Why LA's last big storm caused landslides in only some areas

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The last round of atmospheric river storms drenched Southern California with historic rainfall, and by one measure, it came close to beating a record for the most rain over a three-day period.

While the rain was widespread, damage—including landslides— was focused mostly on certain hillside neighborhoods. Why didn't the storms cause catastrophic landslides across a greater swath of the region?

We spoke with the U.S. Geological Survey to answer that question. Here are some key takeaways:

Rainfall totals were big

The cumulative rainfall recorded during the early February storms was eye-popping. For the five-day period that ended at 5 a.m. Feb. 8, downtown Los Angeles got more than 9 inches. That's more than 60% of its average annual rainfall.

The scenic mountain range north of Hollywood and Westwood was also hit hard: Bel-Air got about 14 inches of rain. The deluge caused a house to slide off its foundation on Caribou Lane in Beverly Glen, a mountainous neighborhood northwest of Beverly Hills.

Other areas that experienced damaging landslides and mudflows included Studio City, Tarzana, Baldwin Hills and Hacienda Heights.

A large accumulation of rain during a storm is enough to spur a landslide—especially in certain neighborhoods where human modifications to the landscape and drainage can contribute to increased risk.

"Most of those slides that we've seen—that have been in the news—have been in the built environment," said Matt Thomas, a research hydrologist with the USGS' landslide hazards program.

"And so those are hill slopes that might have conditions that predispose them to the landslides more so than normal," Thomas said. "So you can

have oversteepened slopes, poorly developed fill that erode where a house is sitting on. You can have site-drainage conditions that funnel water ... into areas that end up eroding and therefore causing landslides."

There also were mudflows that occurred in expected locations, such as Malibu Canyon and along Pacific Coast Highway. Those areas see frequent rockslides and landslides when it rains.

But rainfall intensity was not epic

It might have felt like the rain was intense in the hills. But by historical standards, and relatively speaking, it was not falling at epic rates.

When quantifying intensity, hydrologists measure rainfall rates per hour.

An inch of rain per hour is considered heavy. But, Thomas said, it was rare to see that kind of intensity during the recent storm.

As a result, there weren't apparent widespread landslides and mudflows across the region's mountainous slopes. Instead, landslides appear to have been limited to neighborhoods that were already at higher risk.

"That's probably what made the difference between news stories that were reporting a lot of landslides in neighborhoods versus widespread land sliding across all of the mountain ranges in a much more widespread event," Thomas said.

The ingredients for landslides

The criteria for what causes widespread landslides in Southern California were first documented in the 1970s, Thomas said.

It starts with at least 10 inches of seasonal rainfall. Downtown Los Angeles didn't pass that threshold until Feb. 4—the first big day of the storm.

The second ingredient is a minimum rainfall rate—at least one-quarter inch per hour. That standard is dated, however, and it's likely a higher rate of rainfall per hour would be required for widespread landslides with bigger impacts.

A dearth of wildfires has helped

The fact that last winter was a wet one for California—helping keep wildfires to a minimum—is also helping against severe flows of mud this winter.

That wasn't the case in 2018. In December 2017, the Thomas fire—the largest in Southern California history—chewed up 281,893 acres over Ventura and Santa Barbara counties, including burning through every watershed above Montecito and Carpinteria.

Then came a period of very intense rain in early January 2018. Fast-moving flows of mud and debris poured from the hills, killing 23 people, destroying 130 homes and causing hundreds of millions of dollars in damage.

Scientists refer to this subset of landslides as debris flows, in which water rushes down and mixes with mud and debris, as well as rocks and branches. In the post-fire Montecito debris flow, the event started as a flash flood that began to pick up mud and other debris, including boulders that were bigger than cars.

A report written by Nina Oakley, now a geohazards climatologist with the California Geological Survey, and Marty Ralph, of the Center for

Western Weather and Water Extremes at the Scripps Institution of Oceanography, said there was a "a period of very intense rainfall" that was the primary trigger during the 2018 storm.

Also critically important is how the soils above the neighborhood changed due to the wildfire, which causes "water-repellent soils" to develop. As a result, "rainfall runoff is dramatically increased in these areas as compared to unburned areas."

Additionally, an accumulation of weeks of prior rainfall isn't needed in a burn zone to precede a debris flow.

What happens when rainfall is intense?

Exactly five years to the day of the deadly Montecito debris flows, there was another round of intense rainfall in that region. Some 7,000 landslides occurred in the backcountry, said Jason Kean, another research hydrologist with the USGS' landslide hazards program. In the cities, there was significant damage from floodwaters. The January 2023 storm caused more than $80 million in damage to Santa Barbara County.

That storm had both ingredients to trigger landslides in the backcountry. It pushed Santa Barbara to have more than 10 inches of cumulative seasonal rainfall, according to the National Weather Service, and there were rainfall rates of 1 inch per hour, Kean said.

Risk for sliding land could increase

As we head into the latter half of winter, Southern California is now firmly above the baseline of 10 inches of rain this water season. Downtown L.A. has recorded 15.8 inches of rain since Oct. 1; that's already more than its average annual rainfall of 14.25 inches.

"Obviously, we've hit that 10-inch mark for the winter season. And so [in terms of future landslide risk] really we're looking for abundant more rainfall, and that high intensity, to kick it off," Kean said.

One key factor that could pose a greater risk in future storms is a "narrow cold frontal rain band," or NCFR for short. "This is basically a meteorological element that can produce high-intensity rainfall," Thomas said. An NCFR was a factor in the deadly 2018 Montecito landslides.

As for our recent early February rainstorm, an NCFR did develop, but it did not produce particularly intense rainfall, Thomas said. But if it had, "it would have been the No. 2 in the one-two punch of producing landslides," he added.

People might quibble over scientists' observations that the last storm wasn't particularly intense. But it can be easy to conflate "how much rain accumulated over the course of the storm compared to how hard it was raining in any given time," Thomas said.

"What we really need for that widespread unzippering of the landscape—in terms of landslide generation—we need that antecedent rainfall and we need the high intensity to fall shortly thereafter," he said.

In terms of landslides, "it's a one-two punch," Kean said. "It's getting things wet and then hitting it hard with a burst."

During the early February storm, "things definitely got wet. ... But the burst to kick things off was thankfully not as big to make the problem worse," he added.

Deep-seated landslides a greater concern later in the season

There's also a subset of slides known as "deep-seated landslides," involving those greater than 15 feet deep, which can be particularly destructive and can happen even on a dry day. There were two memorable deep-seated landslides during and following an epic rainy season in 2005.

The first occurred on Jan. 10 of that year, killing 10 people in La Conchita, a community on the Ventura County coast. The slide occurred at the end of an intense 15-day rainy period.

Another occurred that June in Bluebird Canyon of Laguna Beach after a period of heavy rain from the previous December through February. No rain fell immediately prior to the slide, which destroyed 17 homes and seriously damaged 11 others.

The rain year that ended June 30, 2005, was the wettest in the last generation. An astonishing 37.25 inches fell on downtown L.A. that year—even more than the memorable El Niño season of 1997–98, when 31.01 inches of rain fell, and the 2022–23 rain year, when 28.4 inches fell. Those are the only three rain years in the past 26 seasons when annual rainfall was more than 10 inches above average for downtown L.A.

Deep-seated landslides can occur where the bedrock is very deep and rainwater can seep deep underground. During repeated heavy storms, water can accumulate and eventually destabilize an entire chunk of earth, causing it to collapse downhill. They can happen slowly or with astonishing speed.

In general in Southern California, deep-seated landslides occur in above-average rainfall seasons, Thomas said.