Measuring vegetation structure with airborne laser altimetry

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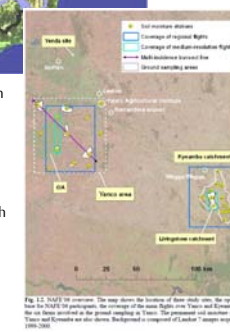
Objectives

Determining the structure of vegetation on a site is important for a range of environmental applications including better modelling the water and energy budgets, and better accounting for the effects of vegetation on remotely-sensed observations, allowing us to "see" the soil beneath. Getting such information manually can be a labour-intensive task, even for small areas. If a means could be found to extract vegetation characteristics from airborne laser altimetry, soil moisture retrievals from satellite could be improved.

The study area – the Yanco area within the Murrumbidgee catchment. Data acquired as part of The University of Melbourne's National Airborne Field Experiment in 2006 is being analysed. Three 17km flights acquiring laser altimetry were carried out along the purple diagonal through the area. Each of the 200 million measurements includes a light curve showing when light is returned from a single pulse.



We are attempting to develop ways to interpret the returns from airborne laser altimetry systems to extract information on vegetation structure. We are examining two types of observations, first-return data where only the height where laser light is first returned is recorded, and full profile data, where the entire returned light curve is recorded, which may include reflections from leaves within the vegetation canopy and the ground. By analysing the full return data, we hope to be able to interpret the vast amount of first return data around the world more usefully.

This main image is rendered from first return points, approximately 1% of the total acquired.

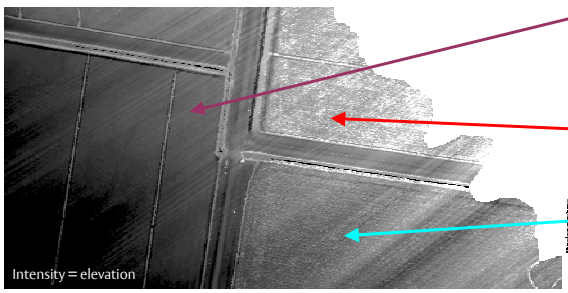
First significant return data

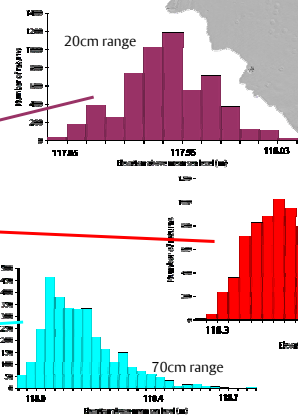
The most common form of laser altimetry data, where for each laser pulse emitted, only the first time a significant amount of light is returned to the instrument is recorded, building up a cloud of x,y,z points

The first significant return from laser pulses incident on this tree were isolated and their elevations histogrammed...

About 35% of the pulses make it all the way to the ground, which means that the distribution of returns above ground can be used to derive structural information. In this case, the aerial photography and shadow can give us information useful in interpreting the laser altimetry data.

Below are the distributions of returns for three differently planted crop fields.





The three fields show different distributions of height returns for different cover types – short grass seems to show a narrow 20cm height range, where taller crops show more range.

Full return profile data – returns from a tree canopy

The complete light curves returning from each laser pulse provide extra information – individual pulses can be incident on a number of parts of the structure and the ground. Above, a random sample of pulses returned from a tree show multiple reflections.

The future

The idea of using single-return laser altimetry to determine vegetation structure is not new (eg. ref below), but our intent is to study the complete light profiles and how they relate to the first significant return observations to enable us to better interpret first returns as a way of extracting information, in combination with multispectral data.

C.J. Houldcroft, C.L. Campbell, I.J. Davenport, R.J. Gurney, N. Holden, 2005, Measurement of Canopy Geometry Characteristics using LiDAR Laser Altimetry: a Feasibility Study, IEEE Transactions on Geoscience and Remote Sensing, **43** (10), 2270-2282

Conclusions

The light returned from laser pulses incident on a range of cover types is reflected from both the ground and the vegetation, so there is information within the observations on the vegetation structure below the top surface of the vegetation. Multispectral data often cannot see below the top layer because of the physical obstruction of direct light, and the reduced solar illumination, however laser altimetry may be able to provide a more comprehensive idea of plant structure This would improve our ability to account for the effects of vegetation upon satellite-based passive microwave observations, and allow improved estimates of soil moisture and snow mass.

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