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Supplement of

Elevation change of the Greenland Ice Sheet and its peripheral glaciers: 1992–2023

Johan Nilsson and Alex S. Gardner

Correspondence to: Johan Nilsson (johan.n.nilsson@geo.uu.se)

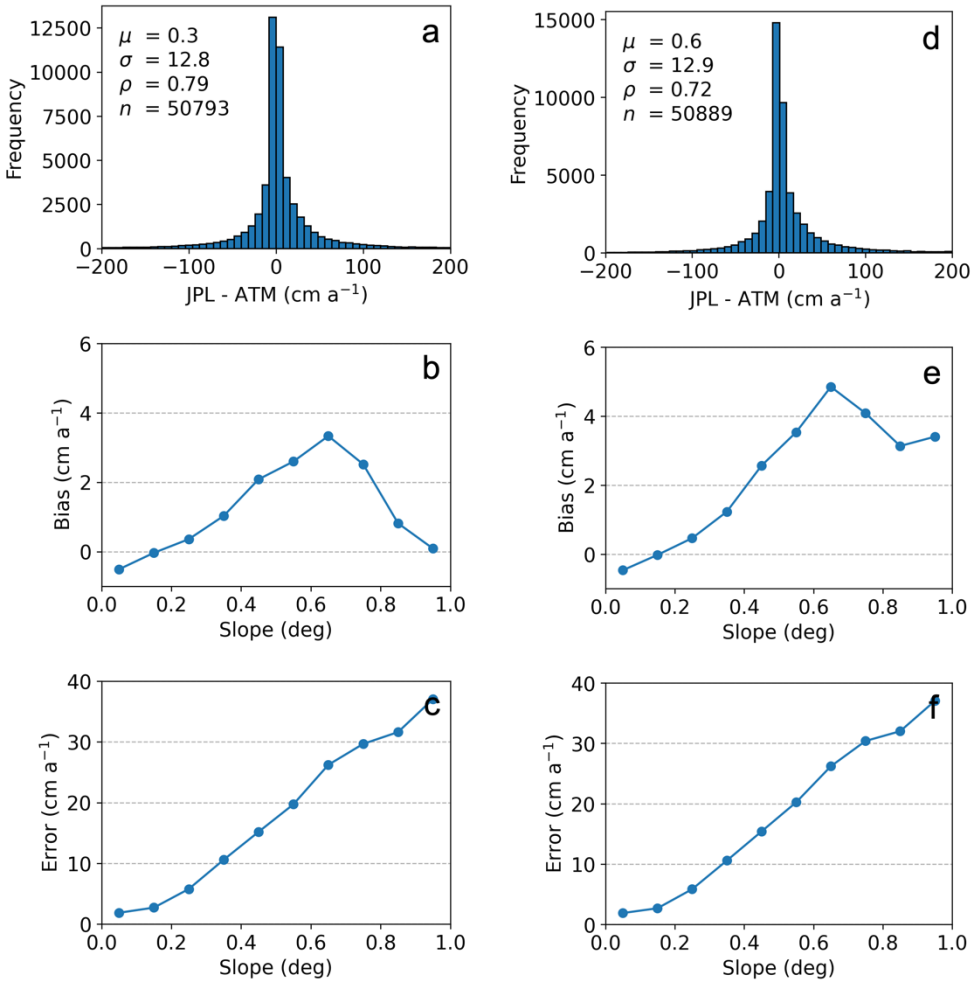

Figure S1: Elevation change validation of two different version of the product compared to ATM derived elevation changes. Where (a-c) is the JPL version with the background model (hypsometry and velocity) applied and (d-f) with ordinary kriging only. Overall statistics (a,d) for the two products are very similar, including the elevation change error (bottom), but a clear difference can be observed for the bias. The bias is relatively consistent for the two products up to 0.6 degrees in slope (b,e) for both products, but at higher slopes the bias is gradually reduced to almost zero. Here, the background model better captures the dynamic component in the fast-flowing areas of the outlet glaciers thus providing a better estimate of the observed change compared to ATM.

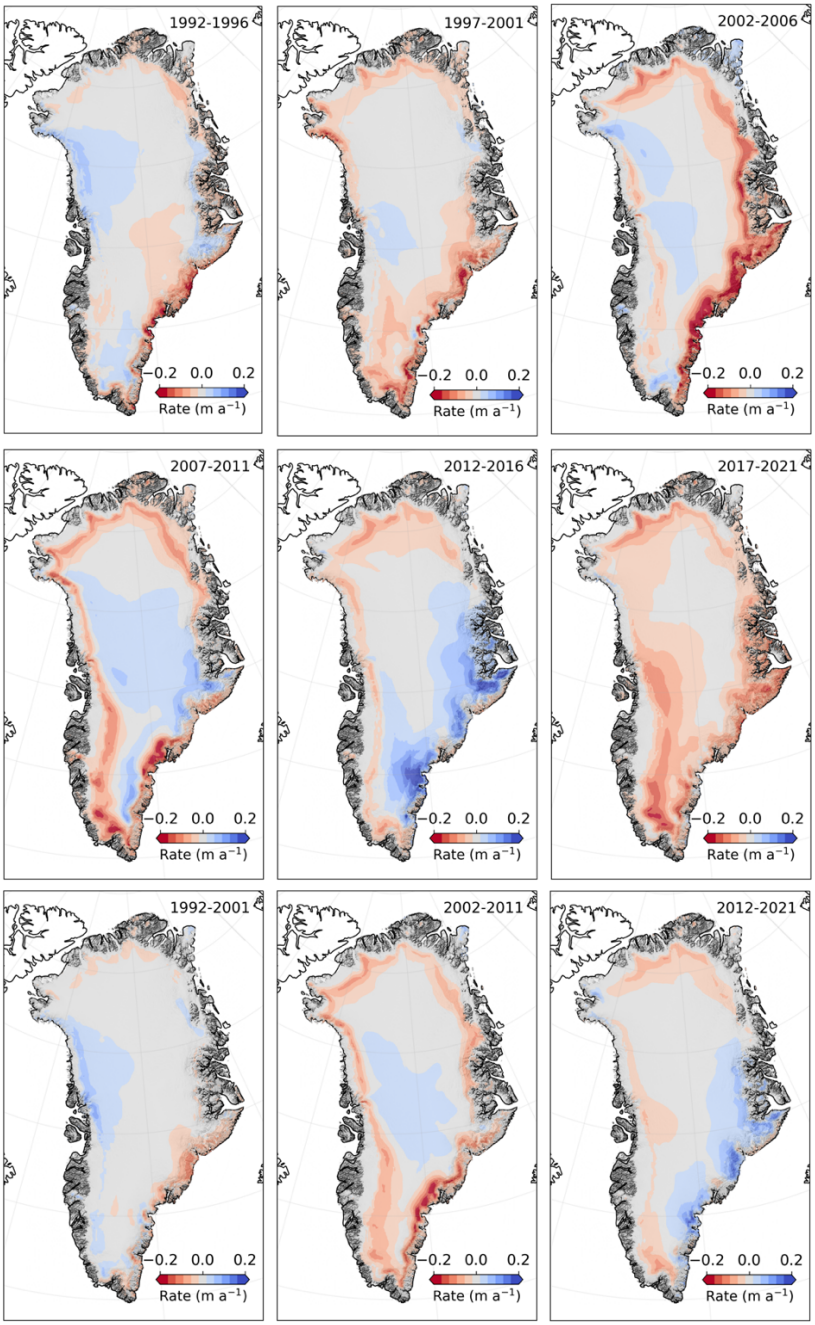

Figure S2: Surface mass balance anomaly (SMBA) generated from the Goddard FDM product over identical time period as in Figure 4. Here clear decadal trends can be observed in the overall surface mass balance of the ice sheet.

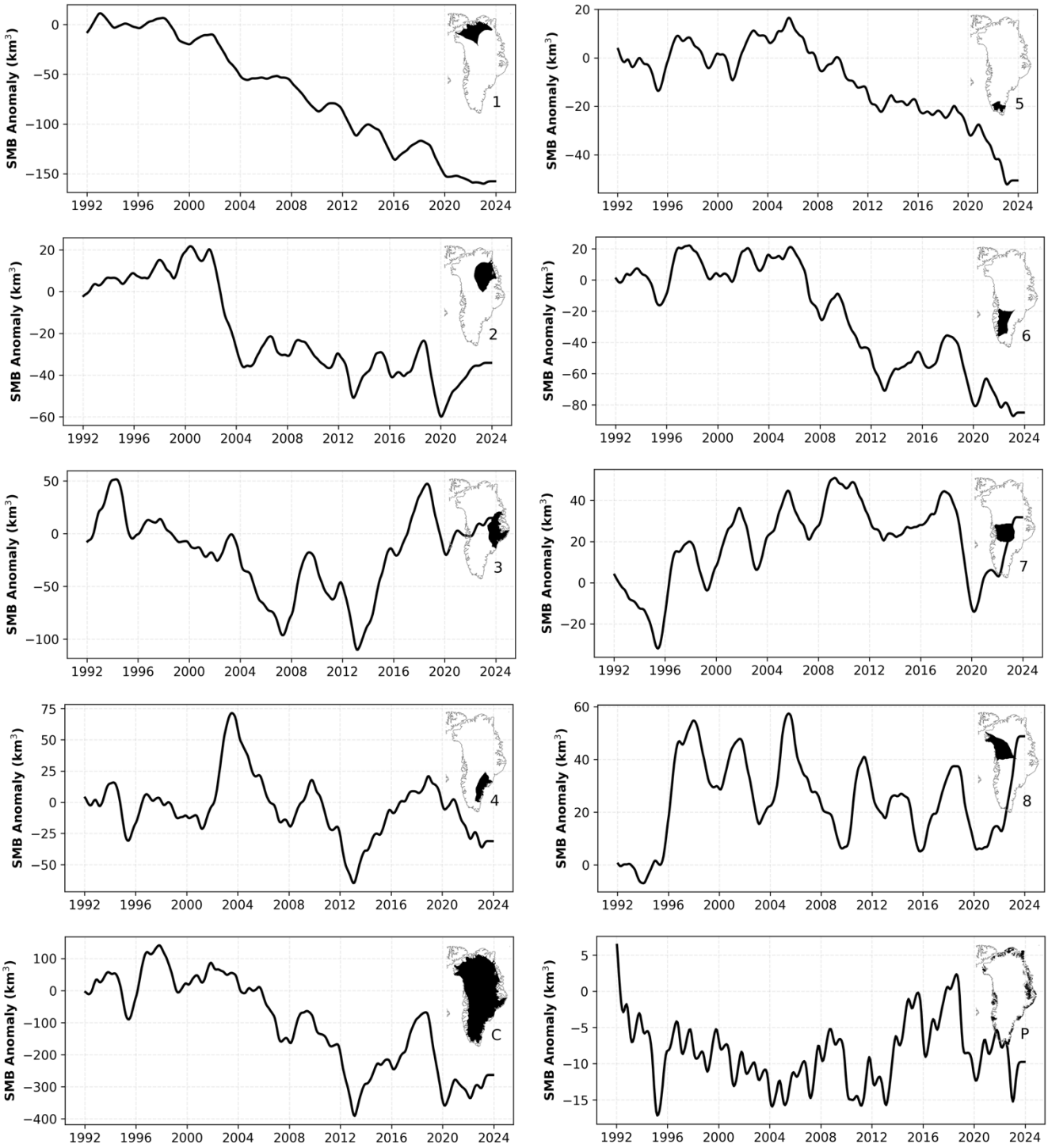

Figure S3: Surface mass balance anomaly (SMBA) generated from the Goddard FDM product (Medley et al., 2022) over identical time period as in Figure 5. Time series have been filtered using a 12-month moving averaging filter to highlight long-term trends.

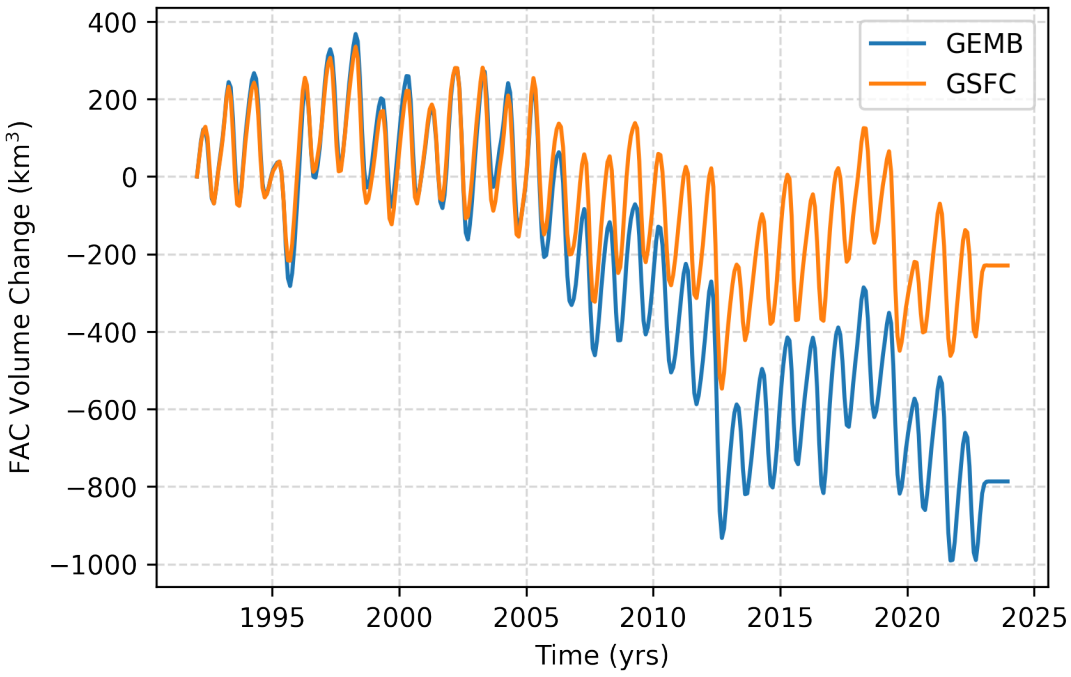

Figure S4: Firn air content (FAC) volume change difference from the GEMB and GSFC firn densification models for all glaciated terrain on Greenland. This includes both the continental ice sheet and the peripheral glaciers over the 1992-2022 time period. The two models show close initial agreement but starts to diverge in the overall trend after 2005 but show overall similar shape.

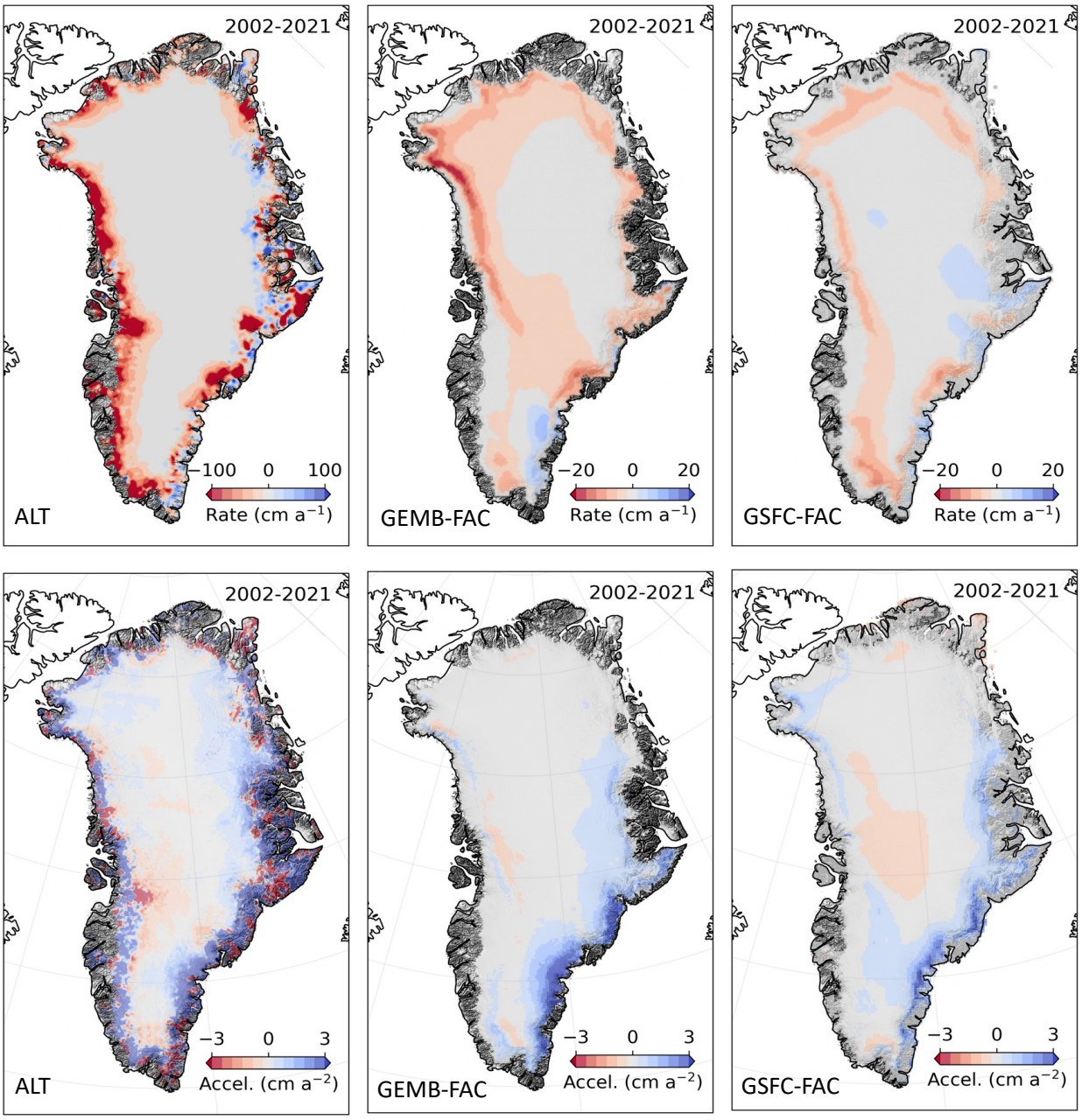

Figure S5: Figure (top) show rates of changes in elevation, plus acceleration, (ALT) (JPL Altimetry Product) and changes in Firn Air Content (FAC) over the 2002-2023 period for the Greenland Ice Sheet. Here two different firn models are shown (GEMB and GSFC). Both the rate and acceleration for the two FAC product show distinct difference both in magnitude and spatial pattern over the GRACE reference period.

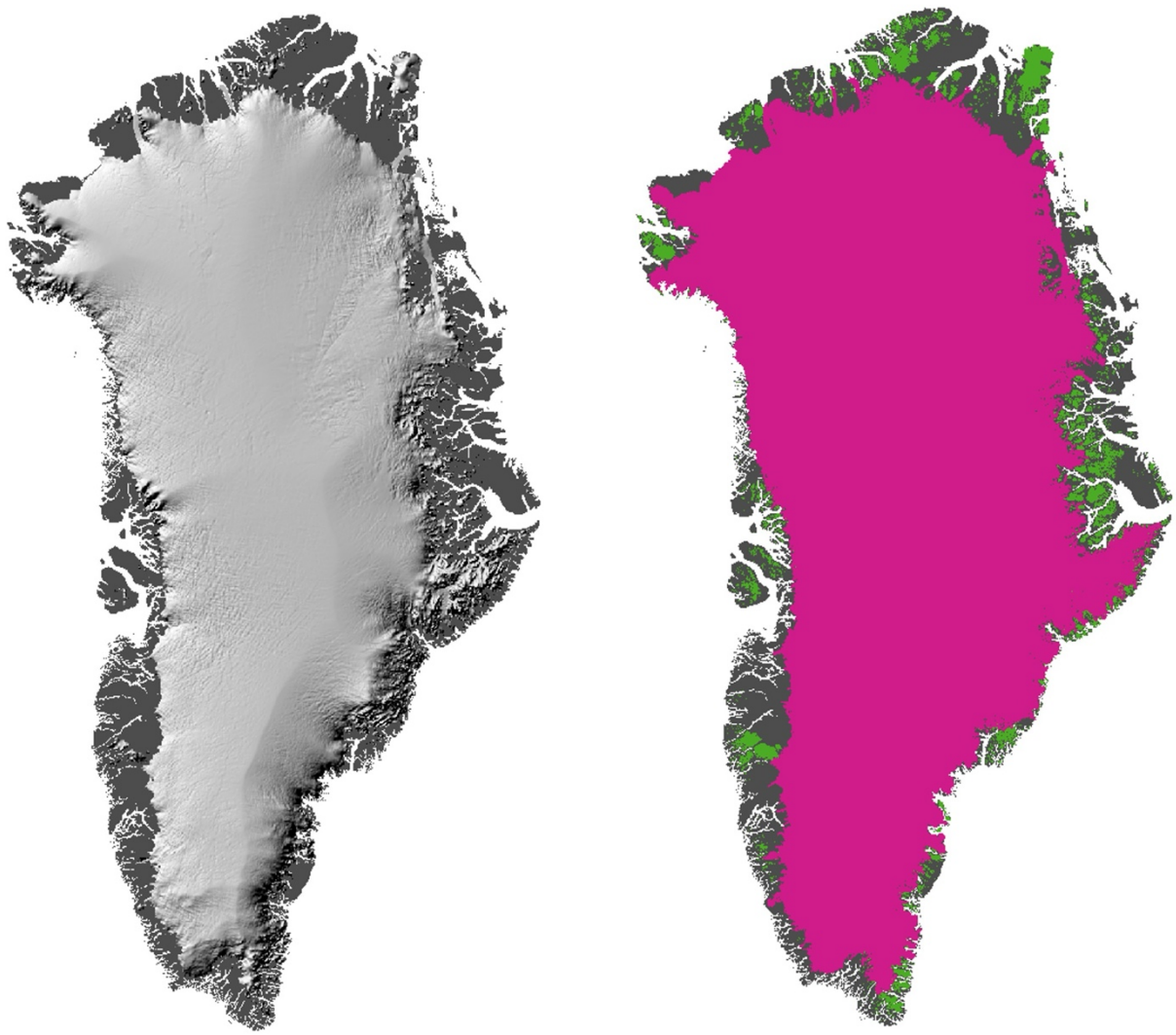

Figure S6. The left panel shows a hillshade of the digital elevation model (DEM) generated for this product, while the right panel displays the delineation of the continental ice sheet (magenta) and the peripheral glaciers (green).

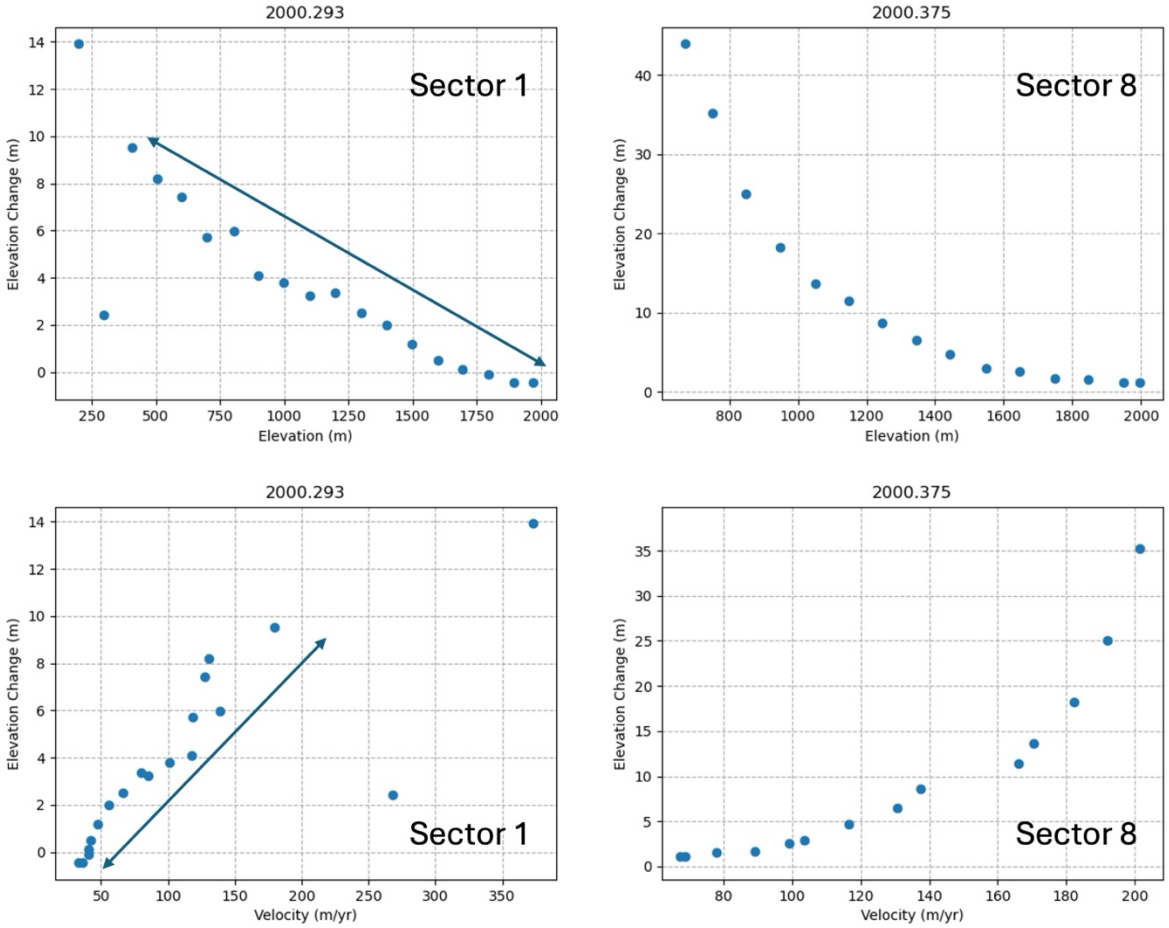

Figure S7. Elevation-change patterns as a function of ice velocity and hypsometry for Basin 1 and Basin 8 in northern Greenland during the ERS-2 observation period. The arrows indicate the approximate velocity range that receives greater weighting through the inverse square of velocity, reflecting its more linear behavior. Basin 8 shows a more strongly exponential relationship; however, a linear model was chosen for computational efficiency and to avoid unstable extrapolations. This approach provides a conservative fit that places greater emphasis on lower velocities, which are typically less noisy.

Table S1: Associated volume change estimates for the provided mass balance in Table 3 in the main text

Regions	1992-2001 ($km^3\ a^{-1}$)	2002-2011 ($km^3\ a^{-1}$)	2012-2021 ($km^3\ a^{-1}$)	1992-2023 ($km^3\ a^{-1}$)	2002-2023 ($km^3\ a^{-1}$)	2003-2009 ($km^3\ a^{-1}$)	2000-2023 ($km^3\ a^{-1}$)	2003-2012 ($km^3\ a^{-1}$)	Area (km^2)
Basin 1	-11±10	-21±6	-15±6	-19±2	-23±3	-11±8	-23±3	-28±6	351,970
Basin 2	16±11	-13±7	-1±6	-2±3	-5±3	-9±9	-5±3	-10±6	510,942
Basin 3	-27±13	-109±9	4±7	-43±3	-46±4	-121±13	-45±4	-115±9	320,960
Basin 4	-3±17	-52±5	-9±5	-23±4	-34±2	-66±7	-32±2	-62±5	165,505
Basin 5	26±6	-27±6	-13±2	-15±2	-23±2	-20±8	-24±2	-27±5	55,554
Basin 6	49±9	-42±6	-22±4	-23±2	-43±2	-20±8	-42±3	-53±5	290,993
Basin 7	3±9	-47±5	-34±3	-31±2	-44±2	-37±7	-43±2	-50±5	407,473
Basin 8	6±10	-70±6	-49±5	-46±3	-59±3	-73±8	-59±3	-76±6	423,025
Periphery	-7±22	-46±14	-12±5	-25±5	-27±5	-53±19	-28±5	-47±13	87,836
Continental	59±60	-380±37	-141±37	-202±15	-276±17	-356±47	-272±17	-420±35	1,714,172

Table S2: Associated firn air content change (FAC) estimates for the provided mass balance in Table 3 in the main text

Regions	1992-2001 (km^3/a)	2002-2011 (km^3/a)	2012-2021 (km^3/a)	1992-2023 (km^3/a)	2002-2023 (km^3/a)	2003-2009 (km^3/a)	2000-2023 (km^3/a)	2003-2012 (km^3/a)	Area (km^2)
Basin 1	-2±11	-7±8	-7±6	-8±3	-8±3	-6±12	-8±3	-7±8	351,970
Basin 2	0±11	-4±8	-1±6	-3±3	-2±3	-1±11	-3±3	-3±7	510,942
Basin 3	-7±15	-8±11	8±8	-3±4	-1±5	-10±17	-2±4	-9±11	320,960
Basin 4	1±13	-12±11	6±9	-2±4	-4±5	-21±17	-4±4	-16±11	165,505
Basin 5	0±8	-3±7	0±4	-1±2	-2±3	-4±10	-2±2	-4±6	55,554
Basin 6	3±14	-7±10	-1±6	-3±4	-6±4	-7±14	-5±4	-9±9	290,993
Basin 7	3±14	-2±11	-4±5	-2±3	-4±4	-1±16	-4±4	-3±10	407,473
Basin 8	4±18	-6±12	-5±8	-5±5	-6±5	-8±18	-6±5	-6±12	423,025
Periphery	-1±6	-1±4	0±4	0±2	0±2	0±6	0±2	-1±4	87,836
Continental	3±44	-49±37	-5±21	-27±11	-34±14	-58±54	-34±14	-57±35	1,714,172