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# What are the best inclination angles and satellite heights for recovering geocenter, $C_{20}$, $C_{30}$, and other low-degree harmonics?

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Satellite Laser Ranging (SLR) to spherical geodetic satellites is used for recovering the Earth's gravitational product GM, geocenter motion, and low-degree zonal spherical harmonics, especially $C_{20}$ and $C_{30}$. However, the orbital parameters of all geodetic satellites launched after 1992 were not optimized toward the gravity field recovery to maximize their sensitivity to specific gravity field parameters. Instead, the minimization of the potential errors of confirming general relativistic effects, such as the Lense-Thirring, was the main trigger in the selection of orbital parameters.

The diversity of orbital parameters in the current SLR constellation is limited. Most of the geodetic satellites have similar inclination angles: LAGEOS-2, Starlette, and Ajisai about 50°; LARES-1 and LARES-2 about 70°; Stella, Westpac, Larets—in the near sun-synchronous orbit with the inclination of 98°. The inclination angle of LAGEOS-1 is complementary to that of LARES-2 forming the butterfly configuration. The geodetic satellites cover only 60° out of 180° possible inclination angle ranges, i.e., only 33%. Moreover, the orbital heights classify satellites into consistent groups: the LAGEOS-1, LAGEOS-2, and LARES-2 orbit at a height of 5800 km; LARES-1 and Ajisai have a height of about 1500 km; whereas Starlette, Stella, and Westpac have the perigees at the height of about 800 km. Therefore, the gravity field recovery and decorrelation of some gravity field parameters by a diversity of orbital parameters is deficient in the current constellation of geodetic satellites.

We employ the Kaula theorem of gravitational perturbations caused by gravity field coefficients to find the best possible orbital parameters for a future geodetic satellite to maximize orbit sensitivity in terms of the recovery of low-degree gravity field harmonics, geocenter, and GM. We use the maximization of the secular rates of the ascending nodes as the measure of the even-zonal harmonics' recovery and the maximum of periodic perturbations of the orbital eccentricity vector for the odd-zonal harmonics. We found that the best inclination for a future geodetic satellite is 35°–45° or 135°–145° with a height of about 1500–1700 km to recover $C_{20}$ and $C_{30}$. For the optimum heights, we consider three factors emerging from the (1) sensitivity of the satellite to a degree-specific gravity field coefficient, (2) the number of satellite revolutions within a pre-defined period, and (3) observability of a satellite from the perspective of ground stations. For a better geocenter recovery and derivation of the standard gravitational product, the preferable height is 2300–3500 km. We found that none of the existing geodetic satellites have, unfortunately, the optimum inclination angle and height for deriving GM, geocenter, and $C_{20}$ because there are no spherical geodetic satellites at the heights between 1500 (Ajisai and LARES-1) and 5800 km (LAGEOS-1/2, LARES-2).