Spatial and temporal distribution of mass loss from the Greenland Ice Sheet since AD 1900 - DTU Orbit (08/11/2017)

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The response of the Greenland Ice Sheet (GIS) to changes in temperature during the twentieth century remains contentious, largely owing to difficulties in estimating the spatial and temporal distribution of ice mass changes before 1992, when Greenland-wide observations first became available. The only previous estimates of change during the twentieth century are based on empirical modelling and energy balance modelling. Consequently, no observation-based estimates of the contribution from the GIS to the global-mean sea level budget before 1990 are included in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Here we calculate spatial ice mass loss around the entire GIS from 1900 to the present using aerial imagery from the 1980s. This allows accurate high-resolution mapping of geomorphic features related to the maximum extent of the GIS during the Little Ice Age at the end of the nineteenth century. We estimate the total ice mass loss and its spatial distribution for three periods: 1900-1983 (75.1 ± 29.4 gigatonnes per year), 1983-2003 (73.8 ± 40.5 gigatonnes per year), and 2003-2010 (186.4 ± 18.9 gigatonnes per year). Furthermore, using two surface mass balance models we partition the mass balance into a term for surface mass balance (that is, total precipitation minus total sublimation minus runoff) and a dynamic term. We find that many areas currently undergoing change are identical to those that experienced considerable thinning throughout the twentieth century. We also reveal that the surface mass balance term shows a considerable decrease since 2003, whereas the dynamic term is constant over the past 110 years. Overall, our observation-based findings show that during the twentieth century the GIS contributed at least 25.0 ± 9.4 millimetres of global-mean sea level rise. Our result will help to close the twentieth-century sea level budget, which remains crucial for evaluating the reliability of models used to predict global sea level rise.

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