Researchers take deep dive into how much water is stored in snow

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OSU civil engineering professor David Hill carries a snow coring device uphill near Thompson Pass, Alaska. Credit: Ryan Crumley.

A heavy snowpack is fun for skiers and sledders, and it also acts like an open-air storage tank that melts away to provide water for drinking, irrigation and other purposes during dry months.

But exactly how much water is held in snowpacks, and for how long?

That information, critical to water managers around the globe, has taken on new clarity thanks to a new, more holistic calculation technique developed by researchers in the Oregon State University College of Engineering.

"Water managers tend to consider a portfolio of infrastructure options—surface water reservoirs, groundwater recharge programs, etc.—to match supply to demand," OSU's David Hill said. "Increased understanding of how much water is in snow should allow them to make long-term planning decisions for how to adjust that portfolio."

The study by Hill, a professor of civil engineering, and doctoral student Christina Aragon looked at nearly four decades of snowpack data. Through their new metric, which they call snow water storage, they identified a 22% drop in how much water is held annually in the mountain snowpacks of the lower 48 states.

"Unlike other widely used metrics that capture snow variables at a single point in time, like maximum snow water equivalent, or describe snow characteristics in terms of time, such as length of snow season, snow water storage is applicable at numerous time and space scales," Hill said. "It's really just a cumulative sum, not a maximum value; it's like adding up the number of miles you drive in a given year, rather than just thinking about the 500 you did on one day for your road trip."

In addition to introducing a better tool for gauging how much water is in snowpacks over periods of time, the findings are important because of what the new metric revealed about mountain snowpacks, which play an outsized role in the nation's water storage.

Hill and Aragon note that of all the water stored in the form of snow in the lower 48, 72% of it is in the mountains, though mountains cover just 16% of the total area.

"There are many ways to describe or quantify our snow resources, but some of the traditional measures, such as the April 1st snowpack, increasingly do not tell the full story," Hill said. "We present a new way of describing snow's water storage ability that adds deeper understanding and has more applicability in cases where our snowfall is increasingly intermittent or, regrettably, turning to rain."

The researchers' work, presented in a paper published in *Hydrology and Earth System Sciences*, builds on a commonly used measurement known as snow water equivalent; as its name implies, it's how much water is left in a container after the snow that was placed in it melts.

"By considering the amount of water held in the snowpack and the amount of time the water is stored as snow, we are able to quantify water storage in different types of snowpacks," Aragon said. "This includes persistent snowpacks, like we typically have at high elevations in the mountains; transient snowpacks, which are typically found at lower elevations; and snowpacks that are transitioning from persistent to transient due to climate warming."

Aragon adds that because the snow water storage metric can be applied to multiple types of snowpacks, it may become increasingly valuable for monitoring and predicting water resources "amidst a future of increased climate variability."

Hill points out that the past several years in the lower 48 have seen a "feast or famine cycle of extremes when it has come to the where and the when of our snow and rain." And in general snowpacks have considerably declined over the past 10 to 20 years.

"That particularly matters in places like Oregon, where 15% of the state's total annual precipitation falls as snow, and our snowpack functions like a reservoir," he said. "It holds back winter precipitation and slowly releases it in spring and early summer. This is useful because, at those times, our rainfall has tapered off for the year, but demand for water is on the rise."

As the climate warms and snowpacks become more and more variable—the winter of 2023-24 is a good example, Hill said—a metric like the new one developed at OSU helps to more objectively quantify the reservoir storage aspect of the globe's snowpacks.

From local to regional scales, he notes, municipal and agricultural users of water need to balance demand with supply, and snow storage dramatically influences the timing of the supply side.

"As we move forward, and as we have moved from the past to the present, the relatively good news is that annual precipitation amounts tend to not change that dramatically," he said. "However, changing temperatures greatly influence snow storage and therefore the timing of water availability."

More information: Christina Marie Aragon et al, Changing snow water storage in natural snow reservoirs, *Hydrology and Earth System Sciences* (2024). DOI: 10.5194/hess-28-781-2024

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