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A comparison of balance velocities with remotely sensed surface velocities on a Svalbard ice cap

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Over the past few decades Arctic average temperatures have risen at almost twice the rate of the rest of the world and this trend is projected to accelerate over this century (ACIA, 2004). The water contained in ice caps and glaciers outside of Antarctica and Greenland could contribute an estimated 0.5 m to global sea level rise (Church *et al.*, 2001). There are several large ice caps on Svalbard which have been the focus of recent research. Vestfonna is the third largest and covers an area of 2,455 km^2 (Hagen *et al.*, 1993). It is drained to the south by four well defined outlet glaciers, two of which were shown to have negative net mass balances in the early 1970s (Dowdeswell and Collin, 1990).

For this study, Aldousbreen was chosen as an example of a Vestfonna glacier for which recent surface velocities could be compared with a calculated balance velocity and with earlier measurements of surface velocity. The recent surface velocities were quantified using a combination of synthetic aperture radar (SAR) differential interferometry following established procedures (Kwok and Fahnestock, 1996; Joughin *et al.*, 1996), and feature tracking using image patch correlation (Strozzi *et al.*, 2002; Luckman *et al.*, 2003; Pritchard *et al.*, 2005).

A balance velocity was calculated for the equilibrium line altitude (ELA, 400 m a. s. l., Hagen *et al.*, 1993), incorporating 1963–95 average accumulation rates from ice-core data (Watanabe *et al.*, 2001), ice thicknesses from radio echo sounding (Dowdeswell *et al.*, 1986), and an accumulation area of 56.6 km^2 (Jiskoot, 1999). The result yielded a surface velocity of 55 ± 25 m a^{-1}, allowing for uncertainties in the areal representativeness of accumulation rates and assumptions made regarding the cross-sectional profile of the glacier. In comparison, differential interferometry on two tandem pairs of ERS-1 and ERS-2 SAR images produced surface velocities for April 1996 at the

ELA (13 km from the glacier front) of over 200 m a^{-1}.

Within 2–3 km of the glacier front, interferometrically derived velocities for April 1996 were of the order of 100 m a^{-1} on the eastern half, while feature-tracked velocities of 200–300 m a^{-1} extended the area covered by interferometry westwards across the glacier front. These 1996 surface velocities are comparable to the 1971/72 values which were based on an analysis of aerial photographs (Dowdeswell and Collin, 1990).

The comparison of 1996 surface velocities with balance velocities at the ELA on Aldousbreen indicates that with accumulation rates equivalent to the 1963–95 average, a conservative estimate of the net mass loss from the drainage basin is equivalent to 0.66 m a^{-1} water. In addition, over the lower 2-3 km of the glacier, velocities are consistent with those measured in the early 1970s, indicating that this rate of mass loss may have been continuing for 24 years.

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