ADVANCES IN AIRBORNE REMOTE SENSING OF TERRESTRIAL ECOSYSTEMS AT NEON AND RELEVANCE TO HYSPIRI

HyspIRI Science Workshop

Oct 16-18, 2012

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The goal of NEON is to *enable understanding* and *forecasting* of the *impacts* of ***climate change***, ***land use change*** and ***invasive species*** on *continental-scale* ***ecology*** by providing infrastructure to support research, education and environmental management in these areas.

CAUSES OF CHANGE

Climate Change: Understanding and predicting climate variability, including directional climate change and its impacts on natural and human systems

Land Use: Understanding and predicting changes in land use and land cover that are critical to biogeochemical cycling, ecosystem functioning and services, and human welfare.

Invasive Species: Understanding and forecasting the distribution of biological invasions and their impacts on ecological processes and ecosystem services.

Interactions and Feedbacks

RESPONSES TO CHANGE

Biogeochemistry: Understanding and predicting the impacts of human activities on the Earth's major biogeochemical cycles.

Biodiversity: Understanding the regulation of biological diversity and its functional consequences for ecosystems.

Ecohydrology: Understanding and predicting changes in freshwater resources and the environment.

Infectious Diseases: Understanding and predicting the ecological and evolutionary aspects of infectious diseases and of the interactions among pathogens, hosts/receptors, and ecosystems.

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Continental Scale Sampling by NEON

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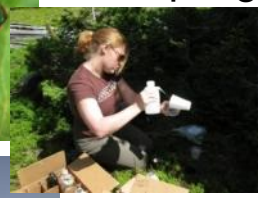
NEON OBSERVING SYSTEMS

- Terrestrial observing system (organismal biology)
- NEON collections
- Aquatic observing system (organismal and instrumental)
- Terrestrial instrument system (climate, biogeochemistry, soils)
- Airborne observing system (remote sensing)
- STREON
- Mobile deployable platform
- Land use analysis package (integration with national data sets & satellite data)



Field sampling

Towers

Surface and ground water

Airborne Remote Sensing

Satellite Data

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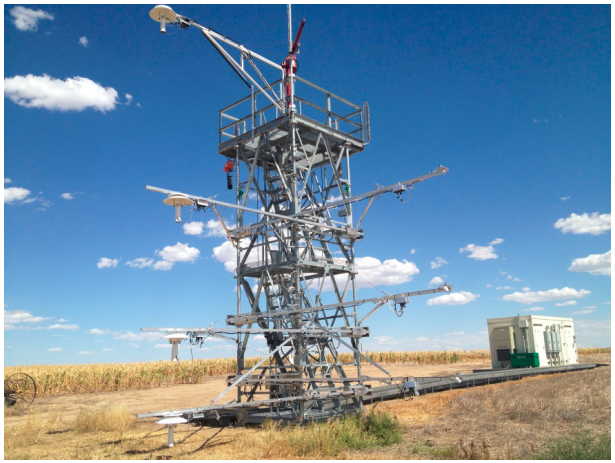
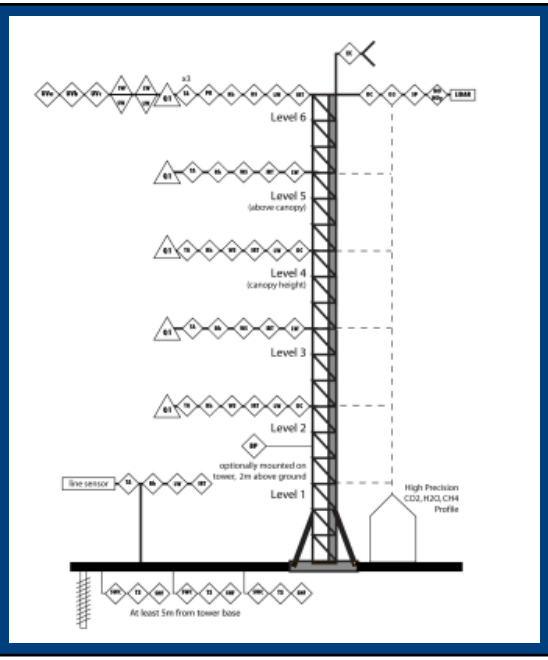
NEON Fundamental Instrument Unit





- Physical and chemical climate forcing
- Ecosystem responses
- Micrometeorological scalars and fluxes
- Soil array
- Stand/plot level sampling
- Automated instrumentation
- Over 2000 measurements per core site at frequencies of daily, and ~0.1 to 20 Hz

Current Status

- Civil construction completed at D03 Ordway-Swisher Biological Station (OSBS)
- Construction started at four additional sites (D01 Harvard Forest, D09 Woodworth, D09 Dakota Coteau, and D10 CPER)
- Site designs – 17 completed, 11 underway
- Tower designs – 10 completed, 13 underway

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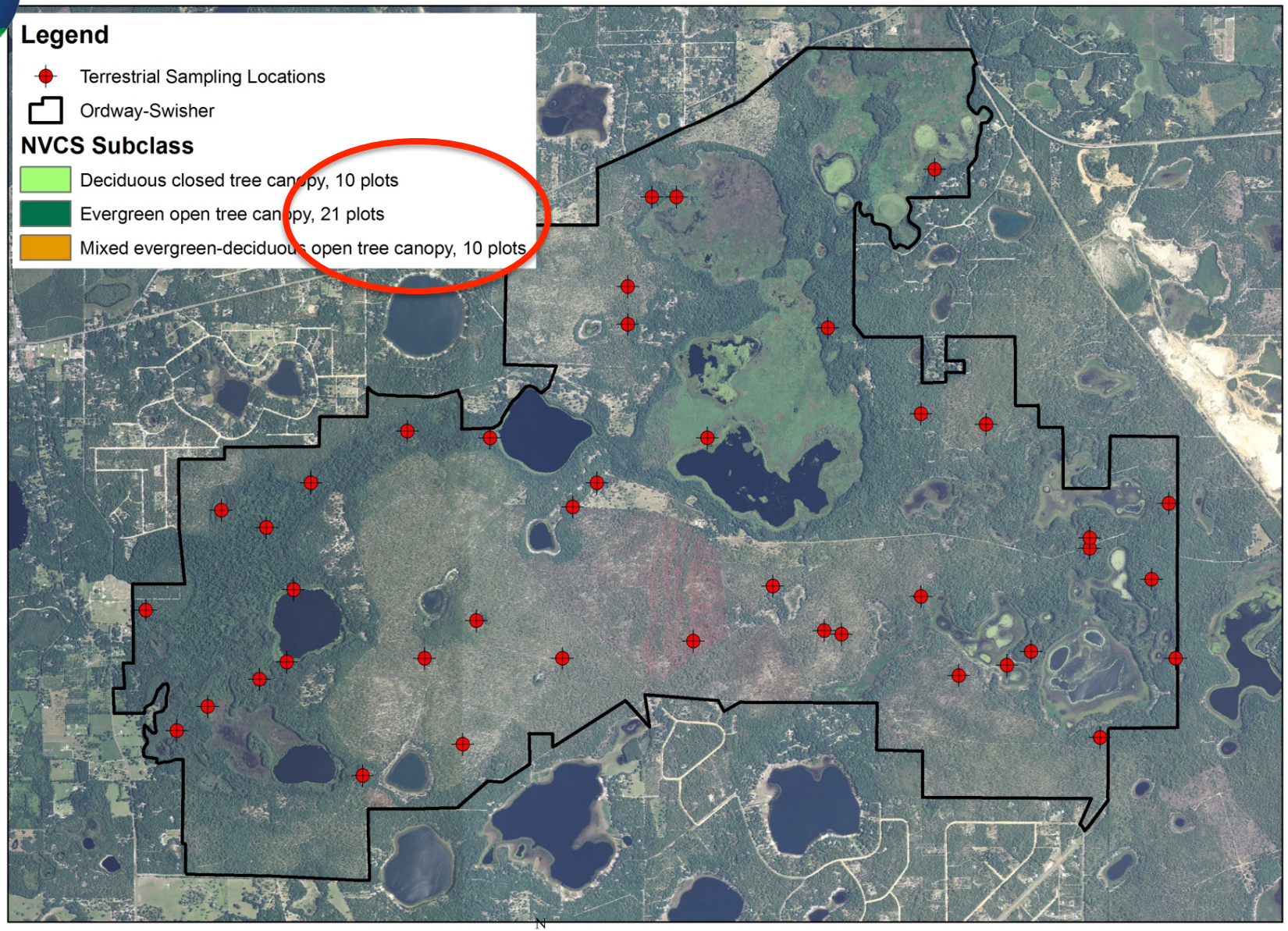
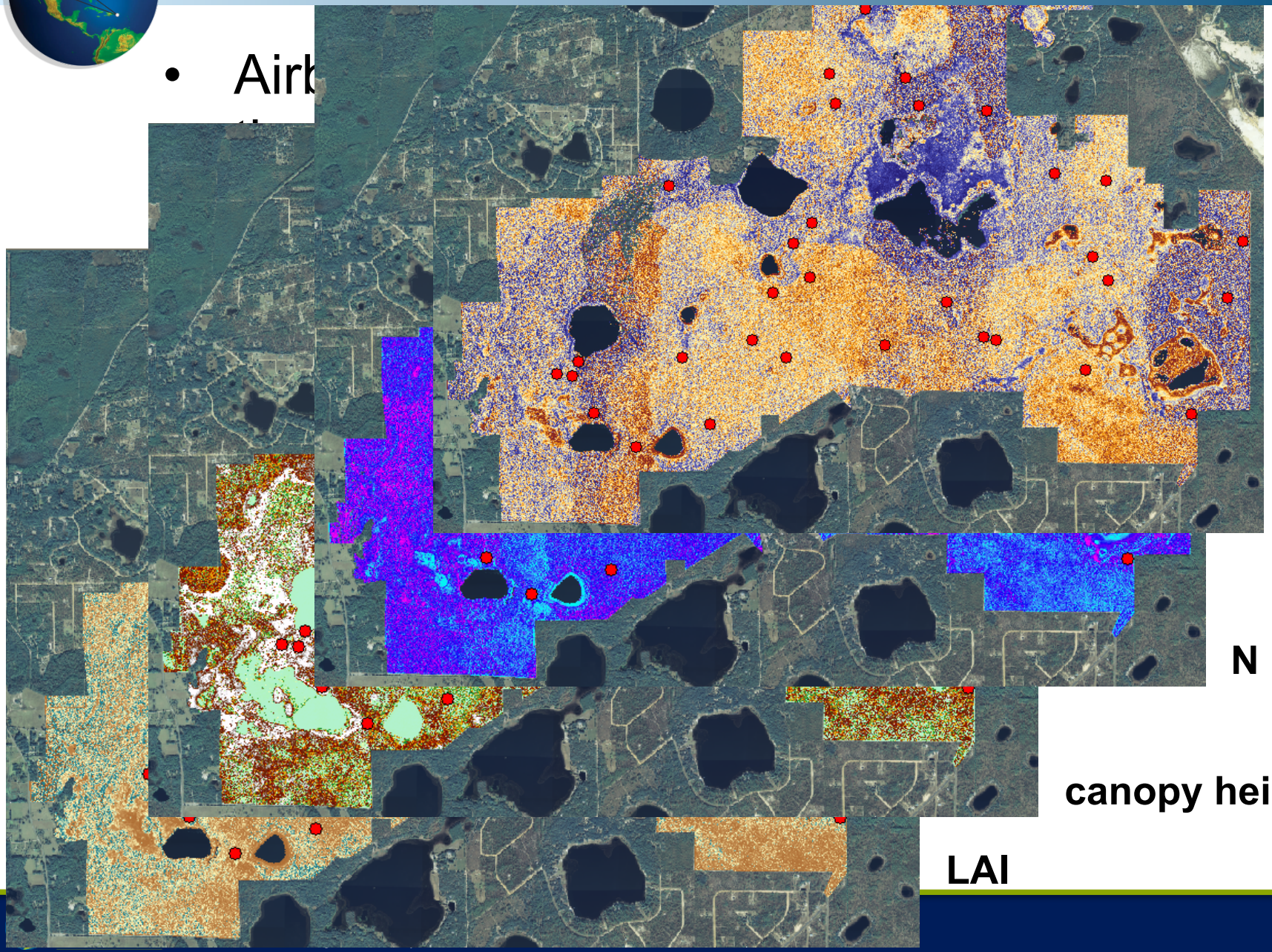
Ordway-Swisher Biological Station, D3



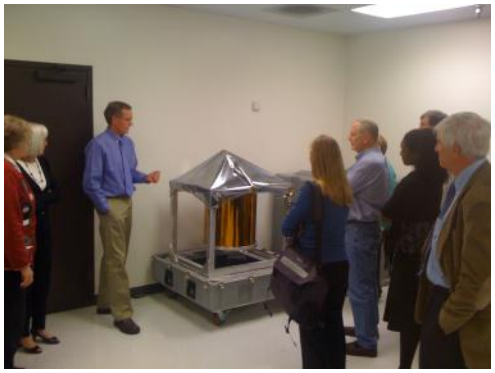
Terrestrial Observation Sample Design

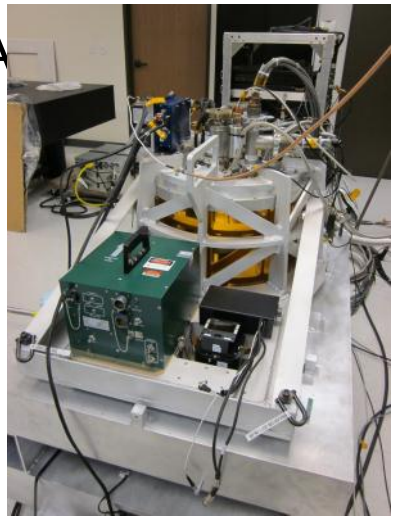
- Airb

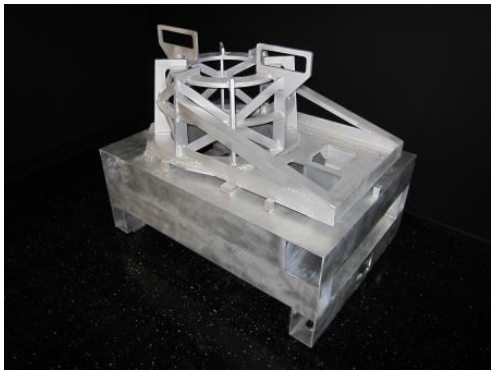


AOP-1 Remote Sensing Payload Status

- Airborne Instrumentation (x3)
  - Waveform-LiDAR
  - NEON Imaging Spectrometer
  - Airborne digital camera
  - GPS/Inertial measurement unit
- Dec 2011 - 1st NEON Imaging Spectrometer (NISDVU) completed at JPL delivered to NEON
- Jan 2012 - 1st Optech LiDA
  Camera system delivered
  NEON
- Jan 2012 – Instruments integrated into Platform Integration Mount







NEON Imaging Spectrometer Development
- NIS-1 due March 2013
- NIS-2 due September 2013

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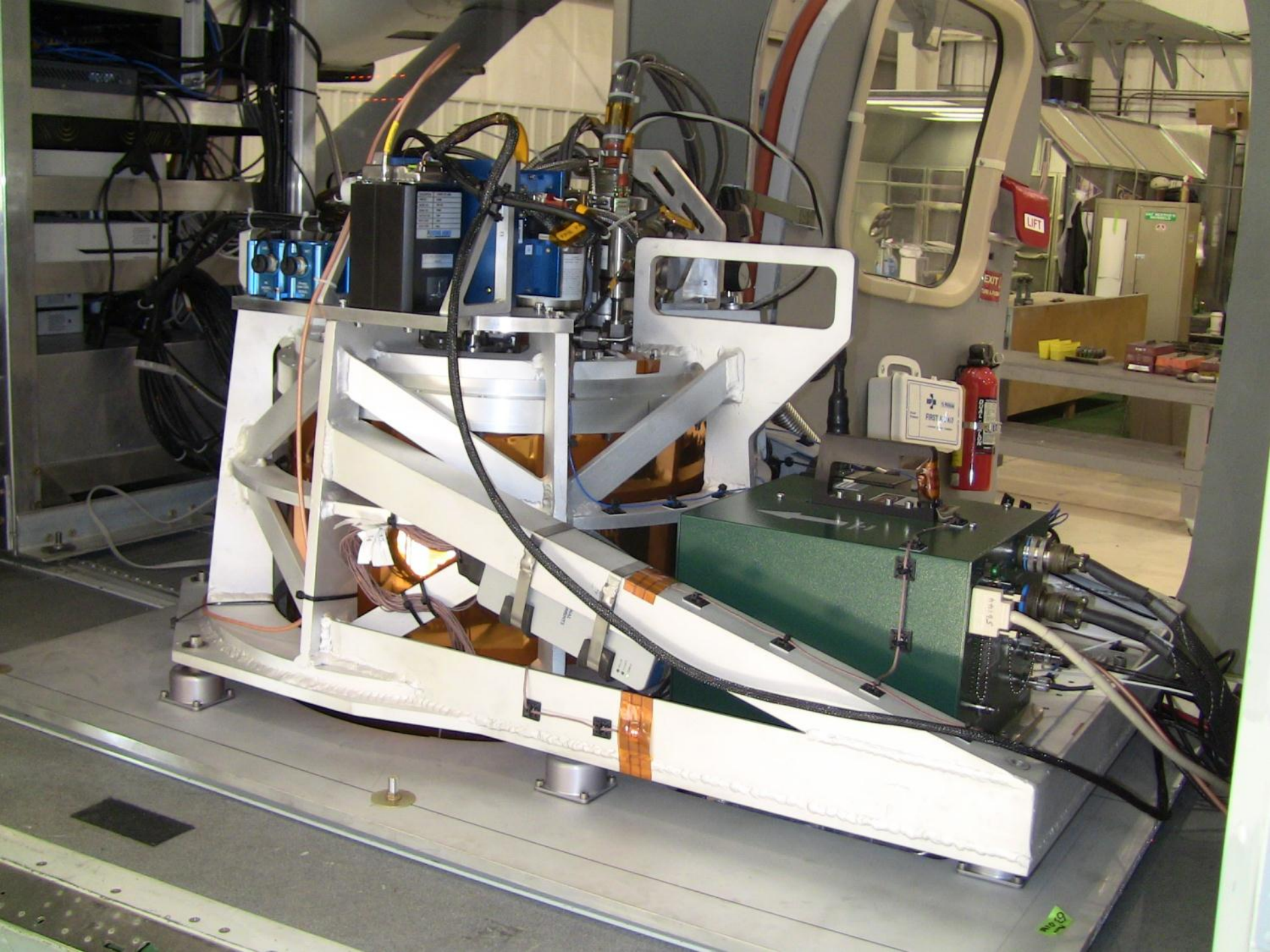
LIFT

AOP-1 Test Flight Campaign (May 2012)

- Goals:
  - First time integration of AOP-1 payload into aircraft
  - Airborne validation of NISDVU performance
  - Test and calibration flights
  - Operator training and experience
- Instrument payload shipped from NEON to Twin Otter International Ltd., Grand Junction, CO on April 27, 2012
- Integration of payload to aircraft: April 29 thru May 4
- Series of test flights conducted around Grand Junction & Telluride, CO and Ivanpah Playa, NV during May 2012

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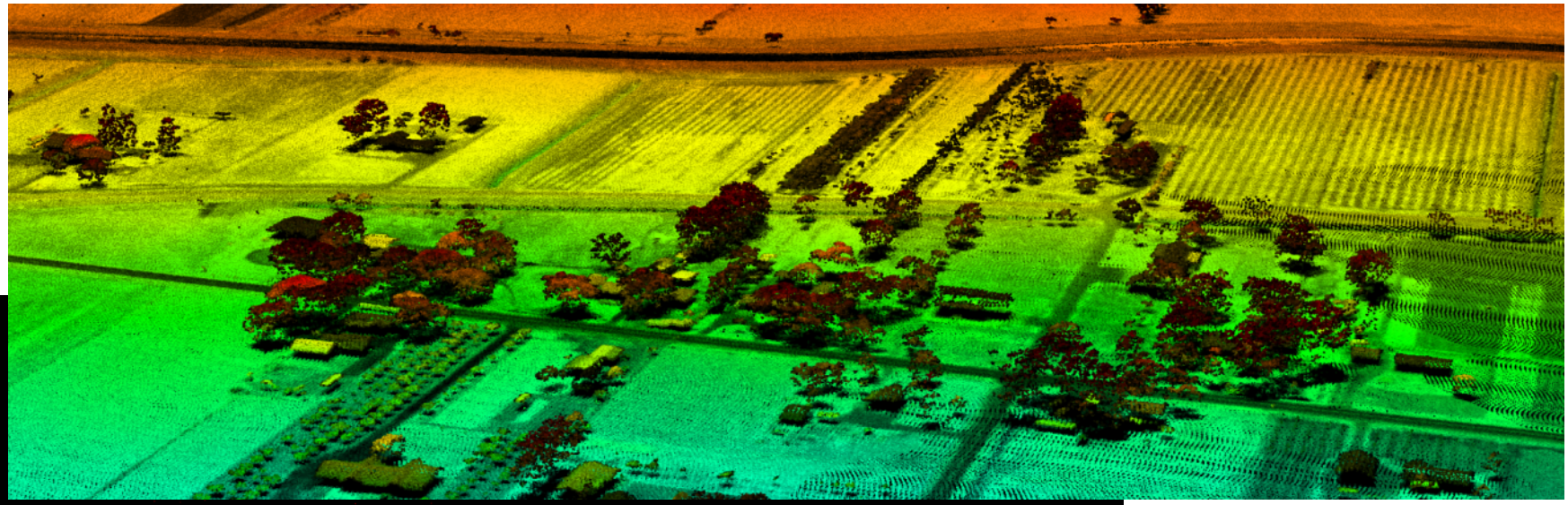
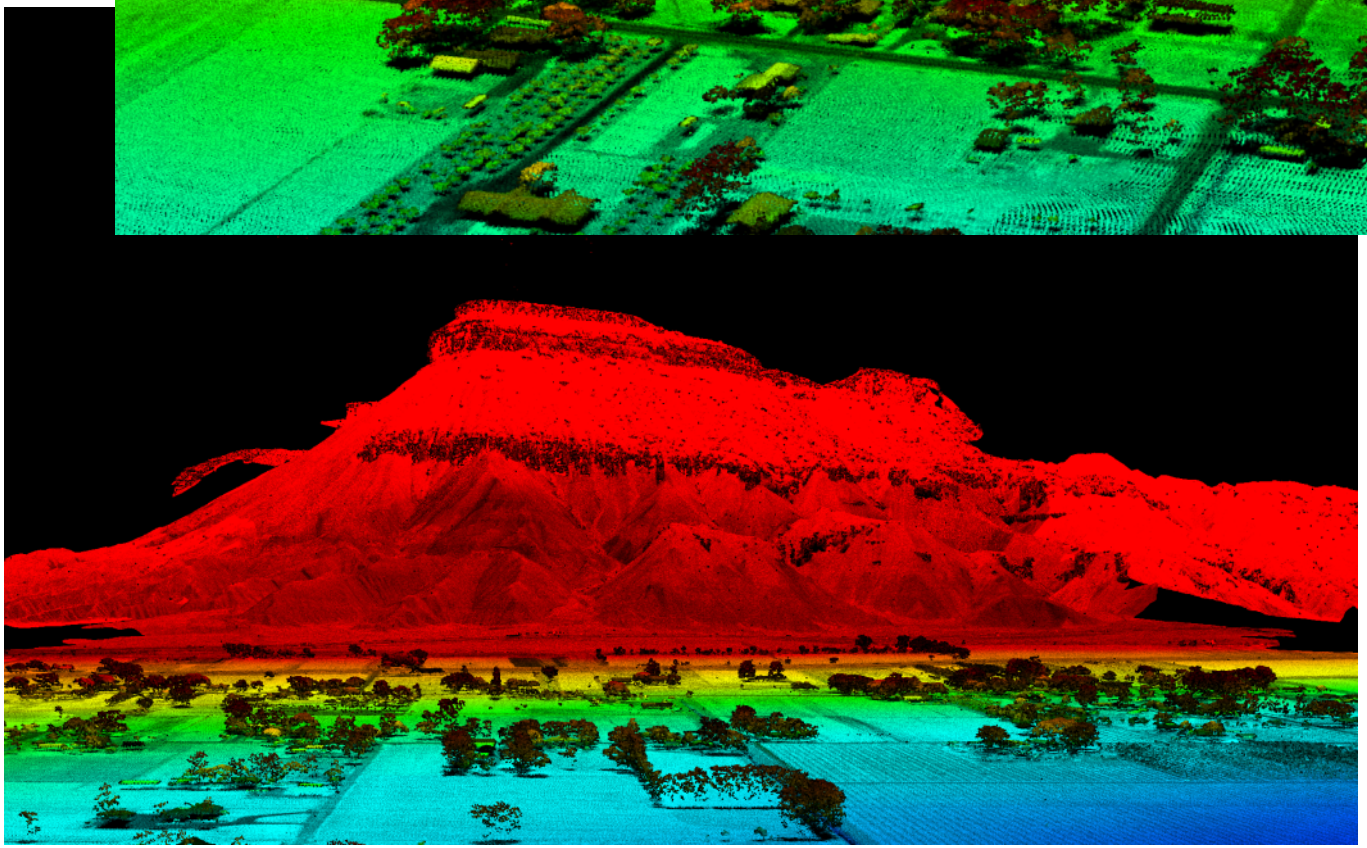
Mt. Garfield/Grand Junction





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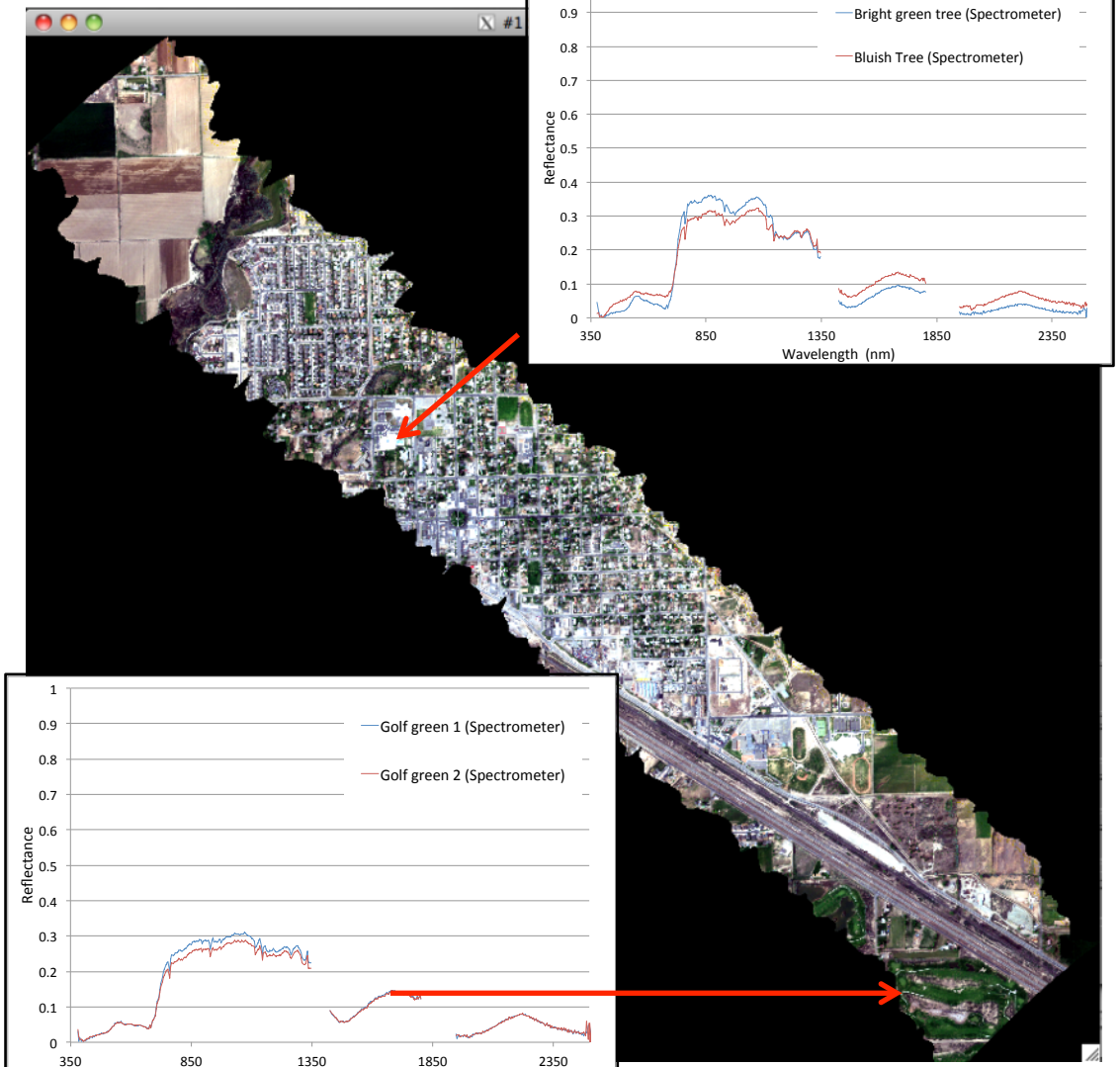
Atmospherically Corrected Fruita, CO Image

Data Products

- Atmospheric correction used to determine surface reflectance.
- Higher level data products derived from reflectance.
- NEON working to test several atmospheric correction algorithms.
- Compare in-situ reflectance to atmospherically corrected spectrometer data to improve results.



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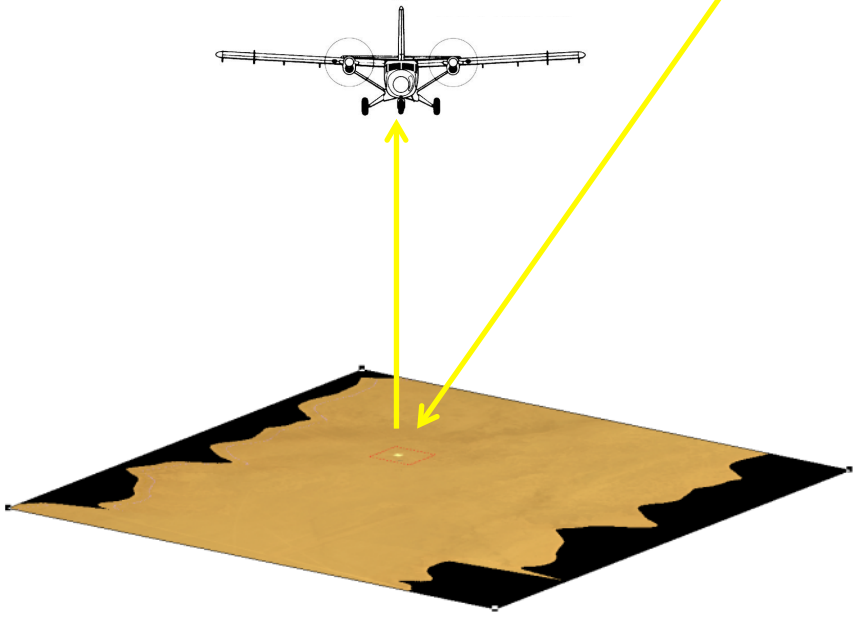
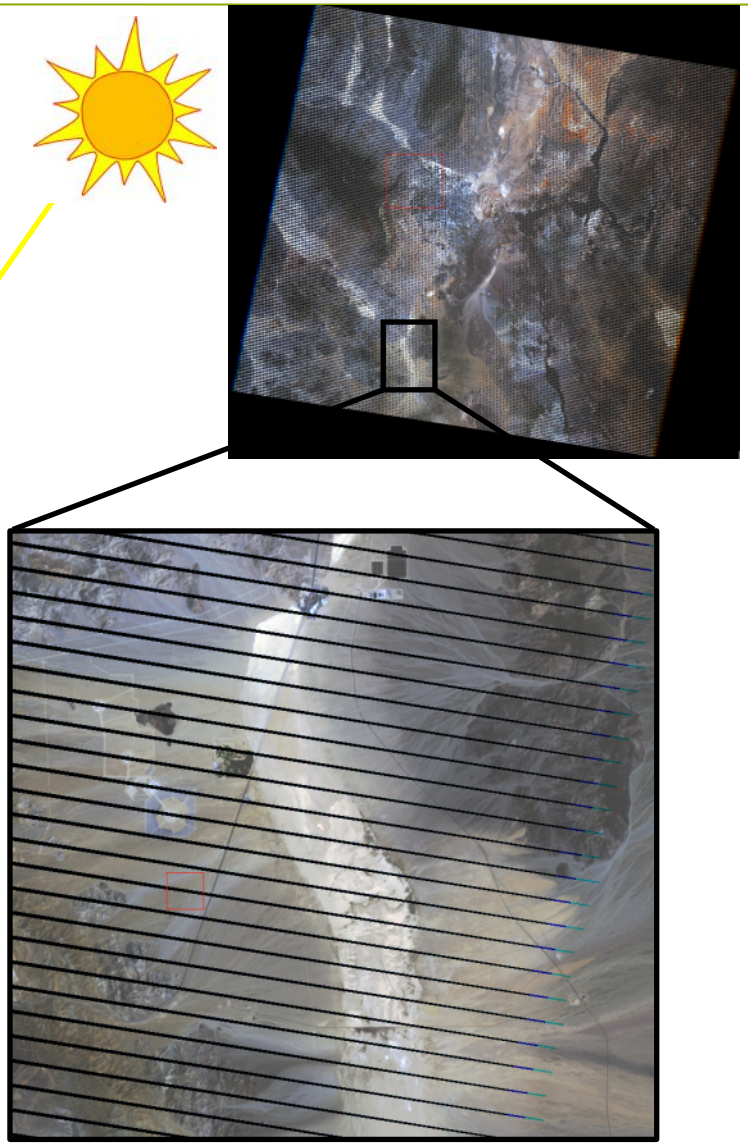
Vicarious Calibration at Ivanpah Playa

- Independently validate the radiometric calibration of Spectrometer
- Validate geolocation of airborne data
- Validate atmospheric correction and reflectance retrieval





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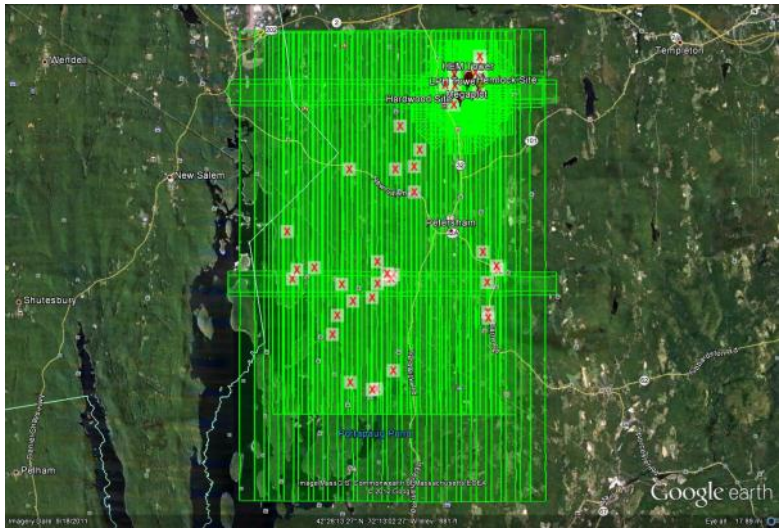
Harvard Forest Campaign: August 2012

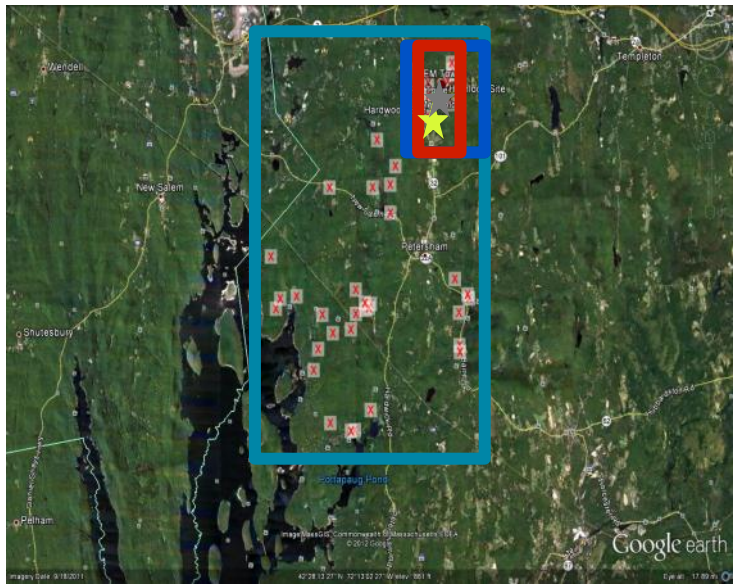
Goals:

- Leverage historical and ongoing ecological research at well characterized sites: Harvard Forest and Bartlett Experimental Forest
- Conduct a nominal AOP data operations survey (Hyperspectral, waveform LiDAR, high-resolution imagery at nominal resolution)
- Conduct instrument test flights: vary instrument collection parameters, aircraft altitude, and spatial sampling to determine the effect on data products and understand instrument performance
- **LiDAR algorithm development and product validation**: collect standard FSU ground observations plus ground LiDAR measurements of vegetation species ID, location, structure, LAI, biomass, etc. to aid in AOP algorithm development and product validation
- **Spectrometer algorithm development and product validation**: collect ground measurements of foliar/canopy chemistry and other vegetation/ ground biogeochemistry to aid in AOP algorithm development and product validation
- Collect a NEON integrated data set to enable new research (primarily AOP and FSU) and support scaling studies (ground to air to satellite)

Flight Collections Overview

- Tuesday August 7: Flight Package C
  - 3km x 4km @ 2000m AGL
  - 3km x 4km @ 1000m AGL
  - 1km x 4km @ 500m AGL
  - Discrete LiDAR and Camera
  - Issue with camera collections on even lines at 1000m AGL
- Wednesday August 8: Flight Package D
  - High density collects of 5 field positions x 4 headings @ 1000m AGL
  - Two locations: Hardwood and Hemlock LiDAR Calibration Sites
  - Discrete and Waveform LiDAR, Camera
  - Issue with camera collections on at least half of the flight lines
- Monday August 13: Flight Package A
  - 9km x 16km @ 1000m AGL
  - Spectrometer, Discrete and Waveform LiDAR, Camera
  - Flight aborted on Line 7 due to low clouds
- Tuesday August 14: Flight Package A
  - 9km x 16km @ 1000m AGL
  - Spectrometer, Discrete and Waveform LiDAR, Camera
  - Issue with spectrometer: no dark/obc data collected
  - Issue with waveform LiDAR: waveform drive filled up on Line 9
  - Note: heavy cirrus clouds blocking sun at times during collection





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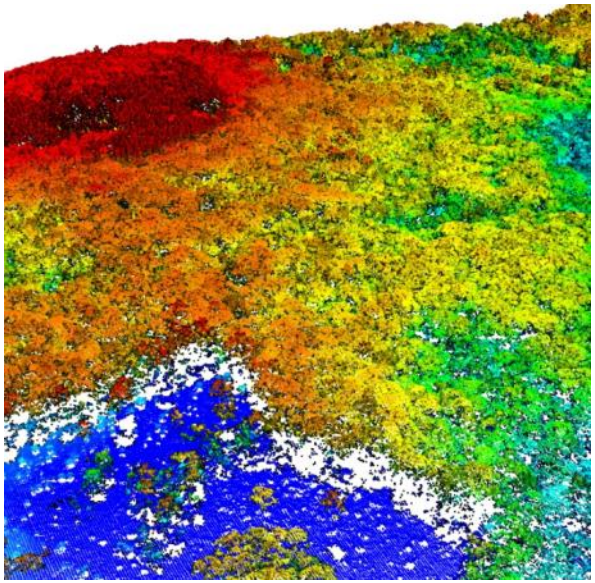
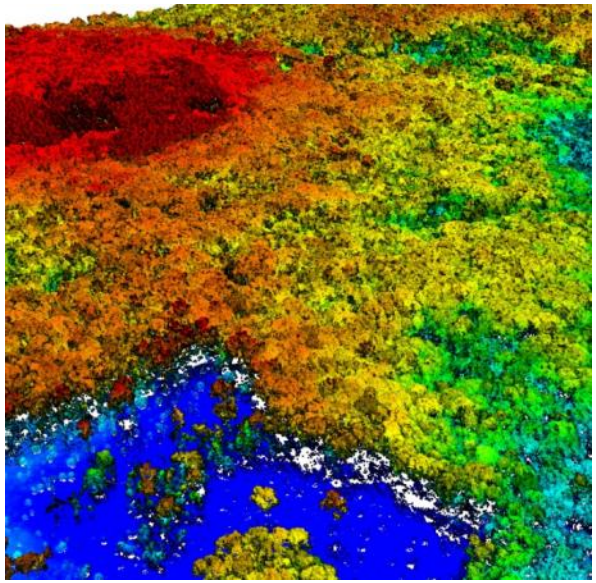
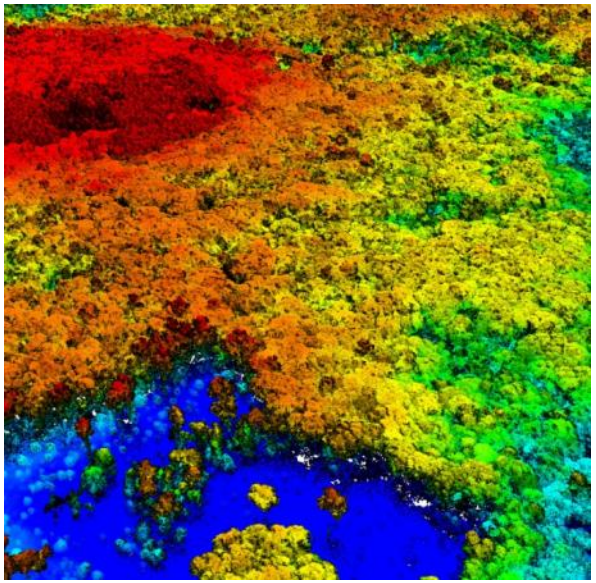
Hardwood Site



Single North-South Line



Five North-South Lines



All Twenty Lines

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Collaborative Ground Measurements

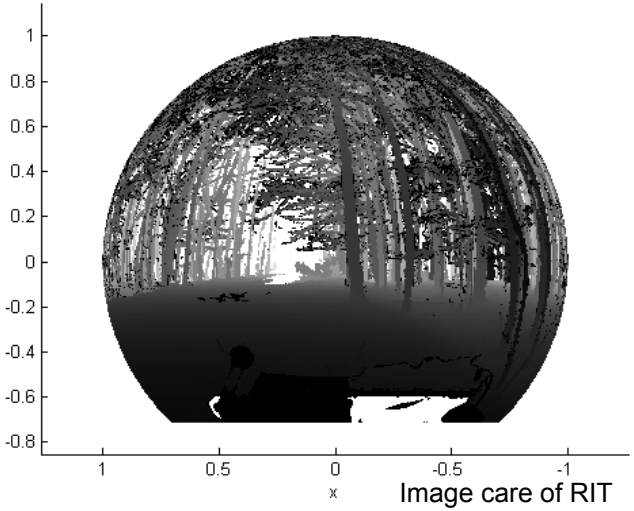
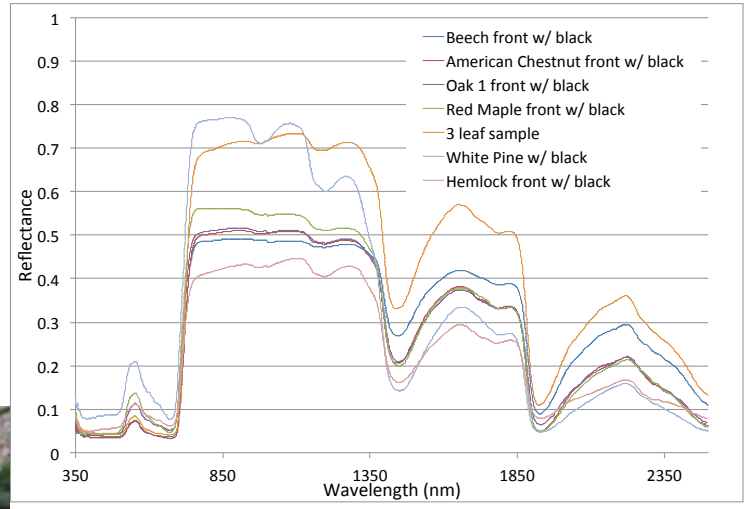


Image care of RIT



Ground-based Lidar

- Crystal Schaaf (U of Mass); Jan Van Aardt (RIT)
- Is there agreement in critical canopy measurements between ground-based Lidar and airborne Lidar?
- Are estimates of key parameters (i.e., canopy ht., canopy volume, leaf area, etc.) similar?
- Does ground-based Lidar offer an alternative (superior?) approach for ground validation of airborne Lidar?
  - Can ground-based Lidar augment (or replace) labor-intensive measurements of trees and allometric equations?

Ground-based spectral measurements of vegetation

- Field spectrometer measurements of plants to develop spectral data base to support vegetation classification from airborne data

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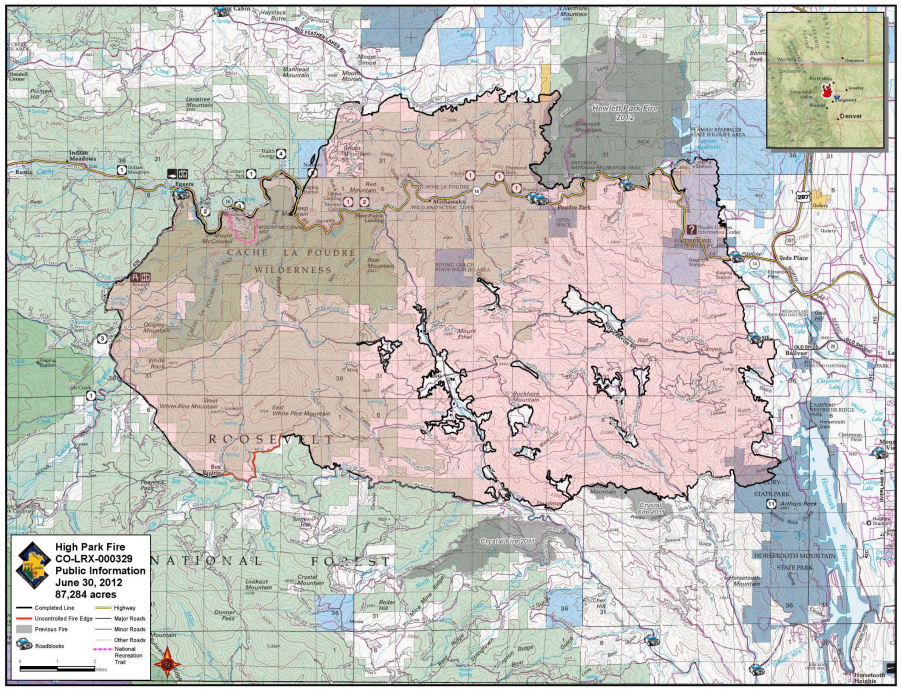
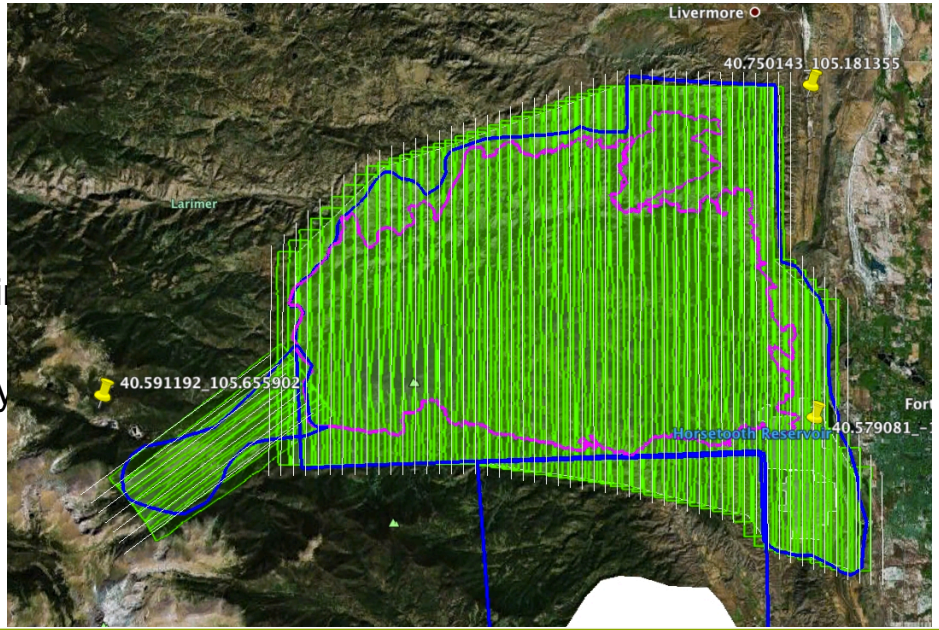
High Park Fire, Colorado



Second largest fire in Colorado history

- June-July 2012
- Destroyed more than 250 structures
- Burnt over 87,000 acres of public and private lands located west and north of Fort Collins, CO
- NEON awarded a RAPIDS proposal to survey the entire burn scar area (August 2012)
- Working with Scientists from Colorado State University
  - How does pre-fire management and pine beetle outbreak shape fire extent and severity?
  - What are post-fire forest developmental trajectories from stands to landscapes?



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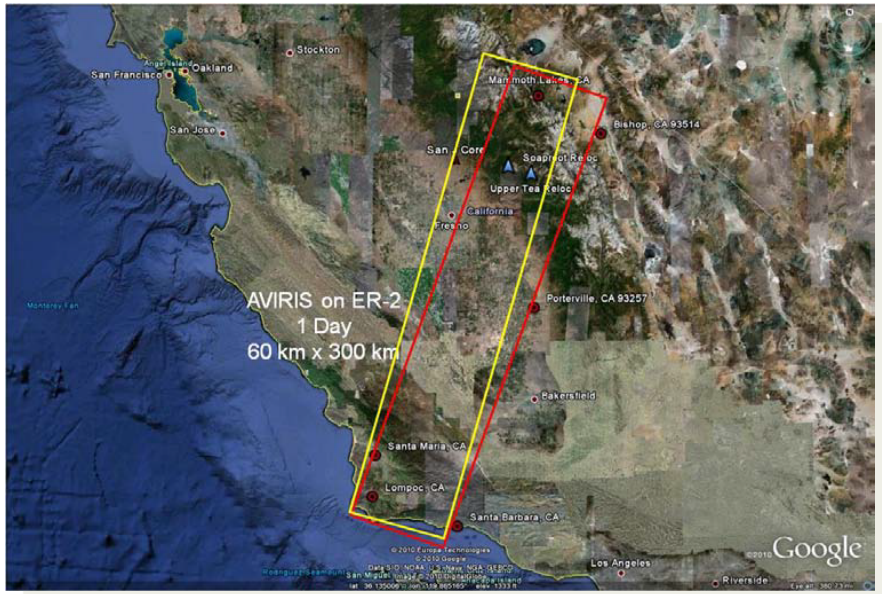
Upcoming HyspIRI Preparatory Flights

- **HyspIRI Preparatory Airborne Flights (Summer of 2013)**
  - Flying AVIRIS-classic onboard the ER-2 to obtain HyspIRI-like data
  - Fly regions with large climate gradients and diversity
  - Large areas; 3 seasons; ≥ 2 years
  - Acquisition from ER-2 (20 km native resolution; aggregated to 60 km to match HyspIRI)
- **NEON**
  - Concurrent AOP flights over NEON sites @ 1-km altitude (1m res)
  - Concurrent satellite acquisitions (MODIS, Landsat, Hyperion)
  - Supporting ground measurements (field spectroscopic measurements, LAI, radiometric calibration, AOD, etc)



Goals:

- Obtain spectroscopic data at multiple spatial scales useful for assessing sampling strategies for the extrapolation of biophysical processes
- Spectroscopic and lidar data at 1-m resolution to support NEON & HyspIRI science product development

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2013 AOP Flight Campaigns

- AOP-2 Validation Flight Campaign (April 2013)
  - Base out of TOI, Grand Junction, CO
  - Engineering/Calibration flights in Grand Junction area, possibly Moab site
- D17 Pacific Southwest Flight Campaign (June 2013)
  - Base out of Fresno, CA
  - Overfly SJER, Soaproot Saddle, and Upper Teakettle sites
- D10 Central Plains Flight Campaign (July 2013)
  - Base out of Broomfield, CO
  - Overfly CPER Core, Rocky Mountain Natl. Park CASTNET Relocatable, North Sterling Relocatable sites
  - Repeat High Park Fire Scar flights (Separate RAPID proposal)
- D3 Southeast Flight Campaign (Oct 2013)
  - Base out of Gainesville, FL
  - Overfly Ordway Swisher, Disney, and Jones Ecological Research Center sites

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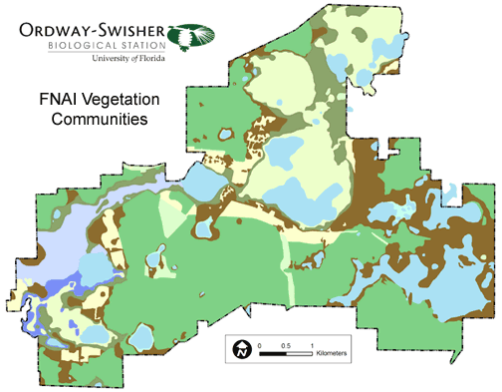
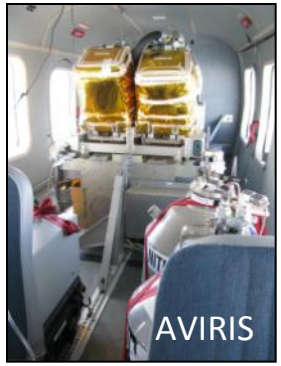
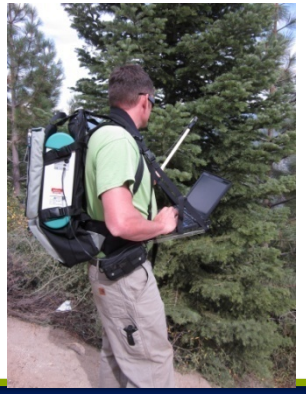
Pathfinder Flight Campaigns

- Pathfinder Campaign 1 (9/2010)
  - Ordway-Swisher Biological Station (near Gainesville, Florida)
  - NASA JPL deployed AVIRIS and NCALM deployed LiDAR system
  - Combined LIDAR and spectrometer dataset collected
  - Prototype field sampling for validation and scaling airborne data
- Pathfinder Campaign 2 (9/2011)
  - NEON Domain 17 Sites (San Joaquin Valley, Southern Sierra Nevada) and elevational gradient
  - NASA deployed AVIRIS on Twin Otter
  - Spectrometer dataset collected
  - Field sampling for data validation and spectral database







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Potential NEON Synergy with HyspIRI

- **NEON Ground/Airborne Validation of HyspIRI**
  - Well-validated annual measurements at 60 sites across the continental US –grasslands, deserts, agricultural areas, deciduous forest, conifer forest, tundra and Arctic
  - Vegetation chemical & structural information measured at all sites; site-specific spectral databases developed
  - FSU can provide ground validation of AOP and HyspIRI measurements
  - FIU towers provide point or airshed measurements of CO_2, aerosol optical depth and other atmospheric constituents
- **Operational Science Algorithm Development**
  - NEON will collaborate with scientific community for science data product development
  - NEON science algorithms developed over a broad range of ecoregions
  - Algorithms and associated error budgets documented in publically-available ATBDs
  - NEON science algorithms and associated software code to be developed to an operational level

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Potential NEON Synergy with HyspIRI

- **Calibration Comparisons with Spaceborne Sensors**
  - Yearly vicarious calibration flights by NEON over well-characterized ground validation sites (e.g., Railroad Valley, Ivanpah Playa)
  - Multi-decadal record of spectral reflectance measurements suitable for calibration comparisons with satellite and other airborne sensors
  - 3rd AOP platform potentially available to support dedicated under-flights of satellite sensors (Landsat, OLI, MODIS, NPOESS VIRRS, HyspIRI)
- **Bridging to Continental Scale**
  - HyspIRI continental-wide 60-m spectroscopic data will support NEON's mission to bridge from AOP plot scale to continental scale
- **Data**
  - NEON data will be openly available to all potential users
  - NEON AOP data will provide the opportunity for developing broad scientific user community of terrestrial remote sensing information in anticipation of the HyspIRI launch

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