# Rain-on-snow flood risk to increase in many mountain regions of the western US, Canada

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Flooding caused by rain falling on snowpack could more than double by the end of this century in some areas of the western U.S. and Canada due to climate change, according to new research from the University of Colorado Boulder and the National Center for Atmospheric Research (NCAR).

The greatest flood risk increases are projected for the Sierra Nevada, the Colorado River headwaters and the Canadian Rocky Mountains—places where residents are no strangers to flood concerns. Conversely, lower elevations in coastal regions of California, Oregon, Washington and maritime British Columbia could see decreases in rain-on-snow flood risk.

The findings were published today in the journal *Nature Climate Change*.

Rain-on-snow events vary widely in timing and scale but can cause costly and damaging flooding as rapid snowmelt triggered by heavy and prolonged rainfall converge in a cascade that can overwhelm downstream rivers and reservoirs. In 2017, California's Oroville Dam nearly failed catastrophically due to such an event, leading to the evacuation of 188,000 people and $1 billion in infrastructure damages.

"Rain-on-snow events can be intense and dangerous in mountainous areas, but they are still relatively poorly understood," said Keith Musselman, lead author of the study and a research associate at CU Boulder's Institute of Arctic and Alpine Research (INSTAAR). "We can infer a little bit from streamflow, but we want to get better measurements and model more of the variables involved."

To study the past, present and potential future of rain-on-snow events, the researchers turned to a state-of-the-art weather modeling dataset developed at NCAR. Known as CONUS 1, the dataset contains weather simulations across the continental U.S. in the current climate and a warmer future based on projected climate trends. The enormous data trove—which took NCAR's Yellowstone supercomputer more than a year to compile—offers unprecedented detail and resolution.

"This high-res dataset allows us to resolve mountains in granular fashion and examine the factors that combine to melt the snowpack when a warm storm comes in and hits cold mountains like the Sierra," Musselman said.

The authors found that in a warmer climate, less frequent snow-cover at lower elevations would decrease the risk for rain-on-snow flood events in areas like the U.S. Pacific Northwest. By contrast, at higher elevations where winter snow will still accumulate despite climate warming (such as in the High Sierra and much of the Rocky Mountains), rain-on-snow events could become more frequent due to increased rainfall that might once have fallen as snow. The events will also become more intense.

The rain and melt produced during rain-on-snow events is projected to increase for a majority of western North American river basins as rain rather than snow affects more mountain watersheds, increasing the corresponding flood risk by as much as 200 percent in localized areas and potentially straining existing flood control infrastructure.

"We were surprised at how big some of the projected changes were," Musselman said. "We didn't expect to see huge percentage increases in places that already have rain-on-snow flooding."

The findings represent an important first step toward better understanding rain-on-snow flood risk in the context of anthropogenic climate change, which could significantly shift the timing and extent of future flood regimes.

The researchers hope that continued investment in snowpack monitoring networks and efforts such as NASA's Airborne Snow Observatory will provide additional ground information, allowing hydrologists and climate scientists to verify their models against observations and better inform flood risk assessment now and in the future.

**More information:** Keith N. Musselman et al, Projected increases and shifts in rain-on-snow flood risk over western North America, *Nature Climate Change* (2018). DOI: 10.1038/s41558-018-0236-4

Provided by University of Colorado at Boulder

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