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Glacial Icemelt in the Wind River Range, Wyoming

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Abstract

The Wind River Range of Wyoming contains the greatest concentration of glaciers in the American Rocky Mountains with two of the larger glaciers being Dinwoody and Gannett Glaciers. This study documents the importance of glacier meltwater to the overall water supply in the Wind River drainage, the loss of ice from Dinwoody and Gannett Glaciers since the 1930's, and the remaining volume of ice in Dinwoody Glacier.

Introduction

The Wind River Range, the largest discrete mountain mass in Wyoming, is host to 63 glaciers including seven of the ten largest glaciers in the American Rocky Mountains (Bonney, 1987). The glaciers occur in the highest parts of the Wind River Range throughout most of its length, with the greatest concentration located within the Fremont Peak quadrangle along the east slope of the Continental Divide. The total area of glaciers, 63 glaciers covering 44.5 km^2, in the Wind River Range is larger than that of all other glaciers, 134 glaciers covering 31 km^2, in the American Rockies (Field, 1975 ; Davis, 1988).

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Glaciers can be considered as natural reservoirs which store water in the winter and release it in the summer. Glacier runoff is most important during the late summer and early fall when low flows are critical for consumptive water users and instream flow needs. This is especially true in years of low precipitation when water from other sources, such as winter snowpack, may be in short supply.

Trends in glacier regime need to be documented and modeled to better understand the implications of long-term trends for water supplies and for obligations under interstate compacts. In particular, Wyoming serves as the headwaters of four major water drainage basins in the West, with the Wind River Range serving two of these. The eastern slope of the Wind River Range contributes runoff mainly to the Missouri River Basin while the western slope contributes runoff to the Colorado River Basin. According to most authors (e.g., Meier, 1951; Dyson, 1953; Mears, 1972), glaciers in the Wind River Range have generally been in a negative regime since 1850, the end of the "Little Ice Age" in Wyoming. However, by 1930, these glaciers had re-advanced back to their 1850 position. Love and Thompson (1987, 1988) discussed trends in the recession of glaciers in the Wind River Range during the past two decades. This trend runs counter to the trend for glaciers in the remainder of the United States. Wood (1988) shows that 46 percent of 50 glaciers examined advanced between 1960 and 1980 with 26 percent receding.

Meier (1951) described in detail the glaciers of the Wind River Range. Although the overall sizes of Gannett and Dinwoody Glaciers have diminished since Meier's measurements, his relative descriptions are still appropriate. Gannett Glacier is the largest glacier in the American Rockies, with an area in 1950 of 4.6 km^2, while Dinwoody Glacier is the fourth largest of the Wind River Range glaciers, with an area in 1950 of 3.5 km^2.

Gannett and Dinwoody Glaciers contribute meltwater to the Wind River drainage via Dinwoody Creek, although the flow from Gannett Glacier originates in Gannett Creek directly below the glacier and joins Dinwoody Creek approximately 1.5 km below Gannett Glacier. Dinwoody Creek flows into the Wind River approximately 40 km below the glaciers.

Runoff

Gannett and Dinwoody Glaciers are located in a National Wilderness. Access to the glaciers is by foot trail, an approximate 40 km hike over picturesque, but strenuous, terrain. Because of the nature of the location, streamflow stations do not exist near the glaciers. The closest gaging station is on Dinwoody Creek, approximately 35 km below the glaciers. Flow records for this station were available for the period 1958 through 1977.

Flow measurements near Dinwoody and Gannett Glaciers were taken for Dinwoody and Gannett Creeks on July 22, 1988. These are the only known flow measurements taken directly below any Wind River Range glaciers. Flow measurements were taken for both creeks near their confluence, which is about 2.5 km below Dinwoody Glacier and 1.5 km below Gannett Glacier. Flow measurements were also taken for Gannett Creek immediately below Gannett Glacier. However, Dinwoody Creek immediately below Dinwoody Glacier did not contain any suitable sites for flow measurements.

Streamflow was observed to have a diurnal cycle, with low flows in the early morning and high flows in mid-to-late afternoon. The flow measurements for Dinwoody and Gannett Creeks were taken from mid-morning to mid-to-late afternoon. From visual observations, the flows rates at 10:00 am to 12:00 noon, the time at which the lower Gannett Creek and Dinwoody Creek flows were taken, could best be defined as average or slightly above average flows.

The flow measurements for Dinwoody and Gannett Creeks constitute a very limited data sample. However, they do provide a rough approximation of the potential impact of glacier meltwater on the runoff from the Wind River Range. The combined Dinwoody and Gannett Creek measured runoff, expressed on a daily basis, was 16.2 x 10^4 m^3 per day. The average long-term Dinwoody Creek July total flow at the Dinwoody Creek gaging station is 37.8 x 10^6 m^3. If the measured flows directly below the glaciers are assumed to represent the average July contribution from the glaciers, then the two glaciers provide approximately 13%, or 5.02 x 10^6 m^3, of the July flow at the Dinwoody Creek gaging station. The percentage would be expected to be lower during the earlier summer months and higher during the later summer and early fall months (Meier, 1969).

From Meier's information presented on the previous page, the combined area of Dinwoody and Gannett Glaciers is about 18% of the estimated total area of all glaciers in the Wind River Range. Assuming the runoff rate, on a per area basis, from the other glaciers to be similar to that from Dinwoody and Gannett Glaciers, then the estimated total July Wind River Range runoff due to glacial meltwater is approximately 28×10^6 m^3.

<u>Trends</u>

Two approaches were used to investigate temporal trends in Dinwoody and Gannett glaciers. Repeat photography was used to document qualitative changes in the glaciers while aerial photos were used to obtain volume measurements providing quantitative support of the changes.

Use of repeat photography to document glacier trends is discussed by Rogers, et al. (1984) and Harrison (1960). Repeat photography of glaciers presents special problems as compared to its use on normal landscapes. Reoccupying the original camera position may be impossible due to changes in the glacier over the years, especially if the original camera position was taken on the glacier itself. Also, differences in the time of year when the photos are taken can be a problem because of different snow cover conditions.

Photographs of sites on Dinwoody and Gannett Glaciers dating back to 1935 were obtained from the American Heritage Center at the University of Wyoming (Varuska, 1989). Six of the original sites were rephotographed during the summer of 1988. In some cases, the glacier thickness had declined to such an extent that reoccupying the original site was virtually impossible. Other locations matched exactly and show dramatic retreat over the years.

Aerial photographs of the study area spanning four decades were obtained from the Shoshone National Forest Ranger Station in Dubois, Wyoming; the EROS Data Center in Sioux Falls, South Dakota; and the University of Wyoming Geology Library. Mapping of the termini and surface area were accomplished using a zoom transfer scope. Aerial photographs, both transparencies and prints, were enlarged to match the scale of a 1:24,000 topographic map of the study area. The boundaries of the two glaciers were then traced for each time period and overlaid to show the extent of glacier change over several decades. The outlines of the glaciers were then digitized using a Tektronic computer and their areas calculated with polygon and area programs. These programs allowed the entire glacier surface area minus any rock outcrops (nunataks) to be computed.

Snow/ice depth measurements were made for each glacier using a stereo zoom transfer scope fitted with a vertical measurement module (ZTS/VM) to analyze stereo-pairs of the aerial photographs. The ZTS/VM computes elevation or relative height of selected points on matched stereopairs. Two sets of aerial photographs, from 1958 and 1983, were measured. The change in height for each of several points on each glacier was measured by subtracting the 1983 data from the 1958 data. The Thiessen-polygon weighted average method was then used to calculate a weighted average depth change for the total glacier surface (Varuska, 1989).

The calculated weighted average depth changes over the 25 year period were 23.4 m and 18.6 m for Dinwoody and Gannett Glaciers, respectively. Water equivalents for the amount of snow/ice lost from 1958 to 1983 were calculated using areas of 3.43 km^2 and 3.97 km^2 for Dinwoody and Gannett Glaciers, respectively, and a density of firn ice of 0.80 gm/cm^3. Water equivalents are 64 x 10^6 m^3 and 59 x 10^6 m^3 for Dinwoody and Gannett Glaciers, respectively. The annual average of the water equivalent of snow and ice lost from the two glaciers between 1958 and 1983 is 4.5 percent of the average June-October runoff to Dinwoody Creek.

Ice Thickness

Point measurements of the ice thickness on Dinwoody Glacier were made during the summer of 1989. A portable monopulse-radar unit was used to obtain measurements at 72 mapped points on Dinwoody Glacier. The 72 points yielded 62 usable values of depth. The average (not areal weighted average) depth of the usable points is about 54 m with the greatest measured depth being 111 m.

A basal topography map and an ice surface topography map will be produced from the radar data. A map of isopach of ice thickness will then be produced and the total remaining ice volume of Dinwoody Glacier will be determined.

Summary

Results clearly show that Dinwoody and Gannett Glaciers are receding, atlthough most of the ice loss has occurred as decreased thickness rather than as decreased area. Repeat photography of older photos dating back over 50 years shows dramatic differences in the amount of snow and ice. Volume reduction is also supported by changes, as obtained from aerial photographs, in depth of snow and ice data spanning four decades.

The amount of snow and ice lost from Dinwoody and Gannett Glaciers from 1958-1983 is significant when compared to current runoff and volume data. Based on the aerial photo work, the water equivalent of snow and ice lost annually from the two glaciers from 1958-1983 is 4.5 percent of the average June-October runoff to Dinwoody Creek.

Dinwoody and Gannett Glaciers were estimated to contribute approximately 13 percent of the July flow to Dinwoody Creek. The late season contribution would be expected to be a greater percentage. These amounts are important from the standpoint of irrigation water requirements and instream flow needs.

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