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Realization of the terrestrial reference frame based on integrated SLR measurements to LEO, geodetic, and Galileo satellites

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Numerous active low Earth orbiters (LEOs) and Global Navigation Satellite System (GNSS) satellites, including the Galileo constellation, are equipped with laser retroreflectors used for Satellite Laser Ranging (SLR). Moreover, most LEOs are equipped with GNSS receivers for precise orbit determination. SLR measurements to LEOs, GNSS, and geodetic satellites vary in terms of registered numbers of the normal points (NPs) or registered satellite passes. In 2016-2018, SLR measurements to LEOs constituted 81% of all NPs and 59% of all registered satellite passes, whereas 10% of NPs and 30% of satellite passes, respectively, were assigned to GNSS. The remaining SLR measurements, 9% of NPs and 11% of passes, were completed by geodetic satellites, including LAGEOS-1 and LAGEOS-2.

In this study, we show that the SLR observations to Galileo, passive geodetic and active LEO satellites together with precise GNSS-based orbits of LEOs and Galileo can be used for the determination of SLR station coordinates. Station coordinates, as well as the realization of the ITRF, are typically determined using SLR observations to passive geodetic satellites, such as LAGEOS-1/2. Here, we use SLR observations to Galileo, LAGEOS-1/2, LARES, Sentinel-3A, SWARM-A/B/C, TerraSAR, Jason-2, GRACE-A/B satellites to investigate whether they can be applied for the reference frame realization and for deriving high-quality station coordinates.

We present various types of solutions based on different solution lengths, different SLR ground network constraining, and the combination of different sets of satellites to investigate the best solution set-up and the relative weights for the variance scaling factors of normal equations. We compare our results with the standard LAGEOS-based solutions and show the consistency level of the results with respect to the classical SLR solutions. Combination of observations improves the station coordinates especially for those stations which provide more SLR observations to LEOs, and Galileo satellites than to LAGEOS.