Improving forecasts for rain-on-snow flooding

December 18 2014

Image: Wikipedia.

Many of the worst West Coast winter floods pack a double punch. Heavy rains and melting snow wash down the mountains together to breach riverbanks, wash out roads and flood buildings.

These events are unpredictable and difficult to forecast. Yet they will become more common as the planet warms and more winter precipitation falls as rain rather than snow.

University of Washington mountain hydrology experts are using the physics behind these events to better predict the risks.

"One of the main misconceptions is that either the rain falls and washes the snow away, or that heat from the rain is melting the snow," said Nicholas Wayand, a UW doctoral student in civil and environmental

engineering. He will present his research Dec. 18 at the annual meeting of the American Geophysical Union.

Most of the largest floods on record in the western U.S. are associated with rain falling on snow. But it's not that the rain is melting or washing away the snow.

Instead, it's the warm, humid air surrounding the drops that is most to blame for the melting, Wayand said. Moisture in the air condenses on the cold snow just like water droplets form on a cold drink can. The energy released when the humid air condenses is absorbed by the snow. The other main reason is that rainstorms bring warmer air, and this air blows across the snow to melt its surface. His work support previous research showing that these processes provide 60 to 90 percent of the energy for melting.

Places that experience rain-on-snow flooding are cities on rivers that begin in the mountains, such as Sacramento, California, and Centralia, Washington. In the 1997 New Year's Day flood in Northern California, melting snow exacerbated flooding, which broke levees and caused millions of dollars in damage. The biggest recent rain-on-snow event in Washington was the 2009 flood in the Snoqualmie basin. And the Calgary flood in summer of 2013 included snow from the Canadian Rockies that caused rivers to overflow their banks.

The UW researchers developed a model by recreating the 10 worst rain-on-snow flooding events between 1980 and 2008 in three regions: the Snoqualmie basin in Washington state, the upper San Joaquin basin in central California and the East North Fork of the Feather River basin in southern California.

Their results allow them to gauge the risks for any basin and any incoming storm. The three factors that matter most, they found, are the

shape of the basin, the elevation of the rain-to-snow transition before and during the storm, and the amount of tree cover. Basins most vulnerable to snowmelt are treeless basins with a lot of area within the rain-snow transition zone, where the precipitation can fall as snow and then rain.

Trees reduce the risk of flooding because they slow the storm's winds.

"If you've ever been in a forest on a windy day, it's a lot calmer," Wayand said. That slows the energy transferred from condensation and from contact with warm air to the snowpack.

Simulations also show that meltwater accounted for up to about a quarter of the total flooding. That supports earlier research showing that snow is not the main contributor to rain-on-snow floods, but cannot be neglected since it adds water to an already heavy winter rainstorm.

The complexity of mountain weather also plays a role.

"The increase in precipitation with elevation is much greater than usual for some of these storms," said Jessica Lundquist, a UW associate professor of civil and environmental engineering. "Higher flows can result from heavier rainfall rates at higher elevations, rather than from snowmelt."

In related work, Lundquist's group has developed a tennis-ball snow sensor and is measuring growth and melt of the snowpack in the foothills east of Seattle. The scientists aim to better understand how changes in climate and forestry practices might affect municipal water supplies and flood risks.

Wayand and another student in the group have developed a high school curriculum for Seattle teachers to explain rain-on-snow events and the

physics behind why they occur. They hope to begin teaching the curriculum sometime next year.

Provided by University of Washington