

EARTH ROTATION AND VARIATIONS OF THE GRAVITY FIELD, IN THE FRAMEWORK OF THE “DESCARTES-NUTATION” PROJECT

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1. INTRODUCTION

In this study, we investigate the links between Earth Orientation and Gravity Field Variations, on the basis of real gravity field data. The masses distributions inside the Earth govern the behaviour of the rotation axis in space (precession-nutation) and in the Earth (polar motion), as well as the Earth rotation rate (or equivalently, length of day). These distributions of masses can be measured by space owing to artificial satellites, the orbitography of which provides the Earth gravity field determination. Then, the temporal variations of the Earth gravity field can be related to the variations of the Earth Orientation Parameters (EOP) (with the Inertia Tensor).

Nowadays, the Earth orientation measurements in space, obtained with Very Long Baseline Interferometry (VLBI), have a precision better than the milliarcsecond level. It is then necessary to consider all the geophysical sources that can improve the models precision. The goal of my PhD Thesis was to use the Earth gravity field measurements, as well as its variations, as a tool to improve the Earth orientation modelisation. We present here the theoretical point of view for such studies, as well as some results obtained.

2. LINKS BETWEEN EARTH ORIENTATION PARAMETERS AND TEMPORAL VARIATIONS OF THE GRAVITY FIELD

The excess of length of day $\Delta(LOD)$ with respect to the nominal duration of 86400 s ($LOD_{\text{mean}} = 86400$ s) can be related to the temporal variations of C_{20} (i.e. ΔC_{20}), coefficient of degree 2 and order 0 of the geopotential development into spherical harmonics. We obtain (see for example Gross 2000, Bourda 2003):

$$\frac{\Delta(LOD)}{LOD_{\text{mean}}} = -\frac{2}{3} \frac{M R_e^2 \sqrt{5}}{C_m} \Delta \bar{C}_{20} + \frac{h_3}{C_m \Omega} \quad (1)$$

where C_m is the axial moment of inertia of the Earth mantle, M and R_e are respectively the mass and the equatorial radius of the Earth, h_3 is the axial relative angular momentum of the Earth, and Ω is the mean angular velocity of the Earth. The loading coefficient of 0.7 (Barnes et al. 1983), multiplying classically $\Delta \bar{C}_{20}$, is here a priori already considered into the C_{20} real data. Figure 2 shows the $\Delta(LOD)$ coming from the ΔC_{20} data of Biancale & Lemoine (2004), compared to the one of Fig. 1 coming from the C04 series of IERS where the “movement” effects and long terms have been removed.

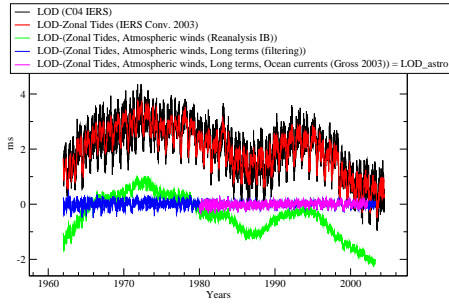


Figure 1: Exces in the length of day: various components of the $\Delta(LOD)$ are removed.

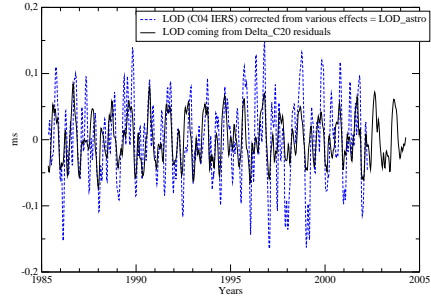


Figure 2: $\Delta(LOD)$ obtained with observed ΔC_{20} data, and compared with $\Delta(LOD)_{astro}$ (see Fig. 1).

The polar motion ($p = x_p - i y_p$) excitation can be related to the geopotential coefficients of degree 2 and order 1 (C_{21} and S_{21}), as following (see for example Gross 2000, Bourda 2003):

$$p + \frac{i}{\sigma_0} \dot{p} = \frac{k_0}{k_0 - k_2} \frac{1}{C_m - A_m} \left[\frac{h}{\Omega} - \sqrt{\frac{5}{3}} M R_e^2 (\bar{C}_{21} + i \bar{S}_{21}) \right] \quad (2)$$

where σ_0 is the Chandler frequency, $k_0/(k_0 - k_2) = 1.43$ (Barnes et al. 1983), A_m is the equatorial moment of inertia of the mantle, and h is the equatorial relative angular momentum of the Earth. We can notice that the loading coefficient of $(1 + k'_2)$ (Barnes et al. 1983), multiplying classically \bar{C}_{21} and \bar{S}_{21} , is here a priori already considered into the C_{21} and S_{21} real data.

An article about the link between the precession of the equator and the temporal variations of the C_{20} geopotential coefficient have been published into A&A by Bourda & Capitaine (2004), on the basis of Williams (1994) and Capitaine et al. (2003). The J_2 rate influence onto the precession acceleration have been studied, as well as the C_{20} periodic influence (annual and semi-annual terms), on the basis of the ΔC_{20} data of Biancale et al. (2002).

3. REFERENCES

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