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Time evolving mass loss of the Greenland ice sheet from satellite altimetry

Ruud Hurkmans (1), Jonathan Bamber (1), and Curt Davis (2)

(1) University of Bristol, Bristol Glaciology Centre, Bristol, United Kingdom (j.bamber@bristol.ac.uk)., (2) Center for Geospatial Intelligence, University of Missouri, Columbia, Missouri, USA.

Mass changes of the Greenland ice sheet (GrIS) may be estimated by the mass budget method (MBM), satellite gravimetry, or via surface elevation changes (dH/dt). Whereas the first two have been shown to agree well in reconstructing mass changes over the last decade, there are few decadal estimates from satellite altimetry and none that provide a time evolving trend that can be readily compared with the other methods. Here, we interpolate radar and laser altimetry data between 1995 and 2009 in both space and time to reconstruct the evolving volume changes. The interpolation algorithm uses ice velocity to constrain the interpolated dH/dt in sparsely sampled areas, in particular narrow, rapidly changing outlet glaciers. The underlying assumption that the spatial patterns of surface velocity and dH/dt are linearly related, which was previously demonstrated for Jakobshavn Isbrae, is here validated for other major outlet glaciers and extended to the entire GrIS. A firn densification model forced by the output of a regional climate model is used to convert volume to mass. We consider and investigate the potential sources of error in our reconstruction of mass trends, and the resulting mass changes are compared to other published estimates. We find that mass changes are dominated by SMB until about 2001, when mass loss rapidly accelerates. The onset of this acceleration is somewhat later, and less gradual, compared to MBM. Our time averaged mass changes agree with published estimates based on gravimetry, MBM, laser altimetry, and with radar altimetry when this is merged with airborne data over outlet glaciers.