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The race to the end: Comparing factors impacting glacial melt rates in Glacier National Park and the Greater Yellowstone Ecosystem.

Background/Objectives

In the semi-arid regions of the western United States, snow and glacial melt provides a large percentage of the annual water supply. Years with low winter snowpack can lead to water stress for ecosystems that do not have a supplemental water source, such as a glacier. The northern Rocky Mountains of the United States has 31 glaciers >0.5 km² (covering 42 km²) found primarily in two regions; Glacier National Park (GNP), and the Greater Yellowstone Ecosystem (GYE). While the glaciers of GNP typically gain more publicity, particularly in regards to their rapid decline, the GYE contains more ice and larger individual glaciers. This study seeks to compare the melt rates of the GNP and GYE glaciers and to infer the causes of any differences in the melt rates, as well as to raise awareness of the substantial changes in the glaciers of the GYE, which are an important water resource for the ecosystem and surrounding communities.

Methods

Analysis was conducted on glaciers >0.5 km² within GNP (12 glaciers) and the GYE (19 glaciers). Glacier surface elevation changes were calculated using the geodetic method by differencing Digital Elevation Model (DEM) data acquired from the Shuttle Radar Topographic

Mission (SRTM) in February 2000 (representing fall 1999 glacier surface elevations) and Airbus derived DEMs between 2011 and 2014. Variables impacting glacial mass balance (physiographic variables: slope, aspect, and solar radiation determined from the SRTM DEM, and albedo, calculated from Landsat imagery; climatic variables: winter and summer precipitation, and summer temperature obtained from the PRISM dataset) were compared with the calculated surface elevation changes for each region. Wilcoxon non-parametric tests were conducted to determine which variables impacting glacial melting were significantly different between the GNP and GYE in order to infer the likely causes of the different melt rates.

Results/Conclusions

Glaciers in the GYE melted at a rate of 0.87 ±0.83 m y^{-1}, whereas glaciers in GNP melted at a rate of 0.21 ±0.70 m y^{-1}, with a Wilcoxon test p-value <0.001 indicating a significant difference. The Wilcoxon test resulted in p-values <0.001 when comparing summer mean temperature, total winter precipitation, total summer precipitation, slope, mean elevation, and annual solar radiation between the glaciers of GNP versus the GYE. Glacier aspect and end of melt season albedo were not significantly different between GNP and the GYE. Despite having significantly lower temperatures and higher elevations, the greater glacial melting in the GYE was likely due to effects of solar radiation as a result of lower latitude and higher elevation, as well as significantly greater winter precipitation in GNP which may have acted as a buffer reducing the rate of glacial melting in the summer. While little can be done at the local level to slow the melt rates, the glacial conditions in the GYE should be more closely monitored to better prepare for adapting water resource management practices in the future.