A single photon lidar system for vegetation analysis

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With thanks to John Armston[4] & Weyerhaeuser Company

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Carbon Monitoring System

- Biomass assessment and change
- Ecologically meaningful scales
- Relevant for forest management
- Method developed for local sites
  - Transferability to larger areas

- Partners including:
  - NASA Goddard Space Flight Center
  - University of Maryland
  - Sigma Space Corporation
  - US Forestry Service

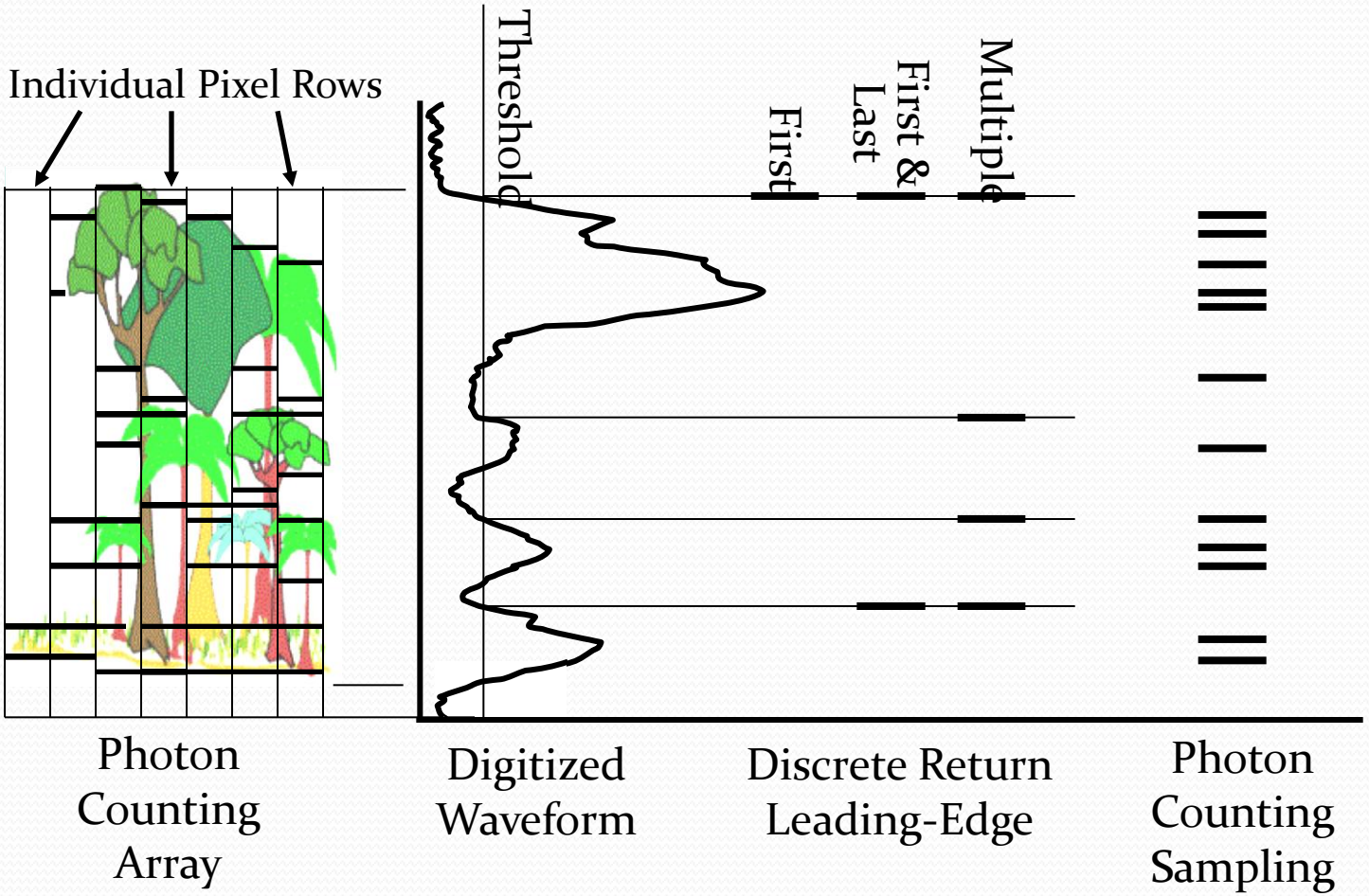
Context

- Emerging technology
  - Photon-counting/ single photon lidar
- Lower laser output energy
  - Extended laser lifetime
- Higher altitudes
  - Regional/national scale mapping
  - Reduced cost/ increased frequency
- Green wavelength
  - Technical readiness for space
  - Background solar noise (daytime conditions)
  - Varies with surface reflectivity

Aims

- Improve understanding of interactions of single photon lidar at a green wavelength with vegetation canopy
- Comparability with more conventional airborne lidar systems
- Sensitivity to vegetation biophysical parameters

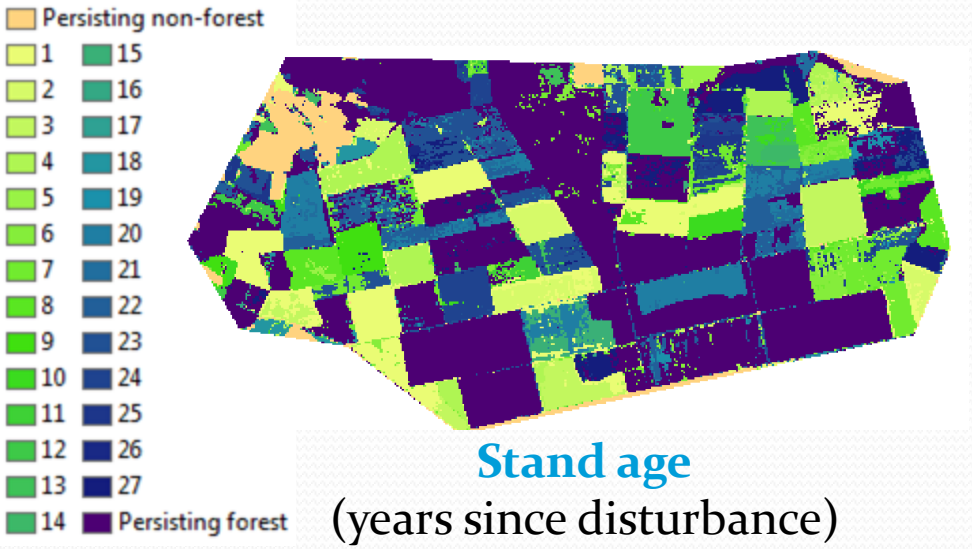
Lidar sensor characteristics



Parker Track, North Carolina, USA

- Commercially-managed
- Loblolly Pine
- Mixed broadleaf stands
- Field campaign
  - Weyerhaeuser Company
  - 7m radius plots
  - Species, DBH > 2.54cm
- Biomass calculations
  - Jenkins (2003, 2004)

Parker Track, North Carolina, USA



Stand age
(years since disturbance)

- Commercially-managed
- Loblolly Pine
- Mixed broadleaf stands
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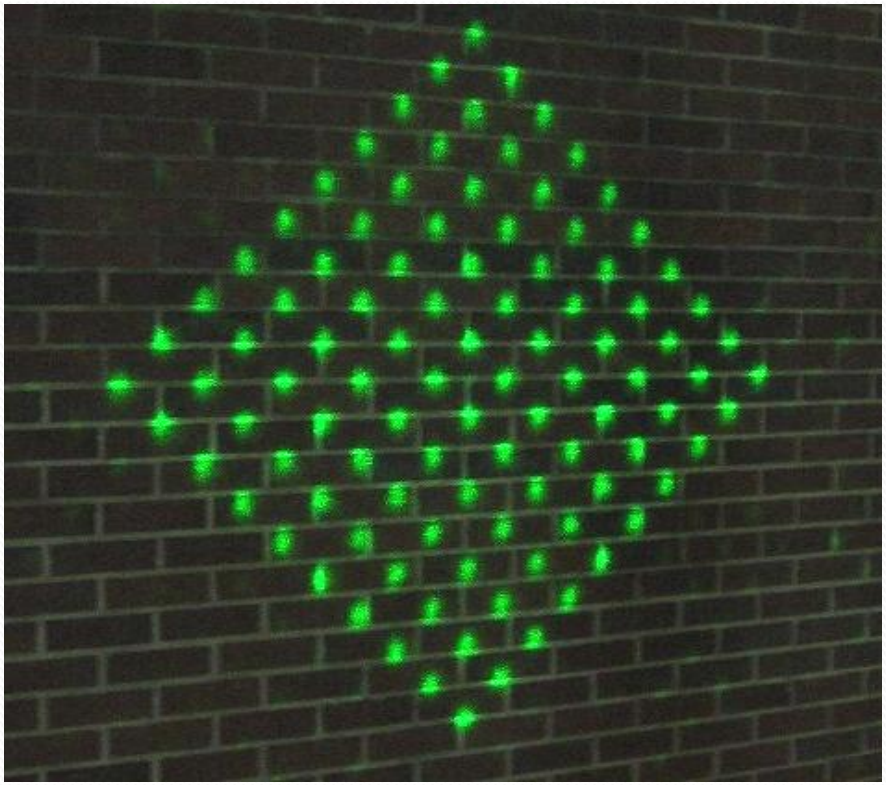
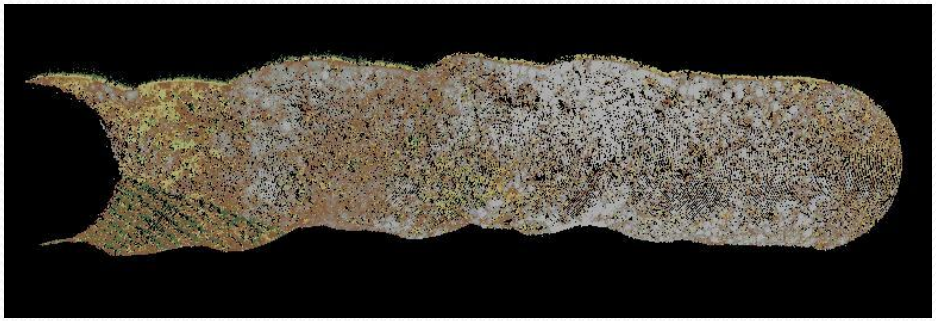
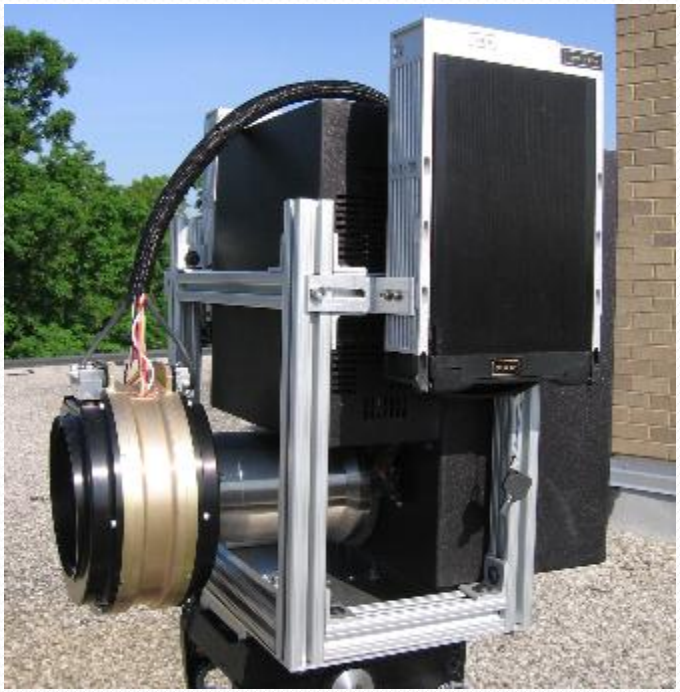
Sigma Space 3D Mapper



- 532 nm pulse
- 710 picosecond pulse width
- High repetition rate
  - 20 kHz
- Split into 100 beamlets
  - 10 x 10 diamond array
  - 50 nJ energy
- System dead time
  - 1.6 ns (22.5 cm)

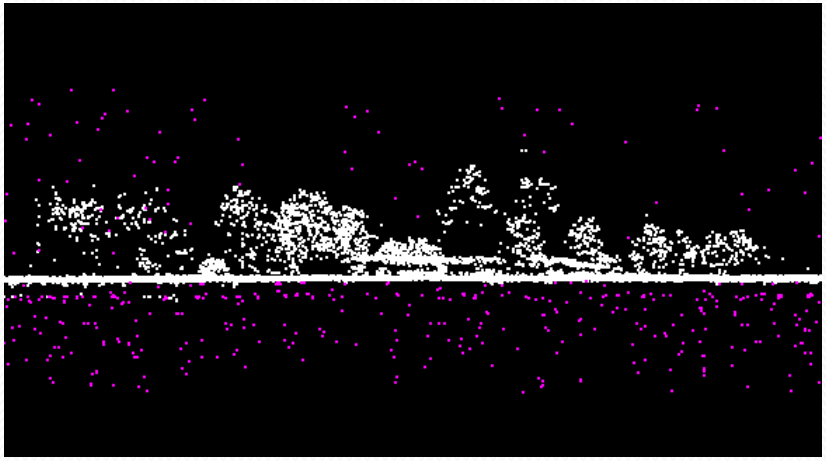
Sigma Space 3D Mapper

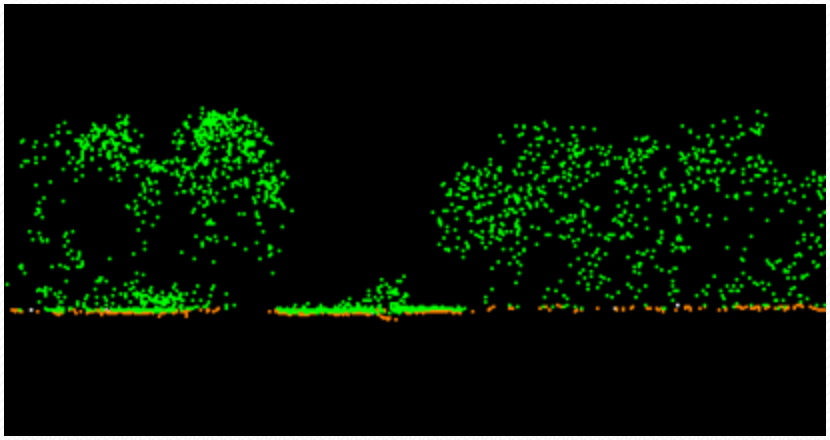




- Parker Track flight campaign
  - October 2010
  - Daylight conditions
- Conical scanning motion
  - Forward and aft looks – two chances to penetrate canopy
  - Constant viewing half angle 9°
  - Correct for pitch & yaw
- Swath width ~230m
- Altitude
  - 610 m
  - Data gaps
- Beamlet footprint diameter
  - 15cm

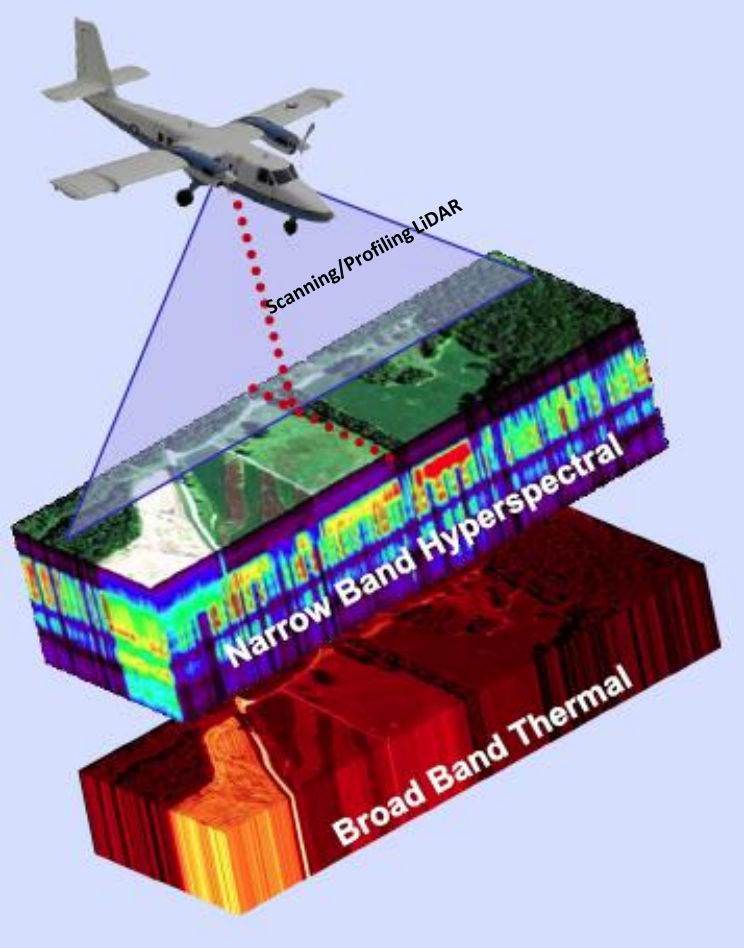
Data processing





- Filter noise photons
  - Identify clustering
  - Isolated points/ below surface
- Treat as conventional lidar
  - Random noise distribution
  - Column of data
- Point classification
- Height percentiles above ground

Goddard Lidar Hyperspectral and Thermal instrument (GLiHT)

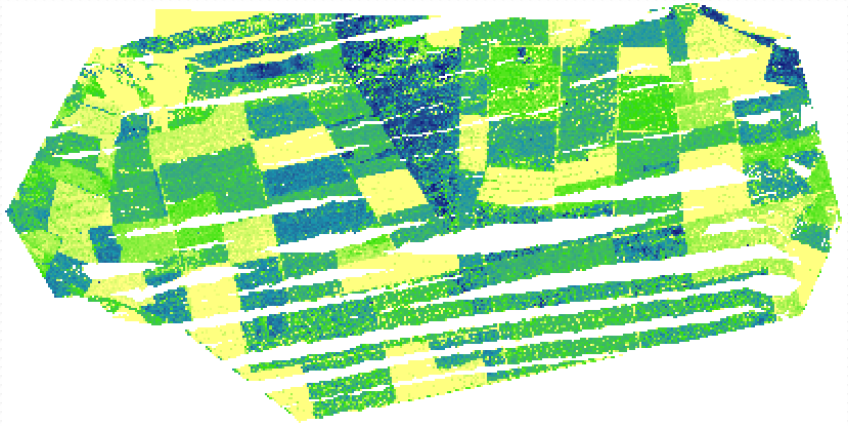


- Parker Track campaign
  - August 2011
- NIR 1550 nm
- Saw-tooth scanning pattern
- Altitude 335m
- Swath width ~ 200m
- Scan angle ± 30°
- Footprint diameter 10cm
- Multiple discrete returns

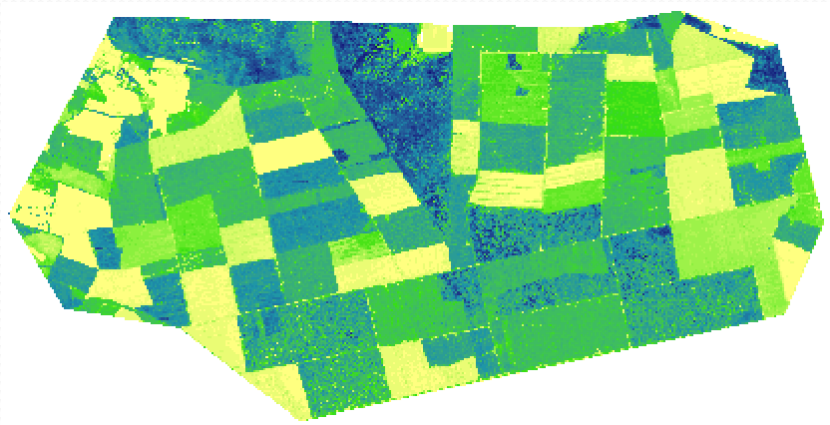
Biomass estimation

Mg/ha
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
100 - 110
110 - 120
120 - 130
130 - 140
140 - 150
150 - 160
160 - 170
170 - 180
180 - 190
190 - 200
200 - 210
210 - 220
220 - 230
230 - 240
240 - 250
250 - 260
260 - 270
270 - 280
280 - 290
290 - 310

Sigma Space PC LiDAR (Autumn 2010)

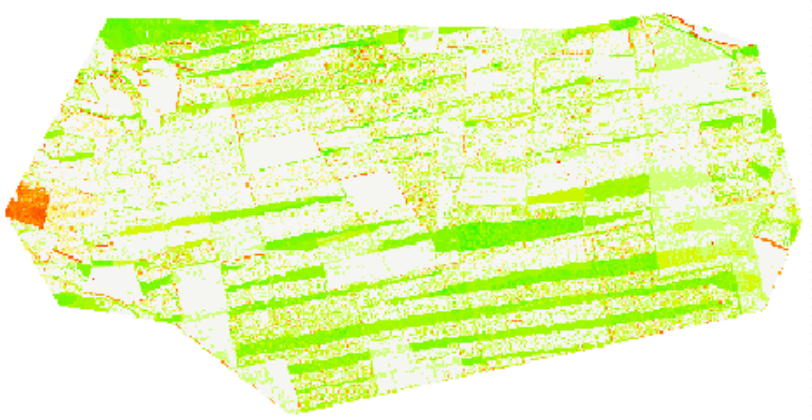


G-LiHT discrete return LiDAR (Summer 2011)

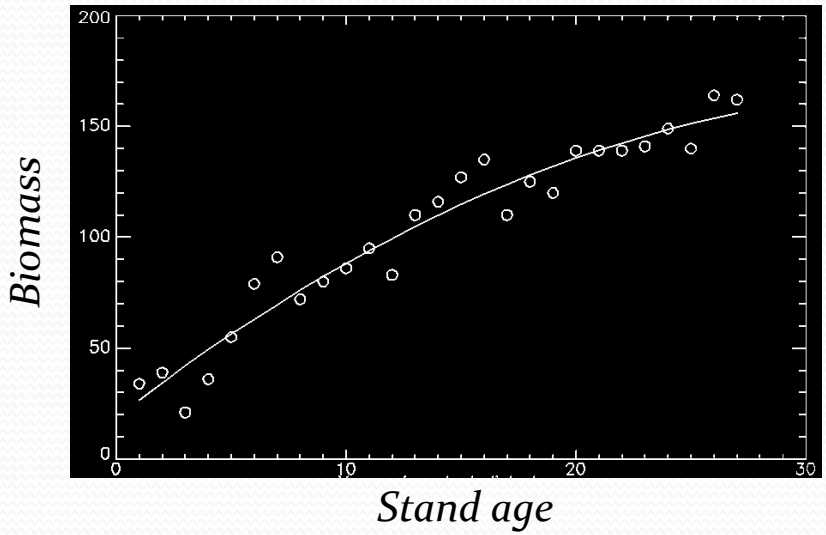


- Regression relationship
  - Assume single class
  - Field plot biomass
  - 95th percentile
- 3D Mapper :
  - R^2 = 0.72
  - SE = 53 Mg/ha
- GLiHT:
  - R^2 = 0.78
  - SE = 47 Mg/ha

Data comparison



- 1 year time difference
- Harvested stand



- Relationships between biomass and stand age
  - Site productivity

Single photon lidar prospects

Opportunities

- Higher altitude
- Laser longevity
- Detector efficiency
- Comparable results
- Technical readiness for space

Challenges

- Ambient noise
  - Classification
  - Rough surface boundaries
  - Performance from space
- Horizontal noise variability
  - Data column
  - Aggregating along-track

Thank you for your attention

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