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Changes in glacier geometry and extent in Svalbard: implications for sea-level rise during the twentieth and twenty-first centuries (SLICES)

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Historical records have shown that over the twentieth century, global sea-level has risen by about 0.18 m and forecasts have estimated a further rise of 0.50 m over the twenty-first century. Of the sea-level rise experienced over the last 100 years, 20-30% is believed to have come from the melt of small glaciers outside major ice sheets. Svalbard, being one of the most important glaciated areas in the Arctic, is expected to make a contribution that may be the largest of any Arctic region outside Greenland. The difficulty of estimating and forecasting both global sea-level rise and past and future contributions of such ice masses is due largely to our lack of knowledge with respect to the mass balance of the world's ice masses. This is largely the result of two main issues. The first is the poor spatial distribution of mass balance study sites as a consequence of logical constraints. The second is an overall lack of long-term mass balance studies. Therefore, the development of methods that address these issues is imperative for solving the climate change/sea-level rise question.

The aim of the SLICES project is to upscale mass balance estimates of selected benchmark glaciers in Svalbard over the twentieth century to arrive at an estimate of twentieth century contribution to sea-level rise for the archipelago. The results will be used to produce sea-level rise contributions for the twenty-first century under a variety of climatic change scenarios. To achieve this, the first issue was resolved by relying on the measurement of mass balance using the geodetic method based on aerial photographs where DEMs of the same area are compared over different epochs. The second issue was resolved through the use of the collection of historical aerial photography held at the Norsk Polarinstitutt in Tromsø that dates back to the early twentieth century. Topographic datasets will be collected using contemporary lidar data as well as contemporary and historical photography. From these, mass balance estimates can be derived using the geodetic method from volume change by assuming a constant ice density of 900 kg m-3 (i.e. Andreassen et al., 2002; Bamber et al., in review). The upscaling will use a regional mass balance model driven by ERA40 reanalysis data from the European Centre for Medium-Range Weather Forecasts.

This paper presents some early results of the project. A series of DEMs and resulting historical mass balance estimates were produced by substituting field-based ground control data required in conventional photogrammetry with commensurate ground control data extracted from a lidar DEMs. The lidar-based ground control was extracted using visual image interpretation and digital image enhancement. In some cases, ground control points were measured on the ground using high quality differential GPS so the quality of this approach could be assessed relative to the more traditional approach.