Applied Technologies, Inc.

Boundary Layer Turbulence and Fire Spread - A Research Study

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APPLICATION BRIEF

According to the National Interagency Fire Center, the first seven months of 2021 (through July 19) have seen 35,806 wildfires, compared with 29,008 in the same period 2020. That equates to approximately 2.5 million acres burned, compared with 1.8 million in 2020. For Tara Strand, General Manager Forests and Landscapes, at New Zealand Forest Research Institute Limited, known as Scion, understanding how fire spreads is key to ultimately respond and prepare for this destructive and growing trend.

“We’ve teamed up with the Missoula Fire Sciences Laboratory with the US Forest Service in testing a theory about how fire spreads,” explains Dr. Strand. “The original theory from circa 1940, is that fire spreads predominantly by radiation—heating the fuels and gasses to the point of ignition. But the work in the lab by the Missoula Fire Lab demonstrated that there were other physics involved that perhaps were stronger than originally thought. One of those is spreading the fire by convection, where warm air rises and colder air sweeps in to take its place. And what they saw in the lab, without winds and in a very controlled environment, is pulsing of the flames, pushing forward and landing on the fuels and igniting the fuel by contact.”

In an effort to test this fire theory in the field and scale it up into real world conditions, Scion’s Rural Fire Research Team began in 2011 assembling a group of fire experts from around the globe. The international team now includes Dr. Craig Clements, Professor and Director, Wildfire Interdisciplinary Research Center and the Fire Weather Research Laboratory, San José State University; Marwan Katurji, University of Canterbury; Mark Finney, Research Scientist at the Missoula Fire Lab and his team; two drone teams, one from University of Canterbury and one from Scion; and Fire Emergency New Zealand, who help with the research burns and support with firefighting crews enabling Scion to conduct their field burns.

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These burns, all in New Zealand, initially began with cereal crops—as uniform a fuel as was available. The team were trying to simulate previous lab conditions, while having to account for the changing winds in the real world. To help understand the scales of turbulence that are impinging upon the fire, as well as the turbulence the fire itself is creating, Strand deploys sonic anemometers on towers throughout the research burns. These sonic anemometers play an important role in enabling the researchers to look at large scale atmospheric circulation, boundary layer turbulence, as well as in-canopy turbulences, and finally, the turbulence that the fire itself generates.

The second set of burns were in gorse, which is an invasive scrub brush that can burn very hot. According to Strand, “We recorded temperatures up to about 1500°C, easily 800°C throughout the fire bed. We had ATI Sonics on 30-meter towers looking at the turbulence as the fire front approached. We did melt some of the wiring and parts of the transducers, but we were able to record excellent data as the fire front approached and entered the footprint of the tower. It was great!”

Since anemometers are such an essential element of her sensor package, Dr. Strand has tested a multitude of sonics from manufacturers around the globe. As a result of these tests, Dr. Strand reports, “We have pushed sensors to their maximum limits, and one manufacture stands out as our sonic-of-choice: Applied Technologies, Inc. (ATI).” Strand further elaborates, “Because of the design of ATI’s sonics, Herb’s (Herb Zimmerman, owner of ATI) units worked all the way up to 240°C. All other sonics we have tested would melt at say approximately

100°C. We've tested them all and the only sonics capable of accurately measuring fire turbulence are ATI's. They remain the only sonics able to handle the heat, without a doubt."

Scion's next study will be a canopy fire of lodgepole pine. "These trees are 15 meters tall and so thick it's like dog hair, so the fire will be extremely hot," says Strand. "We are trying to sort out how we can get similar measurements to our previous burns. We'll have a 60-meter tower where we will put our poor Sonics on, which is why I'd be curious if Herb can design some units that can go even a little hotter. Our goal is to get into the upper parts of the flame, beyond 60 meters, to get an understanding of the turbulences above that 60-meter tower."

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Due to the height and scale of this burn, the research team is exploring the use of a variety of sophisticated instrumentation. All burns have used backscatter Lidar and a SODAR-RASS and these will be highly important during the canopy burns. They also rely on high-speed infrared cameras to get a spatial understanding of the sweeps and the injections that are happening at the fire front. Marwan Katurji at the University of Canterbury is at the forefront of developing the methodology for this type of observation sensor. Dr. Katurji is using the sonic anemometer data from the tower and horizontal temperate data arrays from the Missoula Fire Lab to refine his research methodology. The objective of this collaboration is to obtain an enhanced spatial understanding of the fire rather along with a single vertical profile provided by the tower.

The research will not end with the lodgepole pine burn. They plan to continue to scale up their experimental design to confirm that their theory on fire modelling is validated in the field. The hope is that the data and new theory will help scientists worldwide will understand and be able to model and simulate the extreme wildfire that we're seeing on the landscape today.

"If the theory is correct, it will change everything," emphasizes Dr. Strand. "This will change the way firefighters are trained, how they respond to fire, and how they prepare for a dry summer. It will change the way we understand extreme fire and when fires transitions into extreme burning. And then it may even change the way we prepare for those summers where we know it will be a hot, dry summer, and how we strive to mitigate damages ahead of time."

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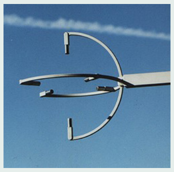
Our sonic of choice: Applied Technologies, Inc.

"ATI is a great company to work with. They have been really supportive of our research and ATI produces the only products that can go into these hot environments. Not only can they handle the heat, they're stable too—they minimally spike and do not have any sort of major issues. They're simply a really great product."

Tara Strand, Ph.D.
General Manager, Forest and Landscapes, Scion

The ATI Sonics Used by Scion



A 3-axis, 3-dimensional, 15 cm, scientific ultrasonic anemometer is a compact design for flux measurements in plant and forest canopies where wind speeds are very low and directions are highly unpredictable.

Vx-Style Probe

A 3-axis, 3-dimensional, 15 cm, scientific ultrasonic anemometer that has been designed for atmospheric boundary layer studies. The design of this probe minimizes flow distortion errors.

K-Style Probe

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