UC Irvine scientists discover what drives California's worst fire years

Clusters of fires started by lightning led to the most devastating blazes.

Friday, January 02, 2026
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UC Irvine News

Two natural resource specialists walk through an area of Redwood Mountain Grove burned in the KNP Complex Fire in California’s Sierra Nevada Mountains to evaluate fire effects.

Picture Credit:
National Park Service

- The study shows why some fire years are far more destructive than others.

- When clusters of lightning-ignited fires merge, even more intense blazes emerge.
- The results highlight a need for weather agencies to improve dry lightning forecasting capacities.

Irvine, Calif., Jan. 2, 2026 — What makes one fire season worse than another in fire-prone parts of the world like California is poorly understood, but in a new study, scientists at the University of California, Irvine reveal how clusters of lightning-ignited fires called fire complexes are the chief drivers of the most destructive fire years. It's a finding that could help agencies better manage such fires when they occur.

"Nobody has ever looked into these kinds of fires before," said Rebecca Scholten, a postdoctoral fellow in Earth system science and lead author of the *Science Advances* study. "We theorized that when two or more fires in a fire complex merge, they would just burn themselves out. But we found the opposite – the fires grow worse."

Scholten's team studied fire complexes that ignited in two or more places between 2012 and 2023: California and Arctic-boreal regions. In California, multi-ignition fires, while rare compared to other kinds of fires like single-ignition solitary fires, accounted for 31 percent of the total burned area, and 59 percent in Arctic-boreal regions.

One extreme example is the August Complex fire that struck California in 2020. That fire scorched about 1 million acres across seven northern California counties. It began after lightning ignited 38 different fires that grew and converged to form larger fires that took months to fully extinguish. Another blaze, the KNP Complex Fire, burned large swaths of California's Sequoia and Kings Canyon National Parks, devastating the area's iconic groves of giant sequoia redwood trees.

To develop a clearer picture of the destructiveness of fire complexes, Scholten's team studied how separate fires within a complex grow and, at times, merge. They found that when fires in a complex merge, they can produce conditions in the atmosphere that lead to extreme fire behavior like pyrocumulonimbus events – fire-triggered thunderstorms that can, in turn, ignite even more fires and hamper fire suppression. Indeed, the team found that fire complexes triggered the majority of pyrocumulonimbus events in Russia and Canada in 2023.

“The concentrated energy released from two fire fronts getting close to one another can allow fires to punch into the upper atmosphere,” said James Randerson, professor of Earth system science and co-author of the study. “When this happens, winds near the surface can become erratic, hampering fire suppression.”

Because of their fast initial growth and long duration, fire complexes regularly deplete agencies of the kinds of resources needed to manage them effectively. Understanding the details of how a complex fire can grow even worse if separate fires are allowed to merge may help agencies make crucial decisions about where to send the limited resources at their disposal.

“It might help you decide which ones you want to put out first,” Scholten said.

The team’s results also highlight the need for weather agencies to develop capabilities to forecast when dry lightning is likely to strike a region. Right now, “dry lightning is not a standard event that weather services try to predict,” said Scholten. “But it’s something that could be useful as fire complexes become more likely to form as the climate continues to warm and create conditions ideal for fires to ignite.”

Funding for the research came from a fellowship to Scholten (Dutch Research Council Rubicon Grant 019.241EN), as well as NASA and the U.S. Department of Energy. The study was a collaboration between the Department of Earth System Science and the Department of Civil Engineering. Other key collaborators included NASA, the Naval Postgraduate School, the Vrije University in the Netherlands and Lawrence Livermore National Lab.

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