Spatial pattern of mass loss processes across the Greenland Ice Sheet from the Little Ice Age to 2010

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ABSTRACT BODY: The Greenland Ice Sheet loses mass through surface meltwater runoff and discharge from marine terminating outlet glaciers. The spatial variability and magnitude of these processes have been studied and described in detail for the past decades. Here, we combine the mass loss between the LIA to 2010 with a SMB model extending back to ~1900 in order to investigate the spatial distribution of mass loss processes.
We use high quality aerial stereo photogrammetric imagery recorded between 1978 and 1987 to map morphological features such as trim lines and end moraines marking the maximum ice extent of the LIA, which enables us to obtain vertical point-based differences associated with former ice extent. These point measurements are combined with contemporary ice surface differences derived using NASA's Airborne Topographic Mapper (ATM) from 2003-2010, NASA's Ice, Cloud, and land Elevation Satellite (ICESat) from 2003-2009, NASA's Land, Vegetation, and Ice Sensor (LVIS) from 2010, and ASTER (Silcast AST14DMO) co-registered to ICESat, to estimate mass loss throughout the 20th and early 21st Century. The mass balance estimates of the GrIS since retreat from maximum LIA is combined with a SMB model for the period for three intervals, LIAmax (~1900) - 1978/87, 1978/87 - 2003, and 2003 - 2010.
Across the GrIS the total mass loss if found to be spatially- and temporally variable. However, when assessing the mass loss due to SMB and mass loss due to dynamic ice loss, we find that that the ratios between these components are variable between the different sectors of the GrIS, e.g. in the southeast sector of the GrIS we find substantial mass loss, possibly driven by high precipitation rates but also the presence of a large number of marine terminating glaciers. Furthermore many areas currently undergoing changes correspond to those that experienced considerable thinning throughout the 20th century. Consequently, comparing the 20th century thinning pattern to that of the last decade, and assuming a similar warming pattern, we argue that the present sensitivity distribution will hold also for future ice sheet mass loss until marine outlet glaciers become grounded.

KEYWORDS: 0700 CRYOSPHERE, 0726 CRYOSPHERE Ice sheets, 0762 CRYOSPHERE Mass balance 0764 Energy balance, 0774 CRYOSPHERE Dynamics.

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