Determining the Spatio–Temporal Distribution of 20th Century Antarctic Peninsula Glacier Mass Change

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Key words: Photogrammetry; Remote sensing;

SUMMARY

Mountain glaciers are a major source of 20th Century and current sea-level rise. The Antarctic Peninsula (AP) is best considered a mountain glacier system separate to the continental West Antarctica Ice Sheet and East Antarctica Ice Sheet that has experienced summer warming and an increase in Positive Degree Days over the last half-century. Changes to glacier fronts and ice shelves, as well as glacier acceleration, are well documented but there is almost no data on mass changes for the more than 400 AP glaciers. A current crude estimate is that the AP is contributing to sea-level change at a similar rate to that of other fast-changing near-polar or large mountain-glacier environments such as Alaska. Forecasting the future impacts of the AP ice sheet on sea level will require a much improved understanding of 20th Century and contemporary glacier mass changes. The only current way to quantify these past changes in glacier mass, and hence contribution to sea-level change through loss of grounded ice, is by detailed photogrammetric measurements from historic aerial photography. This ongoing project is therefore using novel photogrammetric techniques to collate accurate measurements of surface elevation change for 50+ glaciers on the AP over a 50 year-time span. The project uses almost entirely unexploited source images with the aim of transforming the AP from being almost unmeasured to one of the best determined large mountain or near-polar glacier systems, and will establish a suite of benchmark glaciers for monitoring future changes. Results to date have used surface elevations from USGS and BAS airborne (1948-2005) and ASTER space-borne (2001-2010) stereo imagery, combined by a rigorous semi-automated least-squares surface matching approach, to determine multi-decadal glacier surface elevation changes in the western AP for a dozen glaciers. All observed glaciers show near-frontal surface lowering and an annual mean lowering rate of 0.3 m/yr during the four decades following the mid-1960s, with higher rates for the glaciers in the north-west parts of the Antarctic Peninsula. Increased lowering of up to 0.6 m/yr can be observed since the 1990s, in close correspondence to increased atmospheric positive degree days. In all cases, surface lowering reduces to zero within 5 km of the glacier front. Higher altitude elevation increases suggest that much of this lowering may have been compensated by increased accumulation and further experimentation is assessing this hypothesis. The project will provide direct inputs into integrated global assessment of current sources of sea-level rise. Moreover, new insights into the climate controls on the AP system and the sensitivities of sub-polar marine and tidewater glacier systems to climate change will be gained. Results will also feed into ongoing modelling activities that are developing projections based on significant assumptions about recent mass balance in the AP ice sheet, allowing these to be tested, and thereby providing a significant improvement in understanding of uncertainty.