A comparison of remotely sensed surface velocities with balance velocities on two Svalbard ice caps

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Abstract

The water contained in the ice caps of Svalbard is only a small fraction of that contained in the ice masses of Antarctica and Greenland, but a number of factors mean that the short−term potential contribution to sea level rise may be more significant. It is important therefore to investigate the mass balance of these ice caps under the accelerating trend of increasing Arctic temperatures.

This study considers Austfonna, which is the largest ice cap on Svalbard, covering an area of 8,450 km². It is thought to be warm based in the interior ringed by cold−based ice which is punctuated by about 30 faster flowing outlet glaciers. For about half of these outlets, measured surface velocities are compared with calculated balance velocities in order to assess their state of equilibrium. The surface velocities were quantified using synthetic aperture radar (SAR) differential interferometry, following established procedures. The data were acquired by the ERS−1 and ERS−2 satellites, and scenes from 1992 and 1995/96 were processed to produce maps of surface velocity, making the assumption that ice flows in the direction of maximum surface slope. Balance velocities were calculated for the equilibrium line altitudes (ELAs), incorporating a 1986/98 average accumulation rate distribution based on 19 ice cores, ice thicknesses from radio echo sounding, and accumulation areas defined by the drainage basin boundary and the ELA. The balance velocities obtained range from 1 to 70 m/a. A similar comparison is also made for Aldousbreen, an outlet glacier on the Vestfonna ice cap, for which earlier measurements of surface velocity are also available.

Results indicate that some of the outlets are flowing at velocities which cannot be maintained indefinitely under the current climate. For example, the calculated surface component of the balance velocity at an altitude of 330 m for Basin 6, a glacier which drains the eastern side of Austfonna, is about 25 m/a. Measured surface velocities in February 1992, October 1995 and April 1996, at this altitude, were all greater than 40 m/a. That is, the non−equilibrium flow was apparent in autumn and spring velocity measurements, and over a period of 3 to 4 years.