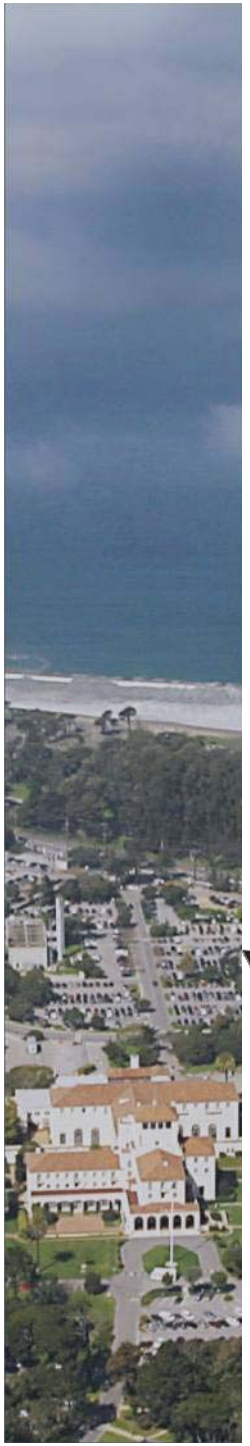


Visualization and analysis of LiDAR waveform data

Richard C. Olsen
Jeremy P. Metcalf

Remote Sensing Center
Naval Postgraduate School
Monterey, CA, USA

SPIE DSS ◆ 9 – 13 April 2017 ◆ Anaheim, CA

Introduction

- Goal:
  - Explore LiDAR waveform data using techniques previously applied to spectral imagery.

- Background:
  - Limited work with waveform data in the existing literature. Discussion seems to have started ~2003 by Wagner (Univ of Vienna)
  - Data have been hard to come by, data formats not defined*, software not available.
  - Existing work mostly focuses on Gaussian fitting or taking moments of waveform distributions. Innovative approach by UT using Voxels.
  - Bathymetry community excluded here – techniques there strongly focused on that application.

  * Thank you to Andre Jalobeanu for breaking the code..

Sensor

Teledyne Optech Titan Multispectral Lidar System

- 3 Channel
  - Channel 1: 1550 nm SWIR – 3.5° forward tilt
  - Channel 2: 1064 nm NIR – 0° forward tilt
  - Channel 3: 532 nm VIS – 7° forward tilt

- Programmable Pulse Repetition Frequency
  - 50 – 300 kHz (per channel); 900 kHz total
  - Operated for NPS by NCALM on June 5, 2016
  - Limited to 100 kHz/channel by waveform collection

Flight – Parameters

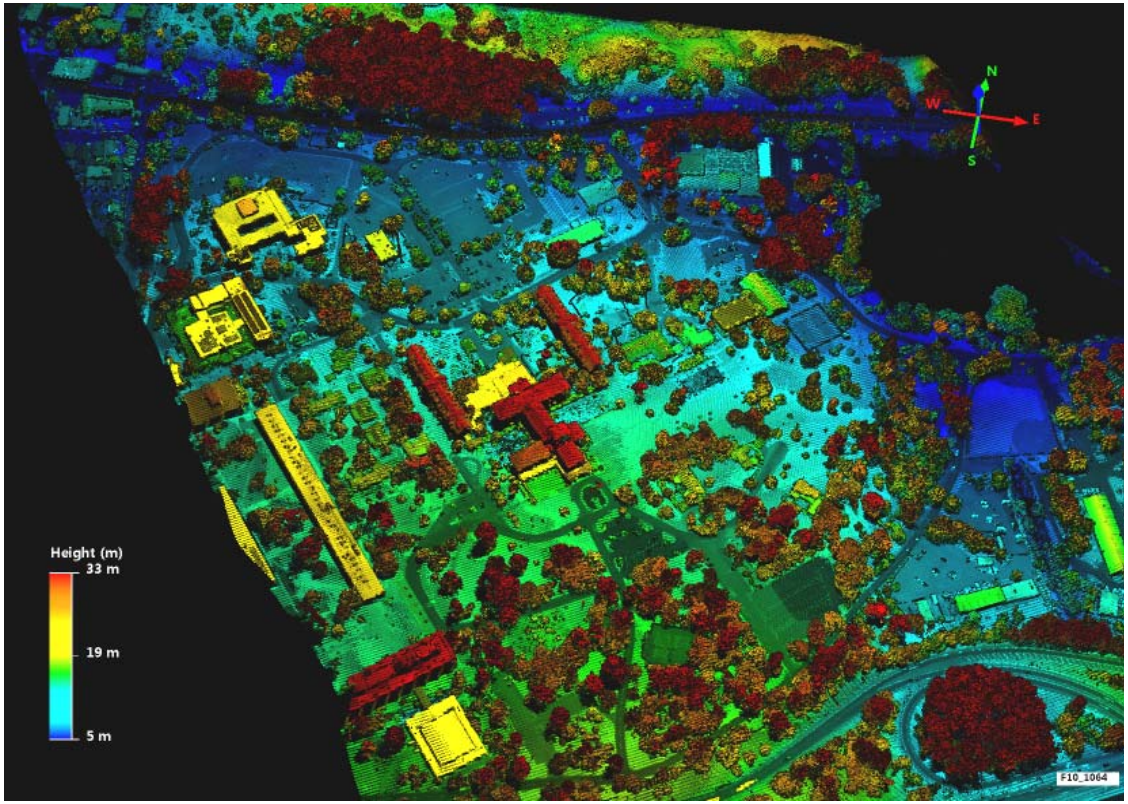
Parameter	**Value**
PRF (per channel)	100 KHz
Field of view	30º
Scan Frequency	40 Hz
Altitude	~ 400 m
Speed	~ 150 knots
Point Spacing (DT/CT)	0.10 m/0.96 m
Point Density	12 points/m^2 (discrete data)

The Software issue

- There seemed to be a disconnect between the data, data format, software, and platform (Windows, Unix…)
- Analysis done with data in PulseWaves format (Martin Isenburg, rapidlasso)
- Interactive Data Language (IDL) used to read in and re-arrange the data so that ENVI could be used.

NPS Campus

- Point cloud display of study area.
- NPS campus – height elevation model
- QTM software



2-color display

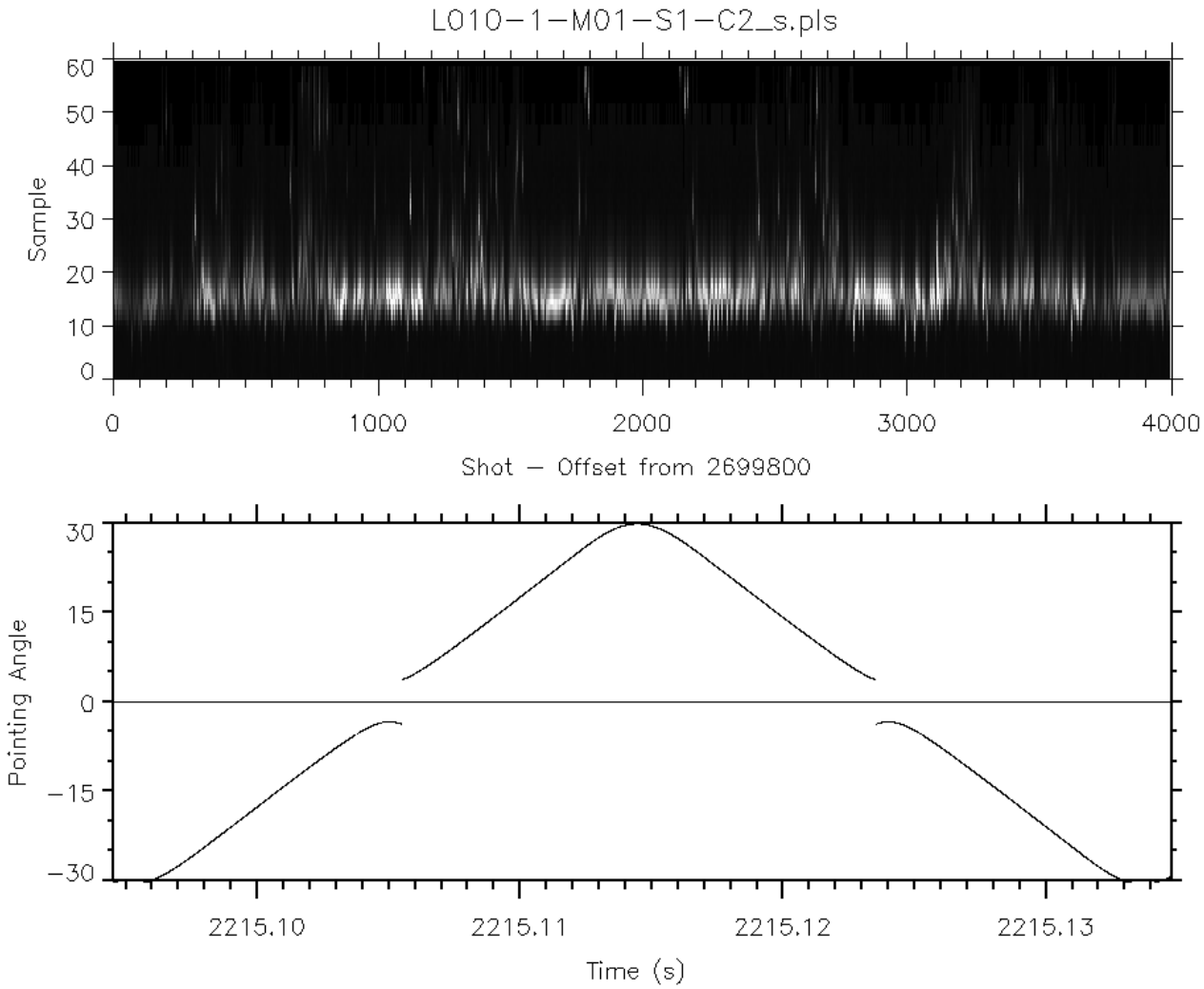
Flight line 10

Channels 2&3

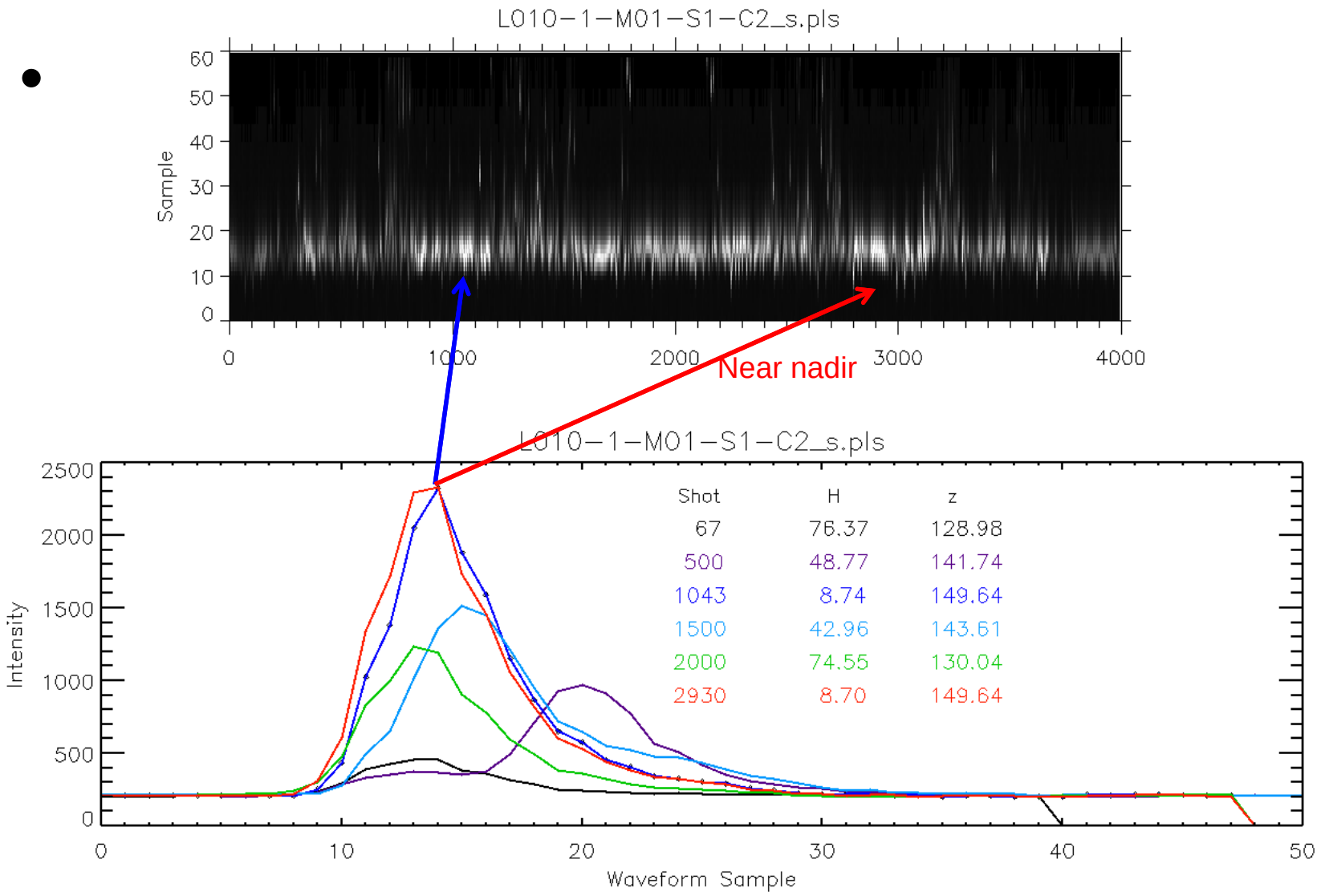
1064/532 nm

Some spectral variability – see McIver paper

Waveform Data Waterfall Display



Waveform Data Waterfall Display



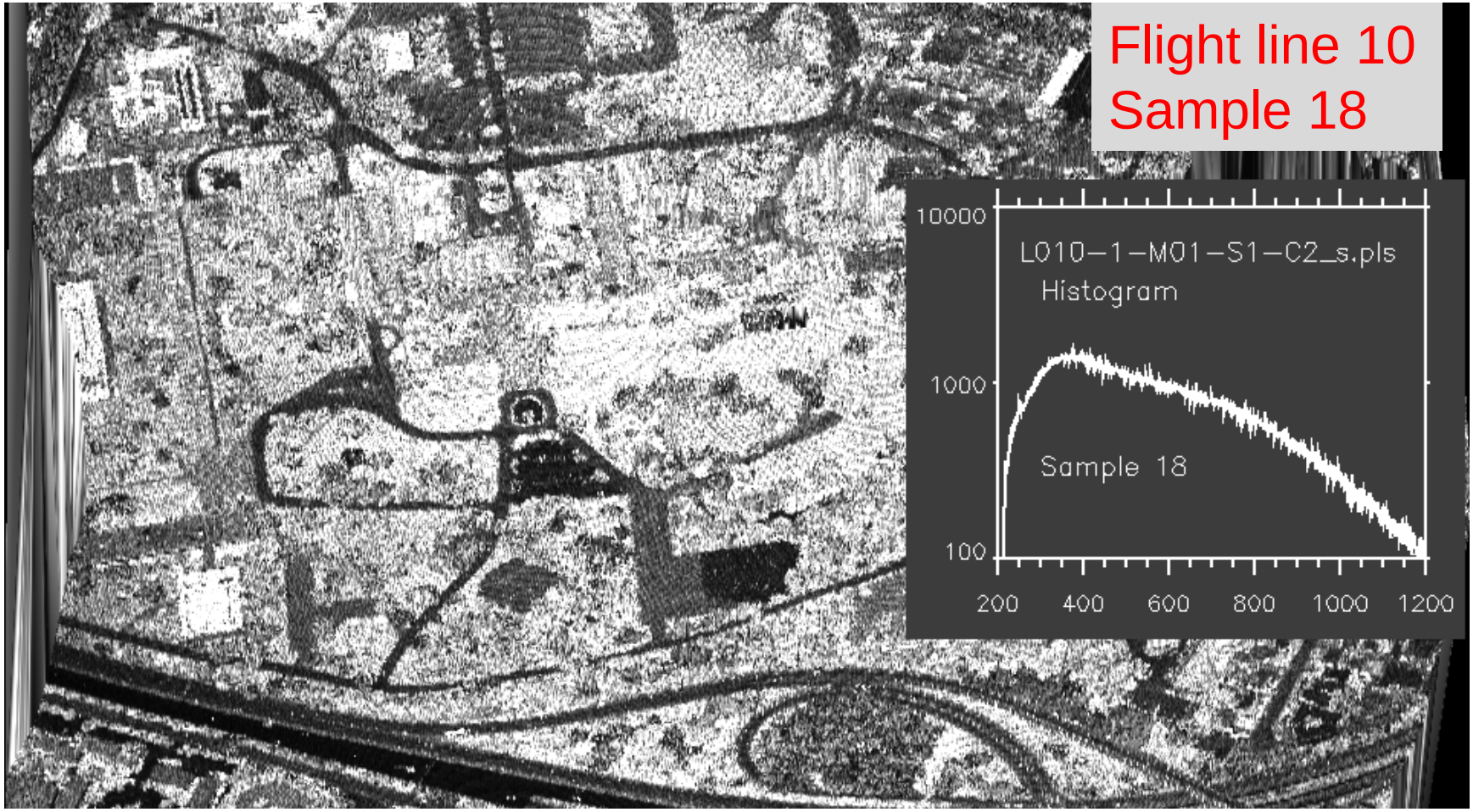
Programming

- Data were read in, gridded at ~1 point/cell using “target” xy information.
  - *An interim solution to the display problem – need to write smarter display approach that maintains full vector quality of the data.*
- Available parameters include an ‘intensity’ parameter which can be used to compare the two channels.
- Reflectance contrast between buildings and vegetation is much greater at 532 nm.

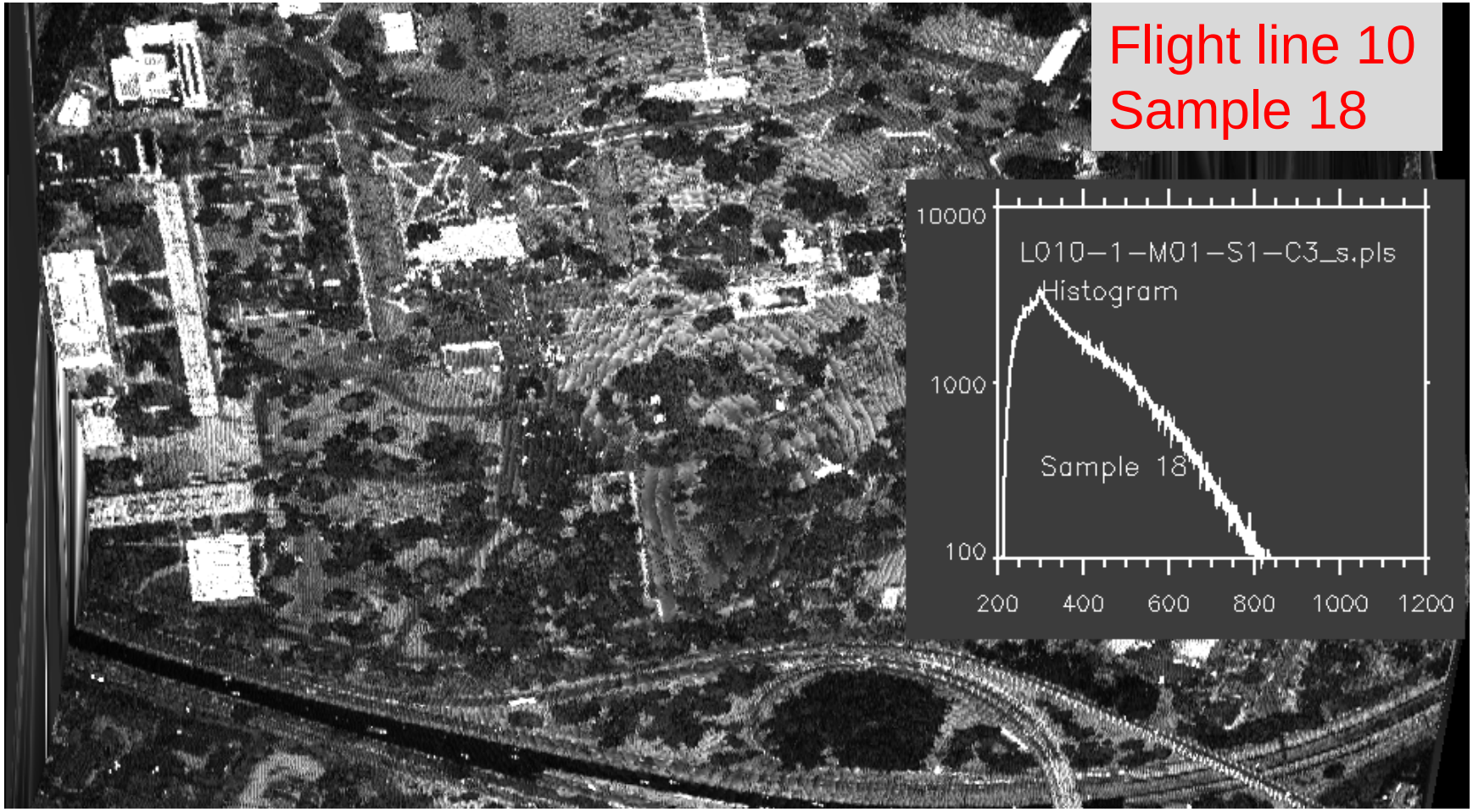
Intensity, 1064 nm

Intensity, 532 nm

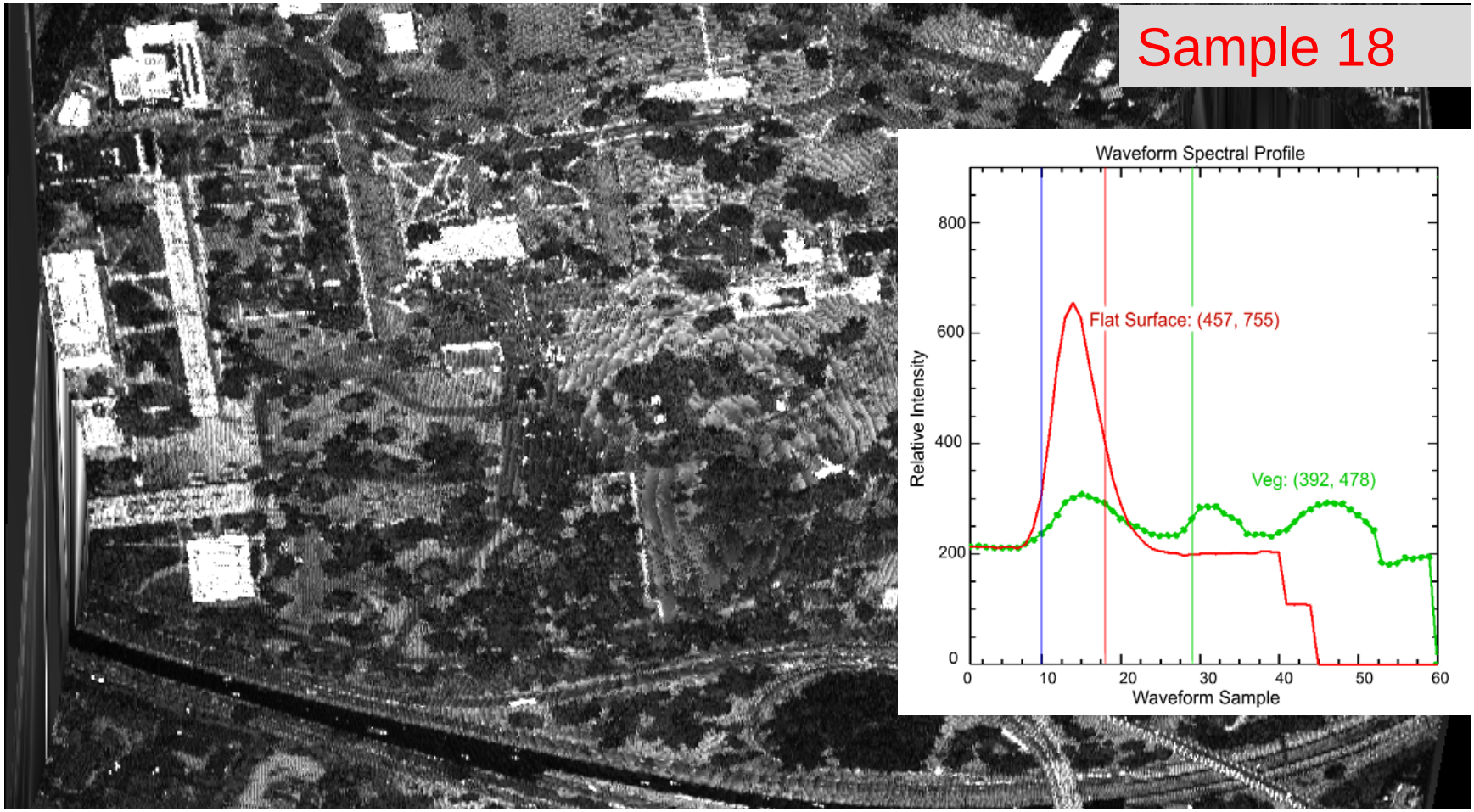
C2 Waveform Samples



C3 Waveform Samples

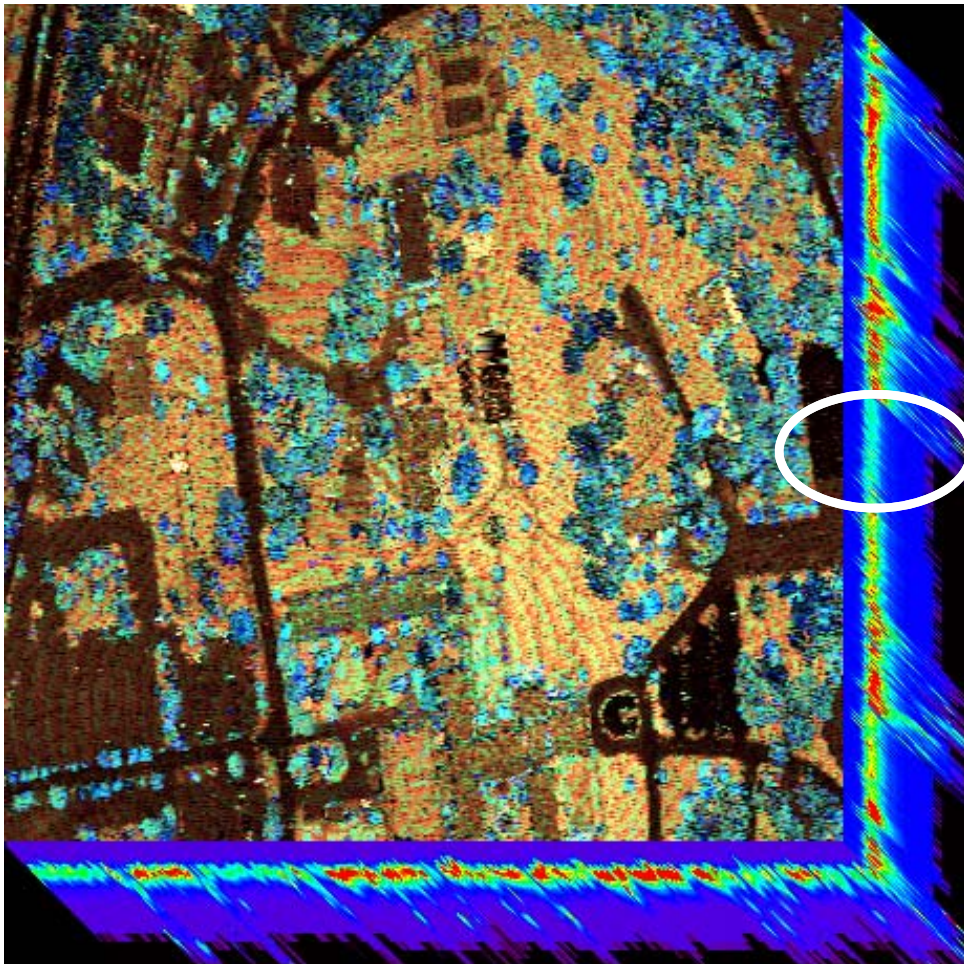


C3 Waveform Samples



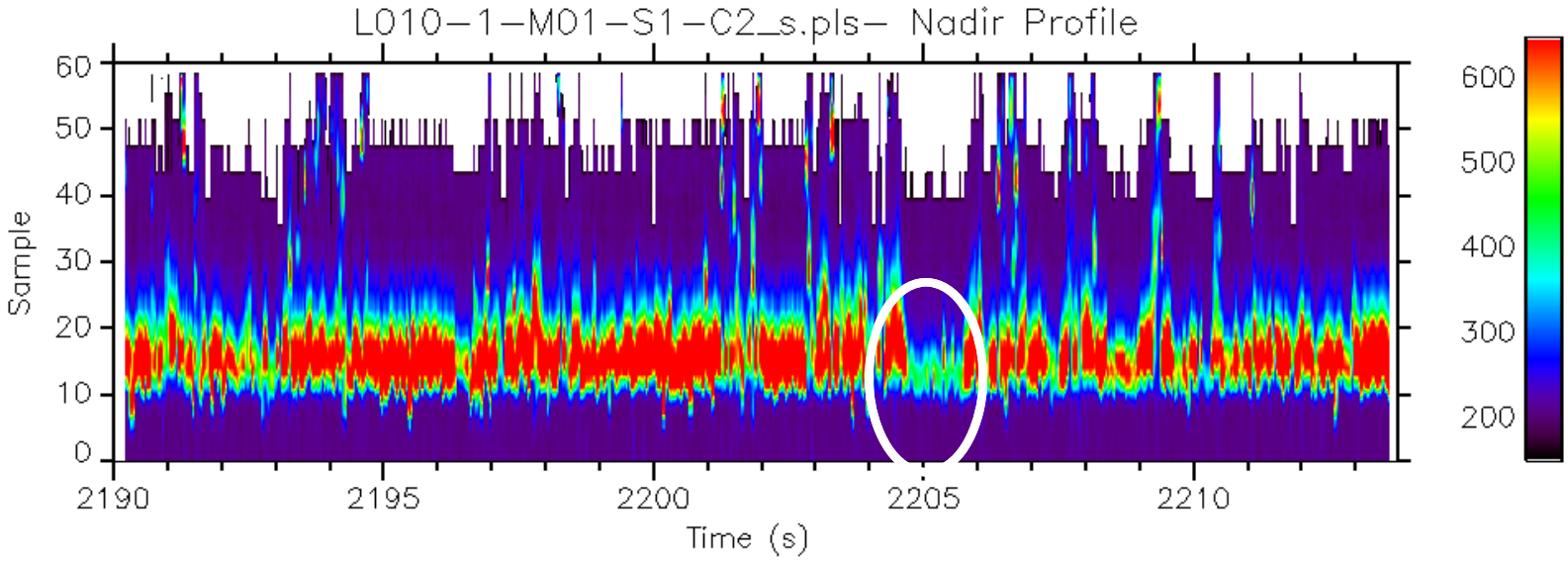
Hypercube

- Spectral Samples, 1032 nm
- R:15
- G:20
- B:25



Spectral Profile

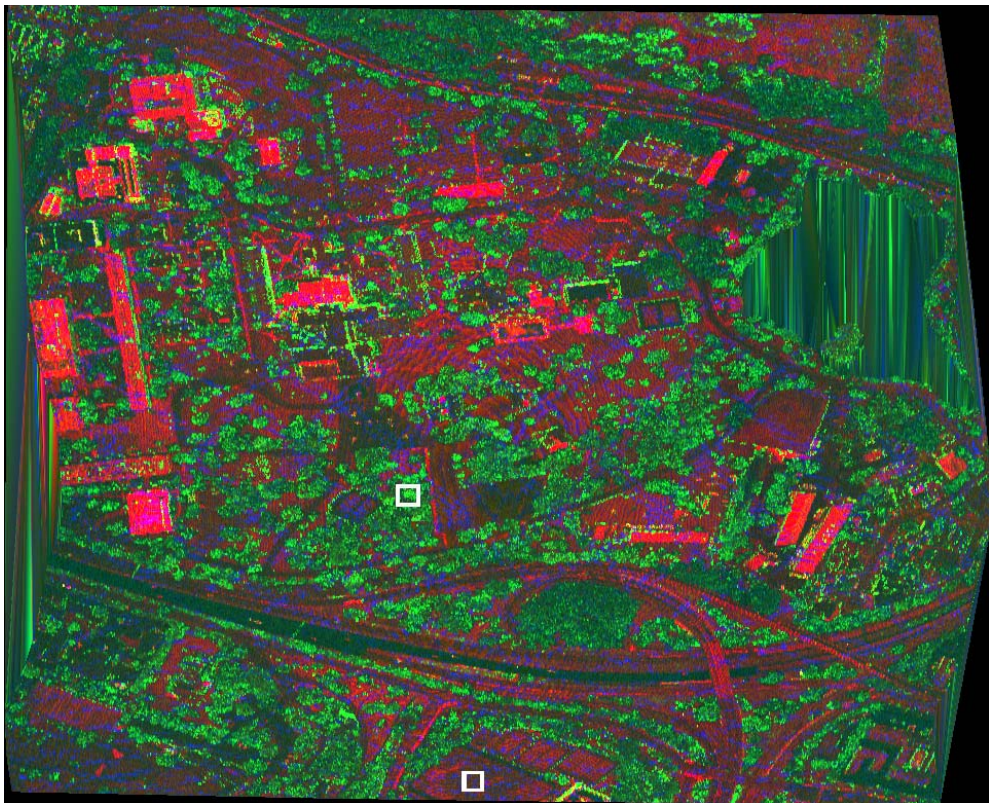
- Nadir track, 1032 nm



Parking Lot (Asphalt)

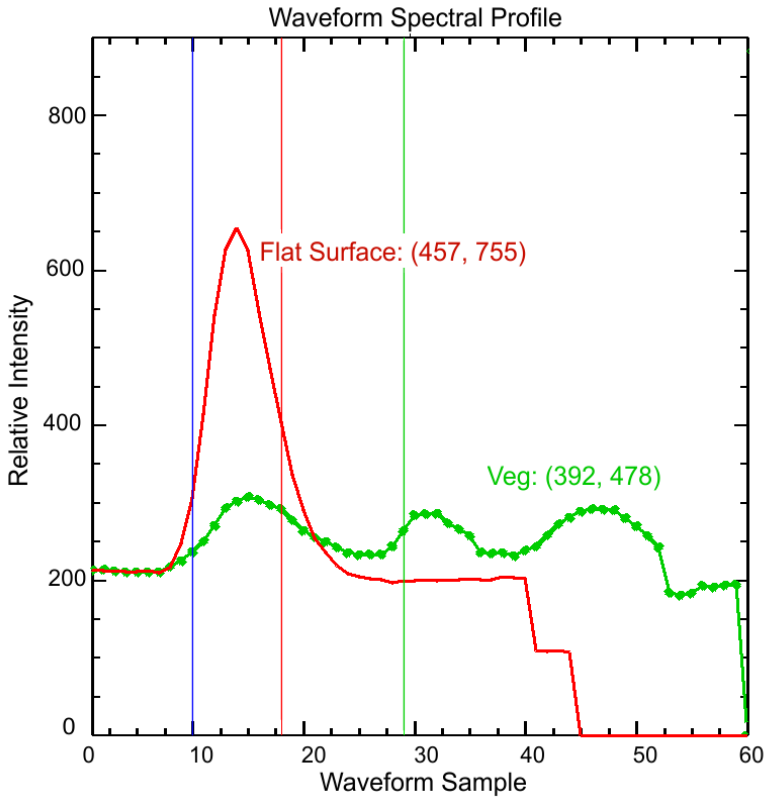
C3 532 nm
R:18, G:29, B:10.

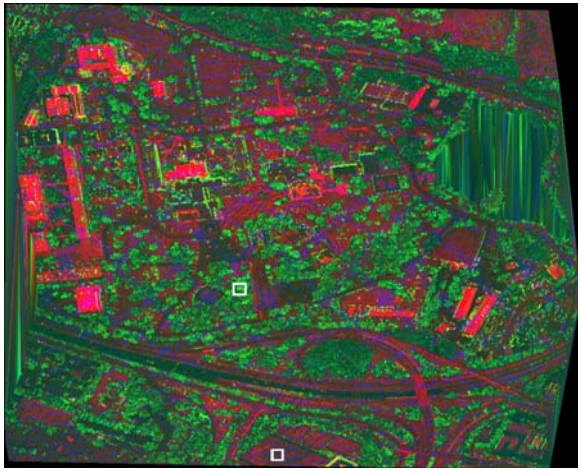
- RGB representation of waveforms, C3



C3 532 nm
R:18, G:29, B:10.

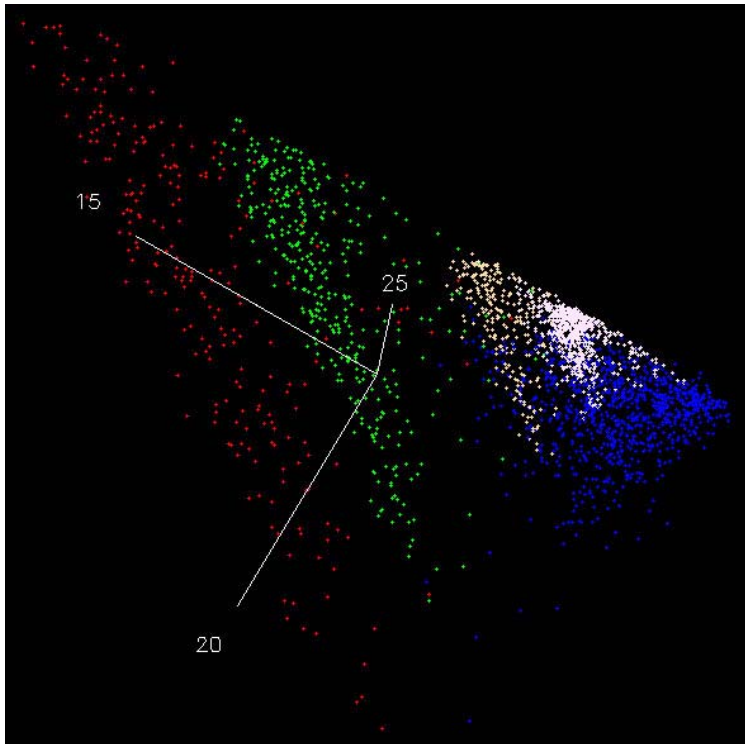
- RGB representation of waveforms, C3

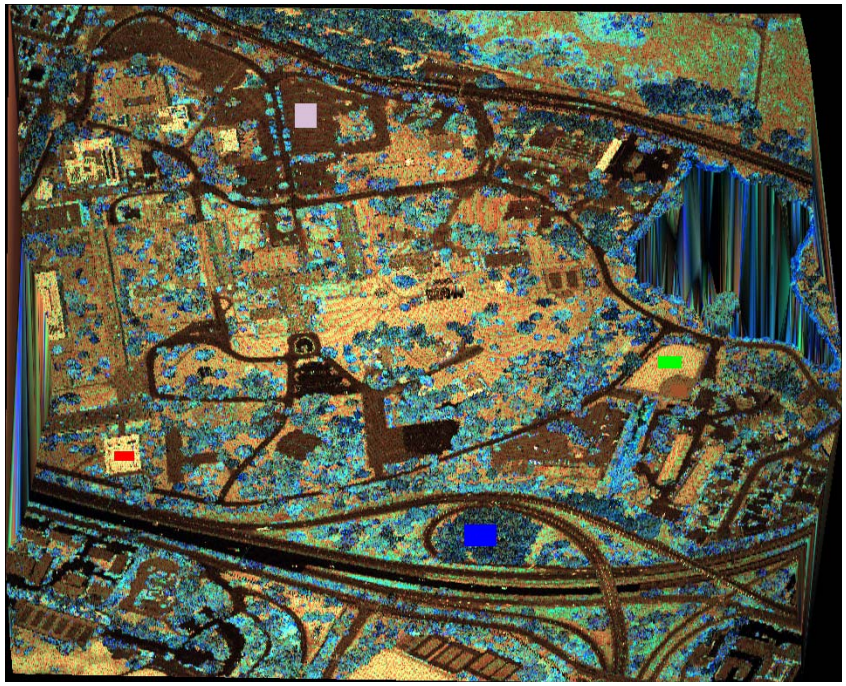




N-Dimensional Visualizer

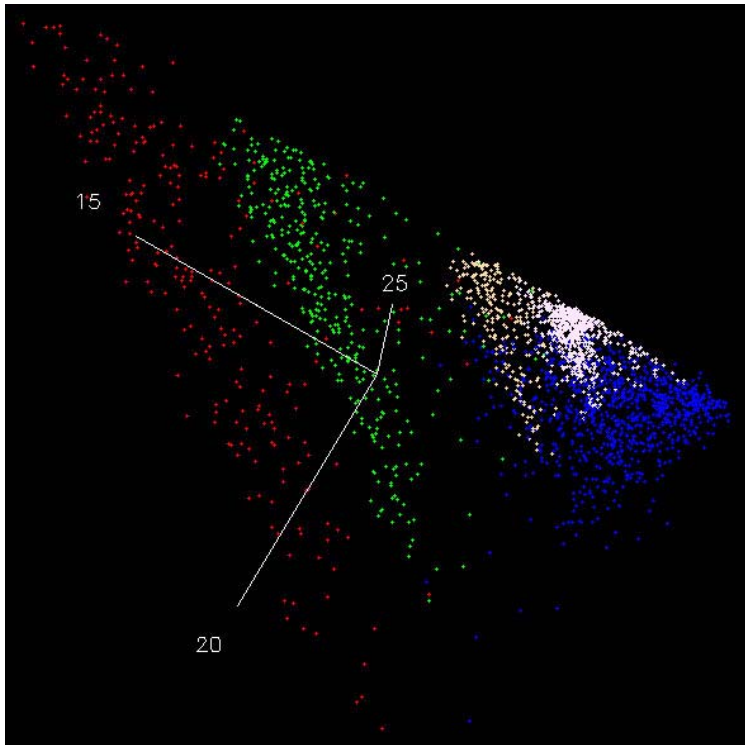
- C2

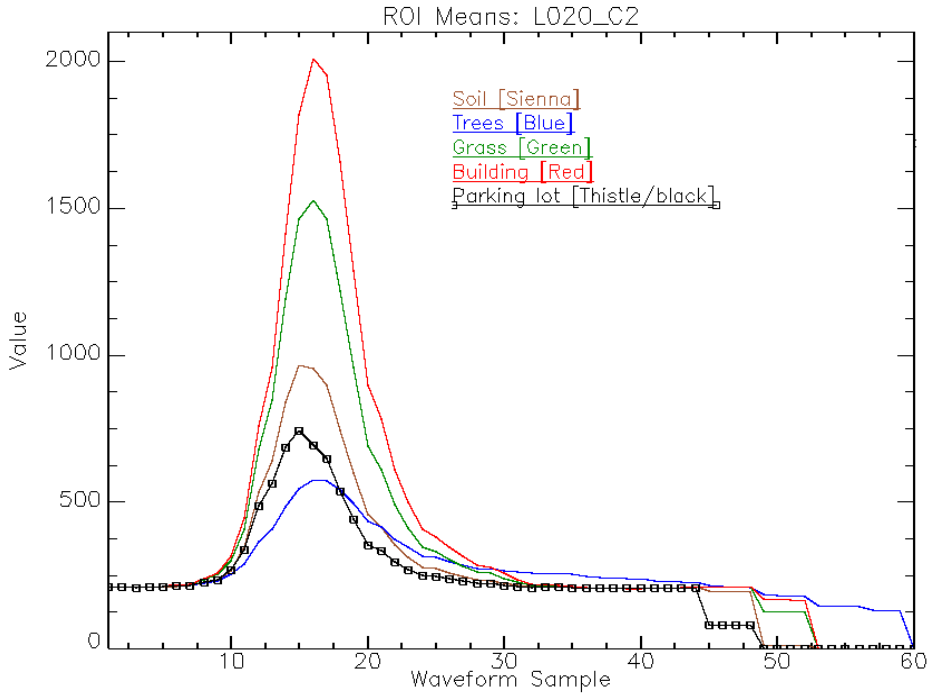




N-Dimensional Visualize

- C2.



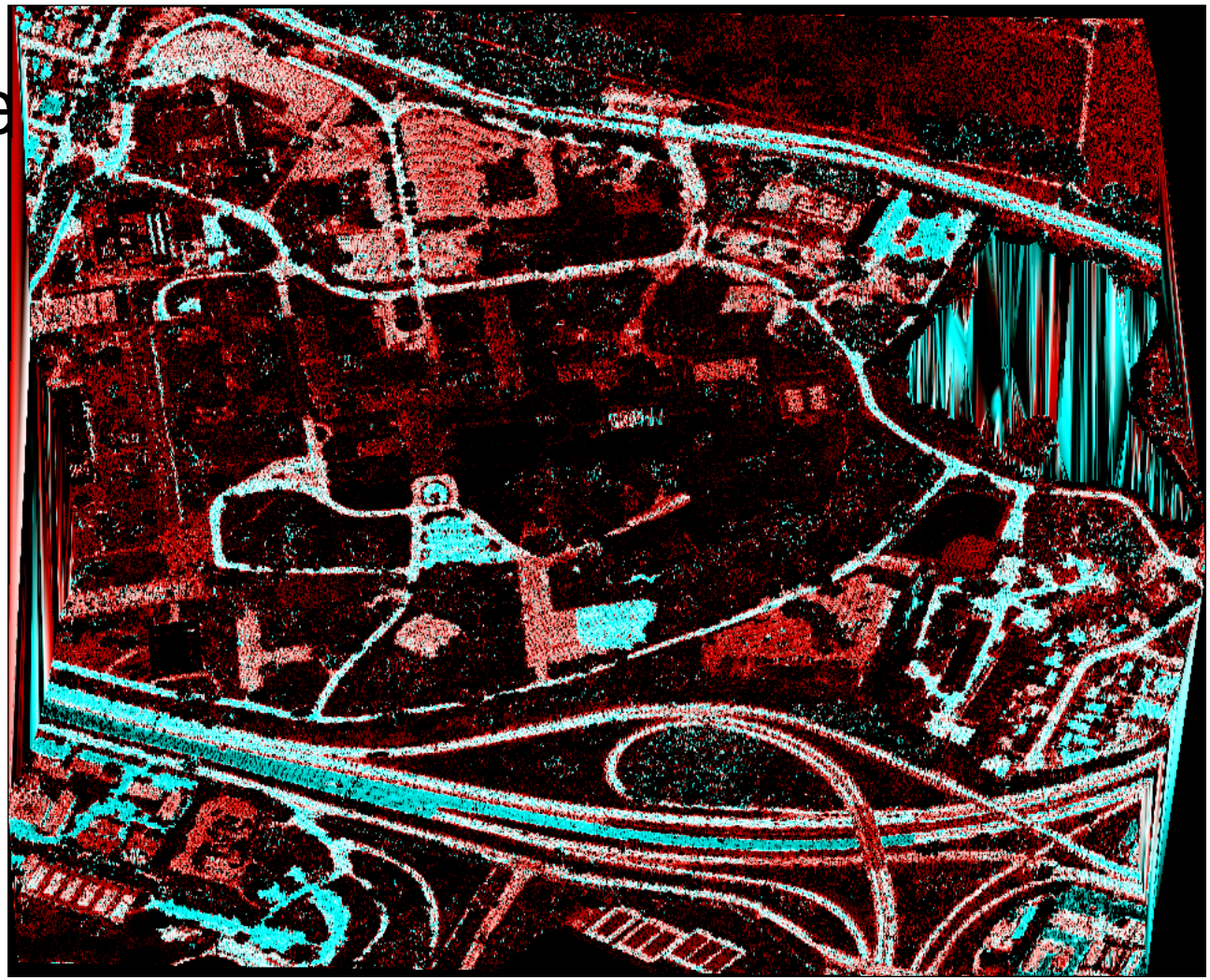


Classification

- The idea here is to use the spectral classification tools available for analysis.
- A quick run with a maximum likelihood classifier was unproductive.
- The more primitive spectral angle mapper had some limited success, as illustrated next.
  - Two classes of asphalt, which the n-D visualizer separated, did classify different regions in the scene

Classifcation

- Spe



Conclusion

- Waveform data have been transformed into x, y, and a waveform spectral dimension analogous to that found in hyperspectral data.
- The display of waveform data in an RGB triple display shows clear distinctions between scene elements.
- A simple classification run showed some success in identifying different asphalt types. (recent result – need to go study in-situ).
- Work to do:
  - Transition to a vector based display approach that does not require gridding the data
  - Study classifiers appropriate to the data
  - Review impact of radiometric correction
  - Compare the two wavelengths
  - Study forest data (Point Lobos)
  - Review data from different systems (Riegl, AHAB, Leica)

For More Information Please Contact:

Richard Olsen

olsen@nps.edu