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The mass balance record and surge behavior of Drangajökull Ice Cap (Iceland) from 1946 to 2011 deduced from aerial photographs and LiDAR DEM

Joaquín Muñoz-Cobo Belart, Eyjólfur Magnússon, and Finnur Pálsson
Institute of Earth Sciences, University of Iceland

High resolution and accuracy (e.g. based on LiDAR survey) Digital Elevation Models (DEMs) of glaciers and their close vicinity have significantly improved the methods for calculation of geodetic mass balance and study of changes in glacier dynamics. However additional data is needed to extend such studies back in time. Here we present a geodetically derived mass balance record for Drangajökull ice cap (NW-Iceland) since 1946 to present. The mass balance is calculated from a series of DEMs derived by photogrammetric processing of aerial photographs (years: 1946, 1975, 1985, 1994) and a LiDAR DEM (2011).
All Ground Control Points (GCPs) used to constrain the orientation of the aerial photographs, used in the photogrammetric processing, are picked from the LiDAR derived DEM, thus eliminating the time consuming and expensive in situ survey of GCPs. The LiDAR DEM also helps to assess the accuracy of the photogrammetrically derived DEMs, by analyzing the residuals in elevation in ice-free areas. For the DEMs of 1975, 1985 and 1994 the Root Mean Square Error (RMSE) of the residuals is less than 2 m, whereas the accuracy of the DEM of 1946 is worse, with RMSE of 5.5 m, caused by the deteriorated images.
The geodetic mass balance yields a negative specific mass balance of $\sim$-0.5 m w.e.a^{-1} for the period 1946-1975, followed by periods of positive mass balance: $\sim$0.2 m w.e.a^{-1} for the period 1975-1985 and $\sim$0.3 m w.e.a^{-1} for the period 1985-1994. Negative specific mass balance of $\sim$-0.6 m w.e.a^{-1} is derived for the period 1994-2011. High mass redistribution is observed during 1985-1994 and 1994-2011 on the three main outlets of the ice cap, related to surges. The derived orthophotographs allow tracking of stable features at individual locations on the northern part of Drangajökull, indicating an average velocity of 5-10 m a^{-1} for the period 1946-1985 and speeding up in the last two periods due to a surge.