathbf{r}_A(t^S) - \mathbf{r}^S(t^S) \right\| + \delta\rho_{trop} + \delta\rho_{bias} + \delta\rho_{rel} + \delta\rho_{CoM} + \epsilon_A^S \tag{1}$$

The first line in (1) represents the purely geometrical part related to the station position and satellite position. The terms listed in the second line contain the correction terms that are relevant for an SLR observation. The individual terms in equation (1) are:

R_{EOP}: Rotation matrix of the Earth's orientation (nutation, UT1, polar motion).

$\mathbf{r}^A(t^S)$: 3-dimensional position of station A in a terrestrial reference frame at the receiving time t^A of the signal.

$\mathbf{r}^S(t^S)$: 3-dimensional position of satellite S in an inertial reference frame at the epoch of signal emission.

c: Velocity of light.

$\delta\rho_{trop}$: Tropospheric correction for the delay in the troposphere.

$\delta\rho_{bias}$: Considered in the SLR analysis to account for a constant offset between the theoretical and the measured distance from the station to the satellite.

$\delta\rho_{CoM}$: Corrections for phase center offsets and variations at the satellite.

$\delta\rho_{rel}$: Correction for relativistic effects.

ϵ_A^S: Measurement error.

Observations performed with the ILRS 7406 Laser Telescope were processed by means of NAOC – SLR Software that enables us to determine, among several other objectives, the DUT1 and coordinates of the Pole with extremely high precision.

The reference frame, measurement and force models essentially follow the IERS conventions.

- Force models. In the development of force models, the following perturbation factors are considered: (1) lunar and solar gravity perturbations, (2) solid Earth tide, (3) ocean tide (CSR4.0), (4) the GGM02C Earth gravity field model, (5) solar and Earth radiation pressure (Cr and derivative Cr adjusted), (6) the drag-like perturbation (Cd and derivative Cd adjusted), (7) thermal radiation imbalances from the Earth and Sun, (8) general relativistic perturbation, and (9) the Earth's rotation deformation perturbation. To improve the precision of the orbital determination, the empirical perturbations due to periodic empirical radial and transverse accelerations are also considered.
- Measurement models. Measurement models are considered as follows: (1) the Marini-Murray refraction model, (2) the offset correction about the center of mass of Lageos-2, (3) station displacement from solid Earth tides, (4) the influence of ocean loading at each site, (5) the influence of permanent tide deformation at each site, and (6) rotational deformation due to polar motion.
- Reference frame. The reference frame utilizes (1) the mean equinox (X-direction) and equator (X-Y plane) of J2000.0, (2) the precession constants of IAU 1976, (3) the nutation coefficients from the IAU 1980 theory of nutation and the celestial pole offset of IERS, (4) the DE403/LE403 planetary ephemeris, and (5) the initial values of station coordinates from ITRF2000.

We present LOD values (Figure 1) and the angular velocity of the rotation of the Earth (Figure 2), calculated for intervals of 7 days.

3. CONCLUSIONS

The results obtained for the LOD and Earth rotation speed shows that the NAOC – SLR software enables us to estimate the astrometric parameters with very high precision.

Values of the LOD found with the San Juan ILRS 7406 SLR observables are fully consistent with those given by IERS for the same epoch.

The larger differences (IERS – SLR) are present just for the days of Japan earthquakes (March 11, 2011) and the strong quake that happened two days before (March 9, 2011). The days are counted in Modified Julian Day. This shows that SLR satellite observations clearly detect changes of the Earth's Rotation Axis caused by important seismic events on the planet. This is fully coincident with the analysis of mass distribution changes in the inside of the Earth and, consequently, of the coordinates of the Pole carried out by the Jet Propulsion Laboratory of NASA (Gross 2000).

As expected, Figures 1 and 2 show a clear symmetry, since the greater the length of the day, the lower the rate of Earth Rotation.

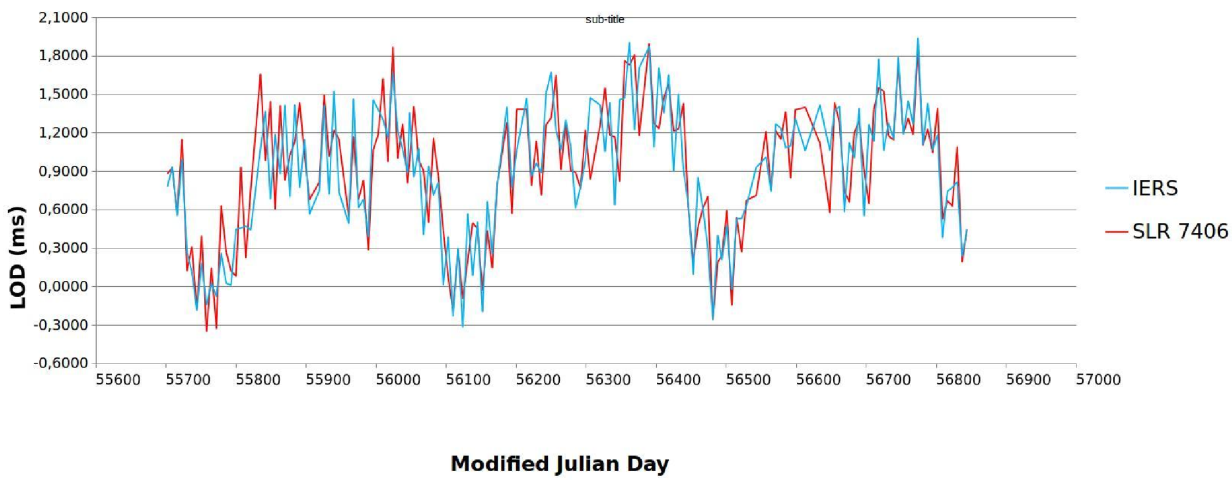

Fig. 1. Length of Day (LOD).

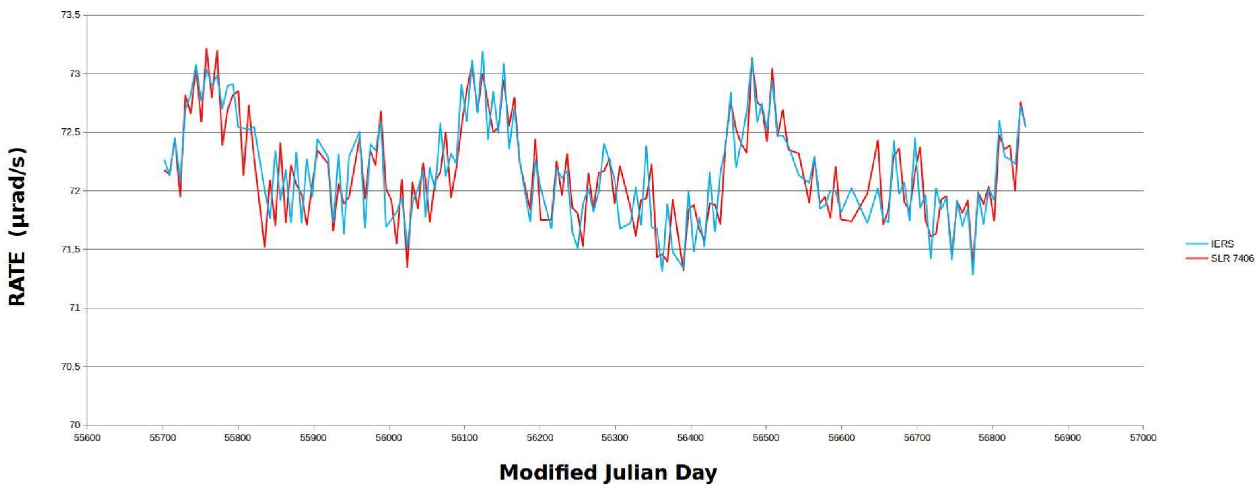

Fig. 2. Earth Rotation Rate.

The results achieved here at the OAFA have expanded our collaborations with the International Services ILRS, IERS and NASA.

REFERENCES

Altamini, Z., Sillard, P. & Boucher, C. 2002, JGRB, 107(B10), 2214, doi:10.1029/2001JB000561

Gambis, D. 2004, JGeod, Vol. 78(4-5), pp 295-303, doi: 10.1007/s00190-004-0394-1

Gross, R. S. 2000, JGeod, Vol. 43(12), pp 627-637, doi: 10.1007/s001900050001

Pacheco, A., & Podestá, R. 2010, In: Marco teórico para la vinculación de las técnicas satelitales SLR y GPS. Tesis de Especialización. Facultad de Ingeniería. Universidad Nacional de San Juan. Argentina

Weidong, Liu et al. 2011, In: Current situation and future of cooperative San Juan SLR station between Chinese-Argentinean. 17th International Workshop on Laser Ranging and 23rd General Assembly of the International Laser Ranging Service. Germany