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Little Ice Age precipitation in southern Norway

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Recently published information on glacier characteristics in southern Norway has enabled analyzing changes in glacier geometry since the Little Ice Age (LIA) to estimate the magnitude of the LIA precipitation anomaly. Glacier inventories in the Jotunheimen region (61.5 N, 8.5 E) were created for (1) 2003 by using a 50-m DEM and 2003 LANDSAT glacier outlines, and for (2) the LIA maximum (about AD 1750) by using LIA glacier outlines with the DEM. Moraine ridges determined in (2) were field checked with GPS in summer 2008. Both (1) and (2) provided area and altitude range, as well as length, slope and aspect. Here 133 glaciers having LIA area > 0.1 km^2 are considered, of which 28 included two or more separate glaciers in 2003.

Area-altitude profiles $A(Z)$ from (1) are transformed to LIA profiles by assuming an area-increase distribution $\Delta A(Z)$ that is concentrated at low altitude and integrates to the measured area difference between (1) and (2). Because mass balance profiles $b(z)$ in this region are nearly linear, the average balance B over the area-altitude profile is equal to the balance at the mean altitude $b(\bar{Z})$. Glacier to glacier variation of the obtained 2003-LIA difference $\Delta\bar{Z} = 88 \pm 52$ m is poorly correlated with any other glacier variable.

For seven glaciers in southern Norway, the NVE glacier research program shows that $db/dz = 6 \pm 0.5$ m w.e./km, with little variation from year to year over recent decades, including a span of annual temperatures that is far greater than the published temperature difference $0.5 \pm 0.1°$ C in the region since the LIA. This engenders confidence that db/dz during the LIA was similar to now. When applied to the calculated 2003-LIA difference in mean altitude $\Delta\bar{Z}$, the balance profile $b(Z)$ yields the balance anomaly of $\Delta B = +0.53 \pm 0.32$ m w.e. at the LIA maximum extent.

Published values of mass balance sensitivities to precipitation 0.12 ± 0.04 m w.e. per 10% increase, and to temperature -0.55 ± 0.10 m w.e. °C^{-1}, when combined with the altitude and temperature anomalies, enable deriving the LIA precipitation anomaly, preliminarily estimated as $\Delta P = 21 \pm 28\%$. By comparison, winter balance at Storbreen over 1989-1995 was 29% greater than the 1949-2006 average.