Citizen scientists' contributions a boon to snowpack modeling

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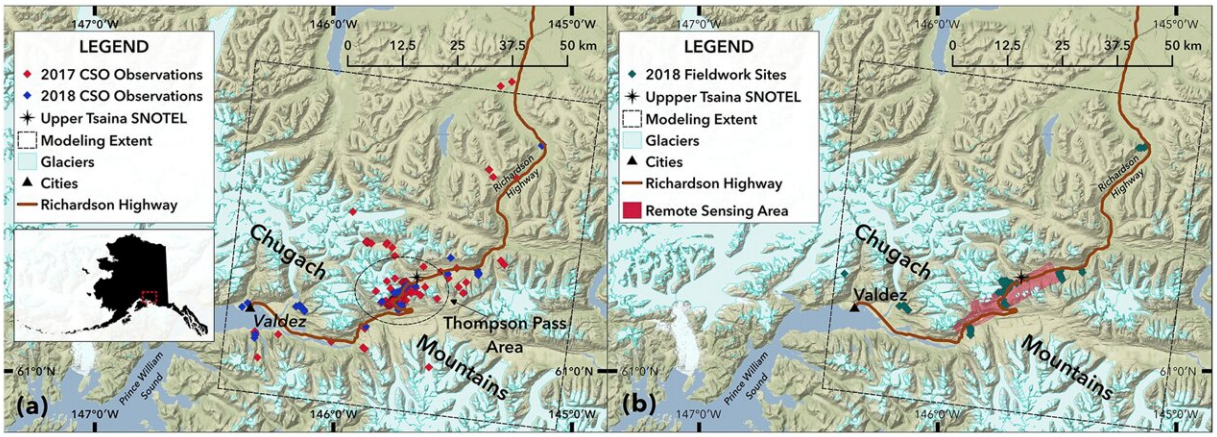

Figure 1. Study area map and fieldwork sites. (a) The study area maps showing the CSO measurements, the modeling spatial extent, and the Thompson Pass region of the Chugach Mountains. (b) The 2018 fieldwork includes 72 sites with co-located snow water equivalent and snow depth measurements. The remote sensing data sets from 2017 and 2018 are overlain on the map, along with the location of the Upper Tsaina SNOTEL station. Credit: DOI: 10.5194/hess-25-4651-2021

Data gathered by backcountry skiers, avalanche forecasters and other snow recreationists and professionals has the potential to greatly improve snowpack modeling, research by the Oregon State University College of Engineering indicates.

Findings, published in the journal *Hydrology and Earth System Sciences*, stem from a NASA-funded project known as Community Snow Observations, or CSO, part of NASA's Citizen Science for Earth Systems program.

The paper is the first documentation of CSO's power to make snowpack modeling better through "organic, opportunistic" data—a notable outcome, said researcher David Hill.

"We have shown citizen scientist contributions are very valuable and that we can do great things in the absence of observational network infrastructure," said Hill, professor of civil engineering at OSU. "In this study, we used a new data set collected by CSO participants in coastal Alaska to improve snow depth and snow-water equivalent outputs from a snow process model."

In western North America, snow's role in ecosystem function and water resource management is critical, the scientists say, and around the world more than a billion people live in watersheds where snow is a major component of the hydrologic system.

"Snowpack dynamics in the mountains have a big role in connecting atmospheric processes and the hydrologic cycle with downstream water users," said Chris Cosgrove, an OSU graduate student during the research. "At our Alaska field site, hydroelectric power generation is the principal concern, but in the lower 48, many agricultural producers and municipal water systems rely on seasonal snow."

In 2017, NASA enlisted Hill and doctoral student Ryan Crumley, as well as researchers at the University of Washington, the University of Alaska Fairbanks and the Alaska Division of Geological & Geophysical Surveys, to recruit citizen scientists and incorporate their data into computer models that generate important snowpack information for

scientists, engineers and land and watershed managers.

Community Snow Observations kicked off in February 2017 and since then thousands of data entries have been made. Led by Hill, Gabe Wolken of Alaska Fairbanks and Anthony Arendt of the University of Washington, the project first focused primarily on Alaskan snowpacks. Researchers then recruited citizen scientists in the Pacific Northwest and in the Rocky Mountain region.

The work is ongoing and getting involved in Community Snow Observations is easy. A smartphone, the free Mountain Hub application and an avalanche probe with graduated markings in centimeters are the only tools needed.

As citizen scientists make their way through the mountains, they use their avalanche probes to take snow depth readings that they then upload into Mountain Hub, an app for the outdoor community.

That's all there is to it.

"We've now taken our modeling work operational," Hill said. "We serve up real-time grids on snow information at many sites across the United States, including the central Cascades in Oregon, at mountainsnow.org. The general public can go there and view real-time information on snow, snow changes and other things like satellite measurements of snow."

In the recently published research, Hill and Crumley, who's now at the Los Alamos National Laboratory, teamed with Wolken, Arendt, Cosgrove and OSU graduate student Christina Aragon to look at how snowpack models for the Thompson Pass region of Alaska's Chugach Mountains improved when citizen science measurements were incorporated.

"Improvements were seen in 62% to 78% of the simulations depending on the model year," Aragon said. "Our results suggest that even modest measurement efforts by citizen scientists have the potential to improve efforts to model snowpack processes in high mountain environments."

Information about snow distribution reaches scientists from many sources, including telemetry stations and remote sensing via light detection and ranging, or LIDAR, but the simplicity of the citizen science data gathering approach allows for many gaps to be filled, the scientists say.

"Snow depth measurements can be made accurately and quickly by anyone with a measuring device," Crumley said. "The potential of mobilizing a new type of data set collected by people like snowshoers and snow machiners is significant because those folks often go to remote mountain environments where so far there haven't been many observations recorded. All of those people can gather data at scales much greater than the capacity of a small group of scientists."

More information: Ryan L. Crumley et al, Assimilation of citizen science data in snowpack modeling using a new snow data set: Community Snow Observations, *Hydrology and Earth System Sciences* (2021). DOI: 10.5194/hess-25-4651-2021

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