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KECK SEAK25 - CLIMATE AND TREE GROWTH IN A TEMPERATE COASTAL RAINFOREST, SOUTHEAST ALASKA

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INTRODUCTION

The State of the Global Climate report of the World Meteorological Organization (WMO, 2026) highlights the continued warming of the planet in the air and oceans, the Earth's energy imbalance, and a looming strong El Niño that will likely exacerbate warming in 2026-2027. North Pacific coastal forests provide a long-term record of these ongoing thermal changes and allow us to explore how linkages, teleconnections and abrupt events impact warming.

Tree-rings are exactly calendar-dated records of environmental change, and in southern Alaska, trees are primarily sensitive to temperature variations. Previous studies have utilized tree-ring records to reconstruct local and hemispheric temperatures (Wiles et al., 2014, 2026; Wilson et al, 2016, 2017; Anchukaitis et al., 2017), glacier mass balance (Malcomb and Wiles, 2013), and hydroclimate in North America (Wiles et al., 2023).This project aimed to continue developing and analyzing new tree-ring chronologies adding to a growing network of records from Alaska and the Yukon (Fig. 1). Keck-SEAK25 student projects have expanded the scope of this work using the newly collected and previous tree-ring records in climate analyses and modeling investigations.

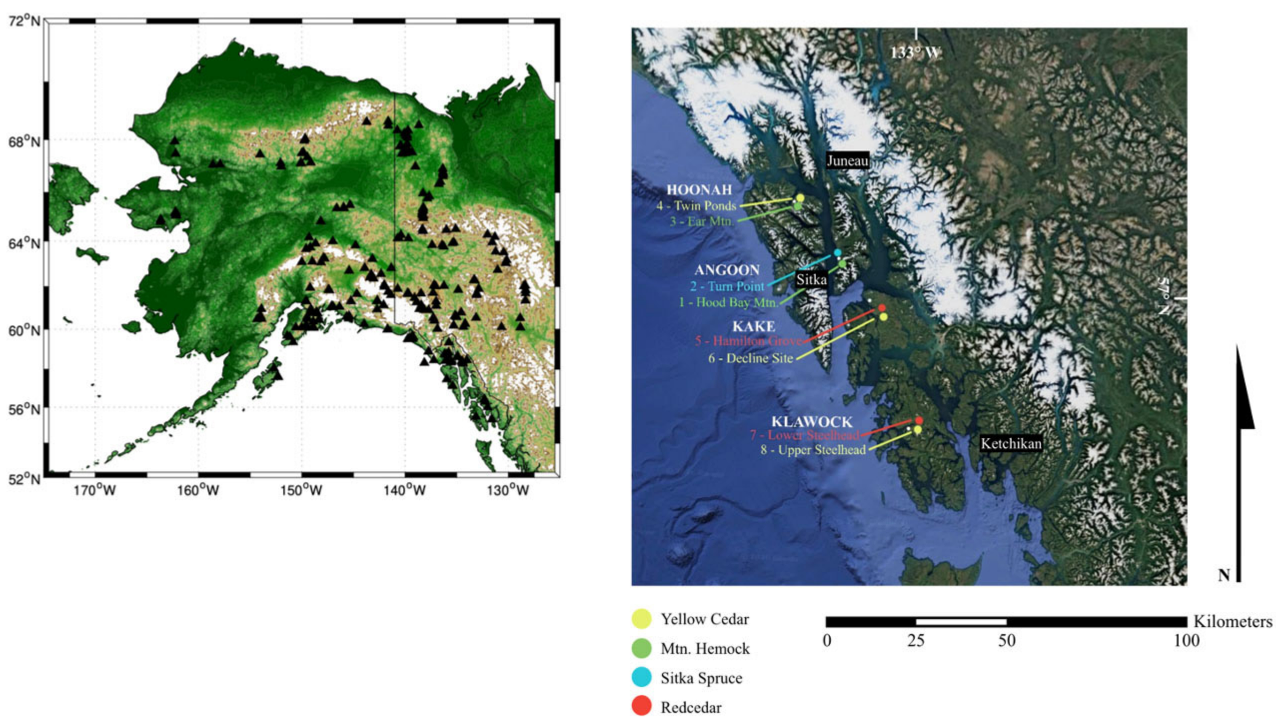

Figure 1. Tree-ring chronologies from Alaska and the Yukon: This project added to this dataset and used the larger network (left map; (E.R. Cook, pers. comm.) for climate reconstruction and modeling. The detail map (right) are the locations of 8 tree-ring width chronologies developed with AYS collaboration over the past 5 years and recently contributed to the ITRDB. Those at Angoon, the Turn Point and Hood Bay Mtn. sites were generated as part of this SEAK25 project.

Another aspect of the project leveraged The Wooster Tree Ring Lab's (WTRL) collaboration with the Alaska Youth Stewards (AYS), which together over the past five years has been actively investigating new tree-ring sites in the forests of Southeast Alaska (SEAK). AYS serve the Tlingit-Haida community in SEAK preparing youth for environmentally-related careers and college. Our collaboration began in 2020 and has grown to include communities in Hoonah, Angoon, Kake and Klawock, which are Tlingit villages in SEAK. Three of these villages, Kake, Hoonah and Klawock, were visited in the summers of 2022 through 2024, and Angoon was the destination of the 2025 field season described here. The aim of this collaboration is to work in the field with the AYS groups, visiting tree-ring sites that the groups have discovered and sampling Sitka spruce, red and yellow cedar, and mountain hemlock stands. The summer 2025 work in Angoon centered on Sitka spruce and mountain hemlock sites. From these collections and those of previous years, we assembled ring-width, tree-ring data, analyzed them for their climate significance, and connected the tree-ring data to climate, forest health, and their potential as a record of past indigenous use, such as bark stripping manifested as culturally modified trees (CMTs; McGrath et al., 2014).

The SEAK25 research group first worked in the Wooster Tree Ring Lab in Ohio learning the fundamentals of tree-ring sampling and lab analyses. The group developed a redcedar tree-ring record from SEAK sampled in previous years. Subsequently, we travelled to Juneau and then Angoon working with the AYS team lead by Gabrielle Sjoberg and Eric Benedict. After tree-ring collections and collaboration in Alaska, the team returned to Wooster to develop the tree-ring records and to conduct the analyses for their individual projects. Projects examined chronologies in the tree-ring archive and newly-produced records to model climate indices and hydroclimate variables and to explore the role of volcanic forcing in North Pacific climate. Several results and research questions not addressed by the student projects emerged during our summer analyses, which we will outline in the results section, followed by a description of each student's project.

RESULTS

Collectively the group developed and analyzed a redcedar ring-width series for its climate signal and then contributed the tree-ring data to the International Tree Ring Data Bank (ITRDB). This Hamilton Grove site is the first redcedar contribution from Alaska (Fig. 2), which was previously collected in Kake, Alaska (Fig. 1). Twenty-four tree cores from the Hamilton Grove site were cross-dated and assembled into a tree-ring ring-width chronology (Fig. 2). We compared this chronology with 150 years of monthly climate records from Sitka, Alaska to determine the climate response in the ring-widths. This statistical comparison yields a correlation (r) that can be assessed for significance using a p-value and the sample size, which is the number of years that the tree-ring record overlaps with the monthly climate records. There is a clear redcedar climate signal and strong signficant correlation with winter temperature ($r = 0.38$; $p < 0.00001$), which is an average of January through March. This is an unexpected result as most trees along the Gulf of Alaska respond to summer temperature changes (Wiles et al., 2014). The 1876 ring is the most narrow in the record and corresponds with a strong El Niño and one of most profound droughts and famines in other parts of the world (Fig. 2; Singh et al., 2018). The relationship between the Gulf of Alaska winter cooling and this strong El Niño event is uncertain.

Sampling of Sitka spruce at Angoon (the Turn Point site) has resulted in a tree-ring width series from low elevation tree-ring series (Fig. 3) combining two sampling sites. The trees included samples from Culturally Modified Trees (CMTs) that were utilized in the past for harvesting sap used as fire-starter.

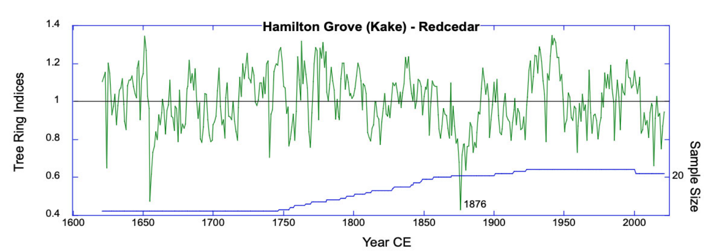

Figure 2. The Hamilton Grove chronology from Kake western redcedar. This redcedar chronology is the first for Alaska and was sampled at the northernmost redcedar site. Other sites further north have been reported, but are not confirmed (pers. comm. B. Buma). The climate signal here is a strong positive relationship with winter temperatures.

This Turn Point tree-ring series has a strong positive relationship with Sitka (January – May average; $r = 0.45$, $p < 0.00001$; $N = 85$) minimum temperatures (nighttime temperatures).

The Angoon spruce site (Fig. 3a) is a low elevation site and the relationship with minimum temperatures is unsteady through time (Fig. 3b). Correlations prior to 1976 are strong with gridded temperature records. However, after 1976, there is virtually no relationship (Fig. 3b). The reason for this change is uncertain but, may be related to the well-known shift in North Pacific climate in 1976-77 (Ebbysmeyer, 1991).

The other site from Angoon, Mountain Hemlock, was sampled in summer 2025 on Hood Bay Mountain (Fig. 4). This site was sampled near treeline and has the strongest relationship with minimum June-August temperatures from Sitka ($N=87$; $r = 0.37$; $p < 0.0004$). The low growth intervals in the chronology (Fig. 4a) are consistent with the 1809 volcanic cooling (Leland et al., 2023) and the cooling around 1698 CE. The apparent drop off in growth after about 1975, which may have occurred after a disturbance at the site, is worth further investigation.

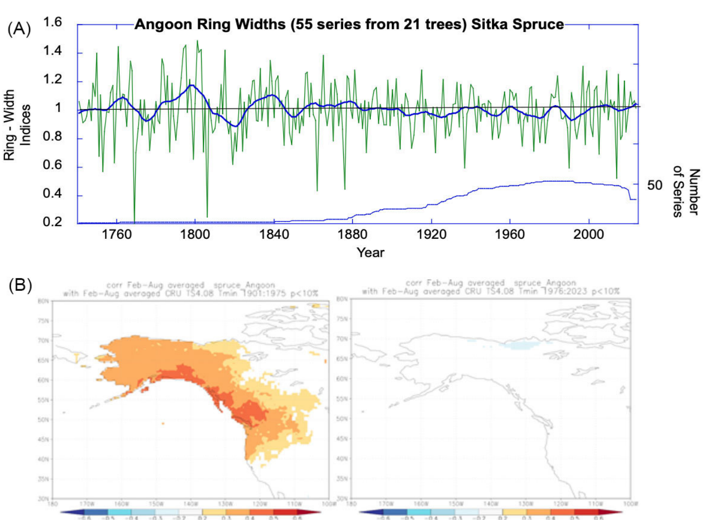

Figure 3. A) Angoon Sitka spruce site. The chronology is well-replicated for the past 150 years and consists of spruce trees at Angoon and at the Turn Point site across the strait from the town. B) Left panel: Prior to 1975 there is a strong positive relationship with minimum temperatures and spruce tree growth. Right panel: after 1975 there is virtually no relationship, which may suggest warming is no longer beneficial to spruce growth or temperature is not limiting the growth of spruce after 1975.

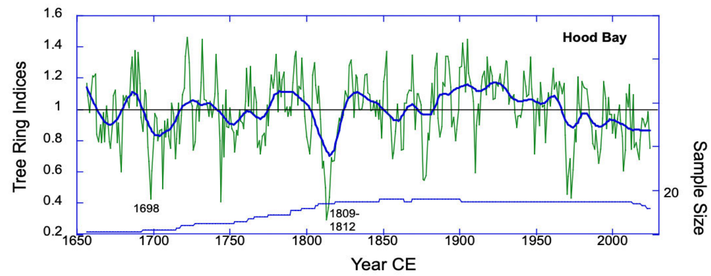

Figure 4. The Hood Bay Mountain, mountain hemlock ring-width chronology. This series is a record of June-August temperatures and shows the volcanic cooling associated with volcanic eruptions at 1698 and 1809. Note also the drop-off after the mid-1970s.

STUDENT PROJECTS

Lynnsey Delio (The College of Wooster) Leveraging the Pacific North America (PNA) teleconnection, Lynnsey Delio used a network of six ring-width series from Southeast Alaska to model the variability of the lake Michigan-Huron Great Lake system, reconstructing the observational record back to 1600 CE. Delio identified several high lake levels that appear to be linked to large-scale volcanic events perhaps due to decreased evaporation with increased ice cover during volcanically-forced coolings.

Isabel Held (Scripps College) In Juneau the group updated the Mendenhall Trail tree-ring series originally sampled in 1999. Isabel Held linked the tree growth in the Juneau region to the USGS gaging station at the Mendenhall River exploring the possibility of reconstructing this river flow. This work is particularly relevant as the 13 August 2025 glacial outburst flood (GLOF) on the Mendenhall River was the largest on record and previous GLOFs have resulted in considerable loss of property.

Dexter Pakula (Carleton College) The group collectively developed the first redcedar tree-ring chronology from Alaska that was formerly sampled from Kake Alaska by The College of Wooster faculty and staff and the Alaska Youth Stewards. The climate analysis of this series was surprisingly strongly correlated with winter temperatures, potentially yielding a proxy for cold-season temperature change. Significantly, this redcedar record showed the most-narrow ring (1876 CE), which corresponds with a major El Niño event. This connection served as a catalyst for Dexter Pakula to investigate and develop the linkages between the monsoonal indices from

Southeast Asia and the North Pacific.

Lev Sugerman-Brozan (Colorado College) examined the volcanic forcing of decadal climate in the North Pacific using a comparison between the observational (based on tree rings) record and a Community Earth System Model Last Millenium Ensemble (CESM-LME) model. He examined the 1452, 1697-98 and 1809 events and their influence on forcing persistent cooling in the North Pacific.

Landon Vaughan (Trinity University) Focusing on the late 1690s in Alaska Yellow Cedar, Landon Vaughn determined that the most-narrow rings in the past several centuries in SEAK were the 1698-99 rings, which are likely associated with the "winter following winter" as reported in the oral histories of the Tlingit. This crucial event was likely volcanically-forced and occurred at the same time the large glacier in Glacier Bay was advancing, leading to the eviction of the Tlingit from their native homeland. The late 1600s was an interval comment to all five of the studies and the relationship between the role of volcanic cooling, natural changes in climate along with solar forcing during this phase of the Little Ice Age is a source of ongoing discussion.

The SEAK25 team all presented their results at the National Meeting of the Geological Society of America at San Antonio, TX. Our SEAK25 work in Angoon marked the 5th year of collaboration between the AYS group and The Wooster Tree Ring Lab. The relevance of the results summarized here and in the student project descriptions is underscored by the new (2026) report of the WMO and observations linking the ongoing Earth's energy imbalance, the looming strong El Niño event that is likely to continue into 2026-27, and the response of the North Pacific ocean air-sea temperatures.

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REFERENCES

Anchukaitis, K.J., R. Wilson, K. Briffa, U. Büntgen, E.R. Cook, R.D. D'Arrigo, N. Davi, J. Esper, D. Frank, B. Gunnarson, G. Hegerl, S. Helama, S. Klesse, P.J. Krusic, H. Linderholm, V. Myglan, T. J. Osborn, Z. Peng, M. Rydval, L. Schneider, A. Schurer, G. Wiles and E. Zorita, 2017, Last millennium Northern Hemisphere summer temperatures from tree rings: Part II: spatially resolved reconstructions, Quaternary Science Reviews 134: 1-18, JQSR-D-16-00439R1.

Ebbesmeyer, C. C., D. R. Cayan, D. R. McLain, F. H. Nichols, D. H. Peterson, K. T. Redmond, 1991. 1976 step in the Pacific climate: Forty environmental changes between 1968–1975 and 1977–1985. Proc. Seventh Annual Pacific Climate Workshop, Asilomar, CA, California Dept. of Water Research, 115-126.

Leland, C., D'Arrigo, R., Davi, N., Anchukaitis, K. J., Andreu-Hayles, L., Porter, T. J., et al. (2023). A spatiotemporal assessment of extreme cold in northwestern North America following the unidentified 1809 CE volcanic eruption. Paleoceanography and Paleoclimatology, 38, e2022PA004581. https://doi.org/10.1029/2022PA004581.

Malcomb, N.L. and Wiles, G.C., 2013, Tree-ring based reconstructions of North American glacier mass balance through the Little Ice Age. Quaternary Research, http://dx.doi.org/10.1016/j.yqres.2012.11.005.

McGrath, S., Howell, W., Wiesenberg, N., Mennett, C., and Wiles, G., 2014, Three hundred years of continuity: a yellow cedar bark stripping site on Pleasant Island, Icy Strait, Southeast Alaska: Geological Society of America Abstracts with Programs. Vol. 46, No. 6, p. 247.

Singh, D., R. Seager, B. I. Cook, M. Cane, M. Ting, E. Cook, and M. Davis, 2018. Climate and the Global Famine of 1876–78. J. Climate, 31, 9445–9467, https://doi.org/10.1175/JCLI-D-18-0159.1.

Wendler, G., Galloway, K., and Stuefer, M., 2016. On the climate and climate change of Sitka, Southeast Alaska. Theor. Appl. Climatol. 126, 27–34. doi: 10. 1007/s00704- 015- 1542- 7.

Wiles, G.C., D'Arrigo, R.D., Barclay, D., Wilson, Jarvis, S. K., Vargo, L., Frank, D., 2014, Surface air temperature variability for the Gulf of Alaska over the past 1200 years: The Holocene, DOI: 10.1177/0959683613516815.

Wiles, G.C., Devereux, K., Gaglioti, B.V., D'Arrigo, R.D., 2023, A 420-Year Perspective on Winter Lake Erie Levels: Geophysical Research Letters 50 (1), doi.org/10.1029/2022GL099911.

Wiles, G., Wiesenberg, N., Lyon, E. , Young, N., Gaglioti, B. , Barclay, D., Cook, E.R., D'Arrigo, R. , Lawson, D., Mann, D., Wilson, R., Reid, E. , Davi, N., Frank, D., Panyushkina, I., Jull, A.J.T., and Howell, W., 2026. A 3870-Year Tree Ring Series for Climate Reconstruction and Dating from Southern Alaska: Arctic Workshop Abstract (Buffalo March 2026).

Wilson, R., D'Arrigo, R., Andreu-Hayles, L., Oelkers, R., Wiles, G., Anchukaitis, K and Davi, N., 2017, Blue Intensity based experiments for reconstructing North Pacific temperatures along the Gulf of Alaska: Clim. Past Discuss., doi:10.5194/cp-2017-26.

Wilson, R., Anchukaitis, K., Briffa, K., Büntgen, U., Cook, E., D' Arrigo, R., Davi, N., Esper, J., Frank, D Gunnarson, B., Hegerl, G., Helama, S., Klesse, S., Krusic, P., Linderholm, H.,

Myglan, V., Osborn, T., Rydval, M., Schneider, L., Schurer, A., Wiles, G., Zhang, P. and Zorita, E., 2016, Last millennium Northern Hemisphere summer temperatures from tree rings: Part I: the long-term context: Quaternary Science Reviews (2016), pp. 1-18 DOI information: 10.1016/j.quascirev.2015.12.005.

World Meteorological Organization (WMO). 2026, State of the Global Climate 2025. Geneva: WMO. https://wmo.int/publication-series/state-of-global-climate/state-of-global-climate-2025.