The contribution of LLR data to the estimation of the celestial pole coordinates

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Abstract

This presentation is focused on the use of Lunar Laser Ranging data for the determination of the direction of the Celestial Intermediate Pole (CIP) in the Geocentric Celestial Reference System (GCRS).
We have first calculated the residuals of LLR observations over a period of 38 years, using the
IAU 2000A-2006 model of precession nutation (i.e. MHB 2000 nutation of Mathews et al. 2002 and P03 precession of Capitaine et al. 2003) and the CIO based procedure. Secondly, we have estimated the corrections to the X, Y coordinates of the CIP based on the IAU 2000A-2006 model every 70 days. Thirdly, we have compared the results with the VLBI celestial pole offsets.

Introduction

The Lunar Laser Ranging technique consists in determining the round-trip travel time of light pulses between a transmitter on Earth and reflectors on the surface of the Moon. It has may applications in various domains including astronomy, lunar science, geodynamics, and gravitational physics.

The main purpose of this paper is to focus on the application of the Lunar Laser Ranging technique in the field of the Earth rotation, especially for the determination of the celestial pole coordinates. We have first calculated the LLR residuals. Second, we have determined the corrections to the celestial pole coordinates and finally compared these corrections with the VLBI estimations.

Calculation and analysis

For the calculation of the residuals, we have used the LLR data from both stations of McDonald and CERGA over periods spanning 1969–2006 and 1984–2005, respectively. Figure 1 shows the residuals obtained for Grasse station. We have separated the figure into two parts in order to see the improvement of the residuals (i.e. since 1987).

Then, we have calculated the corrections to the celestial pole coordinates with respect to the IAU 2006-2000A model of precession nutation (i.e. MHB 2000 as the nutation model and P03 as the precession model) every 70 days. We have used the CIO procedure and the SOFA 2007 routines (see at www.iau-sofa.rl.ac.uk). Figure 2 represents the DX, DY corrections to the celestial pole coordinates obtained with this computation. It shows that from LLR observations, it is possible to have a reliable estimation of the corrections to the celestial pole coordinates (DX, DY).

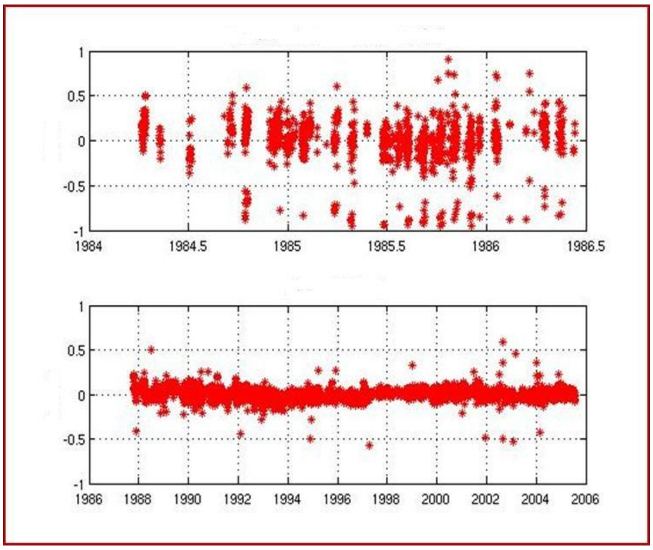

Figure 1. LLR residuals of Grasse station from 1984 to 2006 (in meters)

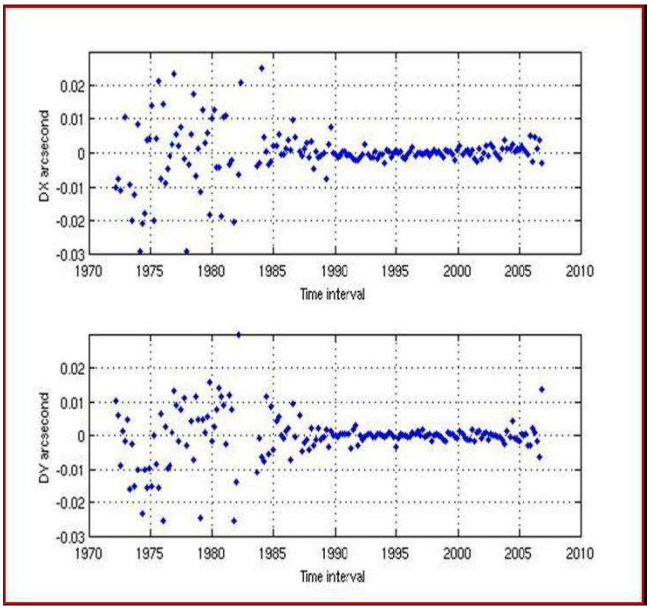

Figure 2. DX, DY corrections to the celestial pole coordinates (LLR data, IAU 2006-2000A precession nutation model) expressed in arcsecond.

Finally, we have calculated the VLBI celestial pole offsets with respect to the IAU 2006-2000A model of precession-nutation using the IVS combined solution (ivse08q1.eops). This solution is given with respect to the IAU 2000A model of precession nutation. In order to be consistent with our work, i.e. to refer the celestial pole offsets to the IAU2006-2000A model, we have used Eq.1 from Capitaine and Wallace (2006; Eq. (41)) which expresses the difference between the IAU2006 and IAU2000 precession models. The results are represented on Fig.3.

$$XIAU2006 - XIAU2000 = 155t - 2564t^2 + 2t^3 + 54t^4$$
$$YIAU2006 - YIAU2000 = -514t - 4t^2 + 58t^3 - 1t^4 - 1t^5 \quad \text{(Eq.1)}$$

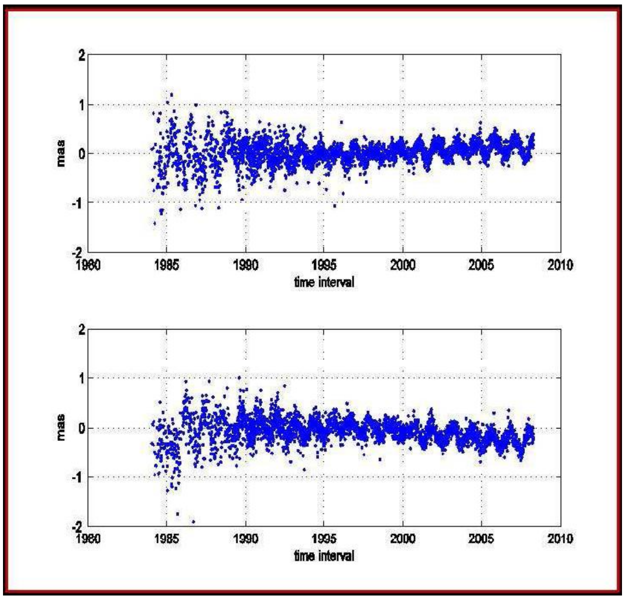

Figure 3. VLBI pole offsets with respect to the IAU 2006-2000A model of precession nutation

Comparing Fig.2 and Fig.3 shows that in both cases there is a significant improvement of the estimation since 1990. It also shows that the estimation of the celestial pole offsets is determined with better precision using VLBI observations.

Conclusion

The determination of the corrections to he celestial pole coordinates using LLR observations is less accurate with a factor 10 than in the VLBI determination. It is due to the imperfect distribution of the LLR observations. However, the interest of using LLR data for such estimations is that it provides independent estimations and a reference to another celestial reference system. A combination of the two techniques will be appropriate in order to improve the calculations.

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SOFA: www.iau-sofa.rl.ac.uk.

Website: hpiers.obspm.fr/eop-pc/models/fcn/index.