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Antarctic and Greenland ice sheet changes seen by ENVISAT radar altimetry and GRACE: comparison and synthesis

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By observing volume and mass changes, respectively, satellite altimetry and satellite gravimetry are complementary tools for ice sheet mass balance studies. We combine results from ENVISAT radar altimetry (2003 - present) and from GRACE (2002 - present) on Antarctic and Greenland ice mass changes.

Satellite radar altimetry over ice sheets has had its limitations due to (1) the incomplete coverage (polar gap), (2) the surface slope induced errors and (3) the ambiguity between changes in surface height and firn properties. Here, we apply the Along-Track Repeat Satellite Radar Altimetry method that largely mitigates the problems (2) and (3). Unlike traditional crossover analyses, the complete along-track information is used. Local slope induced errors and time variations of the radar echoe shapes are accounted for within a simultaneous regression at each along-track position. The method thus exploits much more data (e.g. about 100 times more over Antarctica). Results are shown in terms of trends, seasonal and interannual variations.

Our GRACE analyses concentrate on the 10-daily solutions by CNES/GRGS (Releases 1 and 2) which apply innovative regularization techniques.

For the comparison of the ENVISAT and GRACE results, we account for their different characteristics concerning spatial resolution and coverage, volume versus mass change, and the different sensitivities to errors in the correction for glacial isostatic adjustment. In particular, we use the full GRACE normal equation matrices to describe the filtering inherent to the regularization during GRACE processing. By the synthesis of both kinds of observations we exploit their complementarities and resolve the altimetric signal in terms of ice or firn volume change. This task is notably aided by the consideration of seasonal and interannual signals in addition to linear trends. In result, we present new estimates on ice mass changes and their origins together with an assessment of related uncertainties.