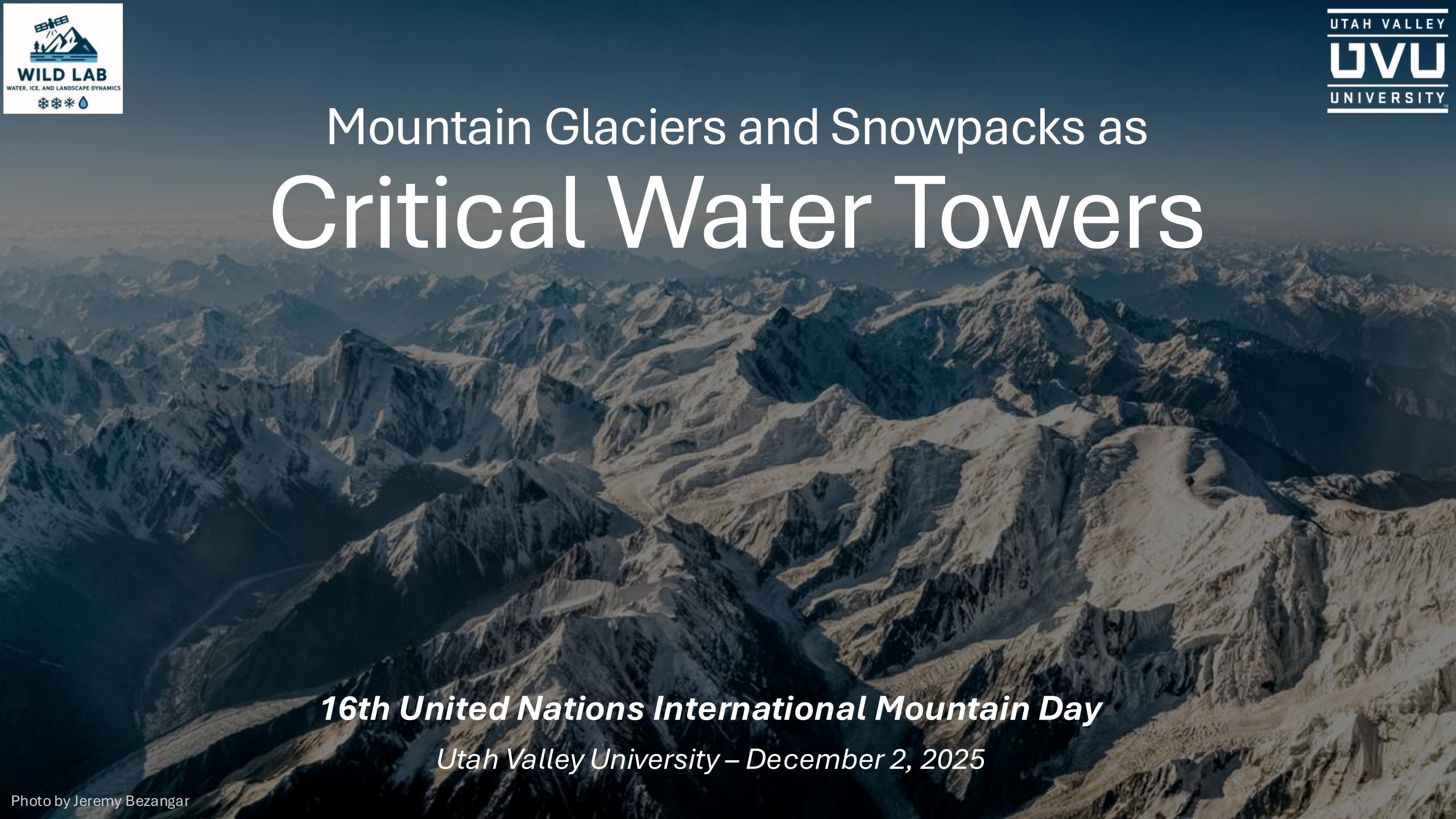

WILD LAB
WATER, ICE, AND LANDSCAPE DYNAMICS

UTAH VALLEY UNIVERSITY

Mountain Glaciers and Snowpacks as Critical Water Towers

16th United Nations International Mountain Day

Utah Valley University – December 2, 2025

Photo by Jeremy Bezangar

Dr. Matt Olson

Assistant Professor, Department of Earth Science at Utah Valley University

Born and raised in the foothills of the Wasatch Mountains

Father, husband, educator, cryosphere scientist, and mountain enthusiast

Ph.D., University of Utah

Modeling and monitoring glacier surface energy balance and surface characteristic changes with satellite remote sensing in High Mountain Asia

UVU snowpack field monitoring program
(Sundance Mountain Resort)

Snowpack model development
(Science to Operations)

Glacier debris cover and monsoonal snow cover feedbacks
(High Mountain Asia glaciers)

Mapping the last ice of Utah
(Alpine rock glaciers)

The Cryosphere

Unmistakable indicators of climate change

Mountain glaciers, seasonal snow, ice sheets, permafrost, sea ice

Global ice feedback loops

Consequences of sea-level rise

Freshwater resource availability

Critical Water Towers

Mountain glaciers and snow

2+ billion people depend on mountain water runoff

55–60% of global freshwater is derived in mountains

Changes in alpine snowpacks and glaciers worldwide

Mountain regions warming 2-3x global rate

Mountain Snowpacks

Global patterns

Seasonal snow covers more than 30% of Northern Hemisphere

Snow changes impact arctic and alpine amplification

Earlier snowmelt and shorter season across mountain regions worldwide

More precipitation falling as rain rather than snow

Regional and Local Snowpacks

Beyond recreation and economics

70% of surface water in mountainous areas of western US

Snowmelt 1-3 weeks earlier across the western US

Low-to-no-snow conditions possible in 30-60 years

80-95% of Utah’s water originates as mountain snowpack

Mountain glaciers

Flowing rivers of ice

More than 200,000 alpine glaciers worldwide

Global retreat of mountain glaciers

Accelerated ice loss

Retreat rates exceed natural variability, and many glaciers have lost 30–70% of their mass

Mountain glaciers

The state and fate

High Mountain Asia – regions have lost >21% in past 20 years alone

Alps – 80–95% volume loss by 2100

Andes – lost 30-50% area since 1970s

North America – GNP has lost >80% and Alaska accounts for >25% global loss

Significant loss is unavoidable even with aggressive emissions reductions

Related impacts

Beyond freshwater and sea-level changes

Increased frequency in mountain hazards

Agriculture and economic decline

Potential political conflicts

Public health concerns

Federal Office of Topography swisstopo

Conclusions

Mountain regions are changing

Earlier snowmelt and disappearing glaciers will impact water storage in regions

Mitigation vs. adaptation

The future depends on the present


Questions?

References

Beniston, M. (2005). Mountain climates and climatic change: An overview of processes focusing on the European Alps. Pure and Applied Geophysics, 162, 1587–1606. https://doi.org/10.1007/s00024-005-2684-9

Dussaillant, I., Hugonnet, R., Huss, M., Berthier, E., Bannwart, J., Paul, F., & Zemp, M. (2024). Annual mass changes for each glacier in the world from 1976 to 2023. Earth System Science Data Discussions, 2024, 1-41.

Hamlington, B.D., Bellas-Manley, A., Willis, J.K. et al. The rate of global sea level rise doubled during the past three decades. Commun Earth Environ 5, 601 (2024). https://doi.org/10.1038/s43247-024-01761-5

Li, D., Wrzesien, M. L., Durand, M., Adam, J., & Lettenmaier, D. P. (2017). How much runoff originates as snow in the western United States, and how will that change in the future?. Geophysical Research Letters, 44(12), 6163-6172.

Mote, P. W., Li, S., Lettenmaier, D. P., Xiao, M., & Engel, R. (2018). Dramatic declines in snowpack in the western US. Climate and Atmospheric Science, 1, 2.

Mudryk, A. Elias Chereque, R. Brown, C. Derksen, K. Luojus, and B. Decharme. (2021) The Arctic: Terrestrial snow cover [in “State of the Climate in 2021”]. Bull. Amer. Meteor. Soc., 102 (8), S287–S290, https://doi.org/10.1175/BAMS-D-21-0086.1.

Pörtner, H. O., Roberts, D. C., Masson-Delmotte, V., Zhai, P., Tignor, M., Poloczanska, E., & Weyer, N. M. (2019). The ocean and cryosphere in a changing climate. IPCC special report on the ocean and cryosphere in a changing climate, 1155, 10-1017.

Pepin, N., Bradley, R. S., Diaz, H. F., Baraër, M., Caceres, E. B., Forsythe, N., ... Zhang, F. (2015). Elevation-dependent warming in mountain regions of the world. Nature Climate Change, 5, 424–430. https://doi.org/10.1038/nclimate2563

Rangwala, I., & Miller, J. R. (2012). Climate change in mountains: A review of elevation-dependent warming and its possible causes. Climatic Change, 114, 527–547. https://doi.org/10.1007/s10584-012-0419-3

Rutgers University Global Snow Lab, Data History. Accessed November 29, 2025.

Siirila-Woodburn, E. R., Rhoades, A. M., Hatchett, B. J., Huning, L. S., Szinai, J., Tague, C., ... & Kaatz, L. (2021). A low-to-no snow future and its impacts on water resources in the western United States. Nature Reviews Earth & Environment, 2(11), 800-819.

Extra