Where to place the future SLR satellite for the best GM, geocenter, C20, and other gravity field parameters recovery?

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Spherical geodetic satellites are employed to determine the Earth′s gravitational constant (GM), track geocenter motion, and recover low-degree spherical harmonics of the gravity field, particularly C20 and C30. However, the orbital parameters of geodetic satellites launched after 1992 were not specifically optimized for gravity field recovery.

The current constellation of spheric satellites shows limited diversity in orbital parameters. Most geodetic satellites have similar inclination angles: LAGEOS-2, Starlette, and Ajisai have inclinations around 50° ; LARES-1 and LARES-2 are inclined at about 70° ; while Stella, Westpac, and Larets are in near sun-synchronous orbits with inclinations of 98° . The inclination of LAGEOS-1 complements that of LARES-2, forming a butterfly configuration. Additionally, the satellites′ orbital heights fall into distinct groups: LAGEOS-1, LAGEOS-2, and LARES-2 orbit at 5800 km; LARES-1 and Ajisai at approximately 1500 km; and Starlette, Stella, and Westpac have perigees around 800 km. Consequently, the current constellation lacks sufficient diversity in orbital parameters to effectively recover the gravity field and decorrelate specific gravity field parameters.

To find the best orbital parameters for the future geodetic satellite, we apply the Kaula theorem on gravitational perturbations. We search for the optimal orbital parameters aiming to maximize sensitivity to low-degree gravity field harmonics, geocenter motion, and GM. We propose maximizing the secular rates of ascending nodes to improve even-zonal harmonics recovery, and maximizing periodic perturbations of the orbital eccentricity vector for odd-zonal harmonics.

Our findings suggest that the optimal inclination for a future geodetic satellite lies between 35° －45° or 135° －145° , with an orbital height of around 1500－1700 km for recovering C20 and C30. The ideal height is determined based on three factors: the satellite′s sensitivity to specific gravity field coefficients, the number of satellite revolutions over a defined period,

and the satellite's observability (visibility) from ground stations. For better geocenter recovery and GM derivation, a height of 2300–3500 km is preferable. Unfortunately, none of the existing geodetic satellites have the optimal combination of inclination angle and height for deriving GM, geocenter, and C20, as no spherical geodetic satellites currently orbit between 1500 km (Ajisai and LARES-1) and 5800 km (LAGEOS-1/2, LARES-2).