SEPARATING LEAVES FROM TRUNKS AND BRANCHES WITH DUAL-WAVELENGTH TERRESTRIAL LIDAR SCANNING

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ABSTRACT

Terrestrial laser scanning combining both near-infrared (NIR) and shortwave-infrared (SWIR) wavelengths can readily distinguish broad leaves from trunks, branches, and ground surfaces. Merging data from the 1548 nm SWIR laser in the Dual-Wavelength Echidna® Lidar (DWEL) instrument in engineering trials with data from the 1064 nm NIR laser in the Echidna® Validation Instrument (EVI), we imaged a deciduous forest scene at the Harvard Forest, Petersham, Massachusetts, and showed that trunks are about twice as bright as leaves at 1548 nm, while they have about equal brightness at 1064 nm. The reduced return of leaves in the SWIR is also evident in merged point clouds constructed from the two laser scans. This distinctive difference between leaf and trunk reflectance in the two wavelengths validates the principle of effective discrimination of leaves from other targets using the new dual-wavelength instrument.

Index Terms—Terrestrial lidar, near-infrared reflectance, shortwave infrared reflectance, leaves, trunks

1. INTRODUCTION

First scans with the SWIR laser in the Dual Wavelength Echidna® Lidar (DWEL) [1], merged with NIR scans from the Echidna® Validation Instrument (EVI) [2], demonstrate the separation of leaves from trunks in early trials in a deciduous hardwood stand at Harvard Forest acquired in August, 2012. Power returned from trunk hits is very similar to power returned from leaves at the NIR wavelength of 1064 nm, whereas returned power from leaves is only about half as large at the SWIR wavelength of 1548 nm. At that wavelength, leaf scattering is strongly attenuated by liquid water absorption, which reaches a maximum at about 1450 nm. SWIR scans were obtained in August, 2012, from the DWEL instrument in engineering mode, while NIR scans were obtained in June, 2010, using the Echidna Validation Instrument (EVI), a heritage instrument to the DWEL.

2. INSTRUMENTATION

The DWEL and EVI instruments share many similarities in design [1, 2]. Both use a rotating mirror to scan in a vertical circle as the instrument revolves in azimuth on its base, thus providing angular coverage of the upper hemisphere and much of the lower hemisphere near the instrument. Laser pulses are long and sharply peaked, allowing both full sampling of the return waveform shape and easy interpolation for accurate distance retrievals. Beam divergence is adjustable, ranging from 1.25 to 5 mrad. Scattering events as far as 100 m from the instruments and beyond can be detected and digitized with 8- (EVI) or 10-bit (DWEL) resolution.

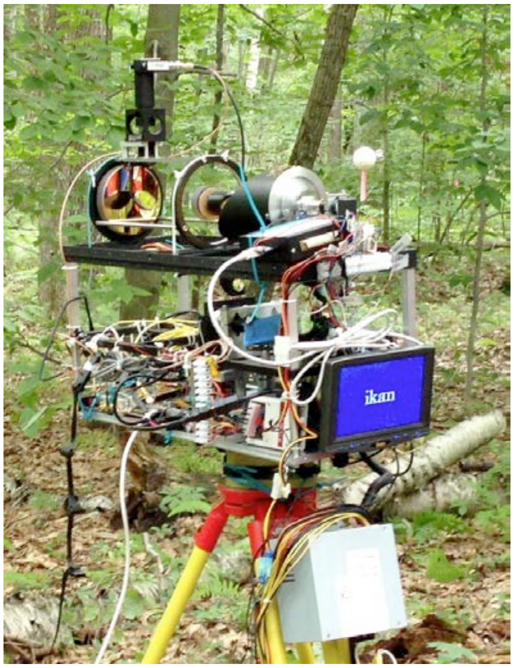

Figure 1. DWEL instrument in engineering scan configuration.

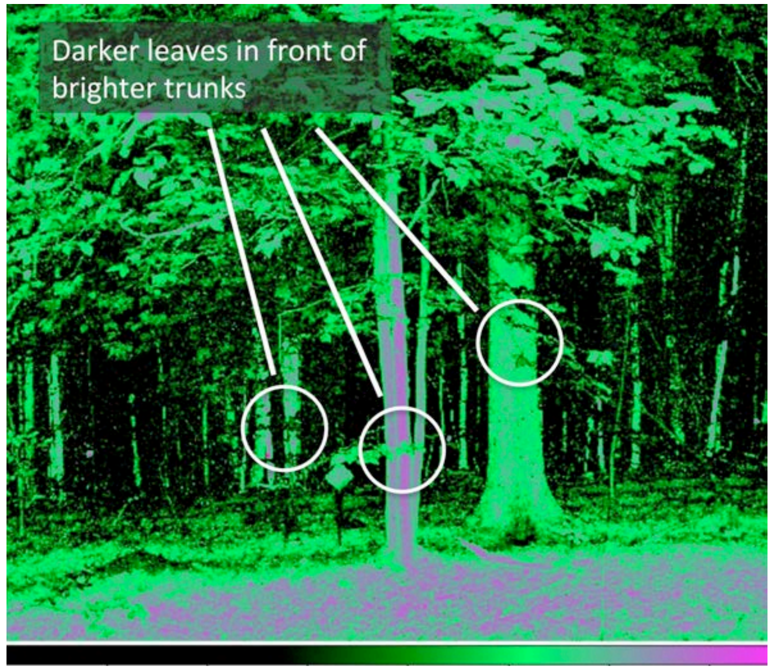

Figure 2. DWEL scan at Harvard Forest, SWIR laser. Color bar indicates returned power, low to high, left to right.

3. DATA

DWEL data were acquired at Harvard Forest, Petersham, MA, on August 1, 2012. The location was the center point of a 1-ha deciduous hardwood plot (100 m by 100 m) that has been scanned by the EVI at intervals since 2007 [3, 4, 5]. The DWEL instrument scanned in engineering mode (Figure 1), acquiring data with the 1548 nm laser only, as the 1064 nm laser was inoperable at the time. Scanning used an unexpanded collimated laser beam of 6-mm cross section, with data recorded at 2 mrad angular intervals in zenith and azimuth. EVI data at 1064 nm were acquired at the same location in June, 2010, using a divergent beam of 5 mrad, sampled at 4 mrad resolution.

4. RESULTS

Figure 2 shows an image of returned power from the DWEL scan at Harvard Forest. Because the power falls off with the square of the range, scattering events near the instrument show higher returned power (violet) while distant scattering events show lower power (dark green). The image shows examples of leafy branches crossing tree trunks at several ranges from the instrument. In each case, the leaves show a significantly reduced signal in spite of being at a nearer range.

Figure 3 shows images from the two scans at the two different wavelengths. The comparison readily shows leaves to be darker at 1548 nm than at 1064 nm. Inset images show regions of interest for a trunk (red) crossed by a leafy branch (green) as seen in each scan. In the 1064 nm scan, the trunk/leaf ratio is 0.95; in the 1548 scan, the ratio is 2.0. The finer scan resolution of the DWEL image (2 mrad) as compared to the DWEL image (4 mrad), provides a more detailed image. In the two years between the scans, a leafy branch in the upper right foreground has grown across the prominent trunk in the foreground.

We were also able to construct a point cloud from the DWEL data and register it to a point cloud obtained from an EVI scan from 2007. Figure 4 shows the two point clouds. The 1548 nm scan clearly shows the trunks that are evident in the 1064 nm scan, but records fewer and darker leaf hits in the understory layer. Some tree growth is also apparent.

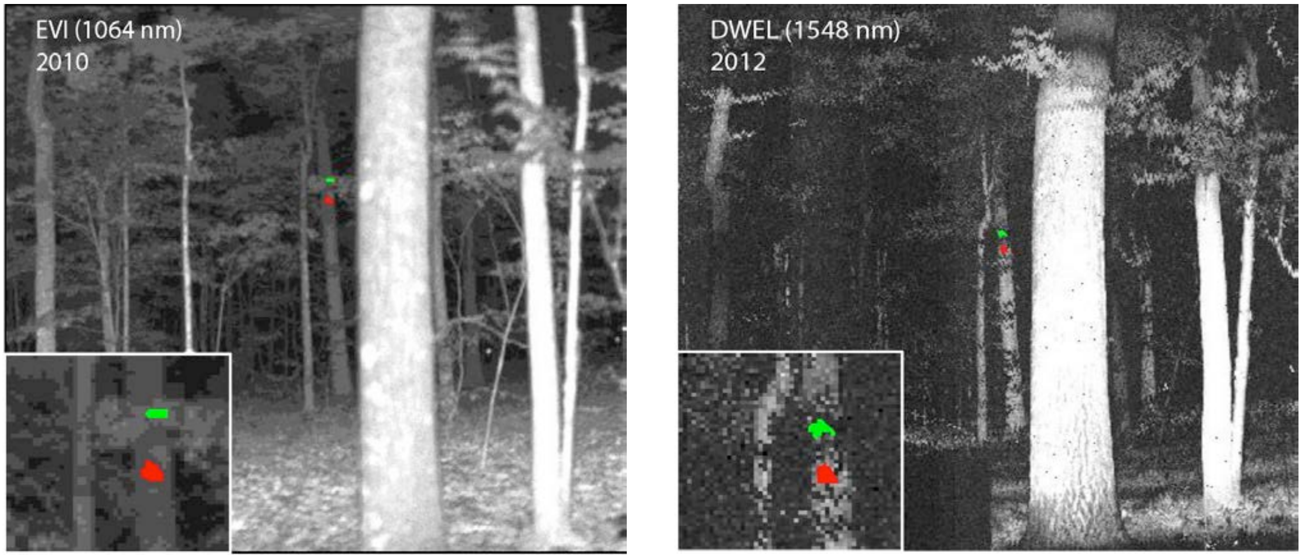

Figure 3. Left, EVI scan at 1064 nm. Right, DWEL scan at 1548 nm. Image brightness is proportional to returned power.

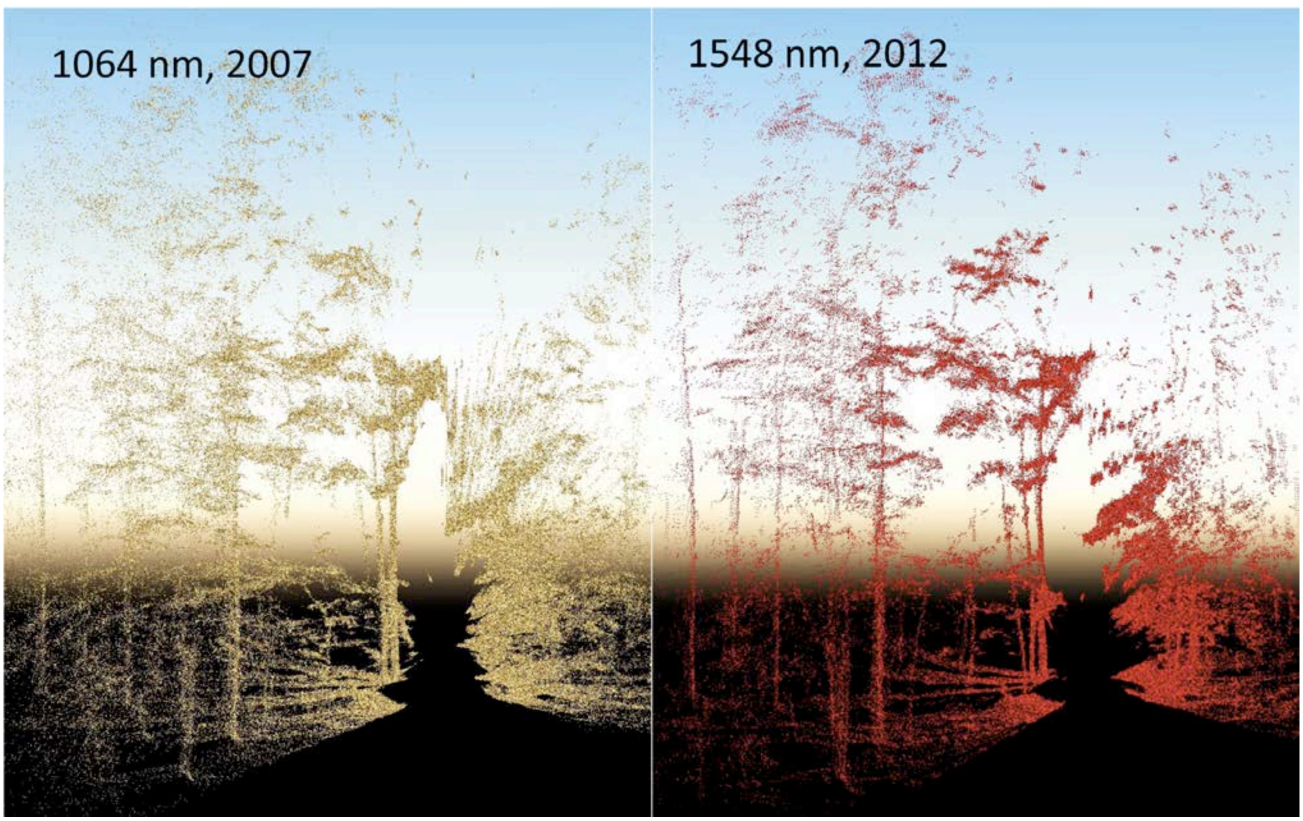

Figure 4. Registered point clouds from EVI (1064 nm) and DWEL (1548 nm), shown in a cutaway view.

5. CONCLUSIONS

This work clearly demonstrates the potential for effective discrimination between leaves and woody trunk and branch stems with a dual-wavelength terrestrial lidar scanner. We also demonstrate the ability of the DWEL to scan effectively and provide data that can be converted to point cloud format and registered to the heritage EVI instrument. The DWEL is now scanning in the laboratory with both lasers and meeting its benchmarks for first full field trials in the June 2013 time frame. We anticipate showing new dual-wavelength scans and point clouds, taken from hardwood and conifer stands, in July at IGARSS13.

6. ACKNOWLEDGEMENTS

This research was supported by NASA under grants NNG06GI92G and NNX08AE94A and NSF under grant MRI-0923389.

7. REFERENCES

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