

Climate change is shrinking snowpack in many places, study shows. And it will get worse

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Sean de Guzman, right, snow survey manager at the California Department of Water Resources, conducts the first snow survey of the season with his team at Phillips Station, Calif., on Tuesday, Jan. 2, 2024. Once regularly snowbound river basins across the globe are increasingly seeing their snowpack shrink and climate change is to blame, a new study found. Credit: Nathaniel Levine/The Sacramento Bee via AP, File

River basins around the world that were once regularly snowbound are increasingly seeing their snowpack shrink and [climate change](#) is to blame, a new study found.

"Many of the world's most populous basins are hovering on the precipice of rapid snow declines," concluded the study of snow amounts since 1981 in Wednesday's [journal Nature](#).

That's because the study found a key threshold for the future of snowpacks in the Northern Hemisphere: 17.6 degrees (-8 degrees Celsius). In places where the winter temperature average is colder than that, the snowpack often survives because it's cold enough. But areas warmer than 17.6 degrees for a winter average tend to see their winter wonderland dreams melt like the wicked witch of the west. And it's happening fast.

"You're potentially in this regime of just really rapid and accelerating losses with warming," said lead author Alexander Gottlieb, an Earth systems scientist at Dartmouth College.

Most past studies have looked at [snow cover](#), which is a simple measurement of whether the ground has snow or not. This latest research examined snowpack, a more encompassing measurement that includes depth and amount, at its general peak in March. Spring snowpack is critical for delivering a steady supply of drinking and [irrigation water](#) to billions of people, with bigger and earlier melts causing problems.

University of New Hampshire Earth systems scientist Elizabeth Burakowski, who wasn't part of the research, said the study shows "beyond a reasonable doubt that humans are responsible for the decline in snowpack in dozens of river basins across the Northern Hemisphere" and melting of the snow "will ratchet up with each degree."

"The study demonstrates that our snow future depends on the path we take to act on climate," Burakowski wrote in an email.

Gottlieb and Dartmouth climate scientist Justin Mankin examined 169 [northern hemisphere](#) river basins, finding a significant 40-year [downward trend](#) in 70 of the river basins, an increasing trend in a dozen and no trend in the others.



The Colorado River runs through lightly snow covered mountains April 12, 2023 near Burns, Colo. Once regularly snowbound river basins across the globe, including the upper Colorado, are increasingly seeing their snowpack shrink and climate change is to blame, a new study found. Credit: Chris Dillmann/Vail Daily via AP, File

In 23 of those shrinking snowpacks, Mankin and Gottlieb, using variations on standard scientific techniques, were able to show that [climate change](#) clearly contributed to the melt. In eight river basins, all in chilly eastern Siberia, they found climate change helped build snowpack as precipitation increased but temperatures stayed cool enough to preserve it.

Europe and North America are getting some of the biggest spring snowpack losses, they found, including the Great Salt Lake, Merrimack, Connecticut, Susquehanna, Hudson, Delaware, Neva, Vistula, Dnieper, Don and Danube river basins.

A good example of shrinking snowpack is the upper reaches of the Colorado River basin in Colorado and parts of Wyoming, Gottlieb said. There, the winter temperature averages around 23 degrees (-5 degrees Celsius), seemingly cold enough for snow because it's below freezing, but not really, he said.

"This is a place where we've started to see these kinds of accelerating losses start to emerge," Gottlieb said. "We see this really clear picture of anthropogenic forest snow loss over the last 40 years or so."

Gottlieb and Mankin documented fingerprints of human-caused warming by using the standard climate attribution method of comparing what happened in the last 40 years of a real warming world to thousands of computer model runs showing what would happen to these [river basins](#) on a fictional planet with no climate change.

Places chillier than 17.6 degrees account for 81 percent of the Northern Hemisphere snowpack, but they don't hold many people, only 570 million, Mankin said. More than 2 billion people live in areas where winter averages between 17.6 and 32 degrees (-8 and zero Celsius), he said.

What's key, especially for water supply, is that "as warming accelerates, the snowpack change is going to accelerate much faster than it has," said Daniel Scott, a scientist at the University of Waterloo who wasn't involved in the study.

That's because what's happening is not gradual. Above a certain temperature, melt gets moving fast. Below that 17.6 degrees mark, it's cold enough that the extra moisture in the air from climate change may result in more snow and increase [snowpack](#), something Gottlieb and Mankin said they saw in eastern Siberia.



In this photo provided by the California Department of Water Resources, the snow level on a mountain peak is seen near the meadow where the first snow survey of the year took place in Phillips Station, Calif., Jan. 2, 2024. Once regularly snowbound river basins across the globe are increasingly seeing their

snowpack shrink and climate change is to blame, a new study found. Credit: Fred Greaves/California Department of Water Resources via AP, File

That 17.6-degree threshold "tells us more clearly how much risk there is and where," said University of Colorado ice scientist Waleed Abdalati, a former NASA chief scientist who wasn't part of the study.

The ski industry—with sometimes stark visuals of manufactured snow on an otherwise brown landscape for winter revelers to enjoy—has long been an easy to understand example of an economy that will suffer from the lack of snow.

Many ski areas wait anxiously every year for Mother Nature to bring enough powder to start running their lifts. [Others have closed](#) altogether after their seasons got too short.

Larger corporate-run mountains, such as Colorado's Aspen Snowmass, are able to operate consistently despite less snow and shorter winters.

"Opening and closing days remain constant due to snowmaking, which shows how important that is," said Auden Schendler, senior vice-president of sustainability at Aspen One, the parent company of Aspen Skiing Company.

They also invested in building new ski runs at higher elevations where [snow](#) is more reliable than at the base, insulating them from substantial economic loss—for now.

"That in no way reduces the urgency of the need to act with force and at scale," Schendler said. Aspen Snowmass is among a growing handful of ski areas that are [embracing climate activism](#) as the new industry

standard, recognizing an urgent need to lobby for climate-friendly policies if they want to exist well into a warming future.

More information: Alexander Gottlieb, Evidence of human influence on Northern Hemisphere snow loss, *Nature* (2024). [DOI: 10.1038/s41586-023-06794-y](https://doi.org/10.1038/s41586-023-06794-y).
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