SUPPLEMENTARY MATERIAL, KARGEL ET AL., "GREENLAND'S SHRINKING ICE…"

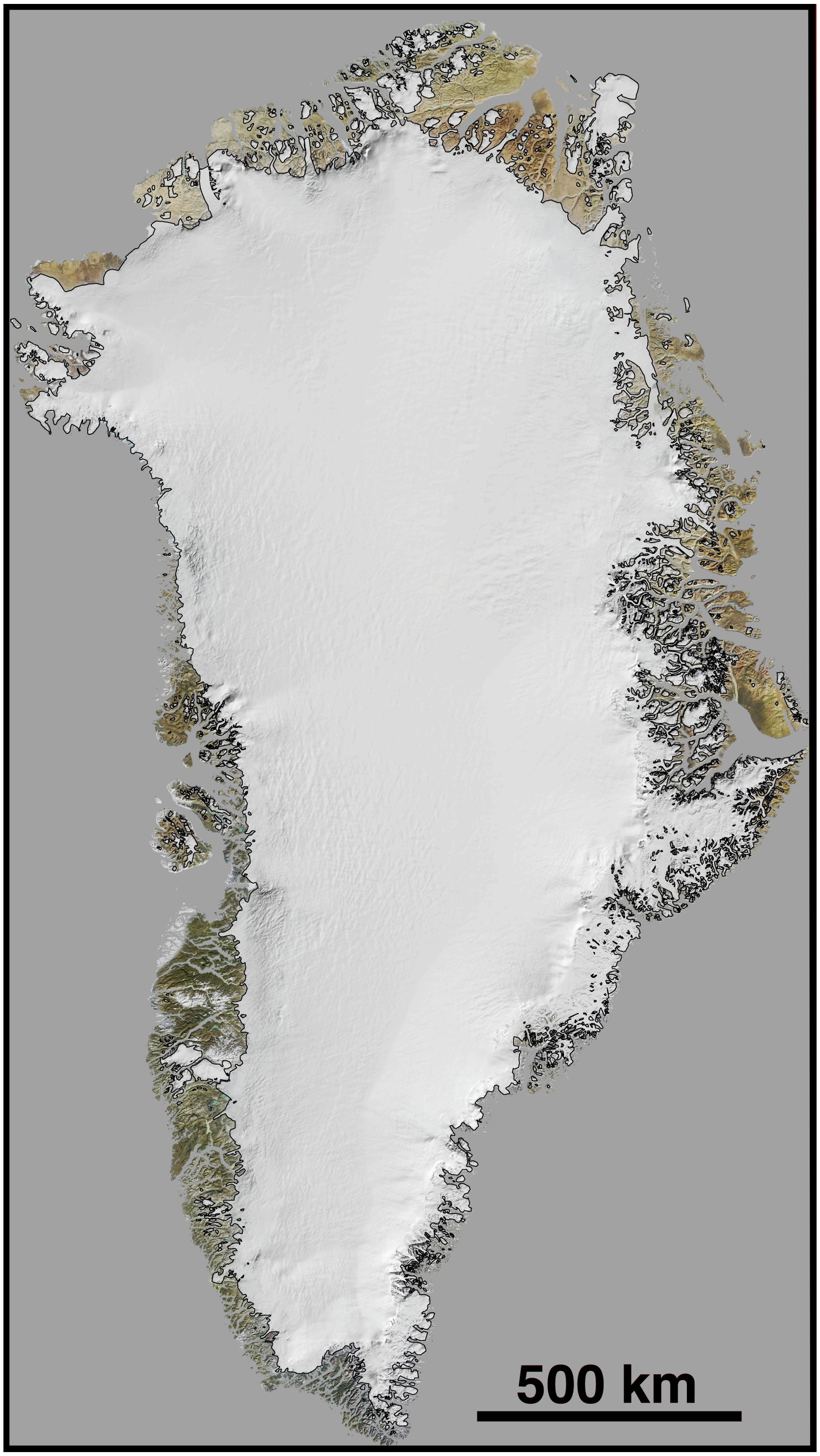

Figure S1. MODIS mosaic overlain by ice outlines from GEUS, to be reported by Citterio and Ahlstrom (in preparation). The MODIS data came from the LANCE (Rapidfire) project at Goddard (http://rapidfire.sci.gsfc.nasa.gov/subsets/?mosaic=Arctic). Tiles of 250-m/pixel clear imagery from 2009-2011, under low-snow conditions in the perimeter areas, were mosaicked by Paul Morin. Remaining cloudy areas were filled in with other tiles. Some residual snowy areas remain (e.g., south side of Disco Bay and the west side of Disco Island). The 90m resolution DEM GIMP by Ian Howat was used to accentuate the relief with hillshading.

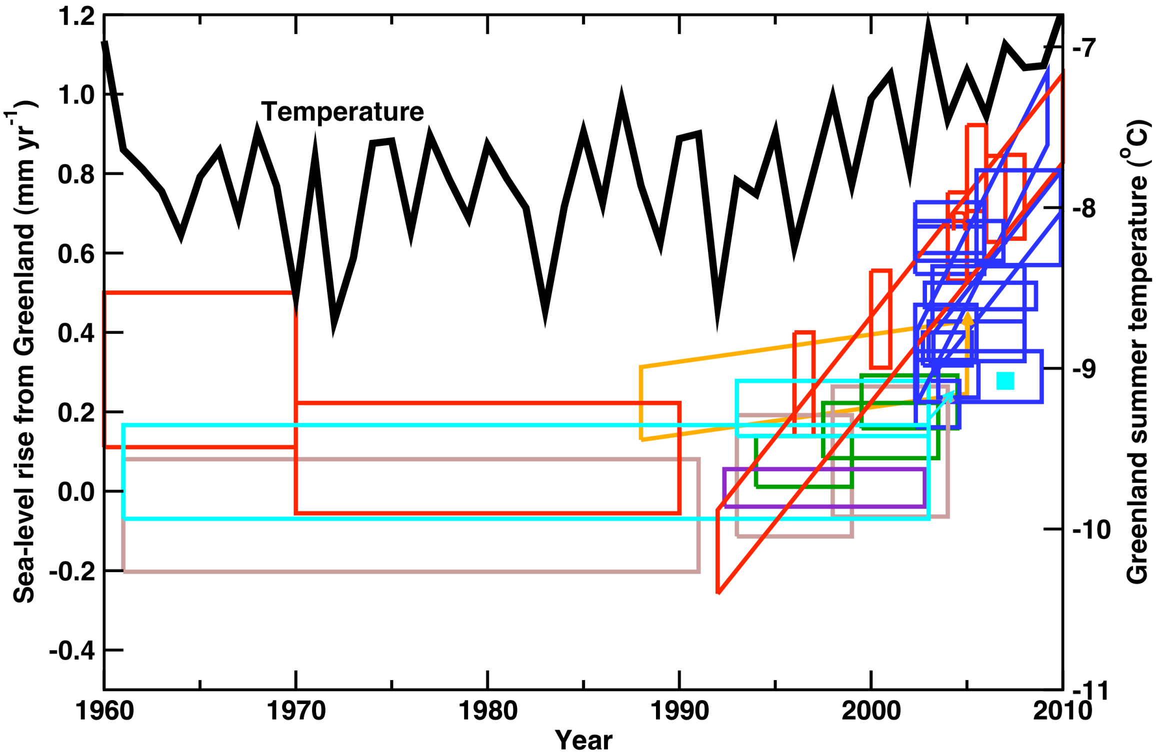

Figure S2. Published estimates of mass balance of Greenland Ice Sheet, updated from Alley et al. (2010; their Fig. 2), together with June-August ice-sheet temperature provided by Jason Box. Each quadrilateral spans the analysis period and the stated uncertainties in mass balance, with no implication that all uncertainties were treated in the same way. Dark blue=GRACE gravity, green=repeat altimetry, red, orange and tan=input minus output, and light blue=assessment. Data sources: Alley et al. (2010), Chen et al. (2011), Peltier (2009), Schrama and Wouters (2011), and Wu et al. (2010).

References for Figure S2:

Alley, R.B., J.T. Andrews, J. Brigham-Grette, G.K.C. Clarke, K.M. Cuffey, J.J. Fitzpatrick, S. Funder, S.J. Marshall, G.H. Miller, J.X. Mitrovica, D.R. Muhs, B.L. Otto-Bliesner, L. Polyak, and J.W.C. White: History of the Greenland Ice Sheet: paleoclimatic insights, Quat. Sci. Rev., 29(15-16), 1728-1756, 2010.

Chen, J.L., C.R. Wilson and B.D. Tapley, 2011, Interannual variability of Greenland ice losses from satellite gravimetry. Jour. Geophys. Res. 116, B07406, doi:10.1029/2010JB007789.

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Rignot, E., I. Velicogna, M. R. van den Broeke, A. Monaghan, and J. Lenaerts: Acceleration of the contribution of the Greenland and Antarctic ice sheets to sea level rise, Geophys. Res. Lett. 38, L05503, doi:10.1029/2011GL046583, 2011.

Schrama, E.J.O. and B. Wouters: Revisiting Greenland ice sheet mass loss observed by GRACE, Jour. Geophys. Res. 116, B02407, doi:10.1029/2009JB006847, 2011.

Wu, X., M. B. Heflin, H. Schotman, B. L. A. Vermeersen, D. Dong, R. S. Gross, E. R. Ivins, A. W. Moore, and S. E. Owen: Simultaneous estimation of global present-day water transport and glacial isostatic adjustment, Nature Geoscience 3, 642-646, doi:10.1038/ngeo938, 2010.

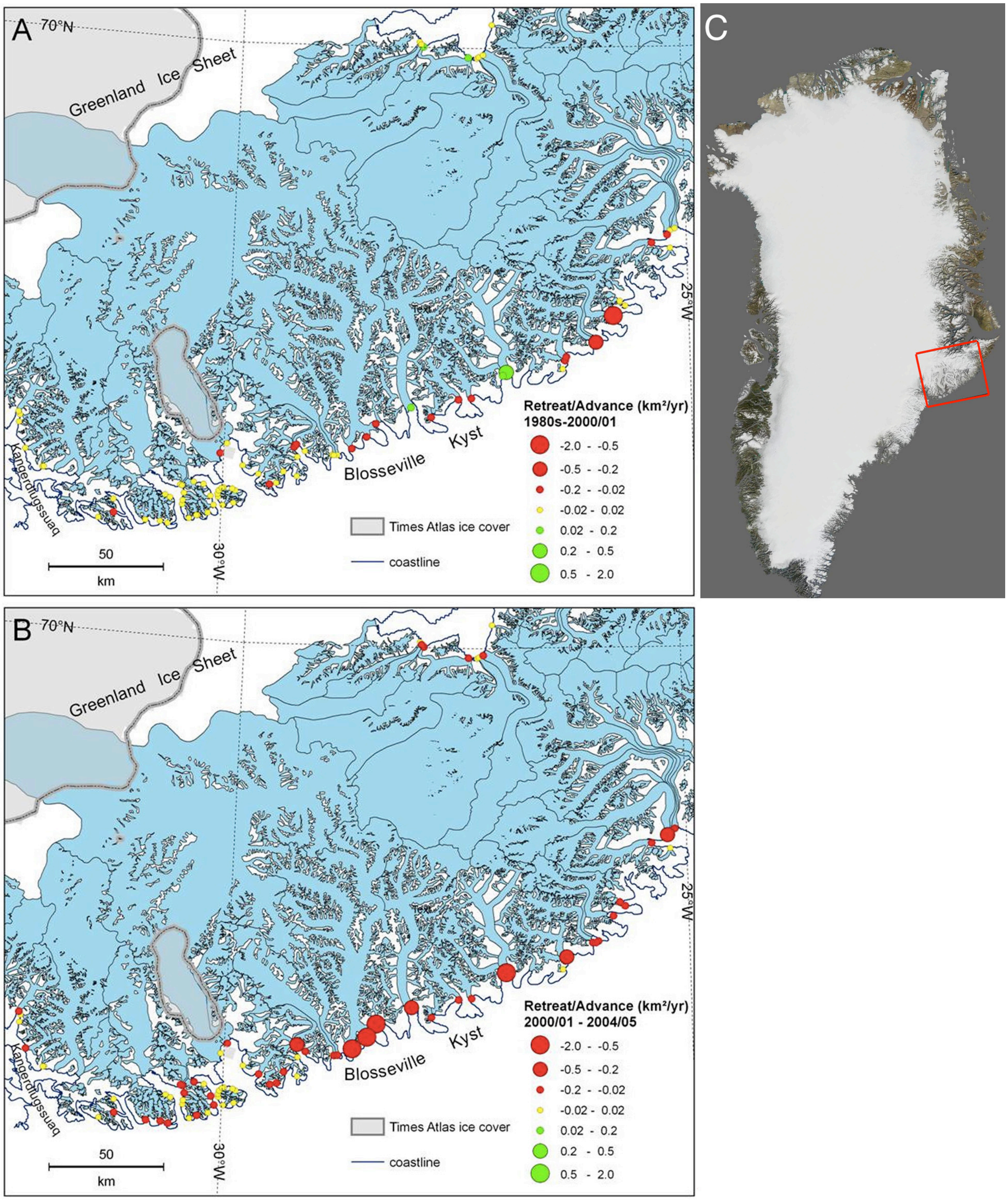

Figure S3: Tidewater margin change rates ($km^2\ a^{-1}$) in a sector of central East Greenland for a) 1980s-2000s and b) 2000/01-2004/05. Advance, retreat and no significant change are indicated by graduated sizes of green, red and yellow circles, respectively. Ice cover for glaciers > 2 km^2 (in blue) is from 2000/01 (see methods). Approximate ice cover from the Times Comprehensive Atlas of the World (13^{th} Edition) (grey with outline), plotted from the ice thickness data (Bamber et al., 2001) from which it was erroneously inferred, grossly underestimates the actual ice cover.

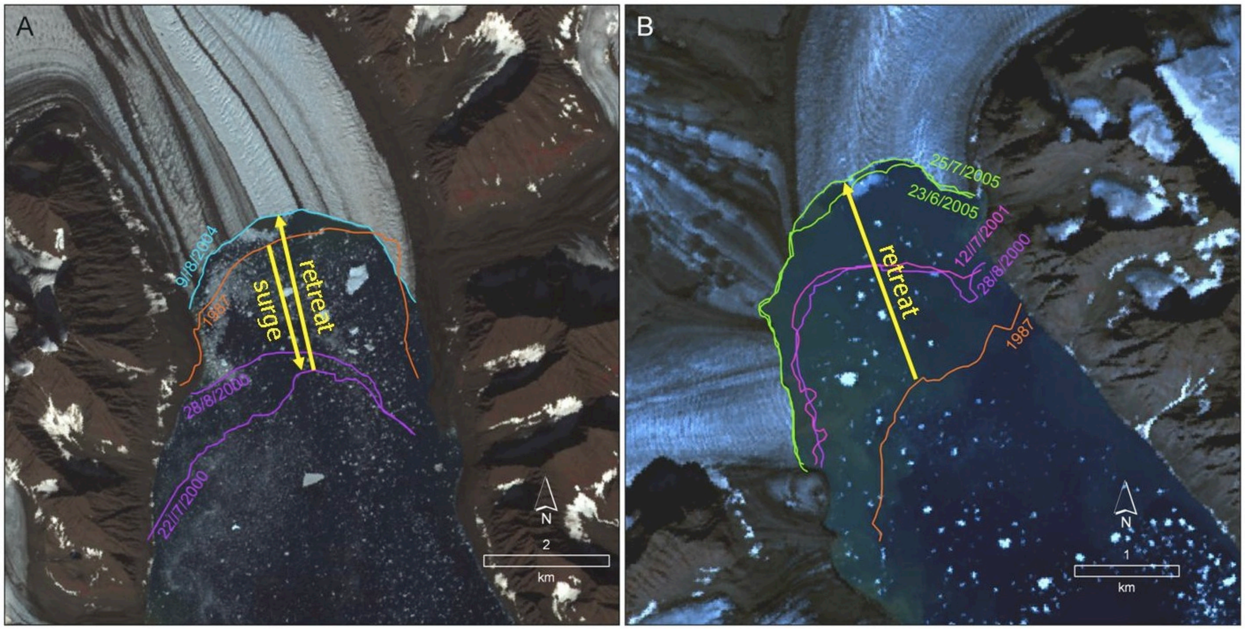

Figure S4: Tidewater margin positions for a) Sortebrae, where its 1992-1995 surge caused the 1987-2000 advance (+ 6.7 km^2) and rapid post-2000 retreat (-7.4 km^2). Net 1987-2004 retreat is 0.2% of glacier area. b) Unnamed glacier complex in the Rosenborg Gletscher Basin with a cumulative retreat of -4.7 km^2 (2% of area). For both glaciers, note the significant seasonal fluctuations.

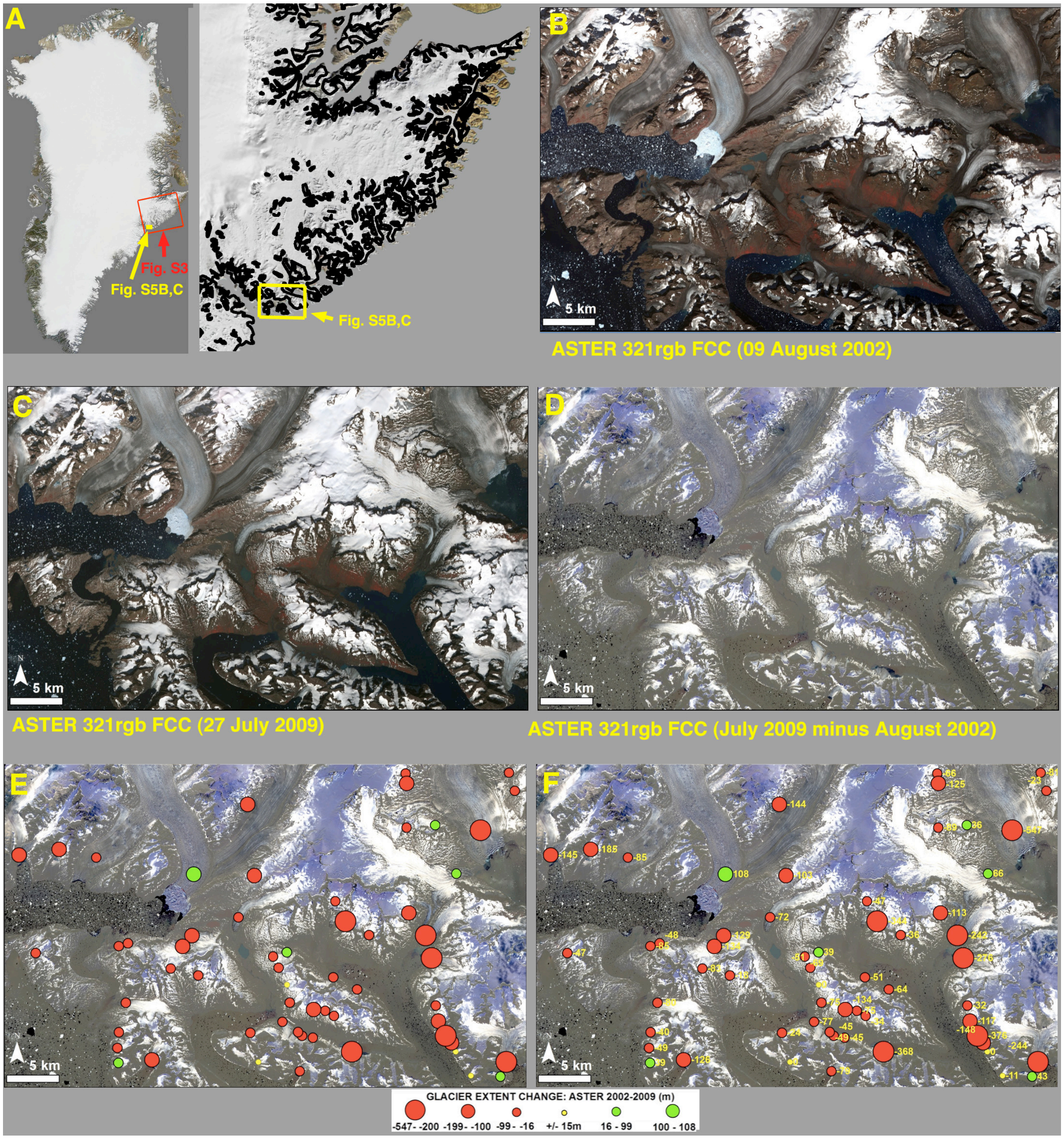

Figure S5. Glacier changes revealed in a pair of ASTER images obtained on near-anniversary dates seven years apart. (A) Location of (B) Orthorectified August 09, 2002 bands-321 RGB FCC subset, upon which the July 27, 2009 subset image was coregistered (C). Eleven ground control points were selected and fit with a first-order polynomial resulting in $RMSE_{xy}$ = 0.27 m. (D) Difference Image = ASTER coregistered 2009 subset image minus 2002 image. Band values rescaled to unsigned 8-bit DN values, and 2 standard deviation stretch applied to enhance the dynamic range of difference image. Areas of no change appear as neutral gray, featureless terrain; areas of surface change appear as black, white, and colored zones. (E) Length changes in glacier terminus positions were determined as follows: a straight, down-glacier centerline (approximating a flow line) was defined and digitally rendered onto the image through the glacier terminus. A second line, perpendicular to the flow line, was digitally rendered at the furthest down-valley extent of the terminus for each position of the terminus. The distance between these lines defines the change in terminus position, or glacier extent. Extent changes are reported in absolute meters retreat (red circles) and advance (green circles), and subsequently binned into gradational classes. (F) Same as E, and showing absolute glacier extent changes, meters (± 15m). The image pair shows overwhelming retreat of glaciers, even though snow cover increased from the earlier to the later image; we note that changing snowcover as shown is a (short-term) weather phenomenon and is different both from climate change and glacier change, which are longer term phenomena.