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Simultaneous relative and absolute orientation of point clouds with "TLS radomes"

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For the georeferencing of point clouds acquired by a terrestrial laser scanner (TLS) targets with known coordinates (control points) can be used. The determination of the target positions in a global coordinate frame with a total station and/or with GNSS can be very time-consuming. For multi-temporal comparison of TLS data these targets can be permanently installed on the measurement site. In permanent changing environments (e.g. high-moutain proglacial environments) this is not possible due to the movement of the targets. Furthermore, the integration of the TLS data with other data sources (e.g. airborne laser scanning data) has to be considered. For that aim the georeferencing of TLS measurements in a global coordinate frame has to be established.

This work describes a new method for the simultaneous relative orientiation (registration) and absolute orientation (georeferencing) of point clouds by using spheres with a GNSS antenna inside. These spheres are thus used as GNSS antenna radomes. Consequently they are called within this work "TLS radomes". The simultaneous measurement with at least three GNSS antennas during the TLS data acquisition leads to long measurement times, i.e. high position accuracy and subsequently a very accurate realization of the datum.

The presented TLS radomes consist of two hemispheres of polyethene enclosing the GNSS antenna. The GNSS antenna is mounted on an antenna rod, which can be enhanced by a prism and/or a reflective cylinder. For a modified optical reflectivity several coatings were tested. The one causing the smallest deformations, the smallest noise, and with the highest reflectivity was chosen. The whole construction can be mounted on a tripod. The TLS radomes are suitable for a wide range of different TLS sensors (i.e. independent of the ranging principle and the manufacturers).

For the simultaneous relative and absolute orientation of the point clouds the centers of the radomes are used as identical points. With TLS these centers can be determined in a sensor own coordinate system (SOCS) by sphere fitting. With GNSS these centers are determined in a global coordinate reference frame. The transformation parameters are estimated within a hybrid least-squares adjustment. Further observations, e.g. measurements with a total station, can be added to the adjustment to improve the accuracy of the estimated transformation parameters.

Several tests were carried out to check the influence of the radome on the GNSS antenna. These tests showed that the radome produces minor phase center eccentricities (1-2 mm) and phase center variations with amplitudes up to 5 mm. Thus an antenna calibration is needed for high accuracy requirements. Furthermore the eccentricity of the GNSS antenna in respect to the sphere center had to be determined.

The application of the TLS radoms is proven on a data set consisting of five TLS scans and GNSS measurements with a duration of up to four hours acquired at the Gepatschferner (Tyrol, Austria).

The TLS radomes were developed within the research project PROSA (high-resolution measurements of morphodynamics in rapidly changing PROglacial Systems of the Alps).