



Historic Glacier Changes in the American West

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Our GIS analysis of topographic maps indicate that more than 8400 alpine glaciers and permanent snow fields, cover an area greater than 650 km² in seven western states of the American West, exclusive of Alaska. As expected mean glacier elevation rises to the east and to the south consistent with spatial gradients in precipitation and air temperature. To our surprise, however, we are able to fit a plane to the spatial pattern of mean glacier elevation with a correlation coefficient of 0.89. Plots of annual precipitation and mean air temperature at the elevation of mean glacier elevation, a proxy for the equilibrium line altitude show two significantly different climate regimes, one dominated by below freezing temperatures and low precipitation and one dominated by above freezing temperatures and high precipitation. Changes in glacier area over time were evaluated in several regions using historic maps and photographs to infer historic glacial extents. Overall, results show a steady retreat after an enhanced retreat during the early 1900s subsequent to the Little Ice Age. However, in some regions, the glaciers have not significantly changed due to local topographic influences that enhance snow accumulation through avalanching and wind redistribution. In other regions show the rate of change is declining, probably due to glacier shrinkage into more topographically favourable environments. Regional differences in the rate of glacier shrinkage have not yet emerged, probably due to important differences in local topographic influences. The overall control on glacier shrinkage is size. Smaller glaciers exhibit greater fractional area loss than larger glaciers. Using area-volume scaling relations, the total volume of melt water lost from the shrinkage of small glaciers (<1 km²) is equivalent to that from larger glaciers. Thus small glaciers and snowfields play an important hydrologic role. Glacier shrinkage reduces their buffering capacity to minimize effects of droughts in alpine basins and reduces their area of influence.