Learning Science Through Research
Published by the Keck Geology Consortium
Short Contributions
Keck Geology Consortium
Volume 38
May 2026
doi: 10.18277/AKRSG.2026.38.03

ANALYSIS OF MENDENHALL RIVER DISCHARGE AND A PRELIMINARY TREE-RING BASED RECONSTRUCTION

ISABEL HELD, Scripps College
Project Advisor: Robert Gaines

INTRODUCTION

Glaciated watersheds in Southeast Alaska are undergoing rapid change as rising temperatures deglaciate basins and alter the hydrology. The Mendenhall River, located near Juneau, Alaska, drains a basin that includes the Mendenhall Glacier. The Mendenhall Glacier has been retreating since the end of the Little Ice Age and in the last two decades has receded more than a kilometer and thinned up to 150 meters (Berthier, et al., 2018). The principal source of the river's discharge is glacial meltwater, making streamflow sensitive to summer temperature variability. As a result, summer discharge is linked to June through August temperatures and can be reconstructed using climate proxies such as temperature-sensitive tree rings.

In Southeast Alaska, tree-ring width chronologies are primarily sensitive to temperature changes and have been used to reconstruct temperature (Wiles et al., 2014), glacier mass balance (Malcomb and Wiles, 2013), and hydroclimate (Wiles et al., 2023). Higher summer temperatures drive glacial melt and tree growth, and thus tree growth can be used as a proxy for temperature change and glacier melt.

Glacial lake outburst floods (GLOFs) are common in this area, originating from an ice-dammed side basin of the glacier known as Suicide Basin (Fig. 1). GLOFs have occurred annually since 2011, producing record discharges and damaging homes and infrastructure in the Mendenhall Valley (NWS, 2025). The August 13, 2025 GLOF produced a record high flow, with the Mendenhall River cresting at 16.65 feet (NWS, 2025). Understanding the historical context of discharge variability is critical for anticipating future flood risk and informing adaptation. This study investigates the hydrologic and climatic dynamics of Mendenhall River and develops a preliminary tree-ring based streamflow reconstruction extending 200 years in the past.

STUDY AREA

The Mendenhall River originates from Mendenhall Lake at the terminus of the Mendenhall Glacier which lies approximately 19 kilometers North from downtown Juneau, Alaska (Fig. 1). The river flows through the Mendenhall Valley and empties into Fritz Cove. The basin receives inflow from tributaries such as Nugget Creek and Steep Creek, though glacial meltwater is the main source of the Mendenhall River's discharge. Juneau has a maritime climate with high annual precipitation, and the USGS has recorded continuous streamflow data at the Mendenhall River (15052500) gauging station in Auke Bay, Alaska

Figure 1. Map of the Mendenhall Valley with river, lake, and glacial features pictured (National Weather Service, 2018).

since 1966 (USGS, 1999). As part of the Keck-SEAK25 project's field season, the Mendenhall Trail tree-ring series originally sampled in 1999 was updated, expanding the chronologies' overlap with the discharge record.

METHODS

Annual discharge data was obtained from the USGS Auke Bay gauging station on the Mendenhall River from 1966 to 2024. Monthly minimum, maximum, and mean temperature records were obtained from the NOAA Global Historical Climatology Network (GHCN-Monthly) for the Juneau No. 2 station (NOAA NCEI, 2019). Correlations were calculated using KNMI Climate Explorer (Trouet & Van Oldenborgh, 2013). Pearson correlation coefficients were calculated between discharge and temperature across all calendar months.

A preliminary reconstruction of annual Mendenhall River discharge was developed using a principal component regression software called PCReg (Cook, 1985). Using PCReg, a combination of twelve Alaskan tree ring width series was compared to the annual discharge of the Mendenhall River. The twelve Alaskan tree-ring were significantly correlated (Fig. 2; $p < 0.05$), serving as predictors of annual discharge. The first two principal components of the tree ring chronologies were used as predictors and the discharge (the predictand) was then used to calibrate a model to reconstruct past average yearly discharge (Fig. 3).

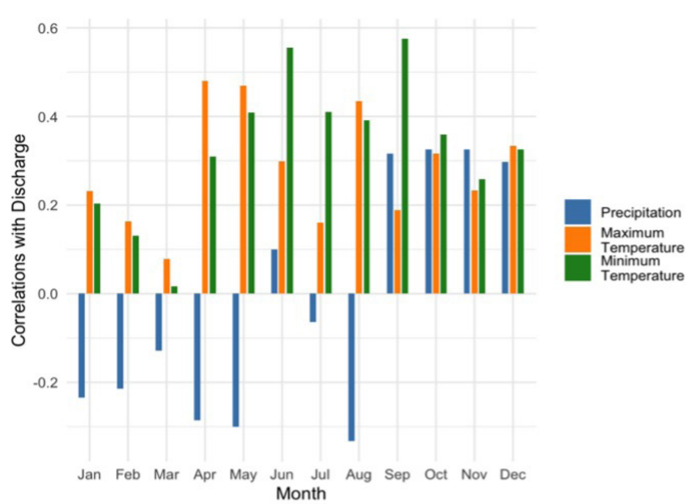

Figure 2. Correlation coefficients between monthly climate variables (minimum temperature, maximum temperature and precipitation) and monthly Mendenhall River discharge.

The calibration period spanned 1966–2000 (n = 35 years). The model was evaluated using the Pearson correlation between reconstructed and observed discharge values. The regression model was then applied to the full length of the chronologies to create a 200 year annual reconstruction. Spatial correlations between reconstructed and observed discharge against gridded minimum temperature fields were compared to assess the geographic coherence of the reconstruction signal (Fig. 4).

RESULTS

Discharge Trends and Climate Correlations

The discharge of the Mendenhall River has been increasing since the mid-1970's (Fig. 3), with higher summer discharges due to increases in Mendenhall Glacier melting during June, July, and August. Annual discharge of the Mendenhall River has increased by approximately 430 cfs between 1966 and 2024, with the most pronounced increases occurring in summer months (June-August), consistent with accelerated glacial melt (Fig. 3). Discharge displays strong positive correlations with monthly minimum, maximum, and mean temperatures in Juneau throughout the summer melt season. Precipitation is a less consistent predictor of discharge with fluctuating positive and negative correlations throughout the year (Fig. 2).

Preliminary Reconstruction

The twelve Alaskan tree-ring chronologies collectively explain over 40% of the variance in annual Mendenhall River discharge over the calibration period. Reconstructed and observed discharge values are significantly correlated ($r = 0.70$, $n = 35$, 95% CI = +/- 0.14), supporting the use of tree rings for a preliminary reconstruction (Fig. 3). The extended reconstruction suggests that several 21st-century discharges - particularly those associated with GLOF events - are exceptional in the context of the past 200 years.

DISCUSSION

The strong temperature-discharge relationship at the Mendenhall River is consistent with the glacier-

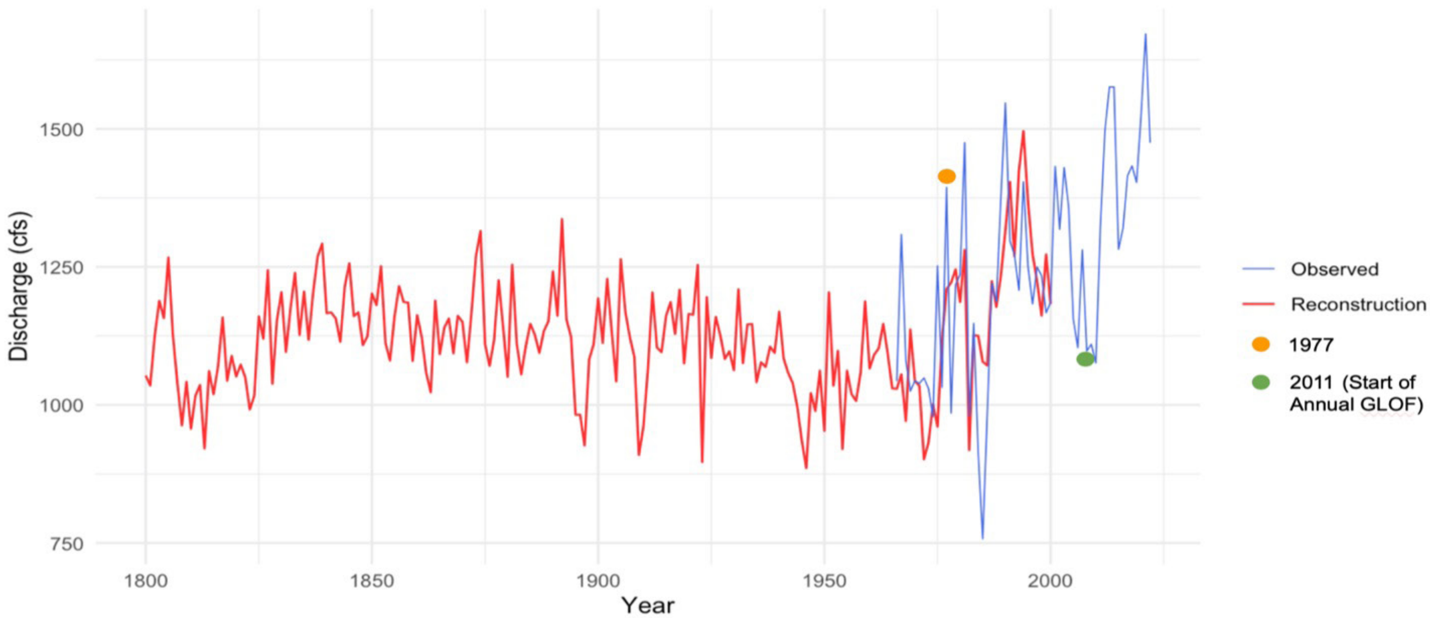

Figure 3. Preliminary reconstruction of annual Mendenhall River discharge in red (ca. 1800-2000). Observed discharge in cfs (1966-2000) shown for comparison in blue.

dominated hydrology of the basin. As summer temperatures rise, accelerated melt of the Mendenhall Glacier directly increases river discharge. This same temperature signal is found in tree-ring width chronologies across Alaska, where ring growth is primarily temperature-limited (Wiles et al., 2014). Therefore, the correlation between ring widths and discharge reflects a shared climate driver - summer temperature.

A major climatic regime shift in 1976-77, associated with a phase transition of the Pacific Decadal Oscillation (PDO) from cool to warm, corresponds with a step increase in Juneau temperatures, precipitation, and Mendenhall River discharge. This shift is evident in both the observational record and in the reconstructed discharge series, lending additional confidence to the reconstruction's ability to capture hydroclimatic variability.

The extended reconstruction places recent high-discharge years in a 200-year context. The finding that multiple 21st-century discharges appear unmatched in the reconstructed record suggests that current discharge levels reflect both climate variability and a sustained shift towards higher baseline discharge driven by accelerating glacial melt. This trend is projected to continue under future warming. Spatial correlations between reconstructed and observed discharge against minimum temperature fields display

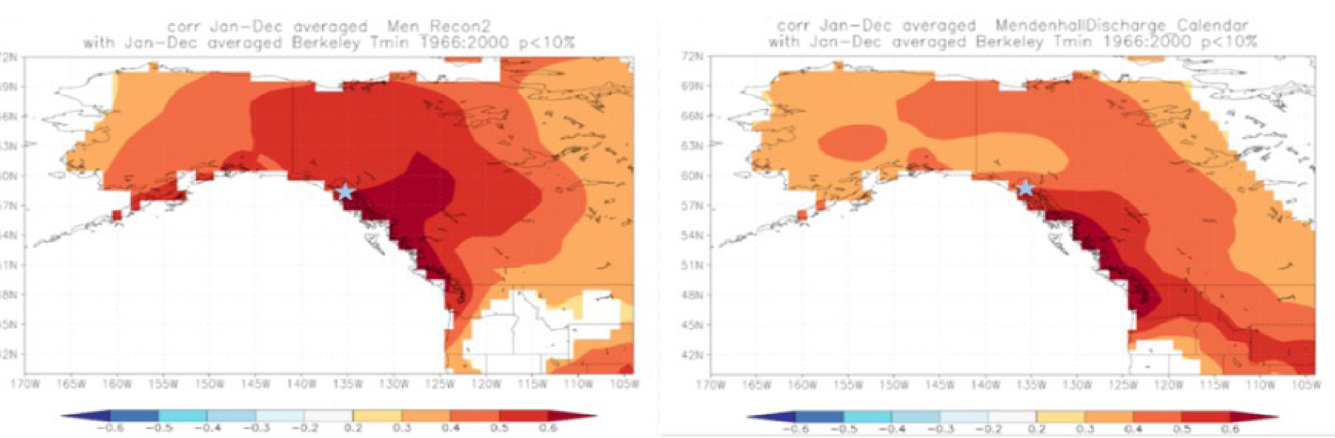

Figure 4. Left) Heatmap of correlations between reconstructed discharge and Tmin. Right) Heatmap of correlations between observed discharge and Tmin. Blue star overlies Juneau, AK.

similar geographic patterns, providing additional validation of the reconstruction (Fig. 4).

CONCLUSIONS

This study demonstrates that Mendenhall River discharge is strongly controlled by summer temperatures, consistent with the glacier-dominated hydrology of the basin. Tree-ring chronologies from Alaska capture this temperature signal and serve as proxies for annual streamflow. A preliminary reconstruction based on twelve Alaskan tree ring width chronologies explains over 40% of discharge variance and correlates strongly with observed values ($r = 0.70$, $n = 35$). The extended record suggests that recent high-discharge years are exceptional in a 200-year context, likely reflecting the combined influence of a 1977 PDO regime shift and glacial retreat. Future work should update the Alaskan tree-ring chronologies to extend the calibration period, and apply formal verification statistics to improve the accuracy of future reconstructions. These findings underscore the importance of long-term hydroclimatic context for anticipating flood risk in the Mendenhall Valley.

ACKNOWLEDGEMENTS

This material is based upon work supported by the Keck Geology Consortium and the National Science Foundation under Grant No. 2050697. Thank you to Dr. Greg Wiles for the thoughtful edits and dendrochronology expertise throughout this process. Thank you Nick Wiesenberg for the hospitality in Wooster and always lending a helping hand. Thank you Lynnsey, Dexter, Lev and Landon - I feel really lucky to have had such an upbeat and smart cohort to collaborate with. Thank you Bob Gaines for the great advice and edits back at Pomona College. Thank you S’eiltin Jamiann Hasselquist for the guidance on Tlingit-Haida history. Thank you to the Angoon community as a whole for their generosity and hospitality.

REFERENCES

Berthier, E., Larsen, C., Durkin, W.J., Willis, M.J., and Pritchard, M.E., 2018, Brief communication: Unabated wastage of the Juneau and Stikine icefields (southeast Alaska) in the early 21st century: The Cryosphere, v. 12, p. 1523–1530, doi:10.5194/tc-12-1523-2018.

Cook, E. R. (1985). A Time Series Analysis Approach to Tree Ring Standardization. PhD thesis, The University of Arizona.

Kienholz, C., Amundson, J.M., Motyka, R.J., Jackson, R.H., Truffer, M., Stuefer, S.L., Nash, J.D., Kress, A., Campbell, C., and Larsen, C.F., 2020, Deglacierization of a Marginal Basin and Implications for Outburst Floods, Mendenhall Glacier, Alaska: Frontiers in Earth Science, v. 8, doi:10.3389/feart.2020.00137.

Malcomb, N.L., and Wiles, G.C., 2013, Tree-ring-based reconstructions of North American glacier mass balance through the Little Ice Age - Contemporary warming transition: Quaternary Research, v. 79, p. 123–137, doi:10.1016/j.yqres.2012.11.005.

Motyka, R.J., O’Neel, S., Connor, C.L., and Echelmeyer, K.A., 2003, Twentieth century thinning of Mendenhall Glacier, Alaska, and its relationship to climate, lake calving, and glacier run-off: Global and Planetary Change, v. 35, p. 93–112, doi:10.1016/S0921-8181(02)00138-8

National Weather Service, 2018, Map of Suicide Basin: National Weather Service, https://www.weather.gov/ajk/suicidebasin (accessed April 2026).

National Weather Service (NWS), 2025, Suicide Basin Monitoring and Current Conditions: National Oceanic and Atmospheric Administration, Juneau, AK, https://www.weather.gov/ajk/suicidebasin (accessed April 2026).

NOAA National Centers for Environmental Information, 2019, GHCN-Monthly temperature data for JUNEAU NO 2 (Station ID: 70381): U.S. National Oceanic and Atmospheric Administration, https://www.ncei.noaa.gov/products/land-based-station/global-historical-climatology-network-monthly (accessed October 2025).

Trouet, V., and Van Oldenborgh, G.J., 2013, KNMI Climate Explorer: a web-based research tool for high-resolution paleoclimatology: Tree-Ring Research, v. 69, no. 1, p. 3–13, doi:10.3959/1536-1098-69.1.3.

U.S. Geological Survey (USGS), 1999, Hydrology, geomorphology, and flood profiles of the Mendenhall River, Juneau, Alaska: U.S. Geological Survey Water-Resources Investigations Report 99-4150, 1 sheet, doi:10.3133/wri994150.

Wiles, G.C., Devereux, K., Gaglioti, B.V., and D'Arrigo, R.D., 2023, A 420-Year Perspective on Winter Lake Erie Levels: Geophysical Research Letters, v. 50, no. 1, doi:10.1029/2022GL099911.

Wiles, G.C., Solomina, O., D'Arrigo, R.D., Anchukaitis, K., Gensiarovsky, Y., and Wiesenberg, N., 2014, Reconstructed Summer Temperatures over the Last 400 Years Based on Larch Ring Widths: Sakhalin Island, Russian Far East: Climate Dynamics, v. 43, p. 111–125, doi:10.1007/s00382-014-2209-2.