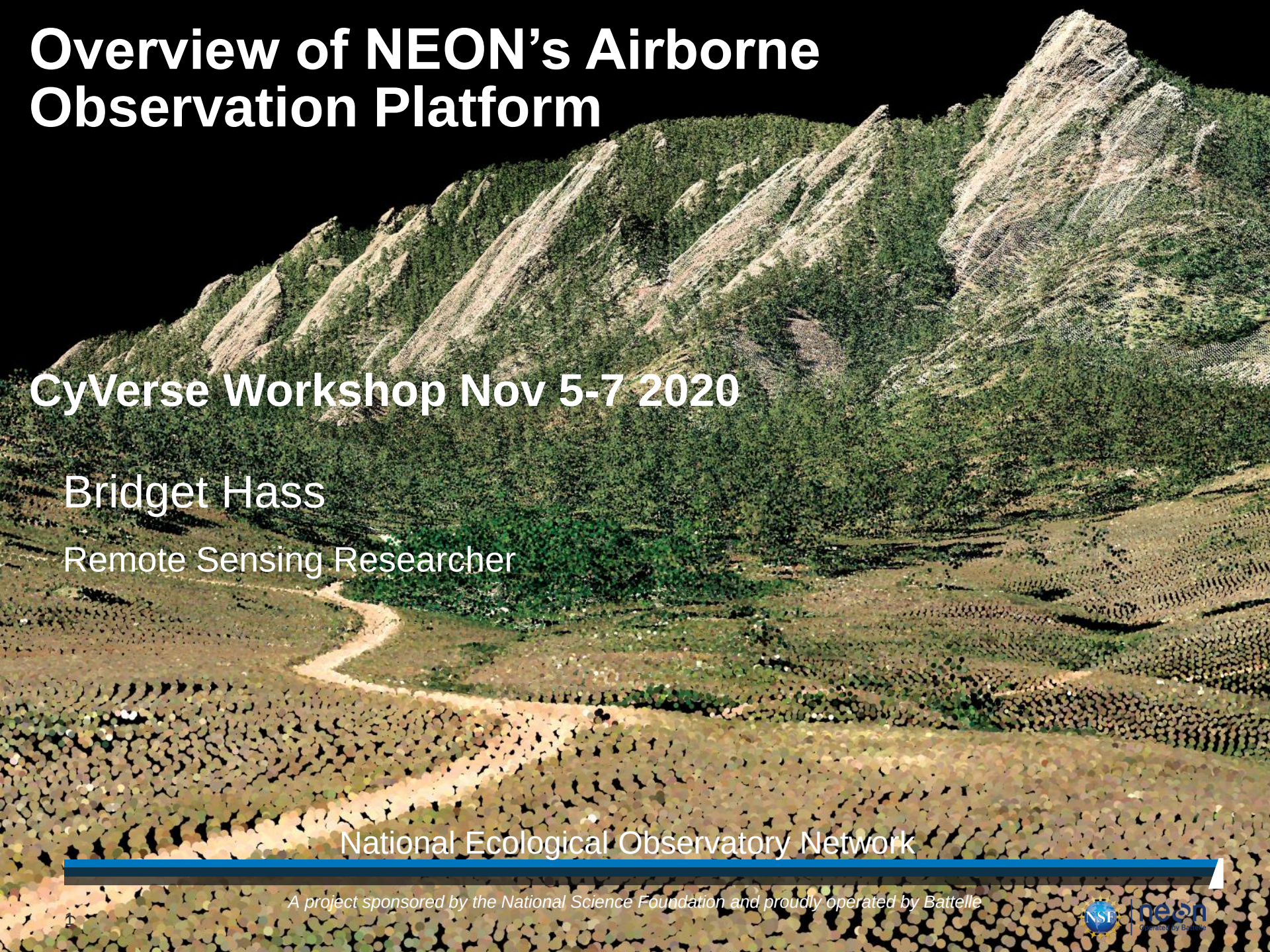
Overview of NEON's Airborne Observation Platform



CyVerse Workshop Nov 5-7 2020

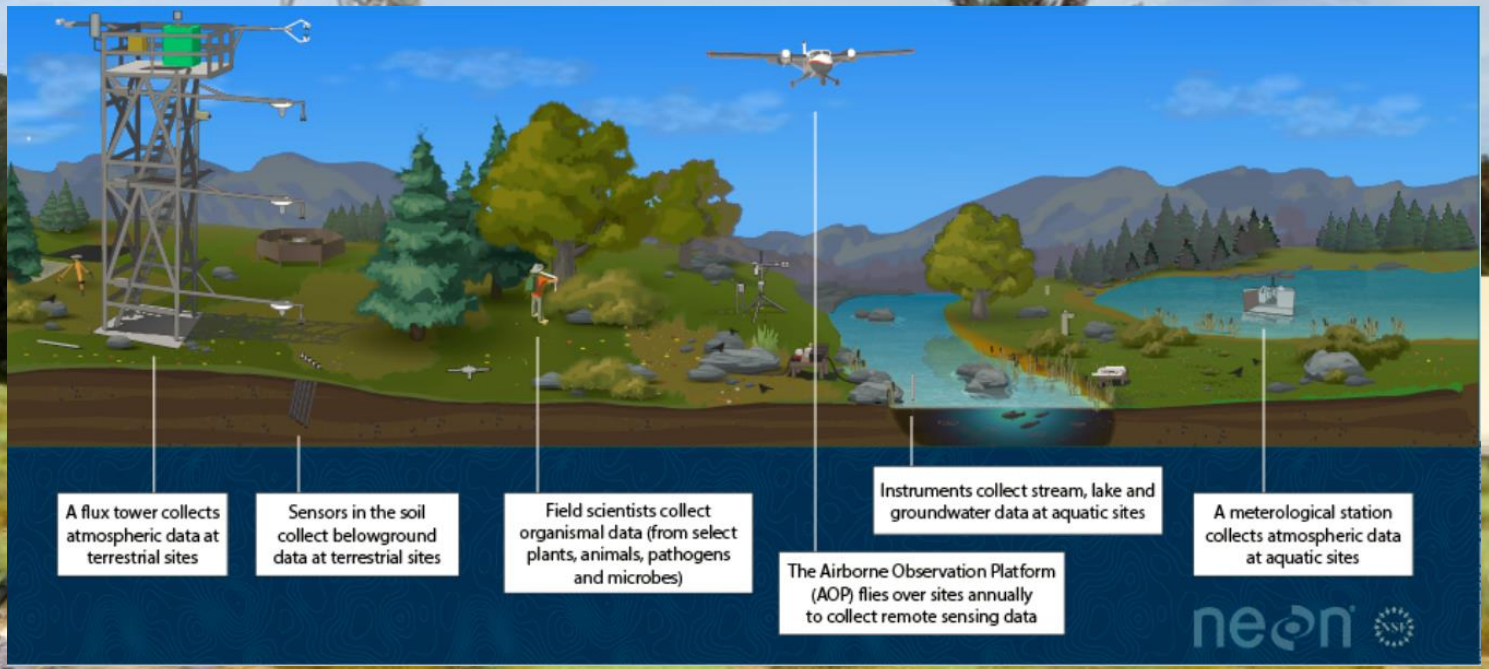
Bridget Hass

Remote Sensing Researcher

National Ecological Observatory Network

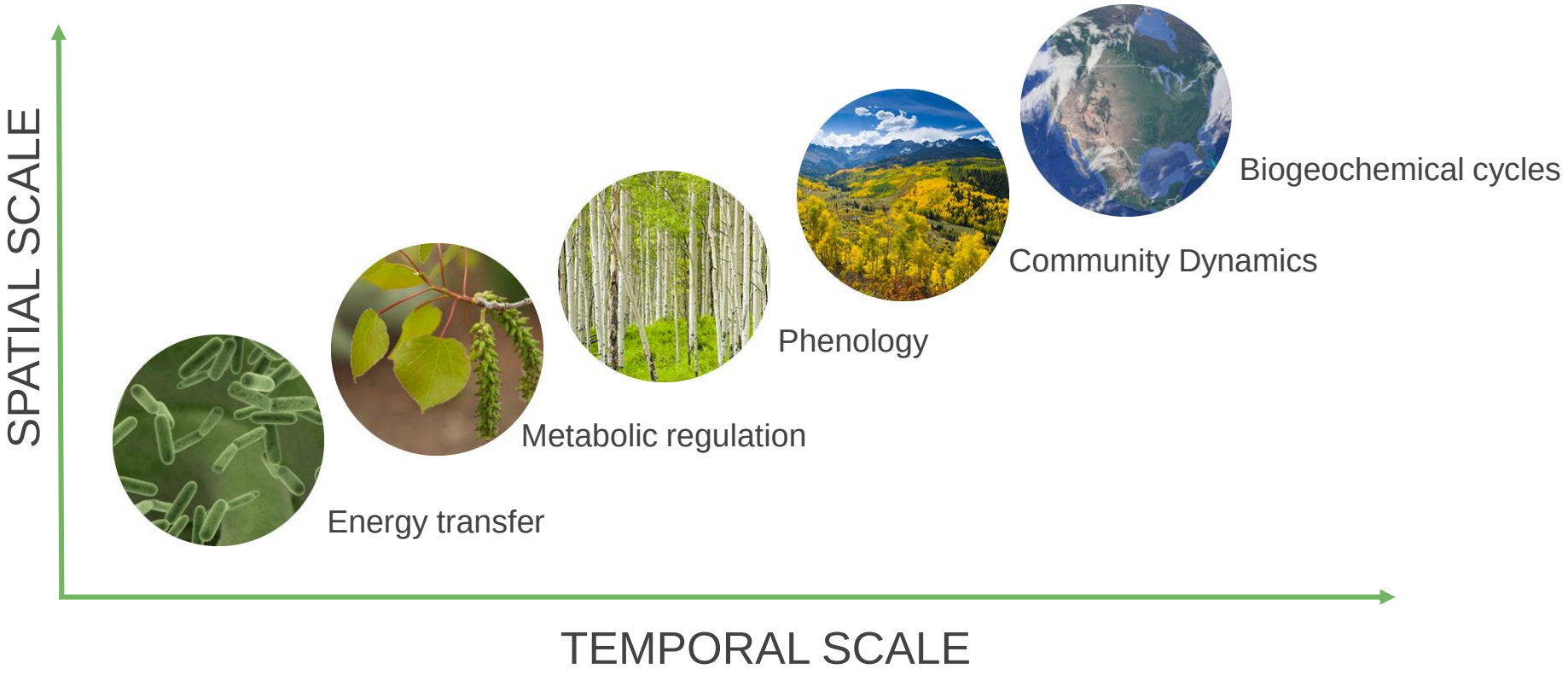
A project sponsored by the National Science Foundation and proudly operated by Battelle

NEON was designed to enable understanding and forecasting the effects of ***climate change, land use change***, and ***invasive species*** on continental-scale ecology.



NEON can be used to:

Integrate ecological observations across multiple scales

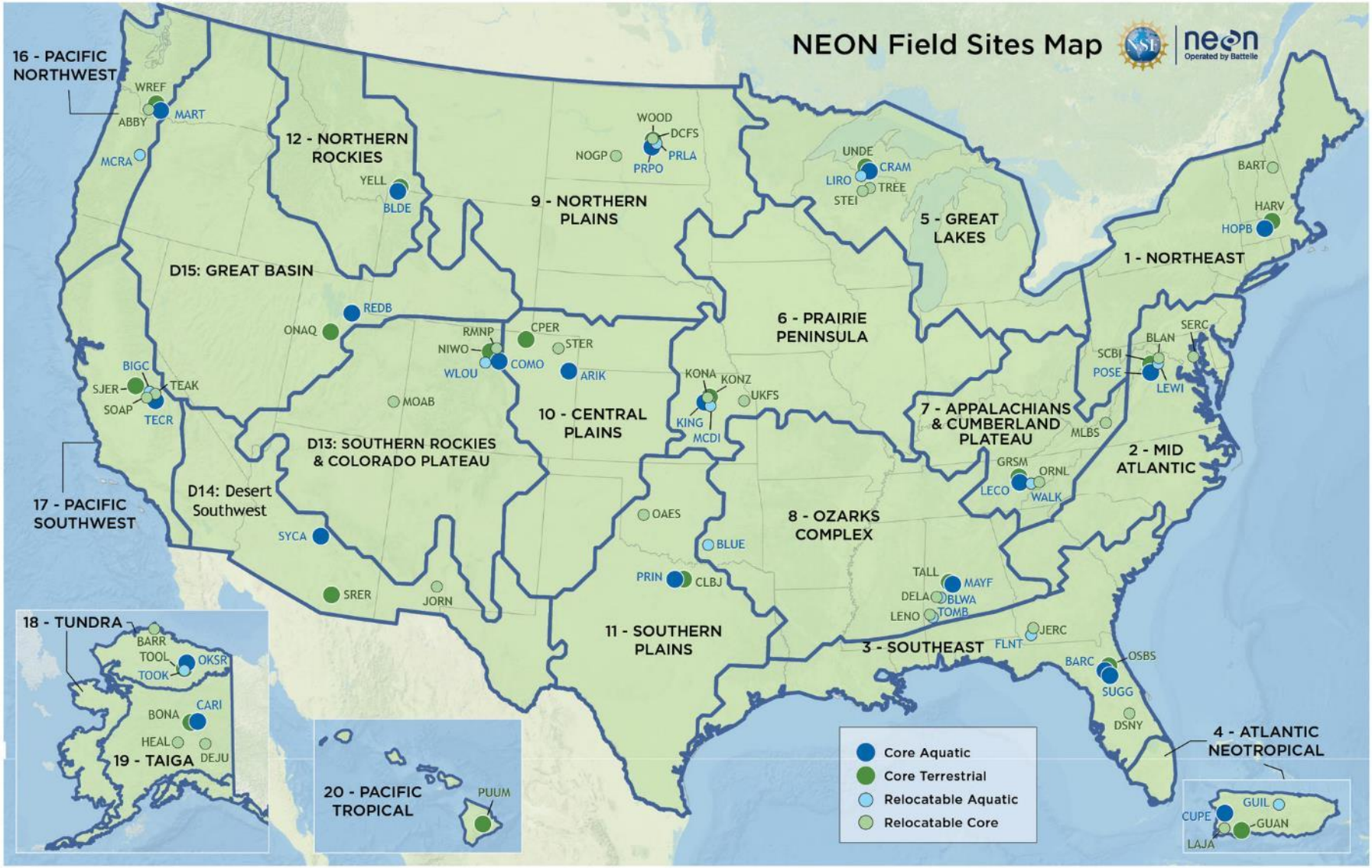


Modified after Schaepman, et al. 2009

NEON Timeline

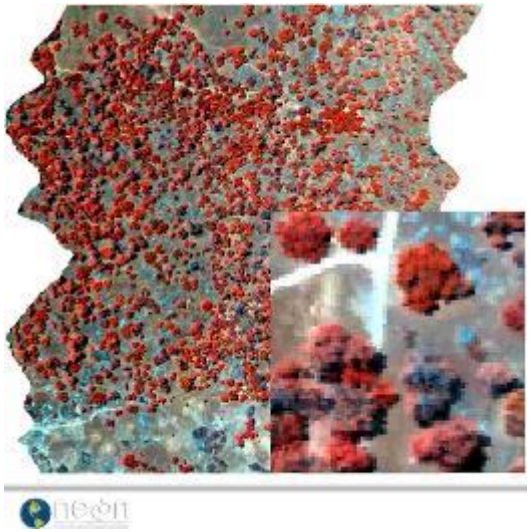
CONCEPT & DESIGN | SITES BUILT OUT | DATA COLLECTION

2004 - 2011 | 2012 - 2017 | 2018 - 2047

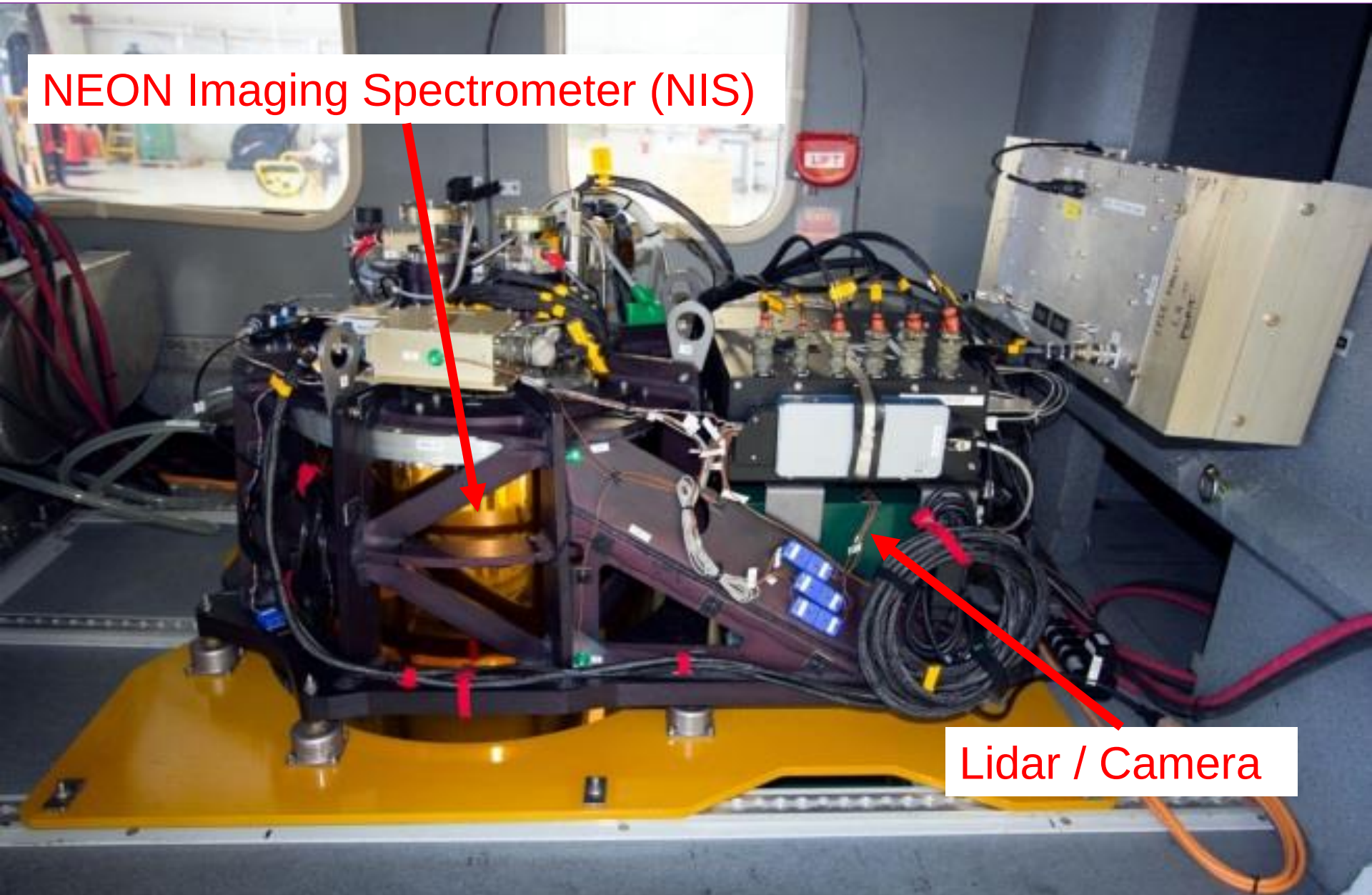


Airborne Observation Platform (AOP)

- Collects airborne remote sensing data
- Covers ‘regional scale’ (min of 100 km^2)
- Data products generated at high spatial resolution (<=1 m^2)
- Waveform Lidar, Imaging Spectrometer and RGB camera



AOP Payloads – three in total

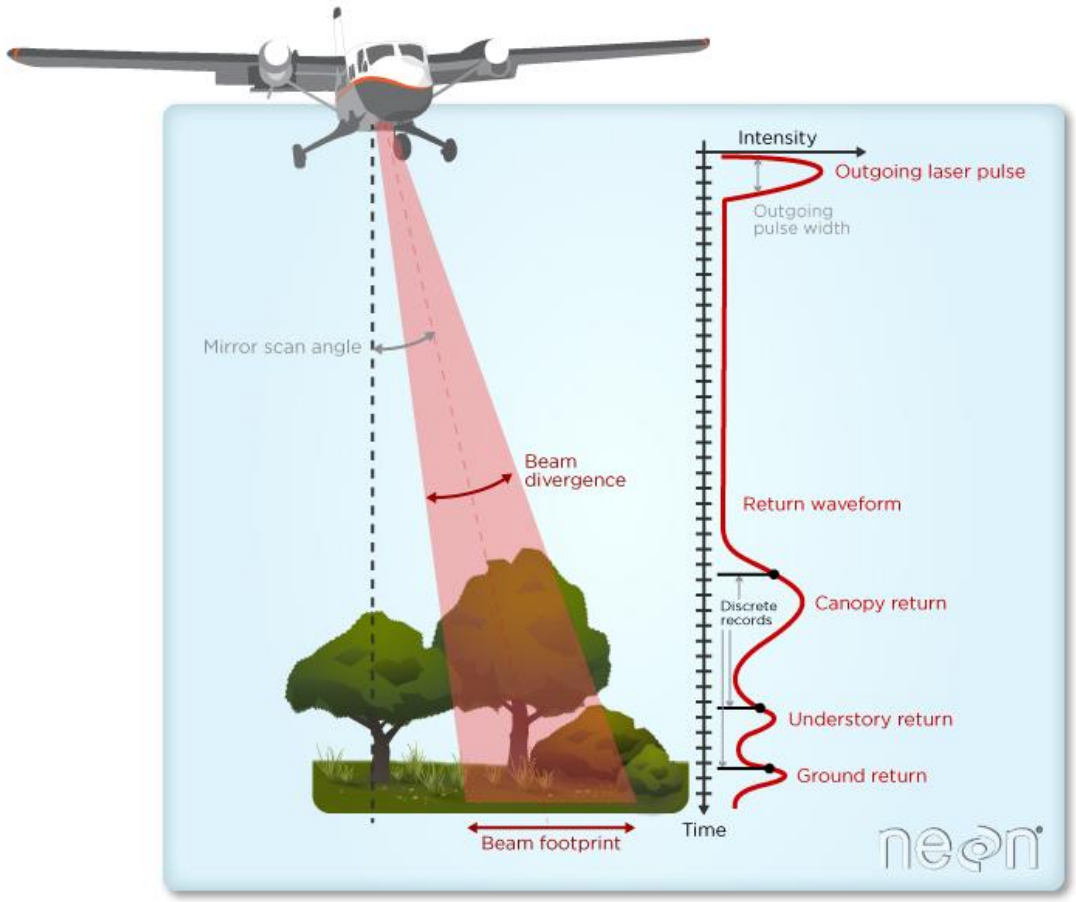


Digital Camera Sensor

- Commercial instrument delivered with Optech or Riegl lidar system: DiMAC D-8900 or PhaseOne iXA
- Purpose
  - Context for lidar and spectrometer
  - Provides sub-meter sampling of scene @ 1000 m AGL
  - High spatial accuracy

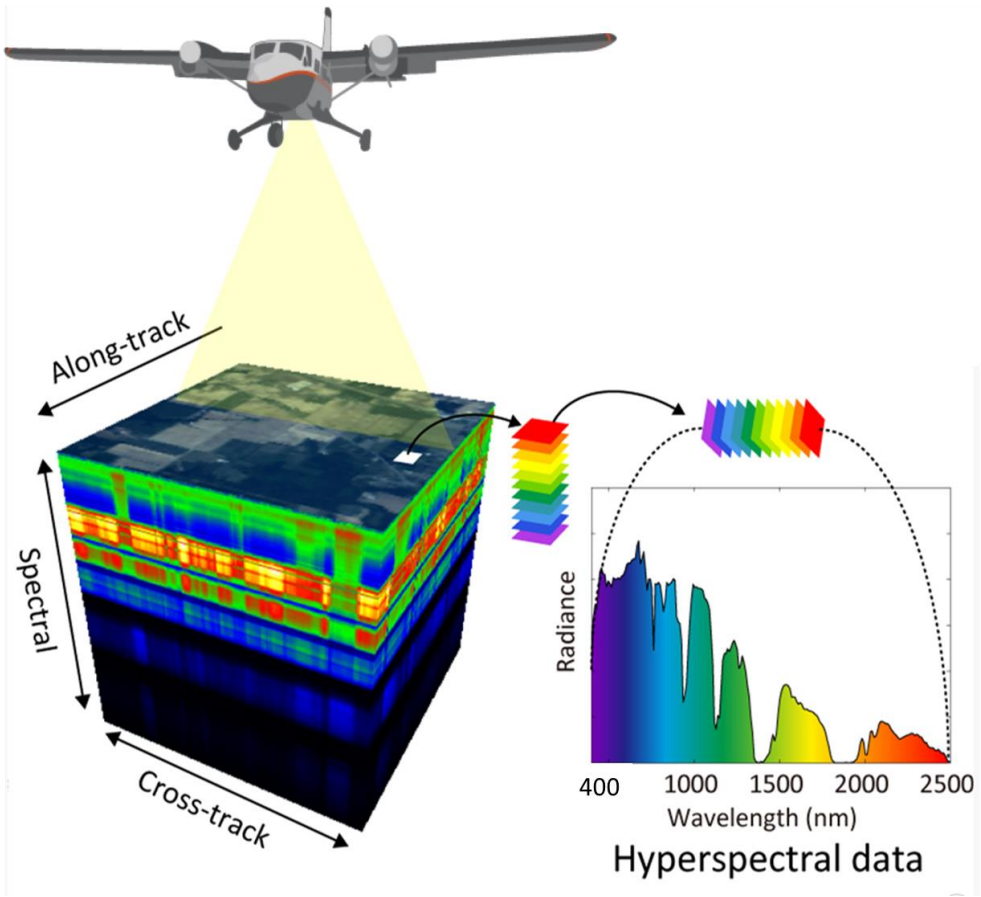
Waveform LiDAR Sensor

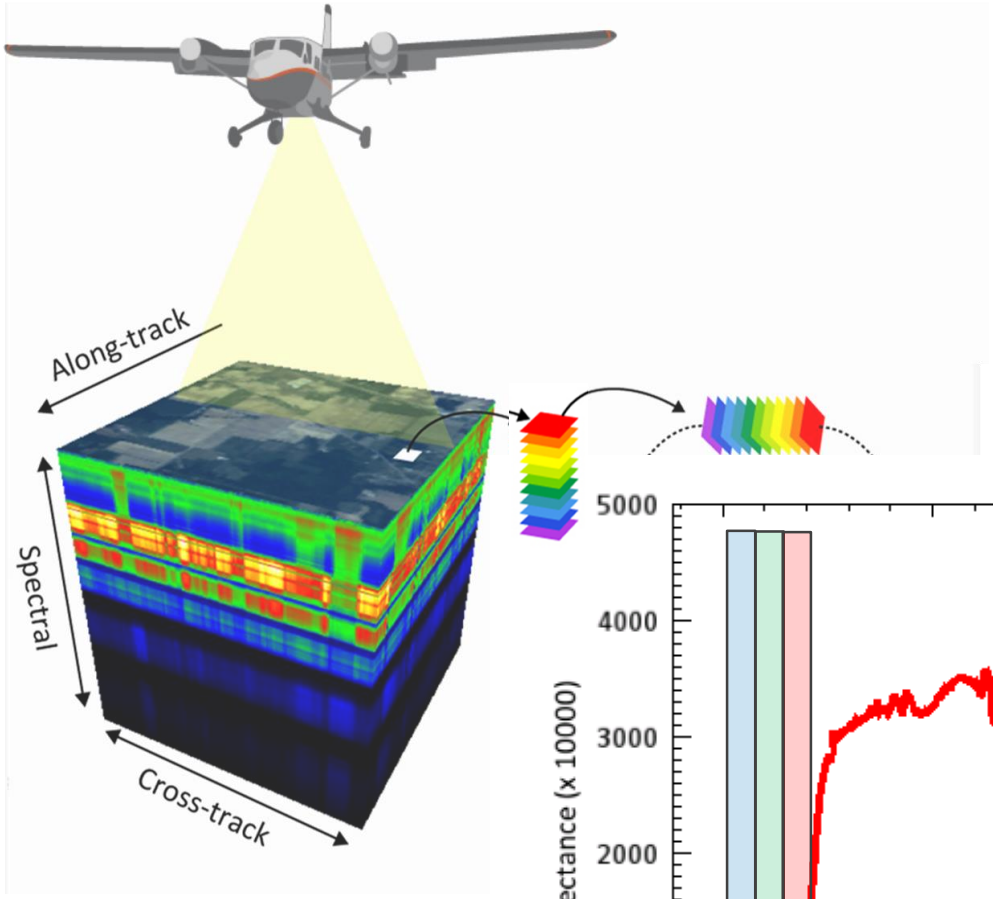
- Active-source instrument
  - 1064 nm
- Transmits laser pulses at up to 1000 kHz
- Capable of recording multiple discrete returns per pulse
- Provides structural (3D) information about the landscape

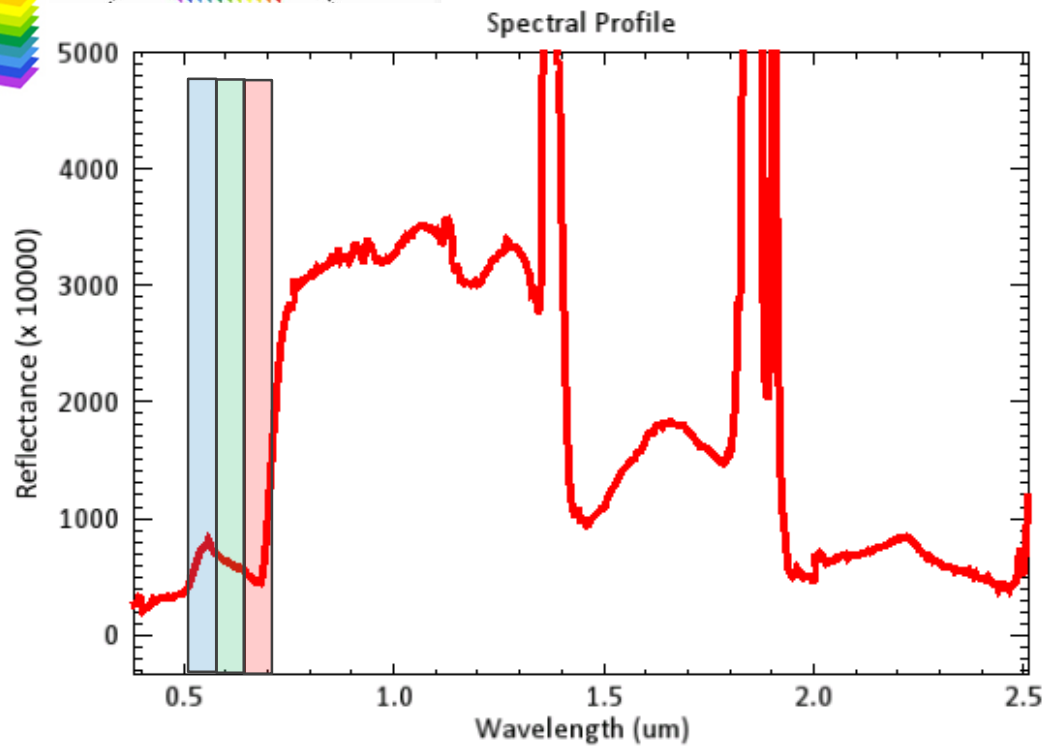


NEON Imaging Spectrometer (NIS)

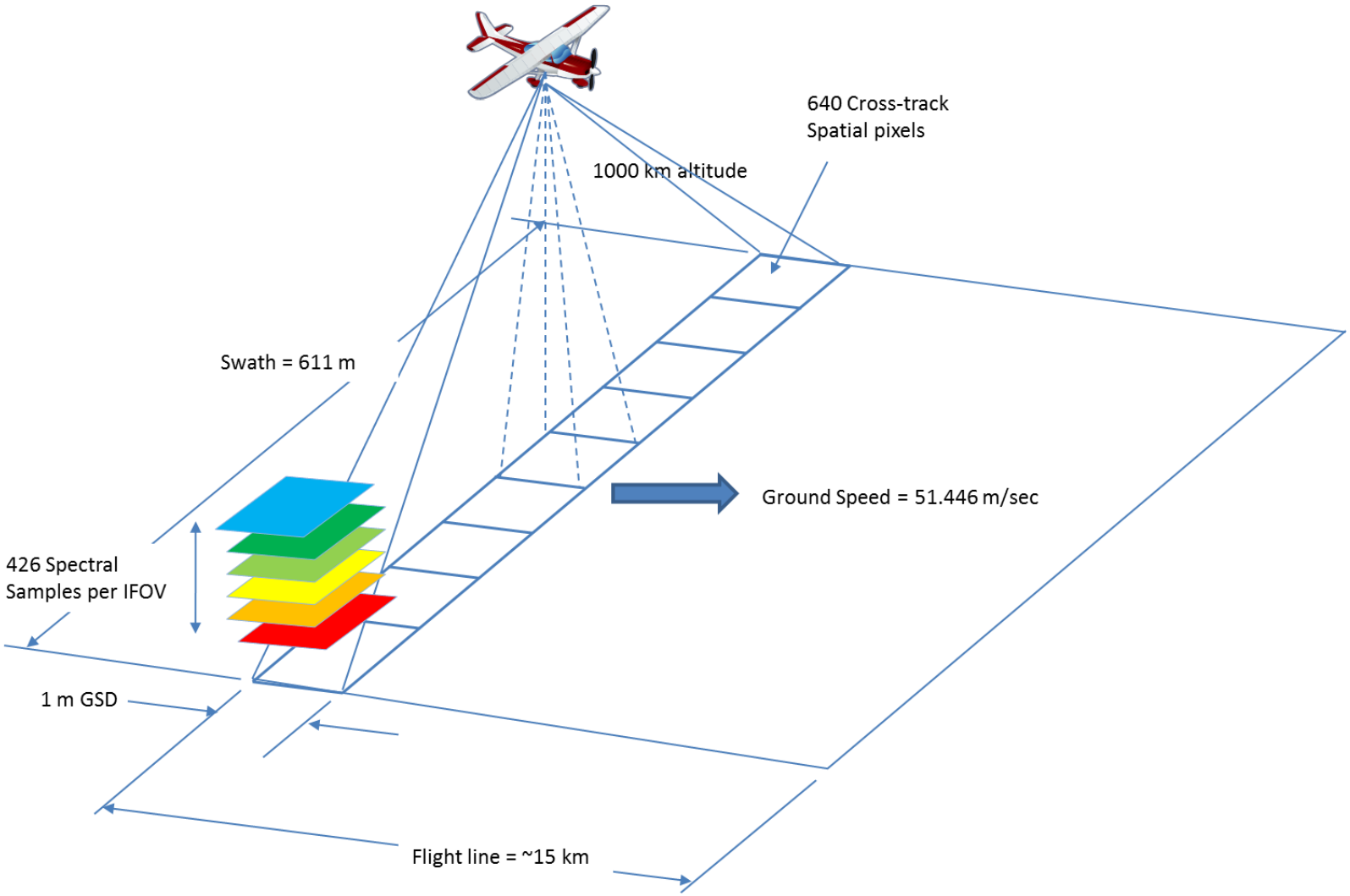
- Images acquired in pushbroom configuration
  - 34 deg across-track
  - 1 mrad along-track
  - 1000m AGL = 1m^2 resolution
- Each 1 mrad pixel imaged light is spread into its component wavelengths 380 - 2510 nm
- 5nm spectral sampling interval with <7.5nm FWHM




Along-track
Spectral
Cross-track

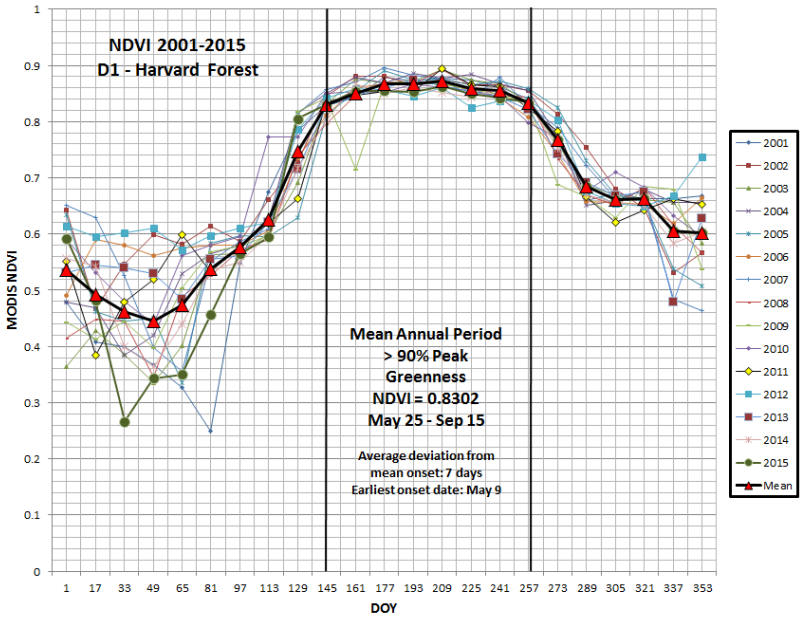

Spectral Profile
Reflectance (x 10000)
5000
4000
3000
2000
1000
0
0.5
1.0
1.5
2.0
2.5
Wavelength (um)

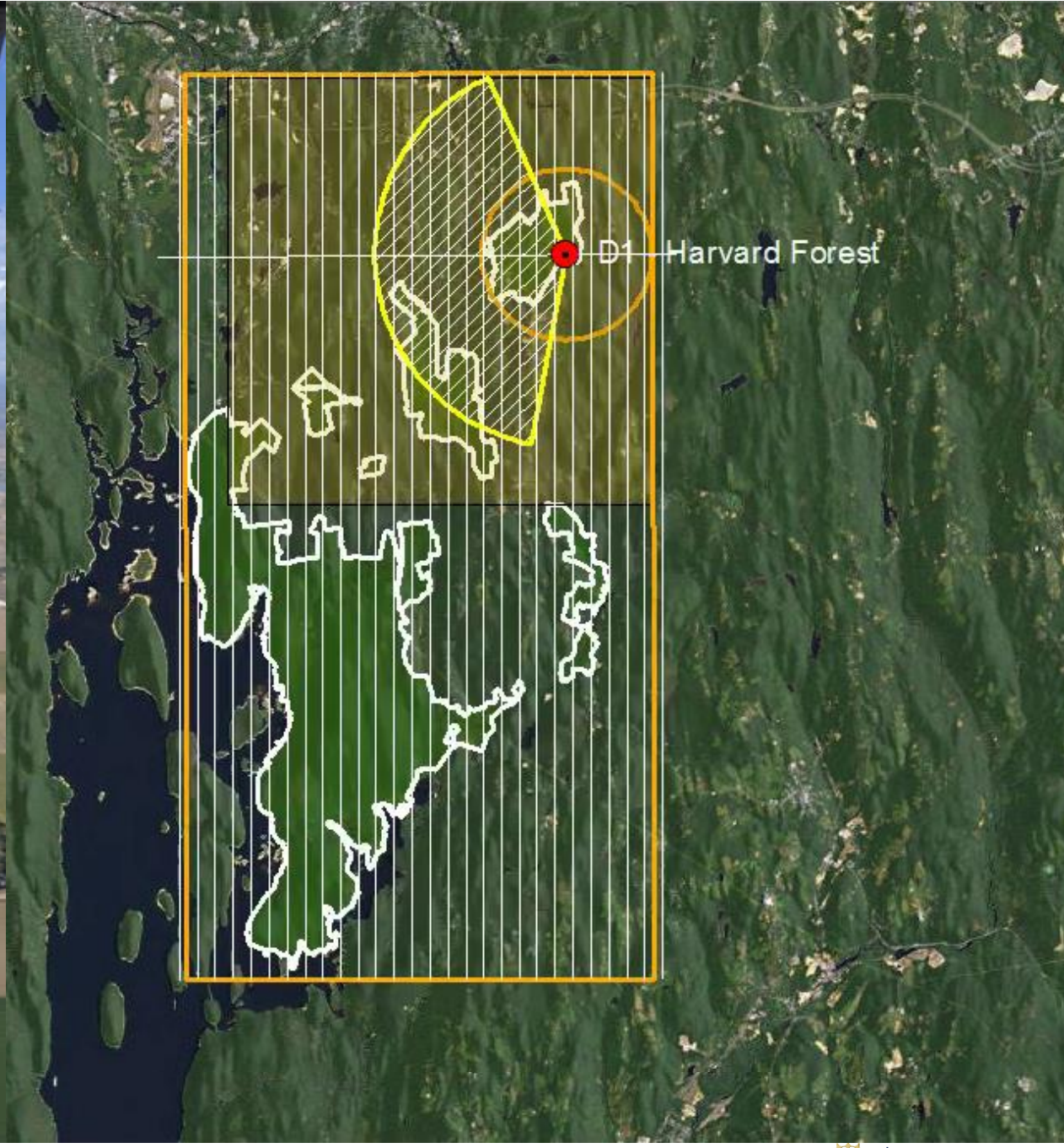
NEON Imaging Spectrometer (NIS) Flight Geometry



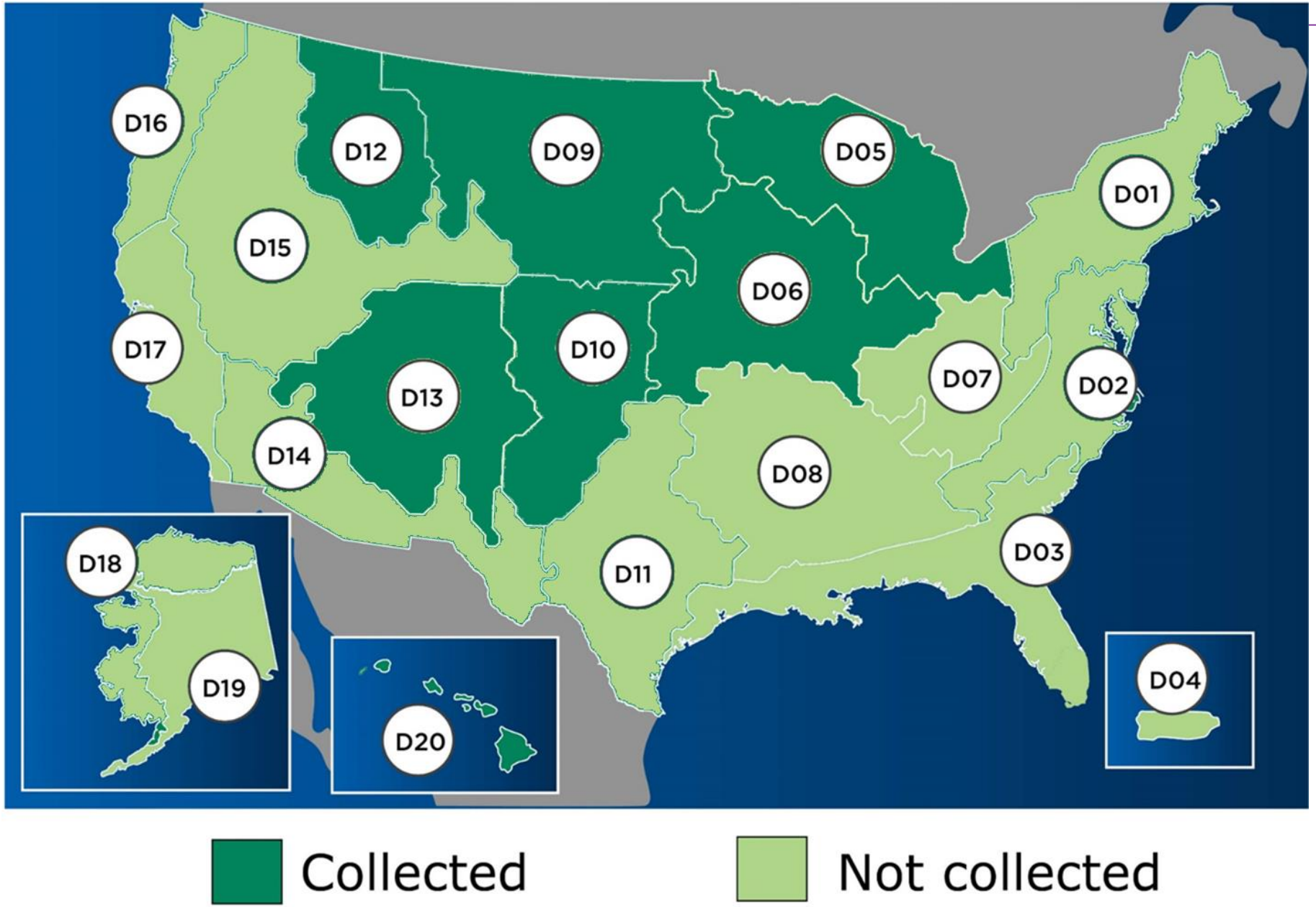
AOP Sampling Collection Requirements

- Clear skies
- Nominal AOP flying altitude = 1000 m AGL
  - collect data at the scale of individual plants
- Minimum 10 km x 10 km box
  - collect regional scale area around NEON sites
- Fly at peak ‘greenness’
  - consistency between annual collections
- Fly N-S lines when solar angles are above 40°

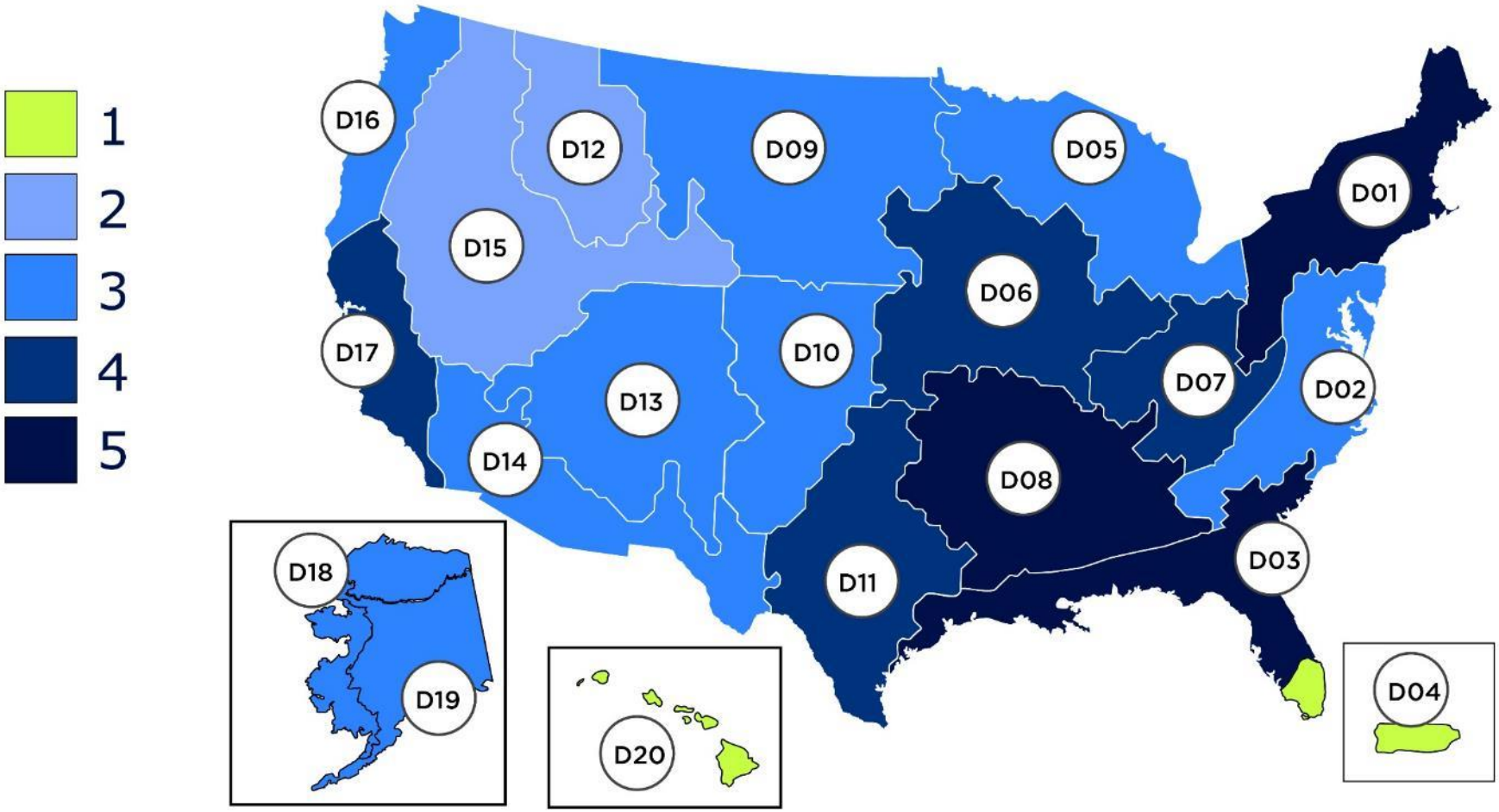


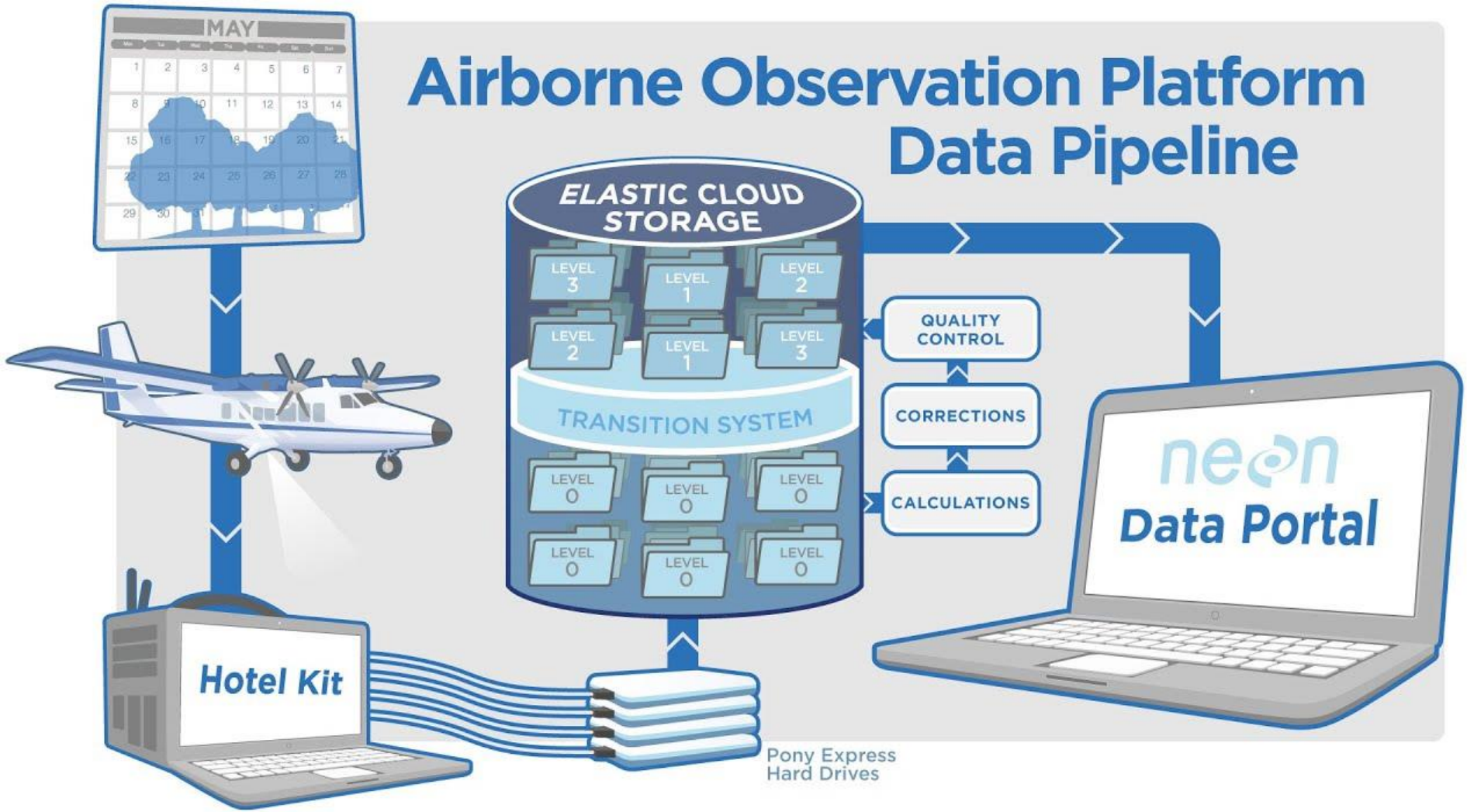

D1
Harvard Forest

2020 AOP collections



2013 – 2019 AOP collections




Airborne Observation Platform
Data Pipeline
MAY
ELASTIC CLOUD STORAGE
LEVEL 3
LEVEL 1
LEVEL 2
LEVEL 2
LEVEL 1
LEVEL 3
TRANSITION SYSTEM
LEVEL 0
LEVEL 0
LEVEL 0
LEVEL 0
LEVEL 0
LEVEL 0
QUALITY CONTROL
CORRECTIONS
CALCULATIONS
neon
Data Portal
Hotel Kit
Pony Express
Hard Drives

NEON AOP data products

Level 1

- Spectrometer Orthrorectified at-Sensor Radiance
- LiDAR Slant Range Waveform
- Discrete Return LiDAR Point Cloud
- Spectrometer Orthorectified Surface Directional Reflectance
- High-resolution Orthorectified camera imagery

Raw data to physical units (flightline)

Level 2

- Vegetation Indices – Spectrometer
- Canopy Water Content
- Canopy Xanthophyll Cycle
- Albedo - Spectrometer
- LAI - Spectrometer
- fPAR – Spectrometer
- **Canopy Lignin*
- **Canopy Nitrogen*
- **Total Biomass Map – Spectrometer*

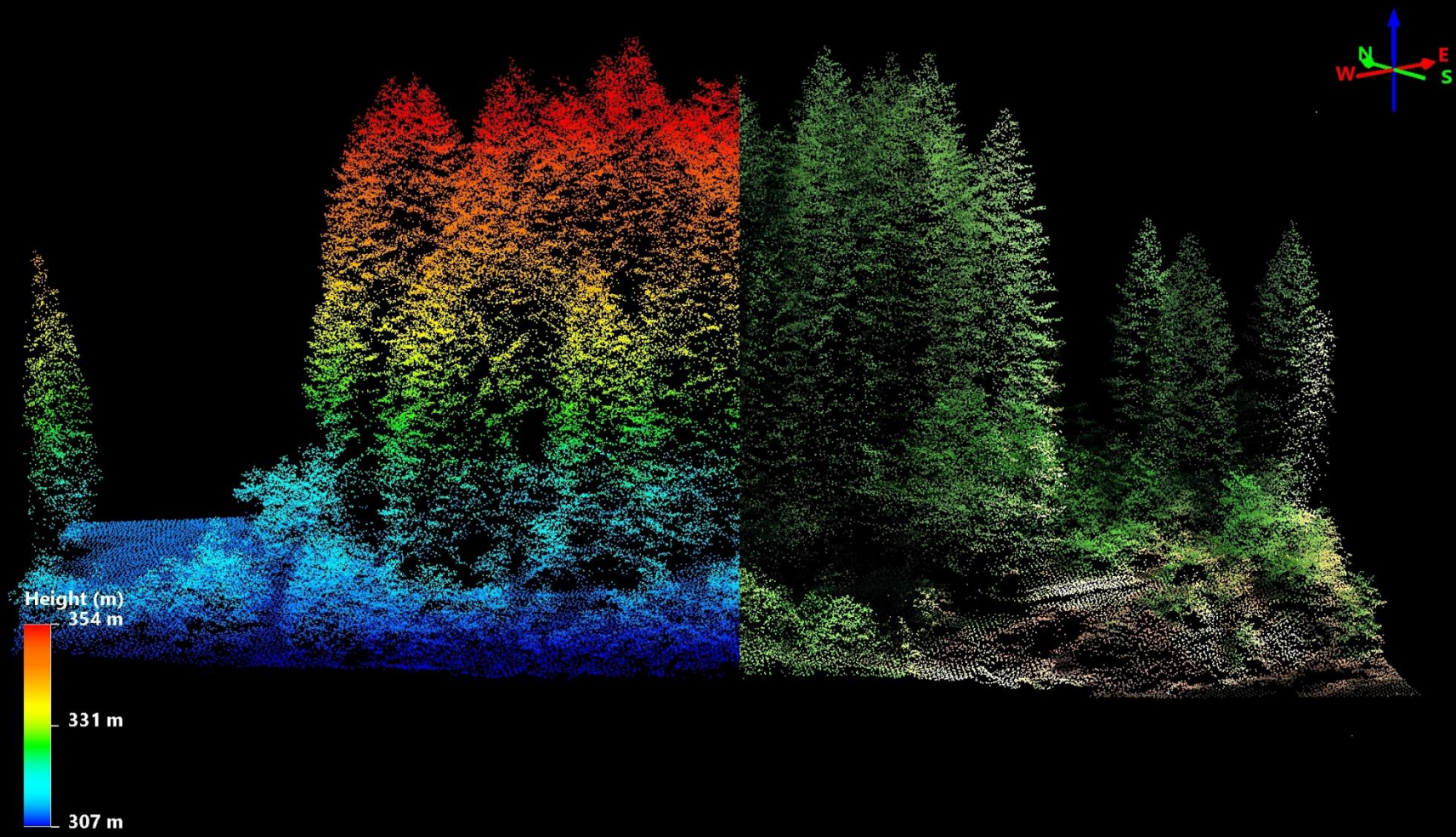
Derived products e.g. spectral indices (flightline)

Level 3

- Spectrometer Orthorectified Surface Directional Reflectance
- High-resolution Orthorectified camera imagery mosaic
- Albedo - Spectrometer
- LAI – Spectrometer
- fPAR – Spectrometer
- Canopy Water Content
- Canopy Xanthophyll Cycle
- Vegetation Indices – Spectrometer
- Ecosystem Structure
- Elevation – LiDAR

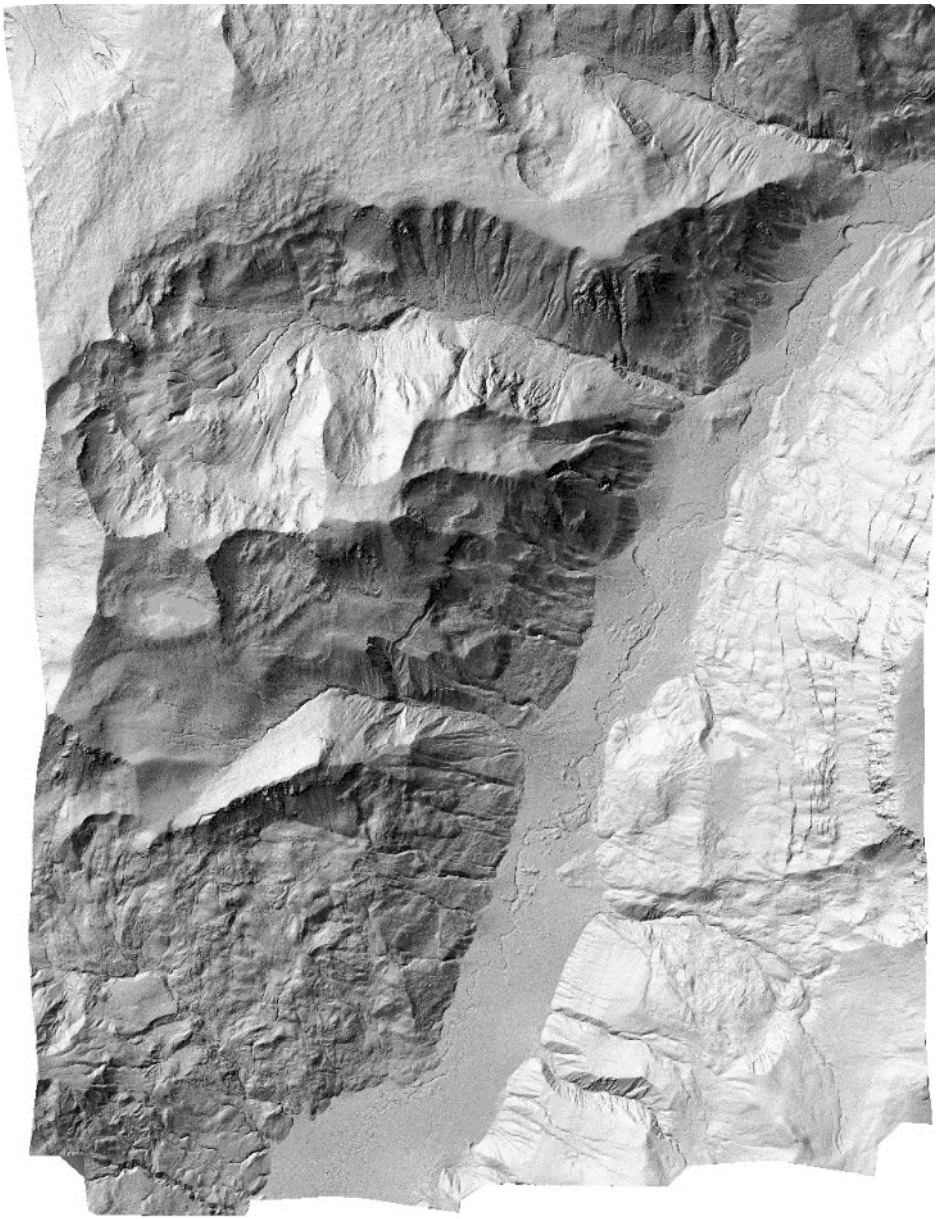
Derived product mosaics (1km x 1km tiles)

ATBDs (Algorithm Theoretical Basis Documents) describing the process for data product creation

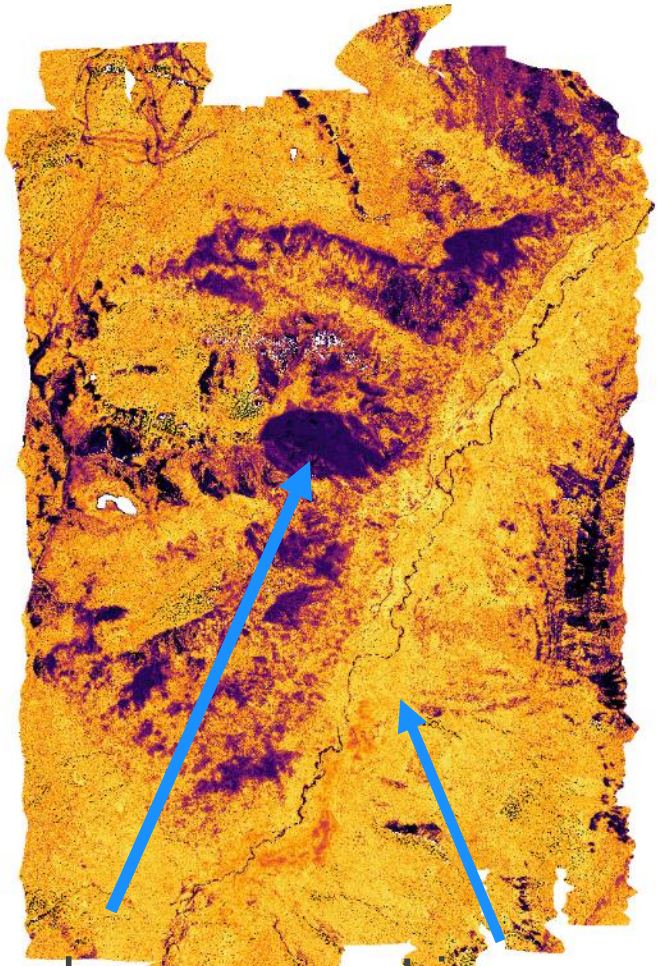

N
E
W
S
Height (m)
354 m
331 m
307 m

DSM

DTM



CHM



Burned area

Live vegetation

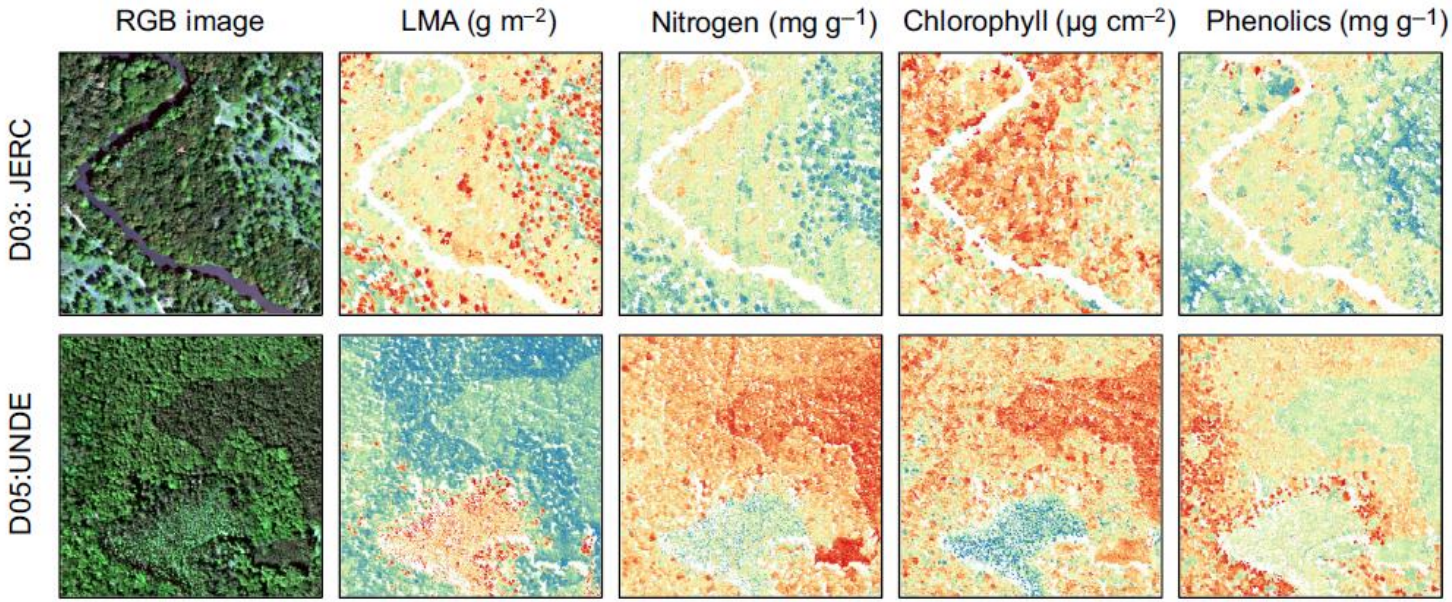
Research Frontier: Foliar Functional Traits

New Phytologist

Research

Foliar functional traits from imaging spectroscopy across biomes in eastern North America

Zhihui Wang[1], Adam Chlus[1], Ryan Geygan[1], Zhiwei Ye[1], Ting Zheng[1], Aditya Singh[2], John J. Couture[3], Jeannine Cavender-Bares[4], Eric L. Kruger[1] and Philip A. Townsend[1]



Wang, Z., Chlus, A., Geygan, R., Ye, Z., Zheng, T., Singh, A., ... & Townsend, P. A. (2020). Foliar functional traits from imaging spectroscopy across biomes in eastern North America. *New Phytologist*.

Research Frontiers: Tree species identification using convolutional neural networks

Open Access Article

A Convolutional Neural Network Classifier Identifies Tree Species in Mixed-Conifer Forest from Hyperspectral Imagery

by Geoffrey A. Fricker [1,2,*], Jonathan D. Ventura [3], Jeffrey A. Wolf [4], Malcolm P. North [5], Frank W. Davis [6] and Janet Franklin [2]

Fricker, G.A.; Ventura, J.D.; Wolf, J.A.; North, M.P.; Davis, F.W.; Franklin, J. A Convolutional Neural Network Classifier Identifies Tree Species in Mixed-Conifer Forest from Hyperspectral Imagery. *Remote Sens.* **2019**, *11*, 2326

Research Frontiers: Image segmentation of tree crowns

remote sensing

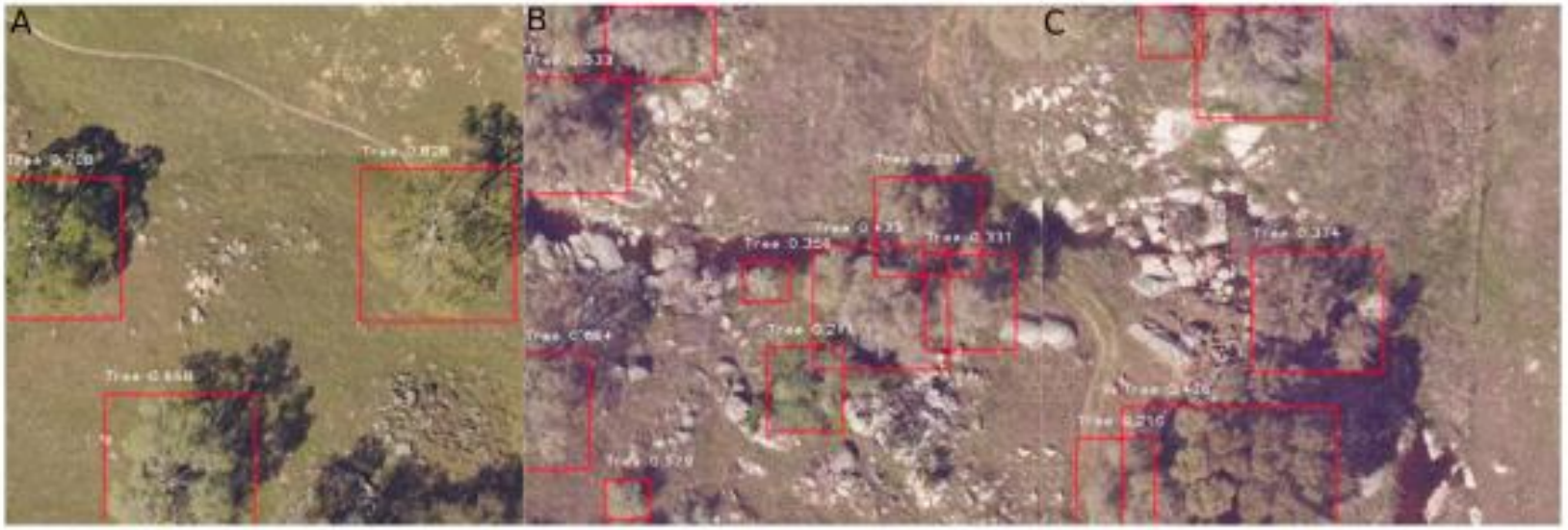
MDPI

Article

Individual Tree-Crown Detection in RGB Imagery Using Semi-Supervised Deep Learning Neural Networks

Ben G. Weinstein [1,*], Sergio Marconi [1], Stephanie Bohlman [2], Alina Zare [3] and Ethan White [1]

https://idtrees.org/



Weinstein, B.G.; Marconi, S.; Bohlman, S.; Zare, A.; White, E. Individual Tree-Crown Detection in RGB Imagery Using Semi-Supervised Deep Learning Neural Networks. *Remote Sens.* **2019**, *11*, 1309.

NSF | neon Operated by Battelle

Research Frontiers: EOS Interoperability

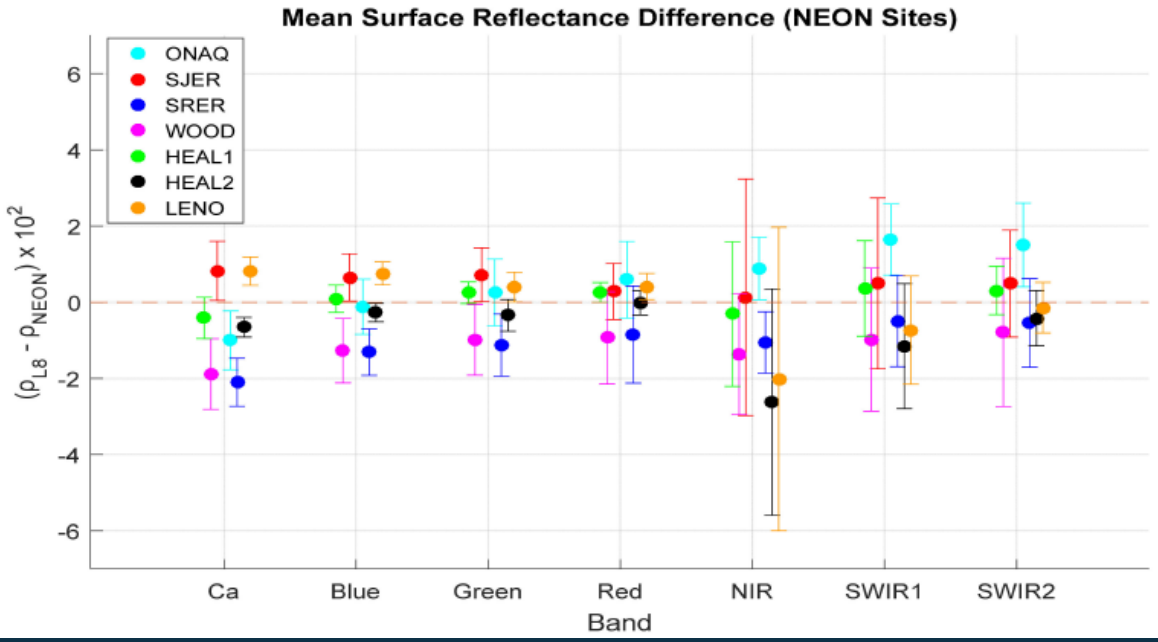
remote sensing

MDPI

Article

Methods for Earth-Observing Satellite Surface Reflectance Validation

Moe Badawi *, Dennis Helder, Larry Leigh and Xin Jing



Badawi, M.; Helder, D.; Leigh, L.; Jing, X. Methods for Earth-Observing Satellite Surface Reflectance Validation. *Remote Sens.* **2019**, *11*, 1543.

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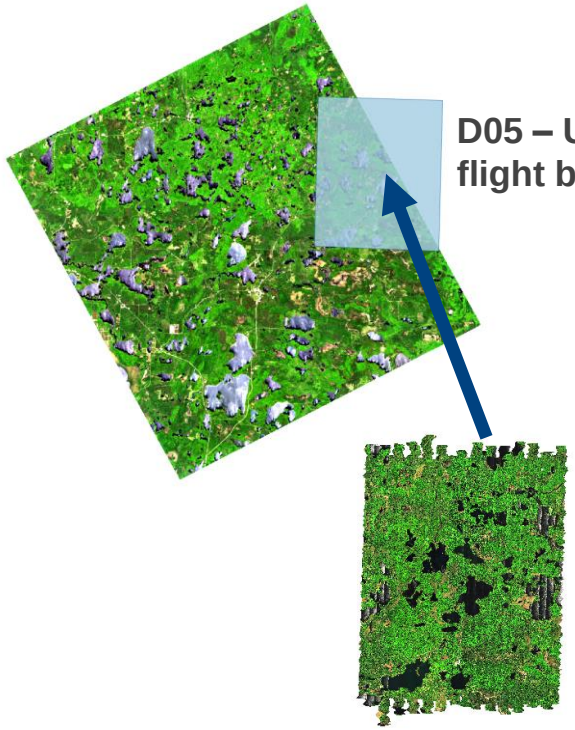
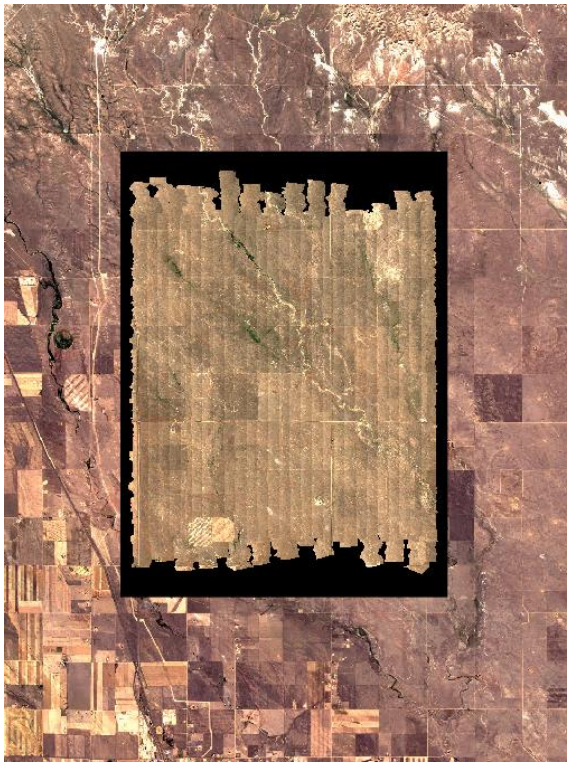
Data Interoperability with EOS

DESIS collection 20190608



Landsat 8 - 20200912

Sentinel 2A - 20200913



Include ground field spectrometer measurements

Data Challenges

- Currently hold ~150 TB of data products, ~80 TB intermediate files
- Anticipate collecting > 75 TB per year (raw and processed)
- At-sensor radiance, waveform LiDAR, reflectance (L1) require majority of the storage space (80%)
- Getting data to our users
- Harmonization of data
- Educating users

Three types of educational materials:

Tutorials

- Links available for those who are new to programming in R and/or Python
- Self-paced learning for accessing, exploring, and analyzing NEON data with open-source software
- Designed for users with some programming experience

Videos

- Wide variety of videos available on our YouTube channel
- Colorful, playful videos that introduce the essential NEON topics
- Science-oriented videos to communicate at the colleague-level
- Recorded ‘presentations’ offer academic seminar-level details

Teaching Modules

- Educational plans for K-12 and Undergraduate classrooms
- Separated into appropriate age groups
- Helps students explore the environment and scientific data

NEON Code Resources

https://www.neonscience.org/code-resources-submission

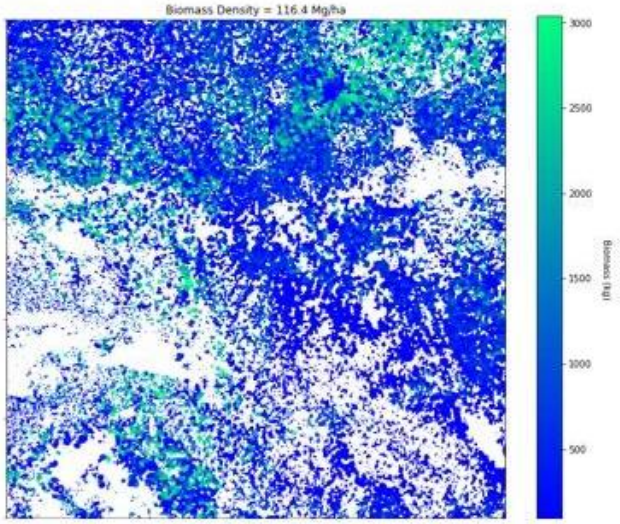
Tier 1: Community Contributed Code	Community contributed code is reviewed to determine that it is publicly available, generally comprehensible, and involves NEON data. Code functionality is not evaluated.
Tier 2: NEON Certified Code	Certified code goes through a code review, to ensure it performs as described and without error.
Tier 3: NEON Production Code	Production code is used in NEON data processing pipelines, to generate NEON data products. It is the end product of a very long and careful development process.

Assignable Assets

https://www.neonscience.org/assignable-assets/airborne-observation-platform

2018 Crested Butte Watershed Study

2018 BB-FLUX Burned Biomass Wildfire Survey



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720.746.4844 | neonscience@battelleecology.org | neonscience.org