Titan Multispectral Lidar Sensor

New methods developed for forest fire impact assessment

The 2016 Horse River Fires destroyed thousands of buildings around Fort McMurray in Alberta, Canada, making them one of the most destructive fires in recent history. As the last flames were put out in early August, a Titan multispectral airborne lidar terrain mapper (ALTM), manufactured by Teledyne Optech, was deployed by the University of Lethbridge to survey the fire's damage to surrounding wetlands and peatlands.

The Optech Titan ALTM uses laser beams at 532, 1064, and 1550 nm to improve data classification.

As we begin to understand the effect of excess carbon in the Earth's atmosphere, governments have started to cut down on the fossil fuels that we burn and switch to renewable sources of power. Unfortunately, intentional burning isn't the only way that carbon can get into the atmosphere. Wetlands and peatland soils like those around Fort McMurray contain massive amounts of carbon, and they are becoming more vulnerable to forest fires as our climate changes. These fires release their carbon into the atmosphere, causing short-term air pollution and long-term environmental damage.

UNIQUE MULTISPECTRAL TECHNOLOGY

The Titan's active multispectral technology offered researchers at the University of Lethbridge a new way to examine the effects of the Horse River Fire on these peatlands. While most commercial lidar systems use only one laser beam operating at a single wavelength, the Titan uses three beams at separate wavelengths (532, 1064, and 1550 nm).

By examining how well each target on the ground reflects each beam, the operator can tell apart different materials in the terrain that the lidar is surveying. For example, some users have used data from the Titan to classify targets as concrete, asphalt or grass, and some users have even successfully differentiated coniferous from deciduous trees.

The researchers at the University of Lethbridge wanted to know whether the Titan's multispectral lidar could show them how deep the peatland soils around Fort McMurray had been burned. This would give them insight into how different types of wetlands and peatlands burn, and how much carbon they would release into the atmosphere.

CALCULATING THE DEPTH OF BURN

Historical lidar data collected in 2008 using a single-wavelength Optech ALTM 3100EA was used as a base reference dataset. Researchers registered the data from both systems using common roadway features and local control points. Both the Titan and the 3100EA were observed to have a relative accuracy of <2 cm RMSEz. Common laser intensity, or cross-section, observations from both datasets were also normalized for improved subsequent analysis.

Ground-level point-cloud data from both systems were then gridded to generate 1-m DEMs and differenced to determine relative volume loss. Differencing the Titan surface model from the 3100EA surface model quantified the depth of peatland soil that had been burned away in the fire.

To verify that these measurements were accurate, the researchers measured the actual loss of soil in several locations based on the depth of adventitious roots in burnt/unburnt areas. There were 14 spots where the field measurements were within a few centimeters of point data within both the Titan and 3100EA datasets. Overall, a strong relationship was established between the lidar-calculated and field-measured loss of soil, demonstrating that airborne lidar terrain mappers are an effective and accurate means of measuring vertical soil loss.

A WIDER SOLUTION WITH THE TITAN

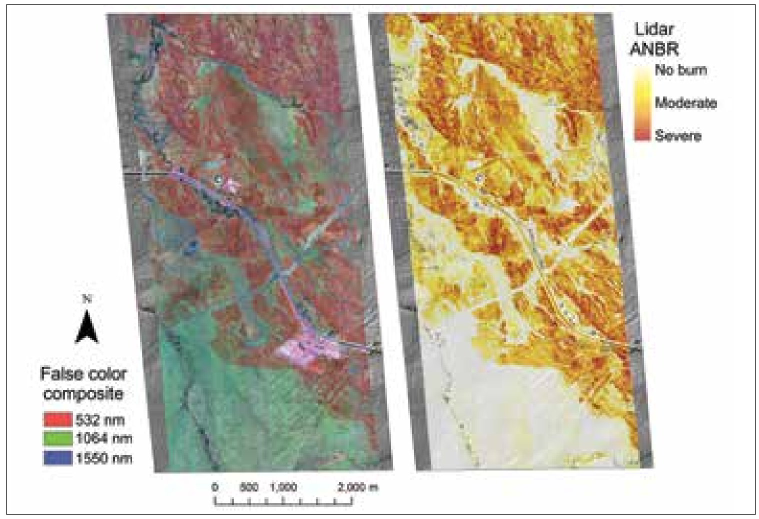
Scientists often use near-infrared (NIR) and shortwave-infrared (SWIR) data from LANDSAT satellite imagery to estimate the severity of a wildfire over vegetated landscapes because the difference between these two wavelengths can clearly differentiate between healthy and burned biomass. This is called the normalized burn ratio (NBR).

However, LANDSAT imagery is low-resolution and represents both canopy and ground-level features. The researchers from University of Lethbridge instead used the ALTM Titan to collect a localized dataset and investigate the use of multispectral lidar, with its canopy-penetrating capability, to derive an alternative calculation of the common NBR measurement. Below-canopy returns from the 1064-nm channel were used as the NIR data, and data from the 1550-nm channel was used as the SWIR data. This resulted in what the researchers called an "active" normalized burn ratio (ANBR).

Comparing the satellite-based NBR with the ALTM Titan's ANBR showed a significant relationship between them. The Titan's ANBR represented conditions at ground level, which cannot be achieved using optical imagery alone if there is an overlying forest canopy. This exciting development means that users can survey a relatively small part of a fire using the ALTM Titan to compute the ANBR, and then potentially use a satellite-based NBR product to extrapolate the total peatland soil loss over the entire fire area.

This latest project expands the application possibilities for multispectral lidar. By more accurately quantifying the depth of burn associated with forest fires in northern boreal forests and the subsequent release of carbon to the atmosphere, we will gain a better understanding of the true impact of fires in northern forests to the global carbon cycle.

This article is based on an original paper by Chasmer, L. E., Hopkinson, C. D., Petrone, R. M., & Sitar, M. (2017): Using multitemporal and multispectral airborne lidar to assess depth of peat loss and correspondence with a new active normalized burn ratio for wildfires. Published in Geophysical Research Letters, 44, 11,851–11,859. https://doi.org/10.1002/2017GL075488. ■



False color composite from the Titan's three beams (left) and the resulting ANBR (right)

CORPORATE PROFILE

TELEDYNE OPTECH has pioneered the design, development and manufacture of advanced lidar instruments for over 40 years. We are widely recognized for our technological depth, with decades of experience in lidar and photogrammetry, as well as auxiliary technologies such as GPS integration and waveform digitization. Our rugged, reliable, and innovative lidar and camera products are deployed on all seven continents—and even on other planets, where a Teledyne Optech lidar provided proof of precipitation on Mars.

From this innovation heritage, our clients have come to depend on us to provide industry leadership with new technologies and capabilities to maximize their collection accuracy and efficiency. Teledyne Optech works closely with commercial, government, military, and space-based organizations to meet their specialized application requirements.

We offer standalone and fully integrated lidar and camera solutions in airborne mapping, airborne bathymetry, mobile mapping, terrestrial laser scanning, and mine cavity monitoring, as well as space-proven sensors. Complete with extensive survey planning, operation and automated post-processing software, Teledyne Optech systems enable clients to collect, manage and deliver survey data to their customers quickly and profitably. Our latest solutions are the backpack-mountable Maverick mobile mapper, the advanced Polaris TLS, and the newly updated ALTM Galaxy PRIME airborne laser terrain mapper.