# Mass Balance and Dynamics of a Valley Glacier measured by High-resolution LiDAR

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The mass balance of a glacier, representing the difference between gain and loss of ice over the course of a year, is the primary indicator of its equilibrium, or lack of it, in response to a possibly changing environment. The ability to monitor glacier mass balance is therefore highly desirable in the context of observation and understanding of the global climate. *In situ* techniques such as repeated surveying of lines or networks of stakes are generally slow and provide limited spatial resolution. Airborne remote sensing methods address both of these problems, and aerial photography and scanner imagery have been used to construct maps from which topographic datasets can be extracted. Recently, however, the performance of airborne scanning LiDAR (light detection and ranging) instruments has increased substantially, to the point where it has become suitable for precise measurements of the surface morphology of glaciers. We describe a case-study on the glacier Midre Lovénbreen on Svalbard. This is a small (6 $km^2$) north-facing valley glacier that has been retreating rapidly since around 1900, currently at a rate of around 5 m per year. High-resolution airborne LiDAR data were collected from this glacier in August 2003 and again in July 2005, with a horizontal sampling interval of less than 2 m and a vertical resolution of around 0.1 m. Since these two dates were at similar points in the balance year, differences in the surface morphology can largely be attributed to secular rather than seasonal variations. The vertical resolution of the LiDAR implies that the mass balance can be estimated to a precision of the order of 0.1 m per year, a factor of at least 5 smaller than the mass balance determined by *in situ* measurements. However, a striking feature of this high-resolution dataset is its ability to resolve surface features such as crevasses and active and relic meltwater channels. We investigate the scope for tracking the motion of these surface features and hence obtaining a direct estimate of the surface velocity field, with a precision of the order of 1 m per year.