GOCE 衛星重力データによる南極重力場の推定とその応用

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Gravity field determination in Antarctica using GOCE data and its applications

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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). Regarding the satellite gravity data, GRACE (Gravity Recovery And Climate Experiment) launched in 2002 is well known and its data have been widely employed for various studies, such as groundwater variations, ice sheet mass changes and other mass movement phenomena. GRACE is superior for studying time-variations of the long wavelength gravity fields. However its accuracy is rapidly decreaseing toword shorter wavelength (less than several handreds km) signals. On the other hand, due to several reasons, the accuracy of in-situ gravity measurements including surface ship and airborne gravimetry is decreasing toword the longer wavelength more than several tens km. GOCE is intended to improve the accuracy of the gravity fields in such intermediate wavelength of about 100 km, and it is expected to improve the accuracy of the gravity fields, in particular in Antarctica where very few gravity reference points are available.

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. Since 2010, ESA has begun to release GOCE data to those who submitted research proposals. 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.

There are three different approaches for the estimations of the GOCE global gravity models. They are so called direct solution (DIR), time-wise solution (TIM) and space-wise solution (SPW). Besides the calculation methods, important differences among these models are the a-priori information employed for the estiamtions. The DIR employs the a-priori information from EIGEN5C and EIGEN-51C; the SPW is affected by the GOCE quick-look model directly and the EGM2008, EIGEN5C and ITG_GRACE2010 models indirectly; the TIM never uses any a-priori information. So far, two solutions, i.e., release 1 and 2 for the individual models have been released, and consequently 6 EGMs are available currently. The difference of the release 1 and 2 are the data period employed. The release 1 models emplyed only 2 months of data from Nov-Dec. 2009, and the release 2 emplyed more than 6 months of data.

Figure 1-a and 1-b shows the gravity anomalies around Syowa station calculated from the release 2 TIM model and EGM2008 model as a reference, respectively. Since the maximum degree and order of the TIM model is 250 while those of EGM2008 is 2190, the resolution of the TIM model in the ocean areas is much worse than EGM2008. However the resolution of EGM2008 on land is worse than TIM, because the main data source of EGM2008 in Antarctica is from GRACE satellite. This implies that GOCE data can improve the accuracy of the garvity field in Antarctica.

The EGG.TRF consists of along-track 1 second 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, Figure 2 depicts the global plot of Tzz, which 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.

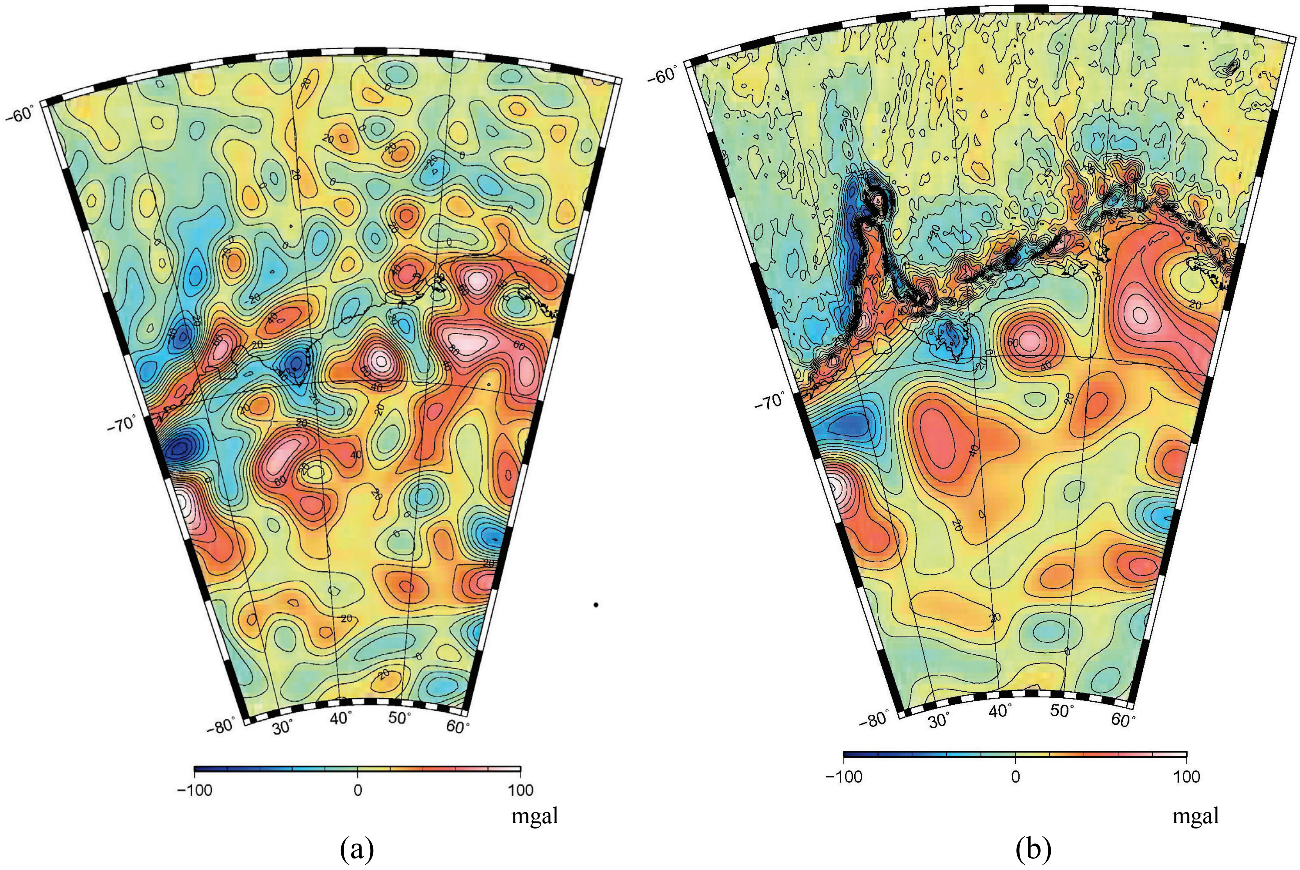

Figure 1. Gravity anomalies around Syowa station calculated from (a): GOCE release 2 TIM model, and (b) EGM 2008 model.

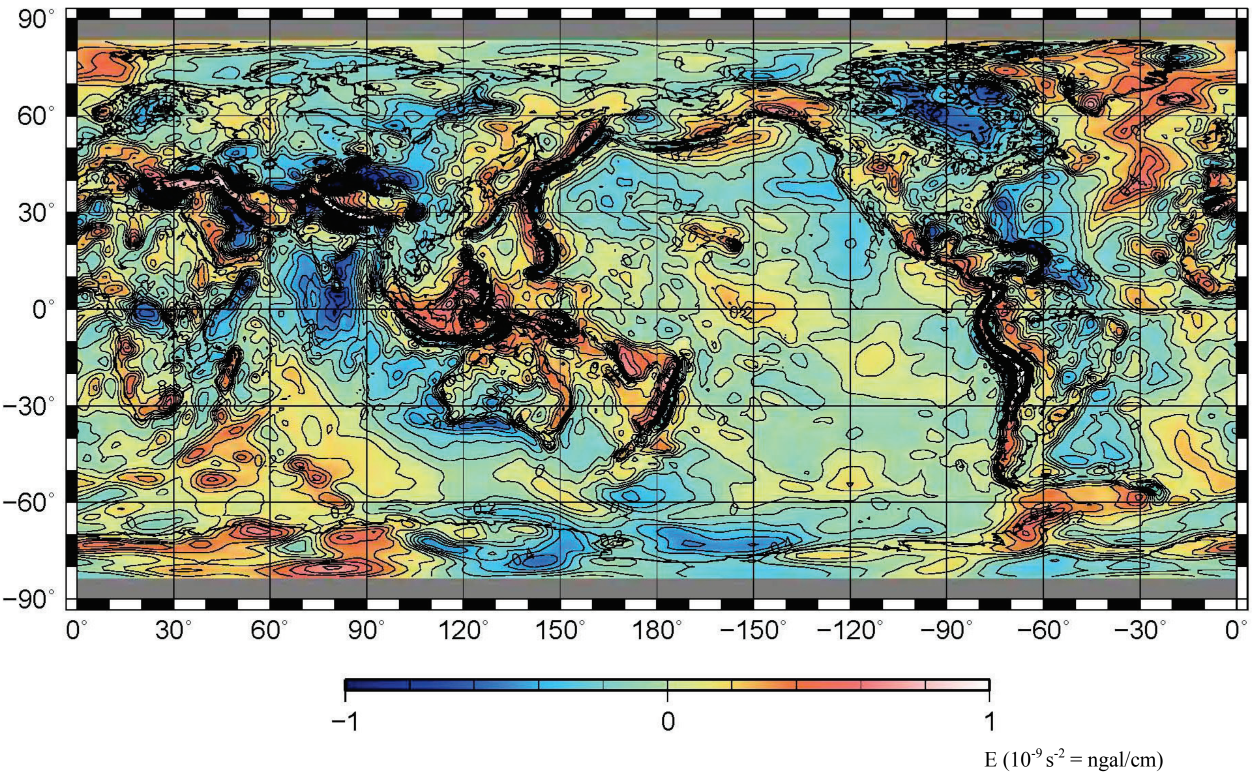

Figure 2. GOCE Gravity gradients (Tzz) from the EGG.TRF data sets.