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An attempt of the local gravity field estimation using GOCE satellite gradiometer data

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GOCE (Gravity field and steady-state Ocean Circulation Explorer) satellite launched in March 2009 by ESA (European Space Agency) aims at improving static gravity fields, in particular in short wavelength. In addition to its low-altitude orbit (250km), the sensitive gravity gradiometer installed is expected to reveal 1 mgal gravity anomaly and 1cm geoid at the spatial resolution of 100km (half wavelength). Since 2010, ESA has begun to release GOCE data to those who submitted research proposals. Using the GOCE data, it is highly expected that applications for local gravity fields as well as global gravity field determinations are widely conducted right away.

Finishing with the six months of the CAL/VAL period after the launch, GOCE moved to the repeat orbit of 979 cycles /61days in September 2009, and has started the full-scale measurement mode. Afterward, Level 1B and Level 2 data has been released in May and July 2010, respectively.

GOCE is designed to determine the gravity fields with HL-SST (High-Low Satellite to Satellite Tracking) and the 6 gravity gradients (the second derivatives of the gravity potential) measured by the gradiometer. The Level 1B data (GOCE.EGG.NOM_1b) include the gravity gradients in the gradiometer reference frame, SST, and the Star Tracker data which show the attitude of the satellite. On the other hand, in addition to the gravity gradients with several corrections in the gradiometer reference frame (EGG.NOM_2), the Level 2 data include the gravity gradients in the local north oriented frame (EGG.TRF_2), precise orbit of the satellite (SST.PSO_2) and spherical harmonic coefficients of the gravity fields (EGM.GOC_2).

Among these data sets, level 1B data are not necessary for many applications. Thus, in this study, the applicability of the level 2 EGM and EGG.TRF has been examined mainly from the view point of local gravity field estimation. As of January 2011, using the 2 months data of Nov-Dec 2009, three EGMs (direct solution, time-wise solution, space-wise solution) with different estimation methods are available. In addition, EGG.TRF data from September 2009 to April 2010 have been released.

Although the direct solution uses EIGEN5C model as a-priori information, space-wise solution uses only quick-look model of GOCE as a-priori information and time-wise solution does not use any a-priori information. Comparing the gravity anomalies calculated from those solutions, the direct solution shows the most smooth anomalies even with all the coefficients upto the maximum degree of 240. However both space-wise and time-wise solutions show almost same smooth results with all the coefficients upto degrees of 210 and 224, respectively. Given that those models use only two months of GOCE data, the accuracy of the final GOCE model is the great expectations.

The EGG.TRF consists of along-track 1 sec sampling data of calibrated gravity gradients, the GPS time of each epoch and the geocentric coordinates (latitude, longitude, r). Among 6 components of the gravity gradients, the global plot of Tzz clearly shows the large structures such as subducting plats, Himalayan collision zone. The present 1 second sampling data could not be used directly because of their large noises. However, if properly processed, the high sampling data are expected to improve the spatial resolution of the local gravity fields, in particular in the areas with poor gravity data, such as polar regions.

Keywords: GOCE, satellite gradiometer, local gravity field