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A study on Antarctic ice-sheet mass changes using satellite data

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Total ice sheet on Antarctica is said to consist of about 90 % of the earth's entire Ice sheet, which is equivalent to almost 60 meters of sea level rise. Nevertheless, because of the difficulties of in-situ observations, it has been difficult to estimate the mass change rate of the whole of Antarctic ice mass. GRACE (Gravity Recovery and Climate Experiment) has been observing time-variable gravity fields and succeeded to estimate the mass change rate for the whole of Antarctica, which was difficult to conduct by other means. However the GRACE observation is the total mass change of the earth including the Glacial Isostatic Adjustment (GIA) and therefore, suffers from the discrepancy between GIA models. In addition, the uncertainties of lower degrees of Stokes coefficients have particularly large impacts in Antarctica.

On the other hand, ICESat (Ice, Cloud, and land Elevation Satellite) is a satellite with GLAS (Geo-science Laser Altimeter System), which can observe ice-sheet elevation changes. In principle, the combination of GRACE and ICESat can yield comparisons between ice-sheet mass change estimates and volume change estimates. Nevertheless, ICESat datasets of 90 days have 180 days of interval time, and therefore, not appropriate to compare with monthly GRACE data. Equipped with RA2 radar system, EnviSat (Environmental Satellite) is useful to compensate ICESat data, for its datasets are available in 35-day repeat cycle from the same period as GRACE. Although the precision of EnviSat RA2 is not as high as ICESat GLAS, continuous observation of height changes in a longer period are considered useful. In this study, therefore, we used EnviSat data as well as GRACE and ICESat, to estimate the Antarctic ice-sheet mass change rates as a whole. In addition, we divided Antarctica into 27 drainage systems, and compared the results of EnviSat with those of GRACE.

The Antarctic ice-sheet mass change rates from GRACE show mass decrease of -174 ˜ -48.4 Gt/year in total, which is consistent with previous studies. GRACE and ICESat are in good agreements in their spatial patterns, and a large mass/volume decrease can be seen in Amundsen Sea Sector (ASE) and Antarctic Peninsula (AP). Due to the scarce measurement densities, the spatial patterns of volume changes from EnviSat does not agree well with those of GRACE or ICESat. Nevertheless, the time-series of volume changes from EnviSat show good agreements with mass changes from GRACE for the whole of Antarctica as well as some of the drainage systems, especially in the regions where the slope magnitude is low. This study shows by making use of EnviSat data, the volume changes in shorter time-scale can be detected for the whole off Antarctic as well as its regions.

Keywords: Satellite geodesy, GRACE, ICESat, EnviSat, Altimeter, Antarctic ice sheet mass change