OSU Scientist Uses Fiber Optics to Measure Water and Air

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Scientists at Oregon State University are using fiber optics to study the temperature of water, the flow of air, and the dynamics of snow melt.

This technology – called distributed temperature sensing (DTS) – uses the same sort of fiber optic communication cables that make your telephone work, to measure temperatures at one-meter intervals over distances exceeding 10 kilometers.

An intense laser pulse is sent down the fiber and the fiber's temperature is computed from the light that bounces back – the warmer the fiber, the more blue-shifted light returns.

"We are able to monitor changes in temperature with greater than 10,000 times the resolution possible a few years ago," said John Selker, a professor of biological and ecological engineering at OSU who has pioneered the new use of this technology.

Selker and his team are using fiber optics in ways that were never imagined by the original developers, which presents challenges in equipment selection, installation, and data analysis. To explore new applications and ensure their availability to researchers, Selker is testing the technology in a series of intensive, hands-on workshops.

Results from tests conducted on the H.J. Andrews Experimental Forest in the western Cascade Mountains of Oregon are reported in the latest issue of the journal Eos, Transactions, American Geophysical Union.

The tests involved three field installations of fiber optic cables. Two installations collected data from streams, recording the dynamic interplay between groundwater and surface water.

"There's a big difference between the stream we see and the stream we don't see," said Selker. Even as the sun and air warm a stream up, the permeable bed underlying it cools it down, soaking up heat as water filters through during the day, and re-cooling at night.

To quantify this thermal exchange, workshop participants used a sack of ice placed in the stream, then followed the pulse of cold water using DTS. When the streambed was deep, the cold pulse dissipated almost immediately. But in sections where the streambed was lined with bedrock, where water could not enter and reemerge, the cold signal traveled for hundreds of meters.

Selker then revealed the invisible part of the stream by translating meter-by-meter temperature observations into a detailed map of the hidden, sub-surface portion – which often holds more water than flows on the surface.

The third installation used a crisscrossed series of fiber optic cables spanning a mountain valley to record the dynamic current of cold air carrying carbon dioxide exhaled by the forest.

Just as the cables in the stream mapped slight differences in water temperature across a gradient, the cables spanning the valley outlined an invisible river that carries cold forest air down the mountainside as the sky darkens.

Selker hopes to show that by running a current along the electrically resistive metal casing of a fiber optic cable, researchers can measure wind speed and air temperature at thousands of points simultaneously from the forest canopy to the valley floor.

His lab has already used this approach to help farmers understand their irrigation systems, hydrologists quantify the water moving underground and geologists document the temperatures of snowpacks.

New environmental applications of DTS emerge almost every day. "It's been quite a ride since a couple of years ago when we first put this technology into a stream," said Selker.

Source: Oregon State University

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