



*Supplement of*

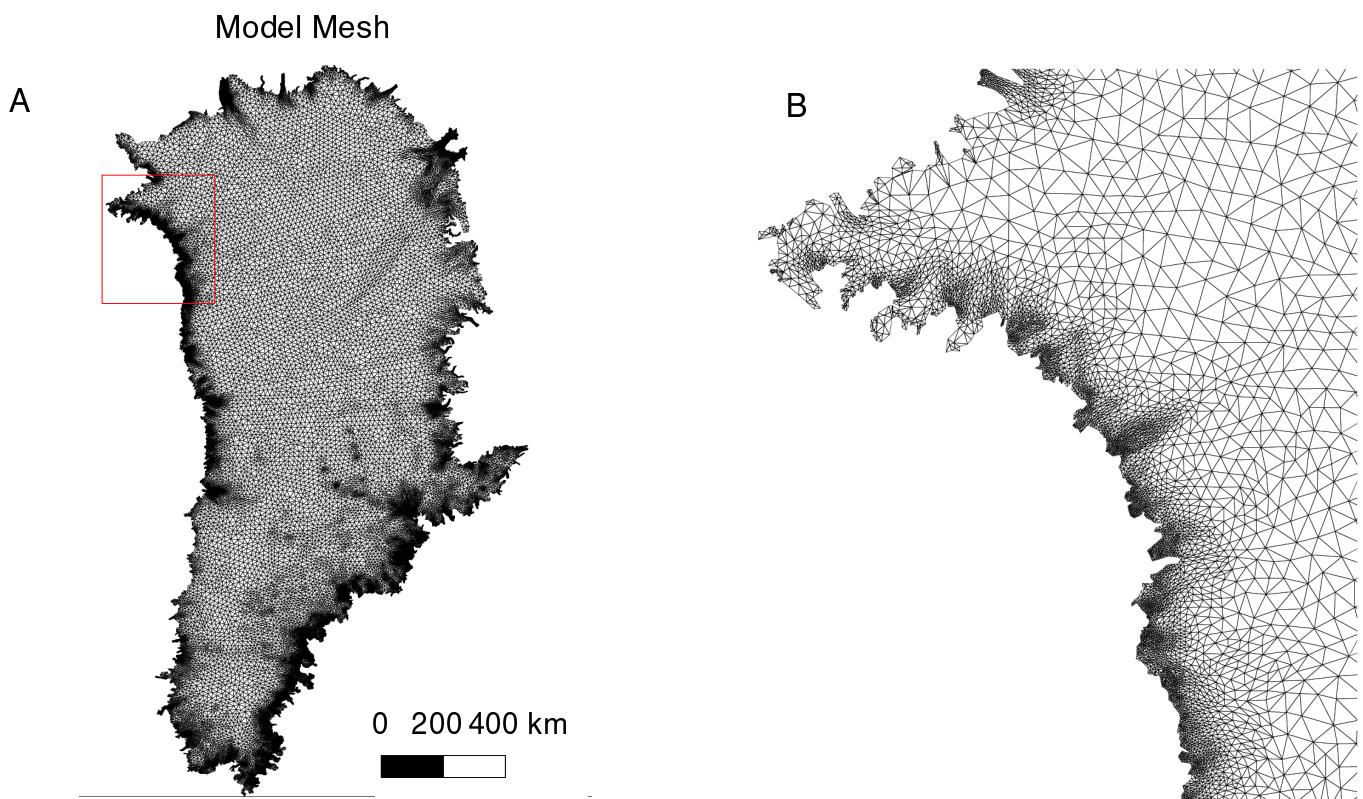
## **Application of GRACE to the assessment of model-based estimates of monthly Greenland Ice Sheet mass balance (2003–2012)**

Nicole-Jeanne Schlegel et al.

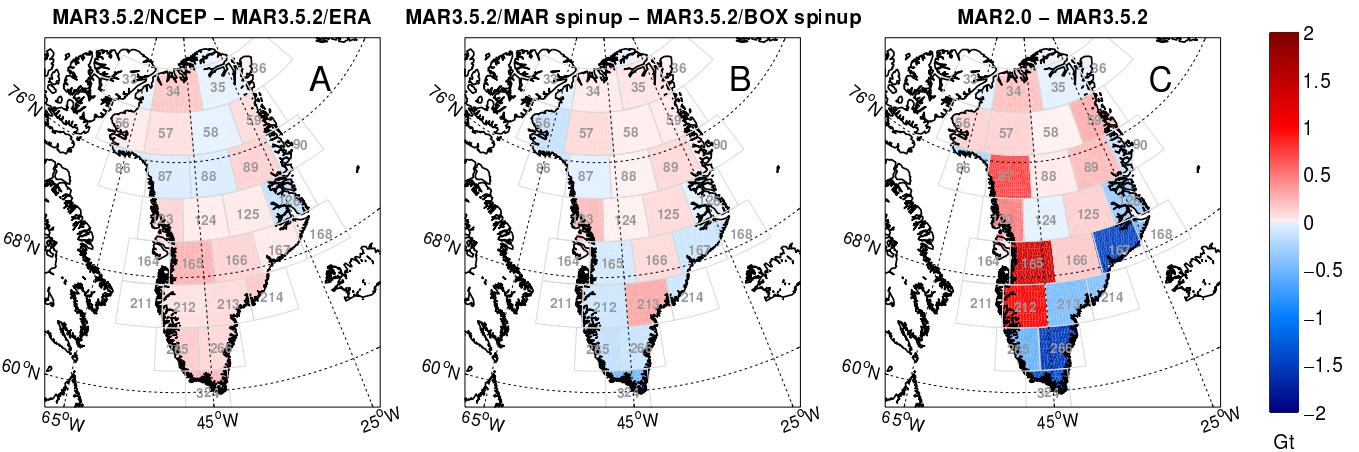
*Correspondence to:* Nicole-Jeanne Schlegel ([nicole-jeanne.schlegel@jpl.nasa.gov](mailto:nicole-jeanne.schlegel@jpl.nasa.gov))

The copyright of individual parts of the supplement might differ from the CC-BY 3.0 licence.

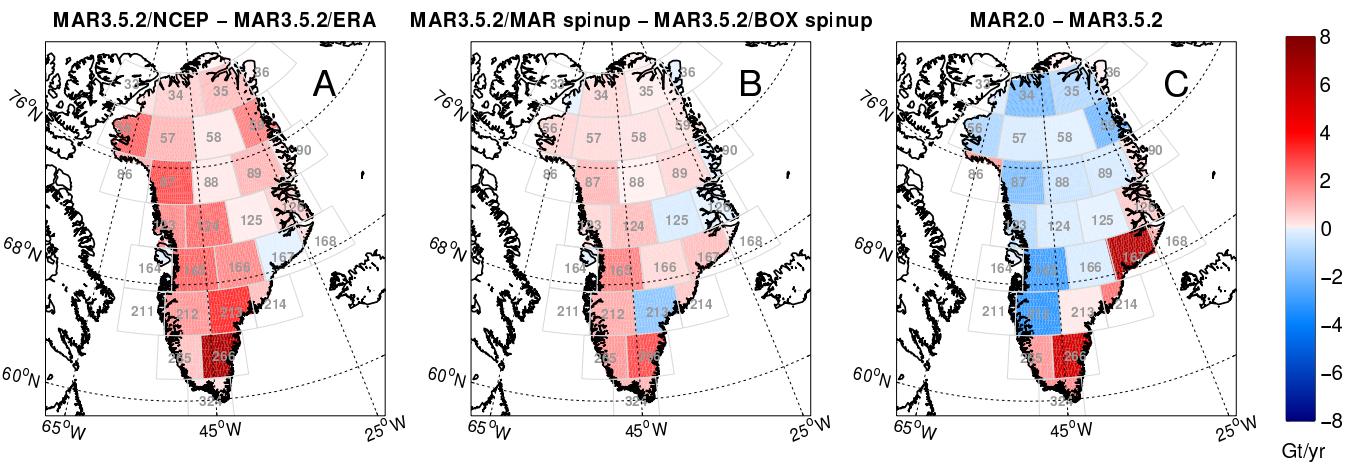
## **Supplement Figures**



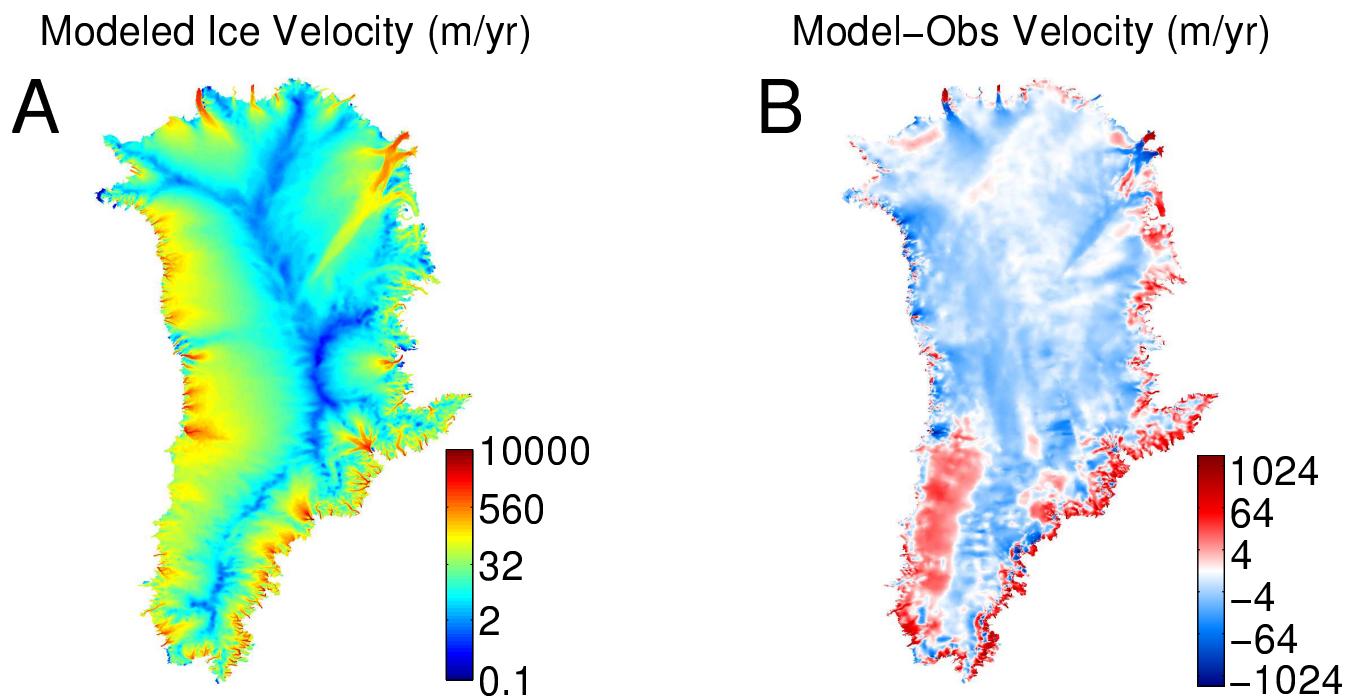
**Figure S1.** The ISSM Greenland mesh for (A) the entire ice sheet and (B) the northwest margin, which, for reference, is outlined in red on (A).



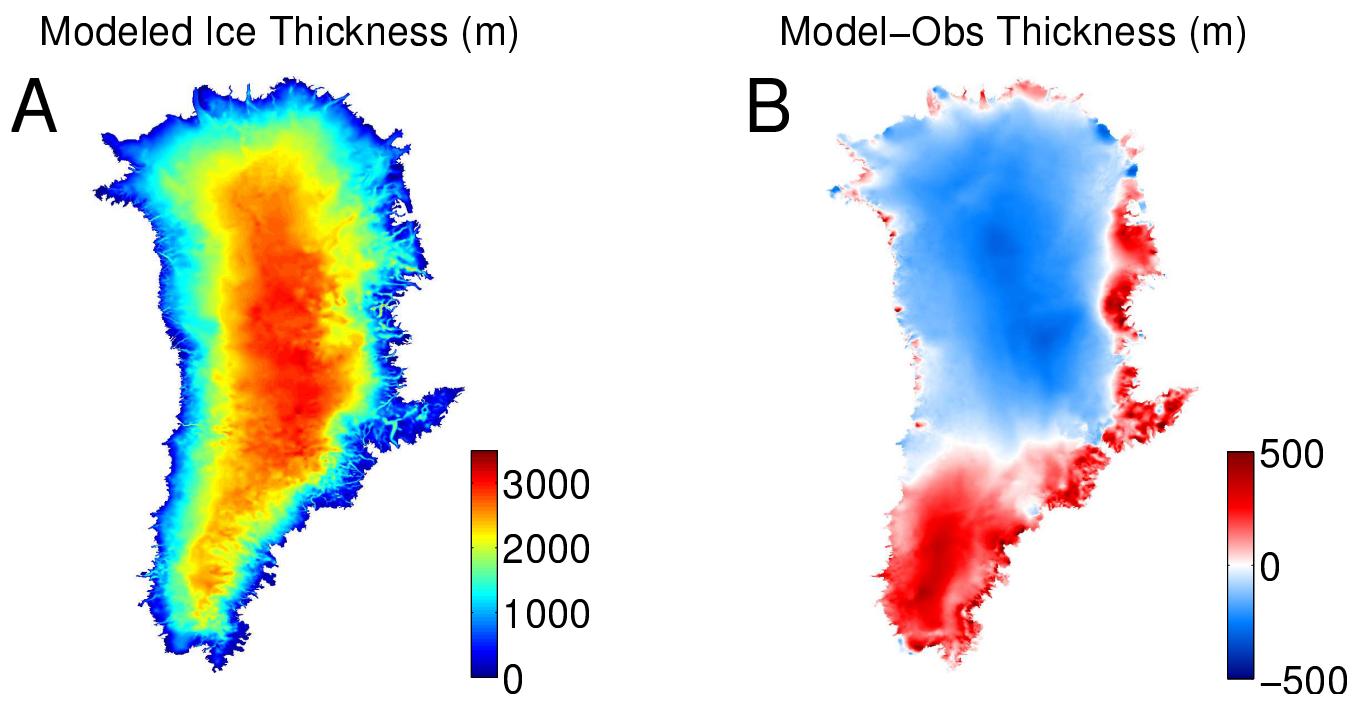
**Figure S2.** Spatial representation of differences in mean annual amplitude from 2003-2012 between various combinations of model spinup and the ISSM\_GrIS MAR3.5.2 presented in the manuscript (i.e. MAR3.5.2 forced by ERA-I reanalysis and BOX SMB used as the reference relaxation climatology,  $\overline{SMB}$ ). Comparison runs include: (A) ISSM\_GrIS MAR3.5.2, where MAR3.5.2 is forced with NCEP1 reanalysis; (B) ISSM\_GrIS MAR3.5.2, where MAR3.5.2 SMB is used for  $\overline{SMB}$ ; and (C) ISSM\_GrIS MAR2.0, where MAR2.0 SMB (forced with ERA-I reanalysis) is used for  $\overline{SMB}$ . Results are less sensitive to variations in RCM forcing (A) and choice of spinup product (B) than to RCM version (C).



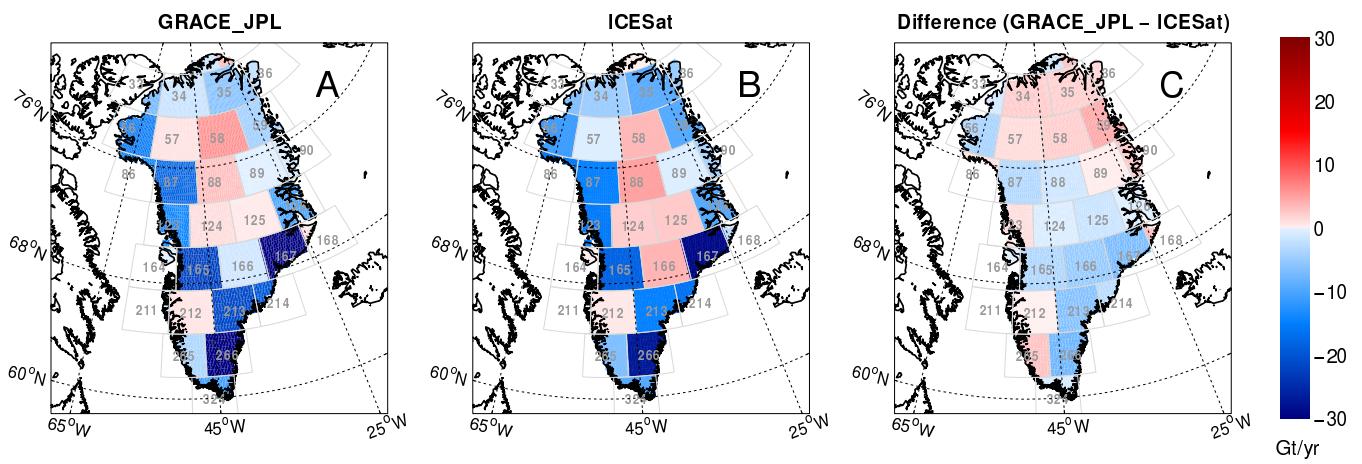
**Figure S3.** Spatial representation of differences in mass trend from 2003-2012 between various combinations of model spinup and the ISSM\_GrIS MAR3.5.2 presented in the manuscript (i.e. MAR3.5.2 forced by ERA-I reanalysis and BOX SMB used as the reference relaxation climatology,  $\overline{SMB}$ ). Comparison runs include: (A) ISSM\_GrIS MAR3.5.2, where MAR3.5.2 is forced with NCEP1 reanalysis; (B) ISSM\_GrIS MAR3.5.2, where MAR3.5.2 SMB is used for  $\overline{SMB}$ ; and (C) ISSM\_GrIS MAR2.0, where MAR2.0 SMB (forced with ERA-I reanalysis) is used for  $\overline{SMB}$ . Results are less sensitive to choice of spinup product (B) than to variations in RCM forcing (A) or to RCM version (C).



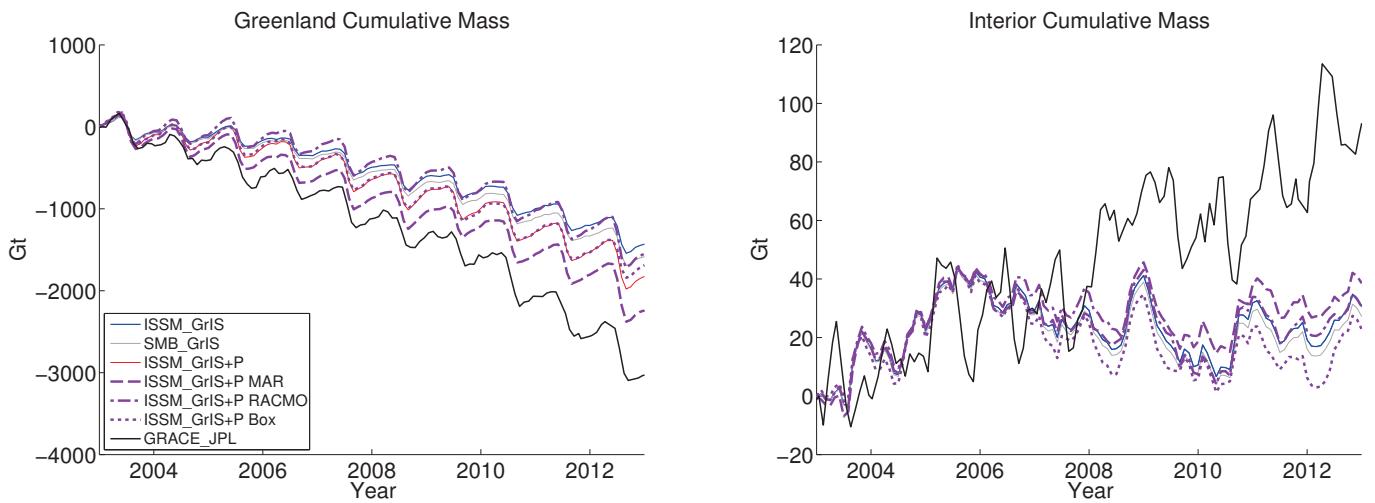
**Figure S4.** (A) Modeled surface velocities (m/yr), from the relaxed ISSM Greenland and (B) the departure of modeled surface velocities from observations. (Rignot and Mouginot, 2012). Note the non-linear color scales.



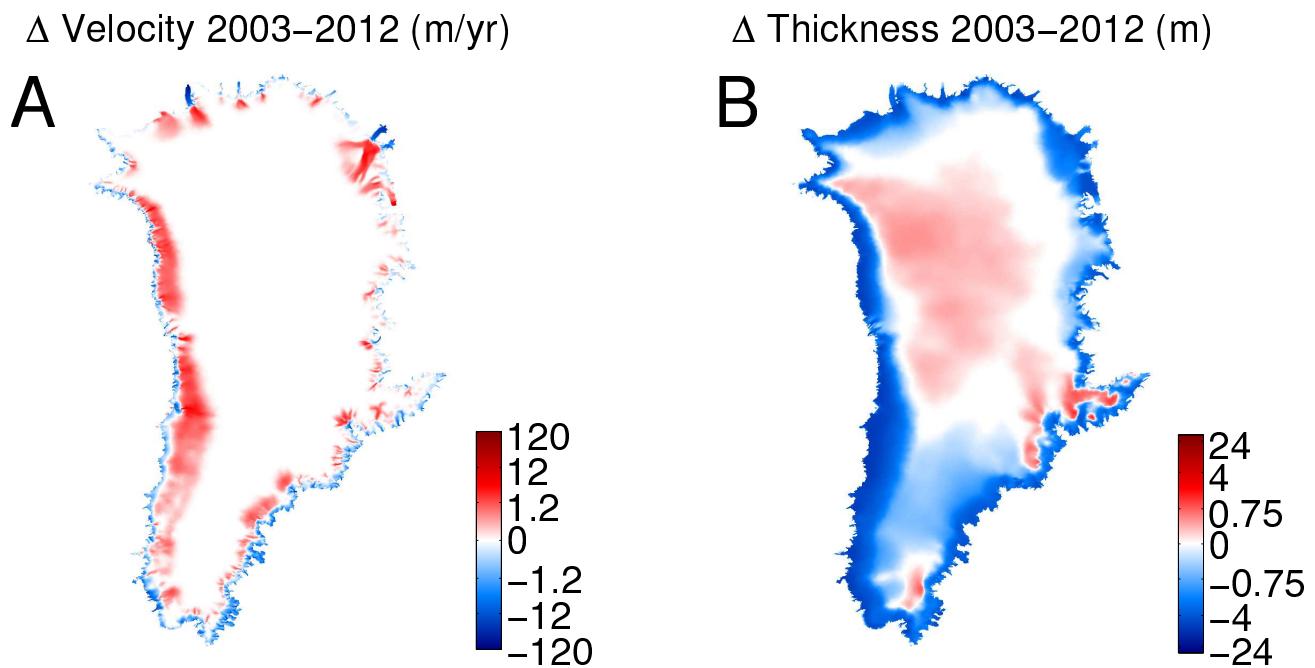
**Figure S5.** (A) Modeled ice thickness (m), from the relaxed ISSM Greenland and (B) the departure of modeled ice thicknesses from observationally-based data (Morlighem et al., 2014b).



**Figure S6.** Spatial representation of trend in surface mass from 2003-2009 as estimated from (A) GRACE\_JPL and (B) ICESat altimetry (Csatho et al., 2014), and (C) the difference: GRACE\_JPL - ICESat.

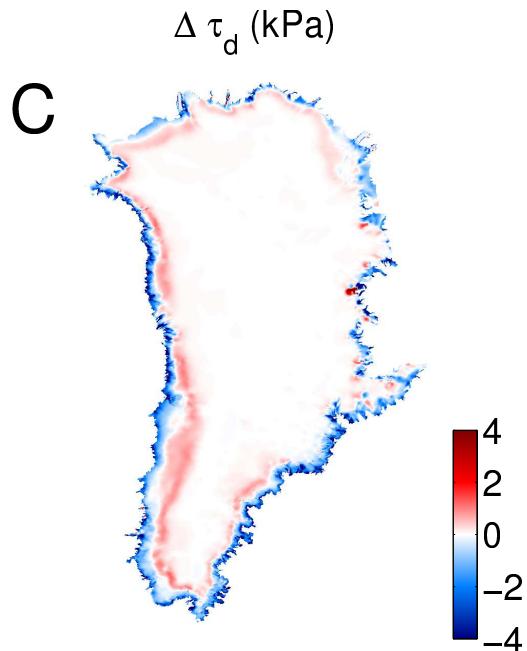
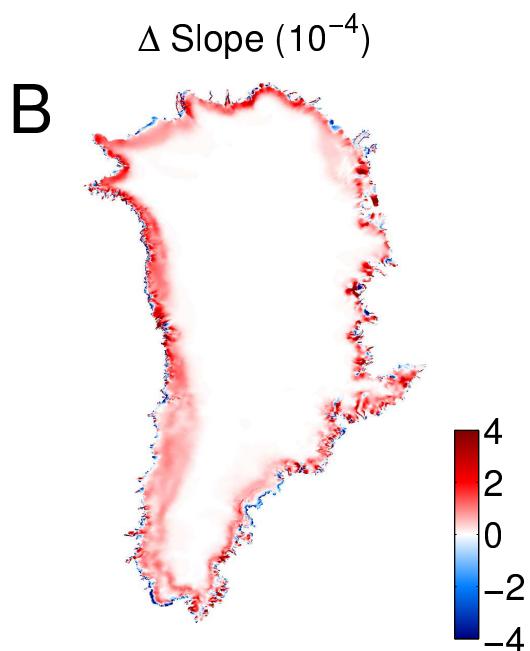
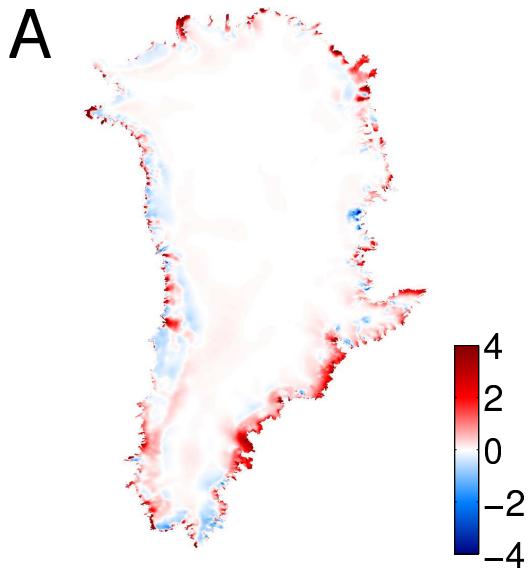


**Figure S7.** Cumulative mass from 2003-2012 for (A) all of Greenland and (B) the Greenland Interior, comparing observations from GRACE (GRACE\_JPL), with model outputs: ISSM over the Greenland Ice Sheet (ISSM\_GrIS), SMB anomalies over the Greenland Ice Sheet (SMB\_GrIS), ISSM\_GrIS with mass from the periphery (ISSM\_GrIS+P), and ISSM\_GrIS+P for each individual SMB forcing (ISSM\_GrIS+P MAR, ISSM\_GrIS+P RACMO, ISSM\_GrIS+P BOX).

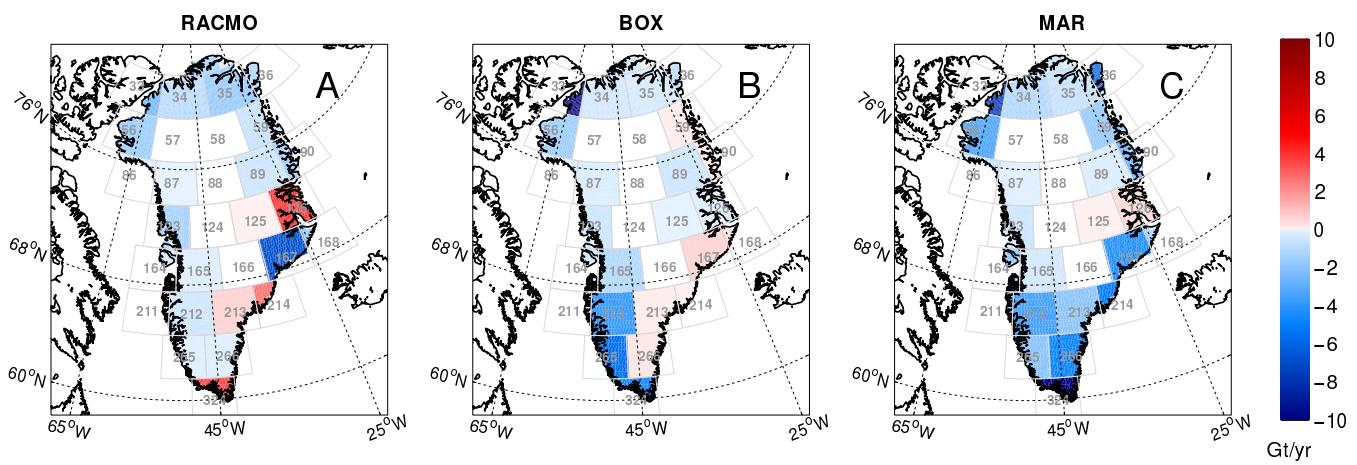


**Figure S8.** (A) Change in modeled mean annual surface velocities (m/yr) and (B) change in model ice thicknesses (m) during the 10-year ISSM simulation period (2003–2012). Model output is presented as the mean of three different ISSM simulation runs (ISSM\_GrIS BOX, ISSM\_GrIS MAR, and ISSM\_GrIS RACMO). Note the non-linear color scales.

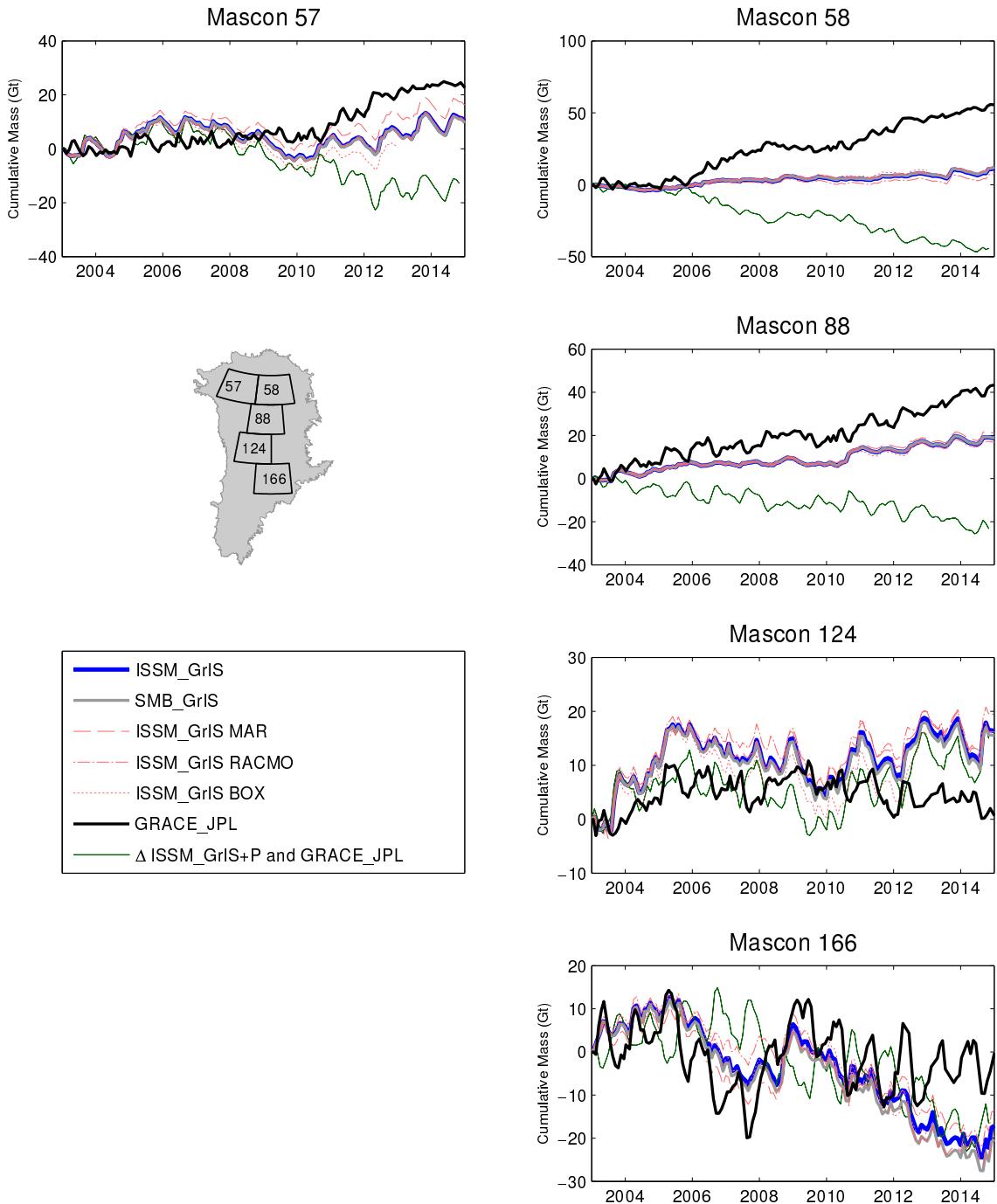
Dynamic  $\Delta$  Thickness (m)



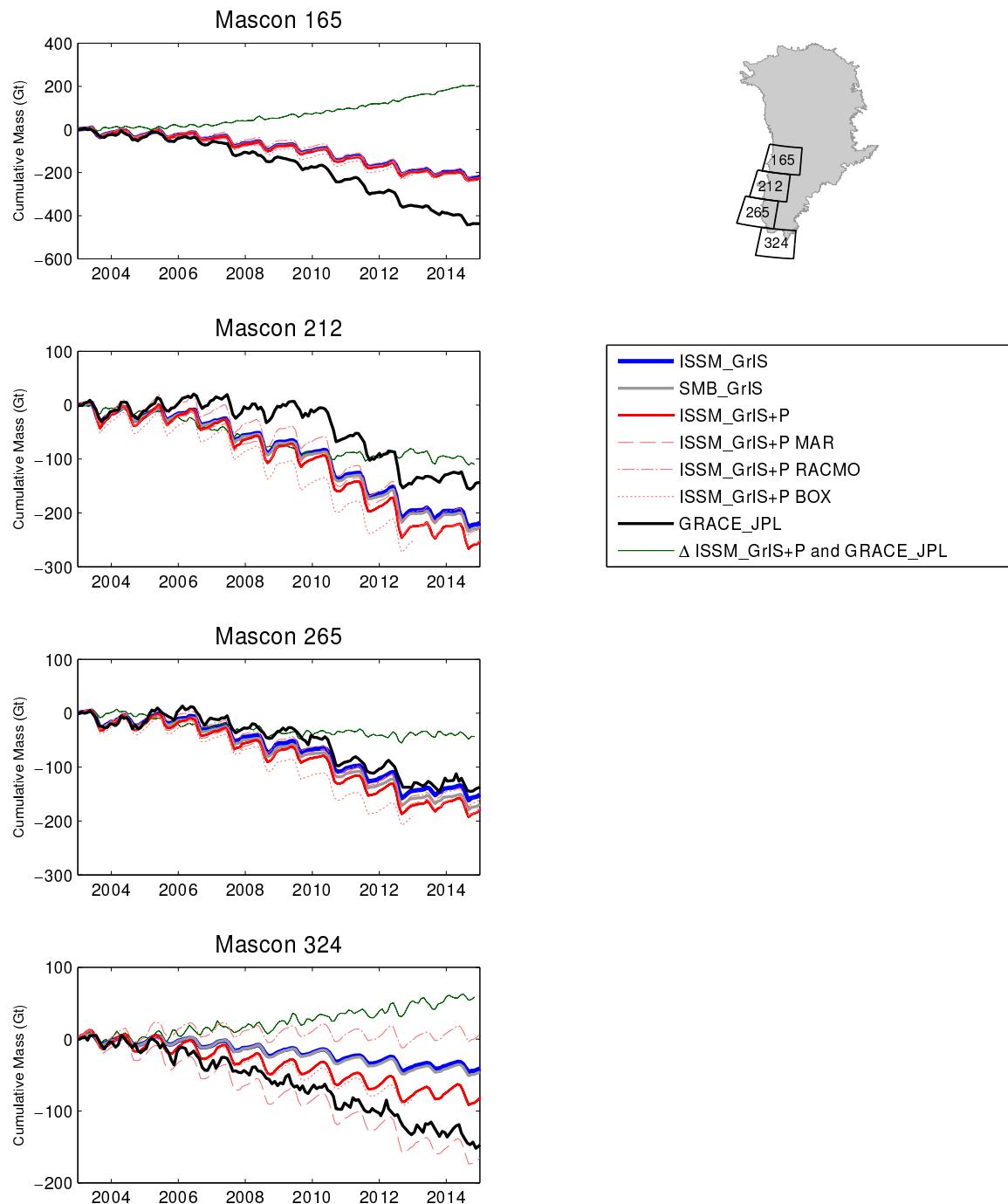
**Figure S9.** (A) Total dynamic ice thickness change (difference between the cumulative mass contribution from the SMB forcing anomalies and the total ice thickness change) simulated by ISSM Greenland (2003-2012); (B) change in surface slope during the simulation; and (C) change in the magnitude of the driving stress over the same period. Model output is presented as the mean of three different ISSM simulation runs (ISSM\_GrIS MAR, ISSM\_GrIS RACMO, and ISSM\_GrIS BOX).



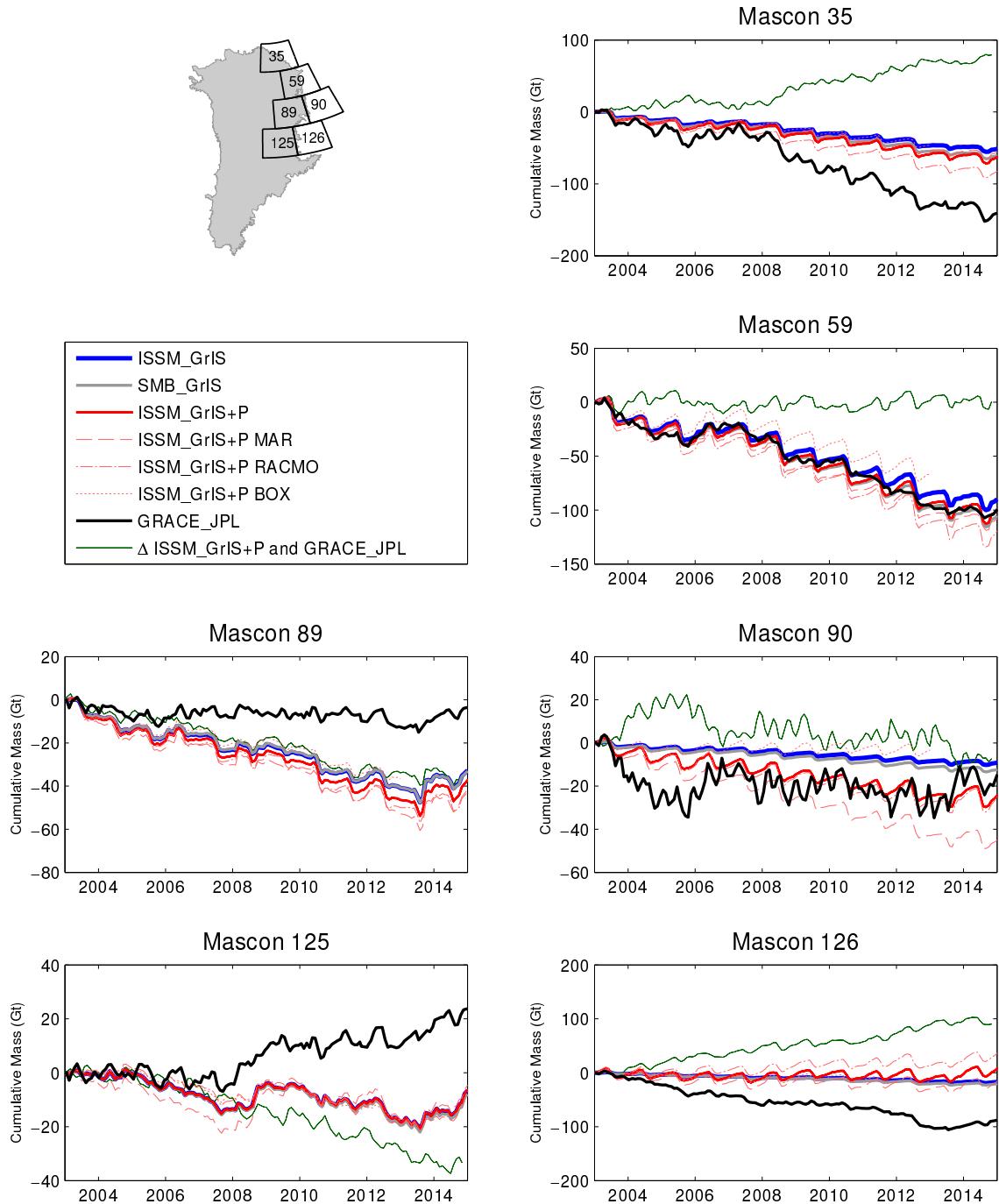
**Figure S10.** Spatial representation of trend in surface mass for the Greenland periphery as estimated from (A) RACMO, (B) BOX, and (C) MAR.



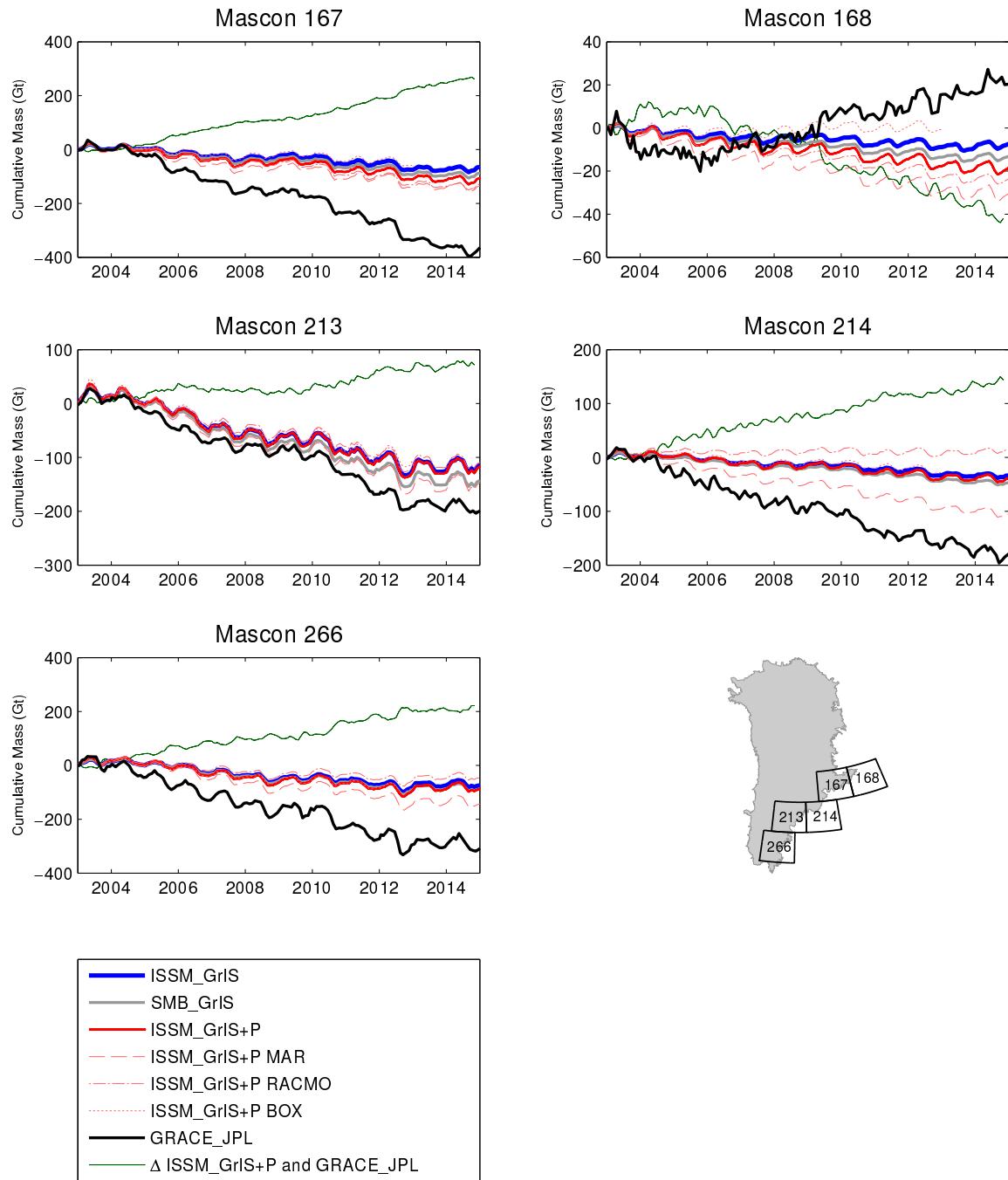
**Figure S11.** Interior mascons, total cumulative mass timeseries for GRACE\_JPL, SMB\_GrIS, and ISSM\_GrIS (including the mean and results from the individual simulations of ISSM\_GrIS MAR, ISSM\_GrIS RACMO, and ISSM\_GrIS BOX). Also included is the residual between GRACE\_JPL and ISSM\_GrIS (green).



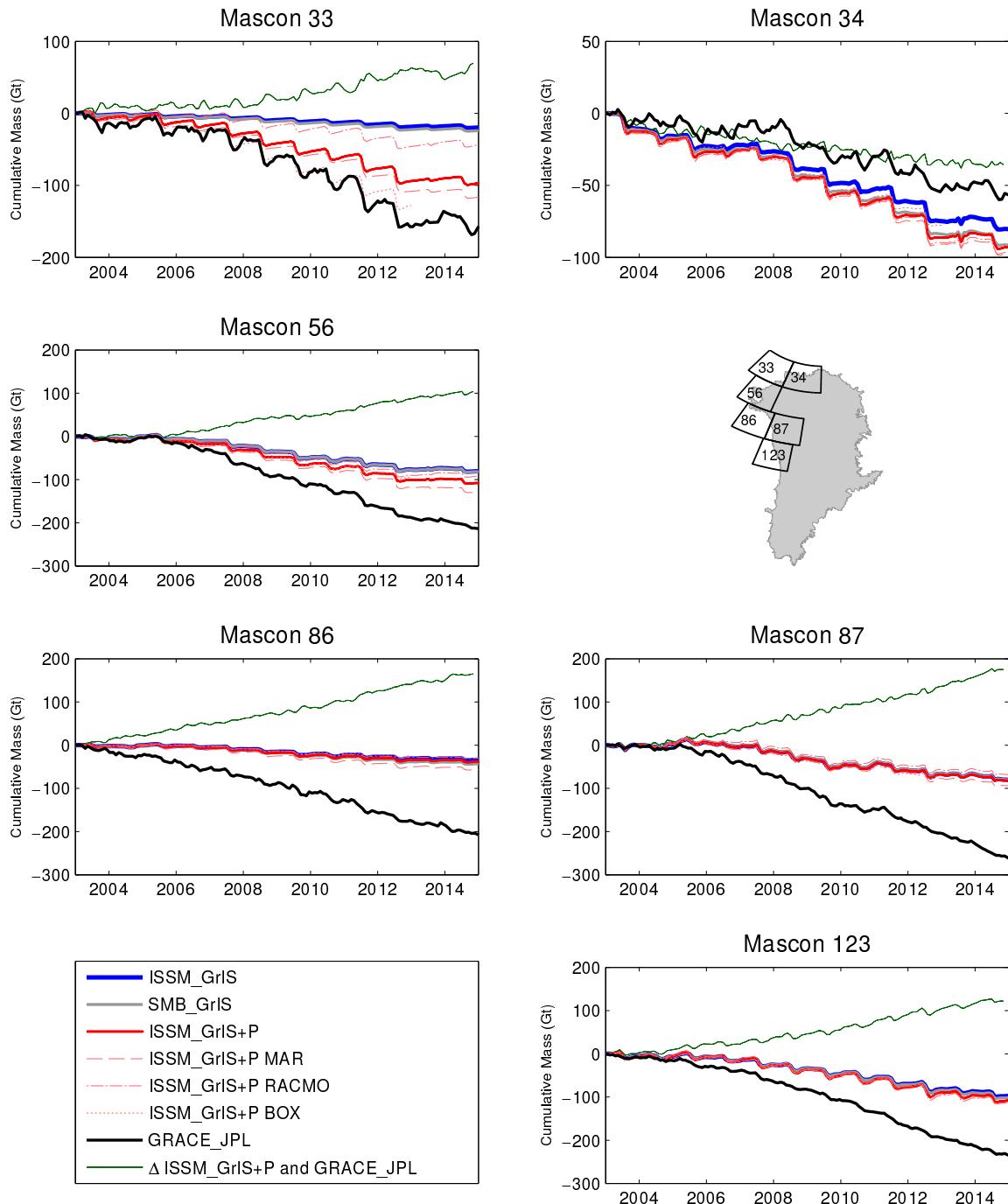
**Figure S12.** Southwest mascons, total cumulative mass timeseries for GRACE\_JPL, SMB\_GrIS, ISSM\_GrIS (including the mean and results from the individual simulations of ISSM\_GrIS MAR, ISSM\_GrIS RACMO, and ISSM\_GrIS BOX), and ISSM\_GrIS+P. Also included is the residual between GRACE\_JPL and ISSM\_GrIS+P (green).



**Figure S13.** Same as Fig. S12 but for Northeast mascons.



**Figure S14.** Same as Fig. S12 but for Southeast mascons.



**Figure S15.** Same as Fig. S12 but for Northwest mascons.