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Supporting Online Material for

Satellite Gravity Measurements Confirm Accelerated Melting of Greenland Ice Sheet

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SOM Text
Fig. S1

Numerical Simulations of GRACE Observed Greenland Mass Rates

These numerical simulation experiments consist of proposing geographical regions that are probable sources of mass change, applying processing steps that replicate the limited spatial resolution of GRACE data, and comparing predictions with GRACE measurements. The experiments do not alter the fundamental limitation of GRACE to resolve small features, but, instead provide an interpretive tool.

The first step in the numerical experiments is to form an approximate estimate of the total mass rates, within the area circled by the white line in Fig. 2a, by summing over grid elements with cosine latitude weighting. The resulting mass rate is about – 190 ± 18 km^3/year. The criterion for selecting the predefined area is to cover as much of the variance and leaked variance from Greenland as possible while, at the time, minimize leakage effects from surrounding regions (16). Second, we assign geographical locations of the predetermined total Greenland mass loss (e.g., – 190 ± 18 km^3/year) to 1° x 1° grid cells near the centroids of the principal features in Fig. 2, using published catchment basin analysis from remote sensing data (*2*). Third, we repeat the first two steps for surrounding regions, including the prominent increases in the Hudson Bay area and Scandanavia where PGR may contaminate estimates for Greenland. Fourth, we convert the grid of mass rates into spherical harmonics, and subject these to the same data processing procedures as GRACE data (e.g., the removal of degree-1 spherical harmonics that are not in GRACE data and the use of the same 2-step optimized spatial smoothing). Finally, we compare the predictions from the above numerical simulations with GRACE observations in Fig. 2. Repeated adjustments of both locations and magnitudes of mass rates result in a mass rate distribution (illustrated in Fig. S1) that provides a reasonable match to the shape and amplitude of features in Fig. 2a, and agrees with the summed rates (i.e., – 190 km^3/year) in the region circled by white in Fig. 2a.

Figure S1 shows the simulation scheme of a particular experiment, in which a total of – 239 km^3/year evenly distributed over the shaded areas in East Greenland. Of this, – 90 km^3/year is evenly distributed in the blue area (i.e., the location of the Southeast Glacier), – 75 km^3/year in the light blue area, and – 74 km^3/year in the orange area, and – 75 km^3/year over Svalbard island (magenta area). The colors in Fig. S1 are only used to distinguish different simulated areas and do not represent the magnitudes of simulated mass loss. To appropriately replicate the two prominent mass increases in Hudson Bay and Scandanavia, presumably from PGR contribution, and quantify potential leakage effects on Greenland mass change, we place two positive anomalies of + 470 and + 130 km^3/year, evenly distributed in these two regions. These two positive anomalies (+ 470 and + 130 km^3/year) are chosen, after extensive numerical experiments, from comparison between simulated results and GRACE observations (Fig. 2a), using the same procedures described for estimating mass changes over Greenland. To further consider possible leakage effects from residual oceanic signal or noise, we also model the mass changes in a few small regions over the ocean (marked as a, b, c, and d) as described in the caption.

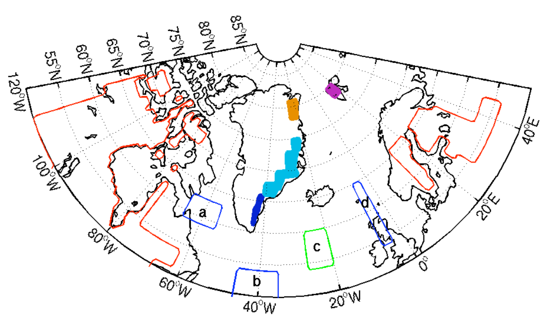

Figure S1. Illustration of simulated areas (shaded areas) of mass changes over east and north Greenland and Svalbard island (northeast to Greenland). – 90 km^3/year is evenly distributed over the dark blue area (Southeast Glacier), – 75 km^3/year over the light blue area, and – 74 km^3/year over the orange area, and – 75 km^3/year over Svalbard island (magenta area). To simulate leakage effects from the two prominent mass increase regions (circled by red lines) in Hudson Bay and Scandanavia, presumably from PGR contribution, we place two positive anomalies of +470 and + 130 km^3/year, evenly distributed in these two regions, respectively. To further consider possible leakage effects from residual oceanic signal or noise, we select 4 regions (circled by blue or green lines), to construct some best-match (to GRACE shown in Figure 1) anomalies of – 40 km^3/year in region (a), – 90 km^3/year in region (b), + 40 km^3/year in region (c), and – 50 km^3/year in region (d).