Orbital perturbation of geodetic satellites detected by the time variation of empirical acceleration

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State-of-the-art satellite laser ranging systems have reached the precision better than 1 cm. Precise orbit determination using satellite laser ranging data should fully utilize such a high precision. However, each dynamic model is not accurate enough and there are still unsolved questions.
Quality of dynamic models directly impacts that of orbit determination. Empirical acceleration expressed as simple functions is generally introduced so that the parameters absorb unmodeled forces and reduce the residuals (Otsubo et al 2014).
The purpose of this study is to extract unknown acceleration factors from systematic behavior of empirical parameters and provide geodetic or geophysical explanations. Thermal acceleration models were discovered over the analysis of the empirical acceleration (Scharoo et al 1991).
"c5++" is space geodetic analysis software developed by Hitotsubashi University, NICT and Chalmers University of Technology. This software can estimate empirical acceleration constant terms and periodic terms in along-track, cross-track and radial components.
We use "c5++" to estimate empirical acceleration parameters of six geodetic satellites: AJISAI, LAGEOS-1, LAGEOS-2, LARES, STELLA and STARLETTE for the past five years. Five empirical parameters are estimated per arc. One is a constant term in the along-track component, two are periodic terms in the along-track component and the rest two are periodic terms in the cross-track component.
The post-fit residual RMS is 7-10 mm for LAGEOS-1 and LAGEOS-2 and 20-40 mm for the other low-orbit satellites.
In the LAGEOS-1 and LAGEOS-2 cases, the magnitude of the along-track constant term is 0-10 pm/s^2, that of the along-track periodic terms is 0-200 pm/s^2, and that of the cross-track periodic terms is 0-1 nm/s^2. In the low-orbit satellite cases, these values are 0-2 nm/s^2, 0-2 nm/s^2 and 0-10 nm/s^2, respectively.
A frequency analysis is applied to the five-year time series of empirical acceleration parameters. For example, the periodic terms of the along-track component of AJISAI are found to have high correlation with the absolute value of the angle between the satellite orbital plane and the Sun. Analyzing such systematic time variations of empirical acceleration parameters should help to extract unknown phenomena in satellite dynamics.

Keywords: satellite laser ranging; SLR, empirical acceleration

