Documenting Twentieth Century Glacier Change with Repeat Photography in the Sierra Nevada, California

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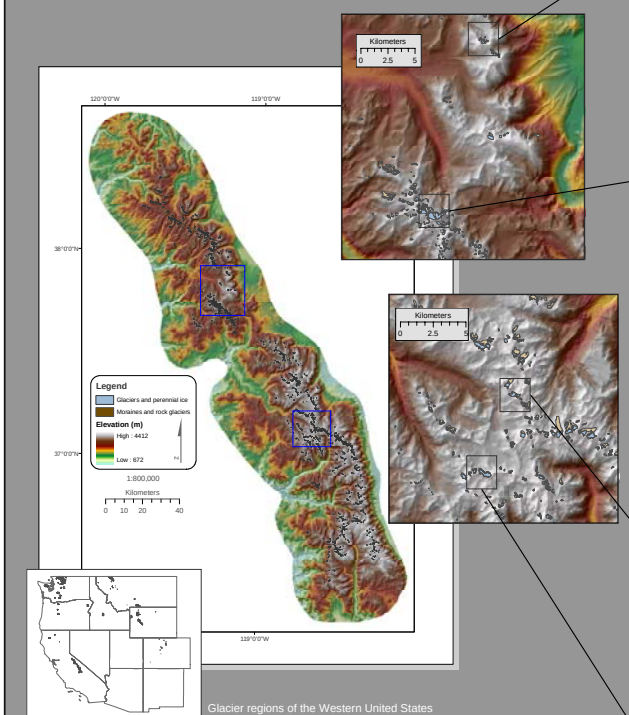
Introduction

Alpine glaciers are important indicators of climate trends within a region and play a significant role in the hydrology of alpine ecosystems. The Sierra Nevada of California contains approximately 497 alpine glaciers and perennial ice features (Raub, 1980). These glaciers provide an opportunity to determine regional responses to warming global temperatures over the past century. Historical photos of glaciers taken by early explorers, land surveyors, and park rangers in the late 19th century and early 20th century are valuable records of past conditions. Repeat photography of glaciers is a useful way to determine how these Sierra Nevada glaciers and perennial ice features have changed through time. During the summer of 2003 and 2004, over 52 repeat images were collected from ten glaciers located throughout the Sierra Nevada.



Glacier regions of the Western United States

Sierra Nevada Glacier Inventory

We performed an inventory of all Sierra Nevada glaciers, perennial ice, and snowfields to understand the distribution and quantity of these features. The GIS database is based on USGS 7.5 minute topographic quadrangle maps (1:24,000 scale). The USGS created these topographic maps from aerial photos taken between 1975 and 1984. A total of 1795 ice and snow features were found along with 454 moraines and rock glaciers.

Repeat Photography

We gathered historical photos from the USGS Earth Science Photographic Archive (http://libraryphoto.er.usgs.gov/) and re-photographed following methods outlined by Harrison (1960) and Klett et al. (1984). The data serve as a visual comparison of change through time. Below are the results from four of the ten locations.

Dana Glacier

1883 I.C. Russell

September 5, 2004 H. Basagic

Lyell Glacier

1883 I.C. Russell

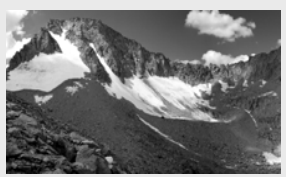
August 15, 2003 H. Basagic

August 7, 1903 G.K. Gilbert

September 5, 2004 H. Basagic

Darwin Glacier

August 14, 1908 G.K. Gilbert



August 14, 2004 H. Basagic

Goddard Glacier

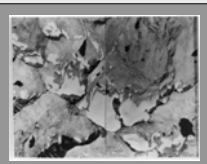
August 13, 1908 G.K. Gilbert

August 16, 2004 H. Basagic

Quantifying Glacier Change

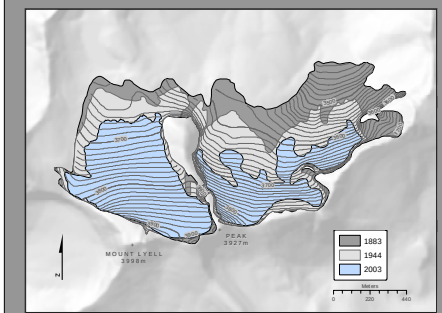
Change in glacier area was calculated for Lyell Glacier in Yosemite National Park for the three time periods of 1883, 1944, 2003. Early photographs and a map by I.C. Russell indicate that the Lyell glacier extent was near or at the Matthes, or Little Ice Age maximum (Russell, 1885). The 1944 extent was delineated from aerial and ground based photographs. The 2003 extent was collected in the field with GPS.

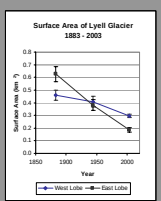
1883 map of Lyell Glacier (Russell, 1885)



1944 Army aerial photograph

Mapping terminus with GPS





Conclusion

Comparisons of the repeat photography reveal that all ten of the glaciers have experienced a reduction in ice volume and surface extent over the past century. Repeat photography is a valuable tool in determining change through time, especially when combined with aerial photos and field measurements. The case example at Lyell Glacier indicate the surface area of the west lobe has been reduced by 30% since 1883, and the smaller east lobe has been reduced by 70%. These results suggest that *topographic controls* strongly influence individual glacier response to regional and global climate change.

References

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Klett, M., Manchester, E., Verburg, J., Bushaw, G. and Dingus, R., 1984. Second View: The Rephotographic Survey Project. Essay by Paul Berger. University of New Mexico Press, Albuquerque.

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Russell, I.C., 1885. Existing Glaciers of the United States. 5th Annual Report of the U.S. Geologic Survey

U.S. Geological Survey, Earth Science Photographic Archive.Online at **http://libraryphoto.er.usgs.gov**

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