Fall snow levels can predict a season's total snowpack in some western states

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Research led by the University of Washington found that, in some western states, the amount of snow already on the ground by the end of December is a good predictor of how much total snow that area will get. In Washington's Cascades (shown here near Cle Elum, Washington, in November), snow on the ground in the fall increases the likelihood that additional 'wintry mix' precipitation will freeze and add to the snowpack later in the season. Credit: Mark Stone/University of Washington

Spring break can be a good time for ski trips—the days are longer and a little warmer. But if people are booking their spring skiing trips the fall before, it's hard to know which areas will have the best snow coverage later in the season.

Researchers who study water resources also want to know how much snow an area will get in a season. The total snowpack gives scientists a better idea of how much water will be available for hydropower, irrigation and drinking later in the year.

A team led by researchers at the University of Washington has found that in some western states, the amount of snow already on the ground by the end of December is a good predictor of how much total snow that area will get. This prediction works well in northern states such as Alaska, Oregon and Washington, as well as in parts of Utah, Wyoming and Colorado. Other states, such as California, Nevada, New Mexico and Arizona, were harder to predict—these regions either had too much variation in their weather patterns and/or got the most of their precipitation after December.

The researchers published these results Sept. 12 in *Geophysical Research Letters.*

"The main thing water managers are asking for—aside from making it snow more, which is usually everyone's first request—is longer lead-time forecasts," said senior author Jessica Lundquist, UW professor of civil and environmental engineering.

"These are hard predictions to make. We're fairly good at long-term average forecasts: what will happen 50 years from now. And we can do short-term forecasts: what will happen less than a week from now. But as for what's going to happen in the next three to four months, that's been kind of a no-go zone. It was really interesting to find that the amount of

snow on the ground by the end of December ended up being a good predictor of peak spring snow."

To look for trends, the team collected data from a network of snow sensors across the western U.S., including Alaska. The researchers analyzed air temperature and accumulated precipitation from 2001 to 2022 for 873 sites. Then the team compared accumulated snow by the end of December (fall snow) to the maximum amount of snow accumulated over the entire winter-spring season (peak season snow).

There were a few different reasons for why fall snow levels predicted peak season snowpack levels. Some areas, such as Alaska, simply receive most of their snow before January. This means their early season snow is close to their peak season snow.

In other places, including Interior Alaska, northeast Utah and southwestern Wyoming, the weather patterns are such that above-average snowfall earlier in the season indicates above-average snowfall is also likely later in the season.

Jessica Lundquist, UW professor of civil and environmental engineering, stands near Gothic, Colorado, for a separate project: studying how sublimation — when snow turns into water vapor — is affecting Colorado's diminishing snowpack. Gothic gets about 40% of its snow by the end of December, but fall snow in this area is not a good predictor of total season snowpack. Credit: Mark Stone/University of Washington

Cooler air temperatures also helped with predictability. In northern states —such as Alaska, Washington and Oregon—or in places at higher elevation, snow on the ground in the fall was less likely to melt between storms because the air remained cool. That means this snow will stick around and add to the total snowpack.

"Another really interesting pattern happens in Oregon and Washington,"

Lundquist said. "We get mixed rain and snow all along the west slope of the Cascades. This 'wintry mix' is so close to freezing that it could freeze or melt when it hits the ground. If you have above-average snowpack early in the year, then the wintry mix will stick to that snowpack and add to it. But if you have a below-average snowpack, that wintry mix is more likely to melt that snowpack and actually decrease it."

When it comes to how climate change will affect which areas are predictable, the results are mixed, Lundquist said. Places that are farther north or at higher elevation are colder to start with, meaning they might not see much change.

But some weather patterns are shifting north. Areas where the prediction works now—such as northern Oregon—might go the way of California, having weather that's too variable for any prediction.

It's going to be important to continue tracking these trends, Lundquist said.

"These snow sensors are in long-term stations, so it's easy to get the most recent data every year," Lundquist said. "And then it's just a simple analysis to predict which areas will likely have the largest snowpack. Though, as my family reminds me, it unfortunately does not let me predict powder days."

Additional co-authors are Laura Prugh, UW professor of environmental and forest sciences; Rhae Sung Kim at the National Oceanic and Atmospheric Administration; and Michael Durand at The Ohio State University.

More information: Seasonal Peak Snow Predictability Derived From Early-Season Snow in North America, *Geophysical Research Letters* (2023). DOI: 10.1029/2023GL103802

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