Effect of seasonal snow-mass change on geodetic solutions at Syowa Station: elastic deformation and gravitational attraction

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In the Japanese Antarctic Station "Syowa," located at 69°0.2646′ S 39°34.9074′ E in East Ongul Island, East Antarctica, three different space geodetic observations (GNSS, DORIS, and VLBI) and gravity observation by superconducting gravimeter have been conducted. These geodetic observations are assumed to capture the glacial isostatic adjustment (GIA) effect caused by the melting of the Antarctic ice sheet since the last glacial maximum; however, the GIA response around Syowa Station is predicted to be small (about -2~2 mm/year) from GIA models. On the other hand, a large seasonal variation of the snowpack depth distribution occurs at Syowa Station. Therefore, it is necessary to accurately evaluate and correct the accumulated snow effect for detecting GIA signal precisely from these geodetic observations.

In this study, we derived seasonal variations of snowpack depth in Syowa Station from the time-series of the surface topography obtained by unmanned aerial vehicle (UAV) photographic survey. We evaluated the effects of snow mass close at the observation points on those geodetic solutions: elastic deformation, and gravitational attraction.

We made the digital surface models (DSMs) from the aerial photographs taken by UAV during the 59th Japanese Antarctic Research Expedition (JARE59) activity (2017-2019) with structure from motion (SfM) method. This aerial photogrammetry was conducted with the fixed-wing UAV "senseFly eBee Plus" and the rotary-wing UAV "DJI Inspire 2" and "DJI Phantom" about every once a month.

We generated the DSMs and the orthomosaic images from aerial photographs using the SfM software "Pix4Dmapper." Then, the time-series variation of snowpack depth distribution at Syowa Station was extracted as the change in the height of DSM after the correction using the corresponding orthomosaic image (Hattori et al., 2019 JpGU). With this obtained snow depth distribution and the assumption of snow density, the elastic deformation and gravitational effects caused by the snow mass close to the geodetic observation points were evaluated.

This analysis reveals that the seasonal accumulated snow mass change at Syowa Station causes vertical variation of about 1mm on GNSS observation and of about 0.1-0.3 μGal (1 μGal = 10^{-8} m/s^2) on gravity observation. In this presentation, we show the details of observed changes in snowpack depth distribution, and discuss the comparison between the estimated elastic deformation and gravity effect of local snow accumulation and the geodetic solution derived from each geodetic facility.

Keywords: Elastic deformation, UAV, structure from motion

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