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GNSS satellites as co-locations for a combined GNSS and SLR analysis

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The space-geodetic techniques GNSS and SLR are co-located not only on ground but in space, at many satellites as well. Using satellite co-location implies that one common set of orbit parameters is estimated based on microwave and SLR observations together (apart from the other common parameters, e.g., ERPs, geocenter).
We use the GPS and GLONASS satellites as co-location point for our studies.
The tie between GNSS and SLR at the GNSS satellite consists of two parts: On the one hand, the offset between the center-of-mass (CoM) of the satellite and the phase center of the microwave transmitting antenna has to be known (this includes the satellite antenna offset (SAO) and the phase center variations). On the other hand, the offset between the CoM and the laser retroreflector array (LRA) is needed. Unfortunately, both quantities are not known as accurately as necessary.
Due to uncertainties in the phase center modeling for the GNSS microwave antennas, GNSS alone cannot provide the absolute scale information. The estimation of a common set of orbit parameters, however, allows it to transfer the scale directly from SLR to GNSS. Therefore, a combined GNSS-SLR analysis using satellite co-locations at GNSS satellites allows it to estimate the SAO for the GNSS antenna reference points without fixing the scale of the a priori reference frame. The resulting GNSS SAO are consistent to the SLR scale, a distinct advantage of such a procedure.
One of the major difficulties encountered when determining the SLR-related parameters (station coordinates, range biases, LRA offsets) from observations to GNSS satellites is the sparseness of SLR observations to GNSS satellites. In order to further improve the stability of SLR-related parameters, we also include the SLR observations to the LAGEOS satellites. This allows it to estimate station coordinates more reliably and to separate the SLR range biases from the corrections to the LRA offsets.
We will address the aspects mentioned above by combining normal equations generated at the Center for Orbit Determination (CODE) from GPS and GLONASS microwave observations on the one hand, and SLR observations to the GNSS and LAGEOS satellites on the other hand. We use the Bernese GPS Software for the analysis of both observation types, which guarantees the highest possible consistency and compatibility.