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Spatial and temporal patterns of recent area change of glacier systems on the Antarctic Peninsula

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Glaciers on the Antarctic Peninsula (AP) have recently shown changes in extent, velocity and thickness. Understanding the response of glaciers to warming air temperatures and ocean circulation changes in this region is critical for understanding future mass balance changes, and yet there is little quantification of change in the mass balance of individual basins and the processes controlling changes in their extent. One reason for this is that the AP is a complex mountainous glacier system and without a topographic model at sufficient resolution the boundaries between individual glacier systems have been difficult to identify. With outlines it becomes possible to calculate changes in area and compare characteristics of individual glaciers.

We present a new Digital Elevation Model (DEM) and a new drainage basin data set for the Antarctic Peninsula, along with an assessment of changes in area of marine-terminating glacier systems from the 1940s to 2010. We explain the methodology used in producing the new 100-m DEM of the region using ASTER GDEM, and the semi-automated drainage basin delineation method based on this DEM. This approach has resulted in outlines for 1598 glacier systems: these include outlet and mountain glaciers, ice caps, piedmonts, ice-covered islands and 'ice walls'. Of these, 903 are marine-terminating glaciers, all of which have coastal-change data at various time periods since the 1940s. Area calculations, along with other attributes, were assigned to individual basins, thus enabling comparative statistical analyses.

We give a summary of these changes both by overall area change and by change in extent at 5-year time intervals, and describe patterns of ice loss both spatially (by latitude and by specific regions) and temporally (trends across time intervals). Although 90% of the 903 glaciers have reduced in size since the earliest recorded date, the area lost varies considerably between glaciers. Largest area loss has occurred to glaciers flowing into Wordie Bay, where the largest basin on the AP lost 329 km2 between 1997 and 2010. Large losses also occurred to the glaciers which once flowed into the Larsen B Ice Shelf (up to 131 km2), and to the large ice piedmont on Adelaide Island (60 km2). In total, 21 glaciers lost > 10 km2 since their earliest recorded position, 209 glaciers lost between 1-10 km2 and 672 showed minimal change (<1 km2). The relative area change is generally inversely correlated with basin size although there are a number of outliers. We examine spatial differences in ice loss and compare regions that differ in consistency of retreat. A statistical analysis of glacier changes alongside glaciological controls obtained from the drainage basin outlines and the DEM can help us to understand why some glaciers behave anomalously, and here we discuss initial findings.