Tracking and fighting fires on earth and beyond

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Mechanical engineer Michael Gollner and his graduate student, Sriram Bharath Hariharan, from the University of California, Berkeley, recently traveled to NASA's John H. Glenn Research Center in Cleveland, Ohio.

There, they dropped burning objects in a deep shaft and study how fire whirls form in microgravity. The Glenn Center hosts a Zero Gravity Research Facility, which includes an experimental drop tower that simulates the experience of being in space.

"You get five seconds of microgravity," said Gollner. The researchers lit a small paraffin wick to generate fire whirls and dropped it, studying the flame all the way down.

Experiments like this, presented at the 73rd Annual Meeting of the American Physical Society's Division of Fluid Dynamics, can help fire scientists answer two kinds of questions. First, they illuminate ways that fire can burn in the absence of gravity—and may even inform protective measures for astronauts. "If something's burning, it could be a very dangerous situation in space," said Gollner. Second, it can help researchers better understand gravity's role in the growth and spread of destructive fires.

The fire burned differently without gravity, said Gollner. The flame was shorter—and wider. "We saw a real slow down of combustion," said Gollner. "We didn't see the same dramatic whirls that we have with ordinary gravity."

Other researchers, including a team from Los Alamos National Laboratory in New Mexico, introduced new developments to a computational fluid dynamics model that can incorporate fuels of varying moisture content. Many existing environmental models average the moisture of all the fuels in an area, but that approach fails to capture the variations found in nature, said chemical engineer Alexander Josephson, a postdoctoral researcher who studies wildfire prediction at Los Alamos. As a result, those models may yield inaccurate predictions in wildfire behavior, he said.

"If you're walking through the forest, you see wood here and grass there, and there's a lot of variation," said Josephson. Dry grasses, wet mosses, and hanging limbs don't have the same water content and burn in different ways. A fire may be evaporating moisture from wet moss, for example, at the same time it's consuming drier limbs. "We wanted to explore how the interaction between those fuels occurs as the fire travels through."

Los Alamos scientists worked to improve their model called FIRETEC (developed by Rod Linn), collaborating with researchers at the University of Alberta in Canada and the Canadian Forest service. Their new developments accommodate variations in moisture content and other characteristics of the simulated fuel types. Researcher Ginny Marshall from the Canadian Forest Service recently began comparing its simulations to real-world data from boreal forests in northern Canada.

During a session on reacting flows, Matthew Bonanni, a graduate student in the lab of engineer Matthias Ihme at Stanford University in California, described a new model for wildfire spread based on a machine learning platform. Predicting where and when fires will burn is a complex process, says Ihme, that's driven by a complex mix of environmental influences.

The goal of Ihme's group was to build a tool that was both accurate and fast, able to be used for risk assessment, early warning systems, and designing mitigation strategies. They built their model on a specialized computer platform called TensorFlow, designed by researchers at Google to run machine learning applications. As the model trains on more physical data, said Ihme, its simulations of heat accumulation and fire-spreading dynamics improve—and get faster.

Ihme said he's excited to see what advanced computational tools bring to wildfire prediction. "It used to be a very empirical research area, based on physical observations, and our community works on more fundamental problems," he said. But adding machine learning to the toolbox, he said, shows how algorithms can improve the fidelity of experiments. "This is a really exciting pathway," he said.

More information: Effect of Microgravity on the Formation and Geometry of Whirling Flames, meetings.aps.org/Meeting/DFD20/Session/P01.5

Contrasting Fuel Moisture Integration Methods in Wildfire Behaviour Modelling Using FIRETEC, meetings.aps.org/Meeting/DFD20/Session/P04.12

Ensemble Predictions of Wildfire Spread Through TPU-Compatible TensorFlow Acceleration, meetings.aps.org/Meeting/DFD20/Session/P04.5

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