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The contribution of multi-LEOs to geocenter motion estimation

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To ensure inter-operability and consistency of various geodetic products for Solid Earth science and operational geodesy applications, a long-term global terrestrial reference frame is required, i.e., the International Terrestrial Reference System (ITRS) and its realization, the International Terrestrial Reference Frame (ITRF). As one of the key parameters in the determination of the ITRF, geocenter motion must be precisely estimated. Space geodetic techniques such as Satellite Laser Ranging (SLR), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS), and Global Navigation Satellite Systems (GNSS), which connect satellites and ground stations, are capable of determining geocenter motion. However, only the SLR technique is currently included in the realization of the ITRF, despite GNSS being widely regarded as a promising technology. Compared to SLR-based solutions, GNSS exhibits lower accuracy due to various modeling issues, including deficiencies in non-gravitational force models. In recent years, numerous studies have demonstrated the significant potential for improving geocenter coordinate estimation through the integration of ground-based observations and space-based observations from low Earth orbiters (LEOs). Nevertheless, the full contribution of LEOs to geocenter motion estimation remains underexplored, largely due to the limited temporal coverage and the small number of LEOs available..

To evaluate the extent of associated improvements, a network of 150 ground tracking stations and up to 13 LEOs (GRACE-A/B/C/D, SWARM-A/B/C, JASON-1/2/3, SENTINEL-3A/3B, and SENTINEL-6A) was processed over a 20-year period (2004–2024). Three solutions were investigated: (1) a reference solution utilizing only ground-based GNSS observations; (2) a combined ground- and space-based solution employing a reduced-dynamic (DYN) strategy for LEO orbit determination; and (3) a combined ground- and space-based solution employing a kinematic (KIN) strategy for LEO orbit determination. All solutions were implemented in accordance with the processing strategy of the IGS's 3rd reprocessing campaign.

In this contribution, we evaluate contribution of space-based observations to geocenter motion estimation through spectral analysis and external comparisons. Significant improvements are observed in the combined ground- and space-based solutions, particularly in enhancing geocenter motion stability and mitigating certain artificial signals. Among the three solutions, the GNSS/LEO integrated solution employing the KIN strategy for LEOs demonstrates a substantial reduction in draconitic errors compared to the others.