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GNSS-derived Geocenter Coordinates Viewed by Perturbation Theory

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Time series of geocenter coordinates were determined with data of the two global navigation satellite systems (GNSS) GPS and GLONASS. The data was recorded in the years 2008-2011 by a global network of 92 combined GPS/GLONASS receivers. Two types of solutions were generated for each system, one including the estimation of geocenter coordinates and one without these parameters.

A fair agreement for GPS and GLONASS estimates was found in the x- and y-coordinate series of the geocenter. Artifacts do, however, clearly show up in the z-coordinate. Large periodic variations in the GLONASS geocenter z-coordinates of about 40 cm peak-to-peak are related to the maximum elevation angles of the Sun above/below the orbital planes of the satellite system.

A detailed analysis revealed that these artifacts are almost uniquely governed by the differences of the estimates of direct solar radiation pressure (SRP) in the two solution series (with and without geocenter estimation). This effect can be explained by first-order perturbation theory of celestial mechanics. The relation between the geocenter z-coordinate and the corresponding SRP parameters will be presented.

Our theory is applicable to all satellite observing techniques. In addition to GNSS, we applied it to satellite laser ranging (SLR) solutions based on LAGEOS observations. The correlation between geocenter and SRP parameters is not a critical issue for SLR, because these parameters do not have to be estimated. This basic difference between SLR and GNSS analyses explains why SLR is an excellent tool to determine geodetic datum parameters like the geocenter coordinates.

The correlation between orbit parameters and the z-component of the geocenter is not limited to a particular orbit model, e.g., that of CODE. The issue should be studied for alternative (e.g., box-wing) models: As soon as non-zero mean values (over one revolution) of the out-of-plane force component exist, one has to expect biased geocenter estimates. The insights gained here should be seriously taken into account in the orbit modeling discussion currently taking place within the IGS.