BEYOND POINT CLOUDS IN FOREST APPLICATION USING AIRBORNE LASER, TERRESTRIAL LASER, AND STRUCTURE MOTION

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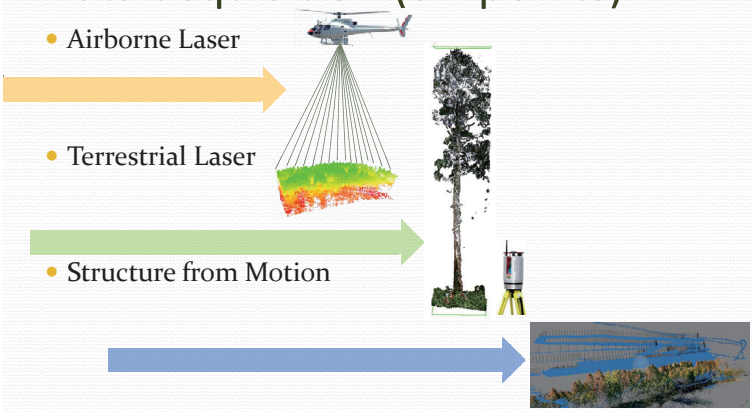
Data acquisition (3D points)

- Airborne Laser
- Terrestrial Laser
- Structure from Motion



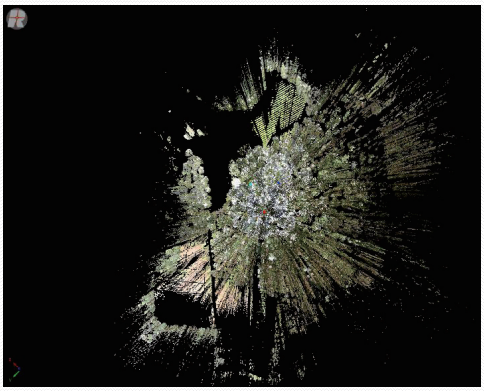
Why it matters? (Forest Monitoring)

International issue
Carbon trading
- REDD (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) framework

MRV(Measuring, Reporting, and Verification)
mainly uses Landsat satellite images (free archive from USGS website)
widely accessible data is required to monitor forest area. But the standard scheme has not been established yet. Top level negotiation is still going on among the related countries.

Google Earth Engine

Terrestrial Laser Scanner (TLS)



Laser sensor	Riegl VZ-400
Laser wavelength Max range	Near Infrared Red 600 m (360° x 100°)
Laser point density range	125,000 points/second (high speed mode) 42,000 points/second (long distance mode)

5

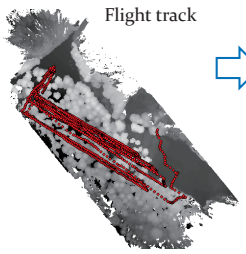
Field validation

- Limited measurement (tree height, DBH)
- Limited samples
- Accuracy

UAV-SfM (Structure from Motion)

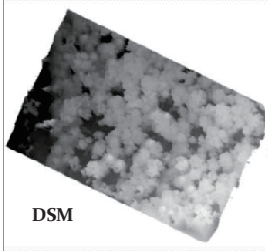
UAV:
DJI Phantom 2

Flight track

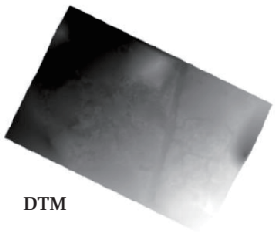


Point cloud

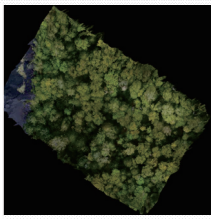
SfM - Agisoft Photoscan Professional



DSM



DTM



Orthophoto

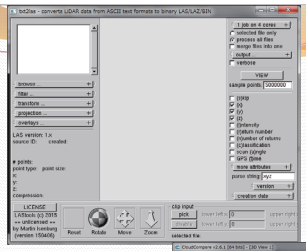
Beyond point cloud
- appication using TLS -

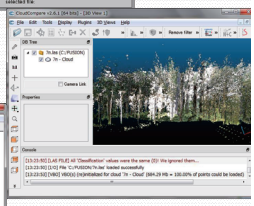
1. Data comparison
2. Data acquisition
3. Ecological study
4. Radar analysis

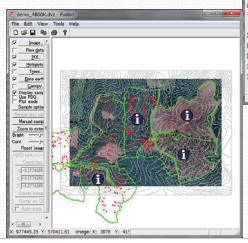
Data Analysis

- 3D data analysis

1. Lastools
2. Cloud Compare
3. FUSION
4. rLiDAR
5. WebLiDAR



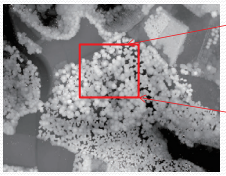




1. Data comparison

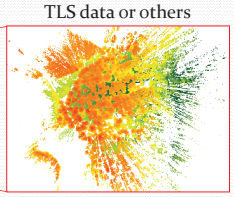
Data Processing - fusion

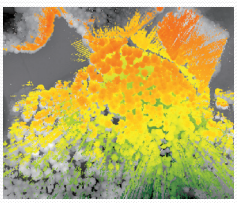
Airborne laser data



3D rotation
rotated to fit to the
referenced data

TLS data or others

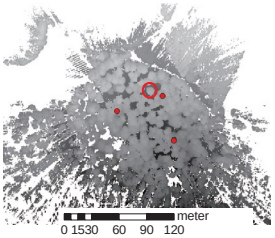




Data fusion between
two different dataset

ALS vs. TLS

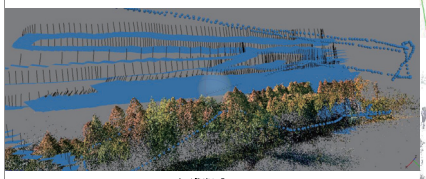
Laser sensor wavelength	RIEGL VZ400 1550 nm
mrad	0.35 mrad
max distance	600 m
angle	100° （+60° / -40° ）

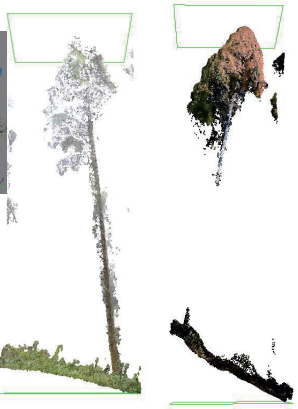


Airborne laser

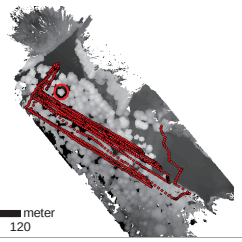
RIEGL TLS

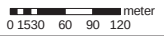
TLS vs. SfM





Agisoft
PhotoScan
Professional





3. Ecological study

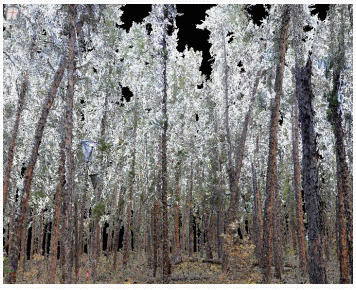
2. Data acquisition

Terrestrial Laser

- In Sept. 2014 and Sept. 2015, 3D data is acquired for our study site.

Quaking Aspen (*Populus tremuloides*)

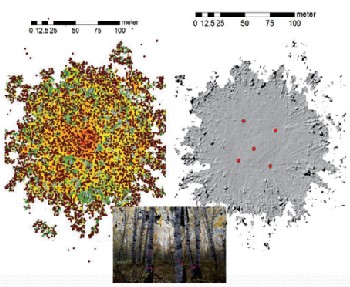
Jack Pine (*Pinus banksiana*)



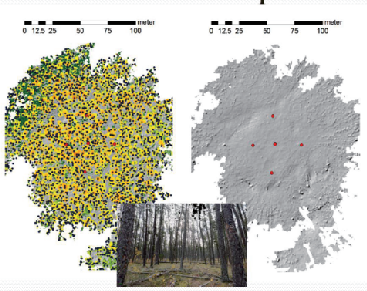
Quadcopter vs. Fixed wing

Stem location and DTM

Quaking Aspen 25m plot



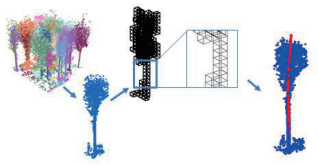
Jack Pine 25m plot

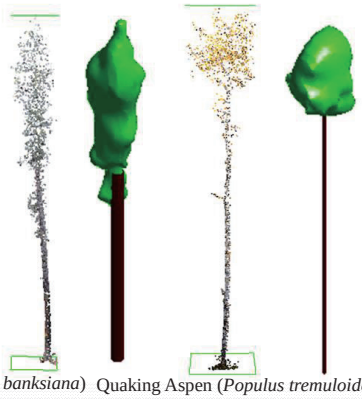


Crown structure

- Wrapping method

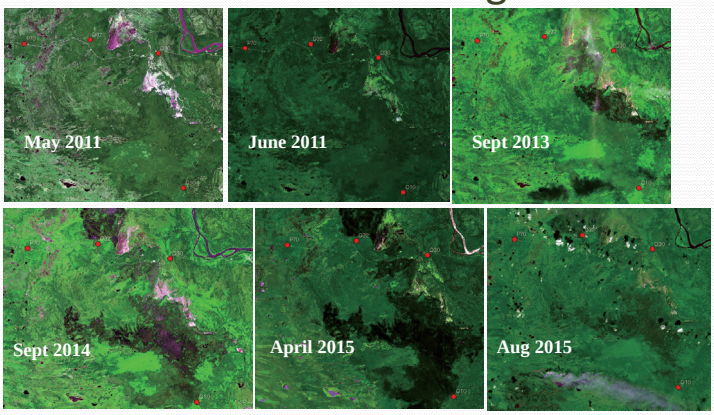
(Kato. et al, 2009, RSE)



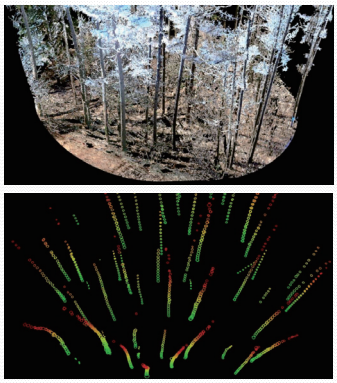


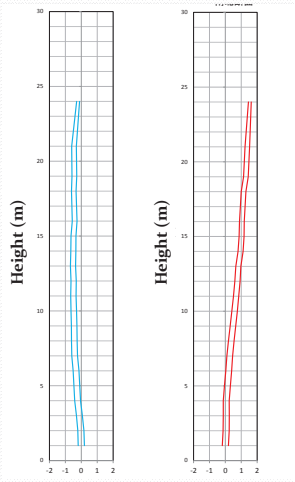
Jack Pine (*Pinus banksiana*) Quaking Aspen (*Populus tremuloides*)

Forest disaster – forest fire
Landsat time series images

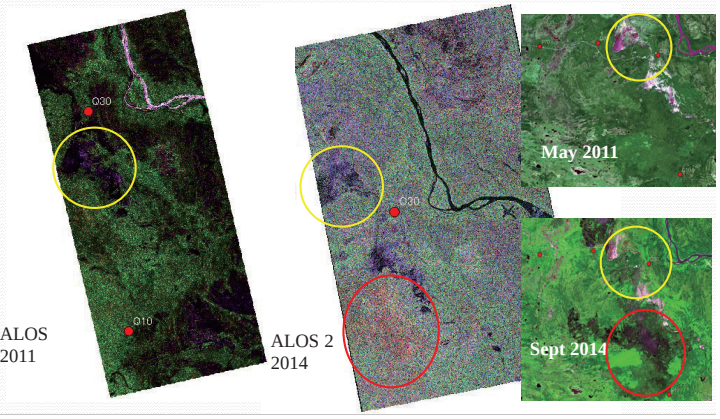


Stem structure



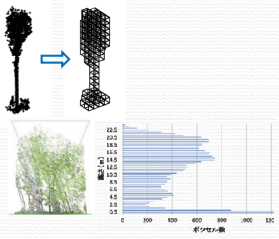


Species classification and forest fire
R: HH G:(1/2)(HV + VH) B: VV



4. Radar analysis

Terrestrial laser vs. radar image



Regression analysis

$$\ln(\mathrm{abs}(\sigma_{0,\,HV})) = \ln\beta_0 + \beta_1\ln h_{10} + \beta_2\ln h_{20} + \beta_3\ln h_{30} + \beta_4\ln h_{40} + \beta_5\ln h_{50} + \beta_6\ln h_{60} + \beta_7\ln h_{70} + \beta_8\ln h_{80} + \beta_9\ln h_{90} + \beta_{10}\ln(Slope) + \beta_{11}\ln(Aspect)$$

Result

- 80^{th} percentile height has $p < 0.05$
- 70^{th} percentile height has $p < 0.01$
- 50^{th} percentile height has $p < 0.1$

→ Canopy scattering

- 10^{th} percentile height has $p < 0.1$
- slope has $p < 0.01$

→ Terrain condition

Conclusion

Canopy descriptor

- TLS and UAV-SfM can provide the better tree canopy structure data than airborne laser data.
- UAV-SfM only covers the upper portion of canopy.
- UAV-SfM and TLS data fusion can locate TLS scanning position accurately.
- UAV-SfM is simple & low cost to provide good quality of 3D data for tree structure.

Radar backscattering descriptor

- Canopy structure can be obtained by UAV to cover the large area and to provide 3D data. This ground truth 3D data can describe more about the detail backscattering mechanism.

UAV-SfM and TLS data fusion is the best to collect field data efficiently.

Thank you very much.
Any questions?

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