Airborne remote sensing instrumentation for the National Ecological Observatory Network

NEON, Inc.
Airborne Observation Platform
1685 38th St Suite 100
Boulder, CO 80301

Joel McCorkel
Michele Kuester
Brian Johnson
Tom Kampe
Keith Krause

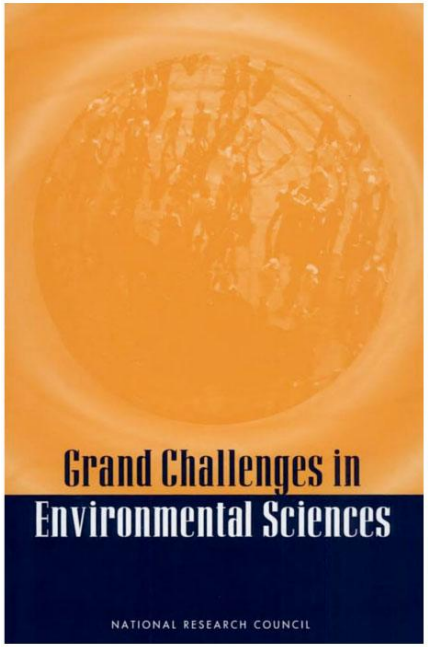
JACIE 2011 – Boulder, CO

NEON's mission is to enable understanding and forecasting of climate change, land use change, and invasive species on continental-scale ecology -- by providing infrastructure and consistent methodologies to support research and education in these areas.

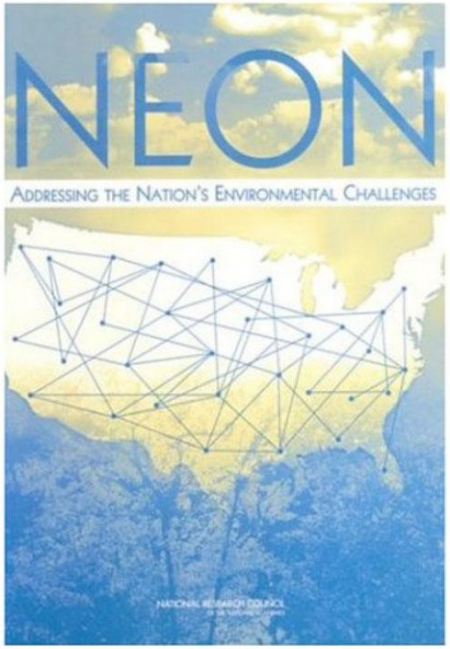
- **Information infrastructure:** Consistent, continental, long-term, multi-scaled data sets that serve as a context for research and education. All data free and openly available.
- **Physical Infrastructure:** A research platform for investigator-initiated experiments, new sensors and observations at NEON sites.

Grand Challenges in Environmental Sciences

1. Biodiversity
2. Biogeochemical cycles
3. Climate change
4. Ecohydrology
5. Infectious disease
6. Land use
7. Invasive Species

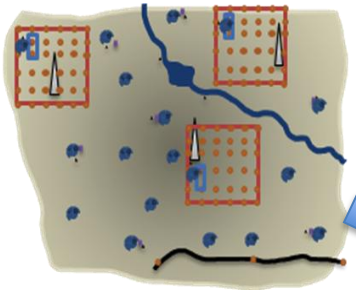


National Research Council Press 2001 Washington DC



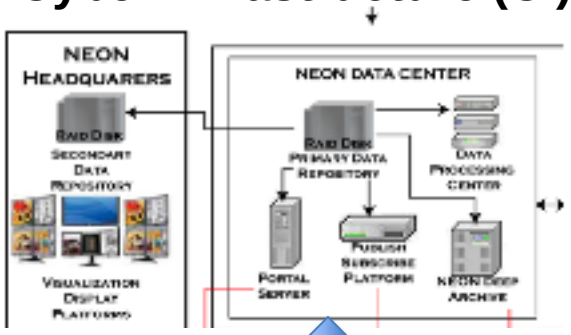
National Research Council Press 2003 Washington DC

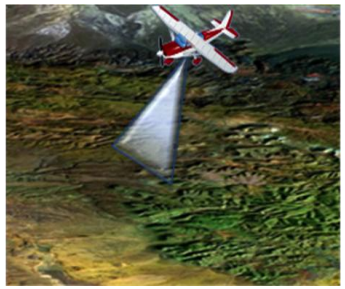
NEON groups



Biological sampling (FSU)

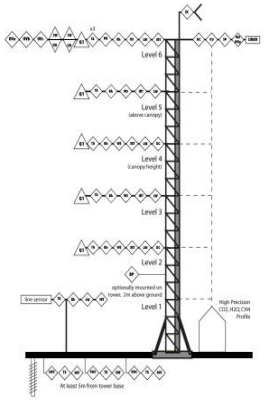
Cyber infrastructure (CI)



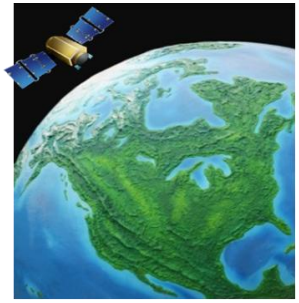


Airborne remote sensing (AOP)

Aquatics and Stream Experiment (STREON)



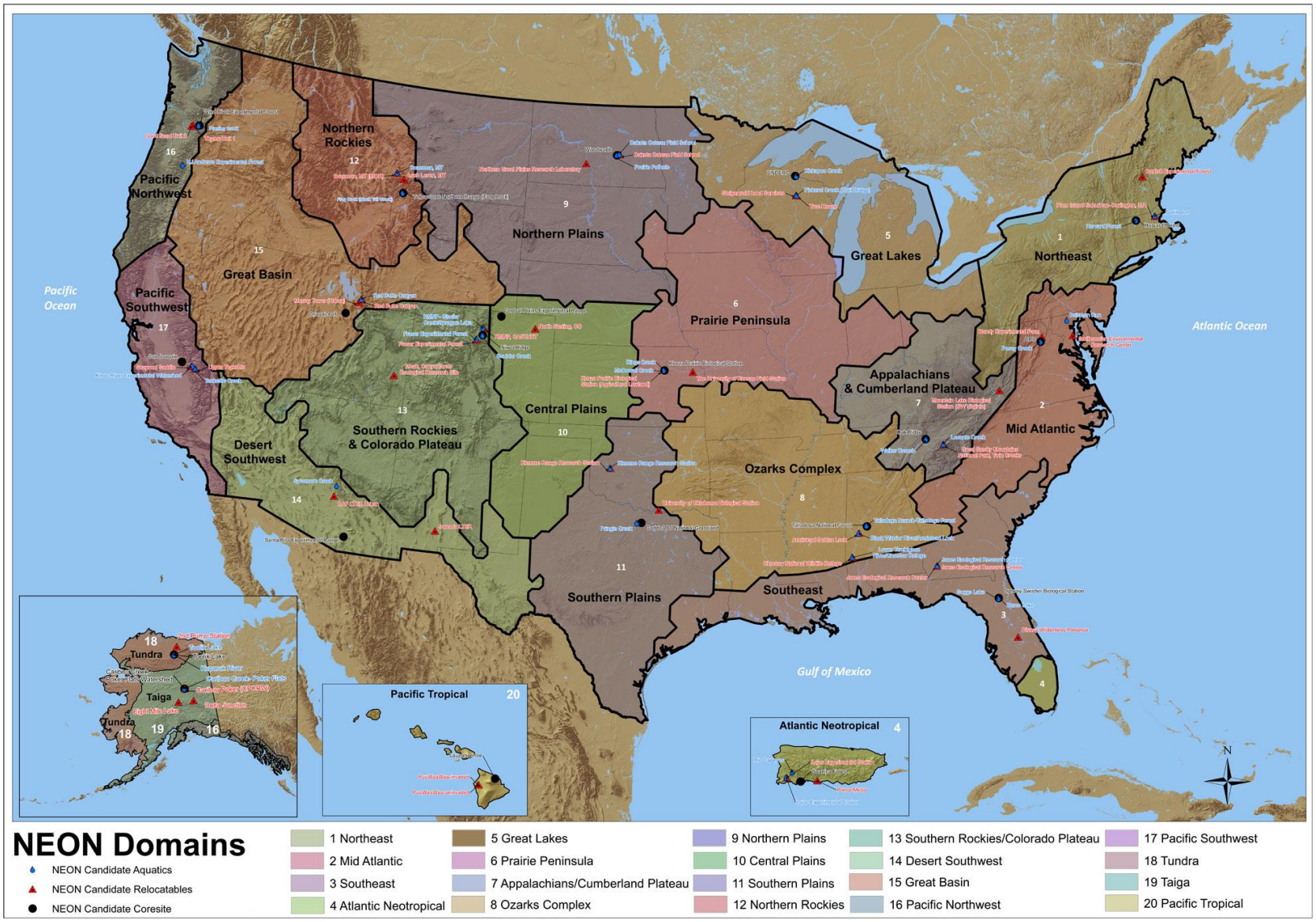
Flux towers (FIU)



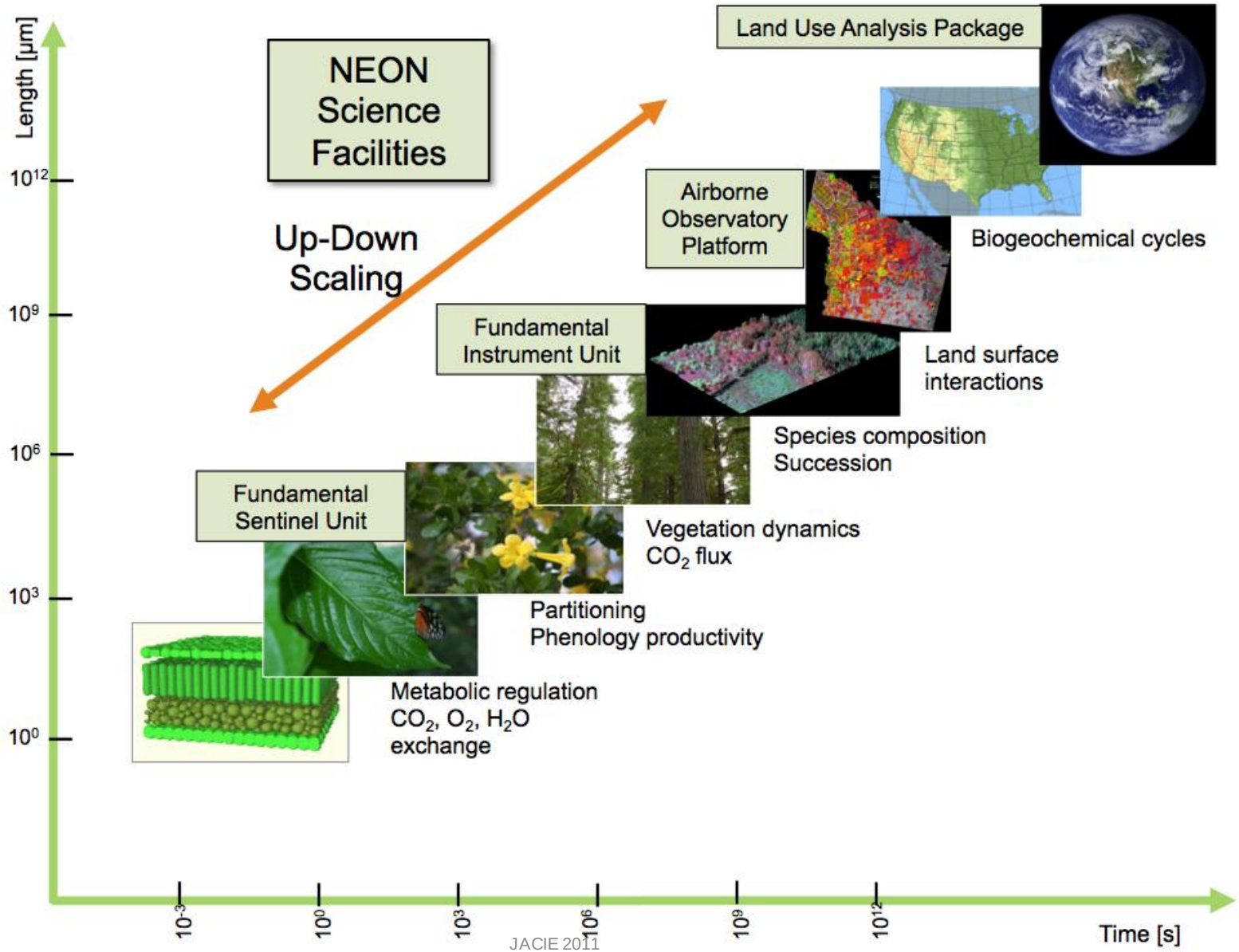
Satellite remote sensing (LUAP)

Civil science

NEON's 60 sites in 20 Domains



NEON scaling Strategy



Talk summary

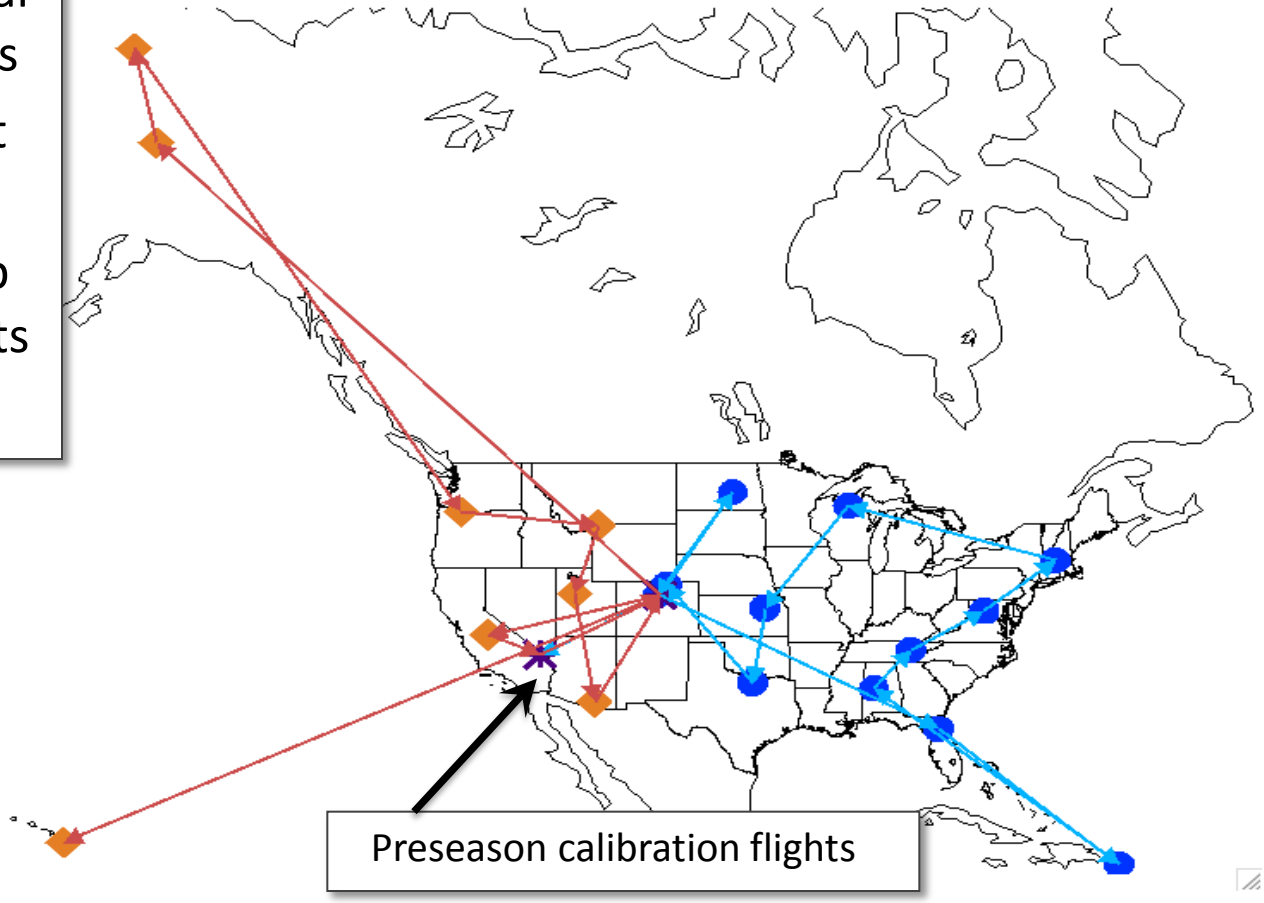
- NEON mission
- Airborne package
  - Imaging spectrometer
  - Operations
  - Calibration plan
- Pathfinder Flight 2010 with AVIRIS
  - Airborne data
  - Ground data

Role of Airborne Remote Sensing

- AOP will observe invasive species, land use drivers and ecosystem responses surrounding the NEON Core and Re-locatable sites
  - land cover
  - vegetation structure
  - Invasive plant species
  - biochemical and biophysical properties
  - ecosystem functioning
- Bridge scales from organism and stand scales to the scale of satellite based remote sensing (e.g. meter-scale)
- Observe targets of opportunity (e.g. PI-science, wildfires)

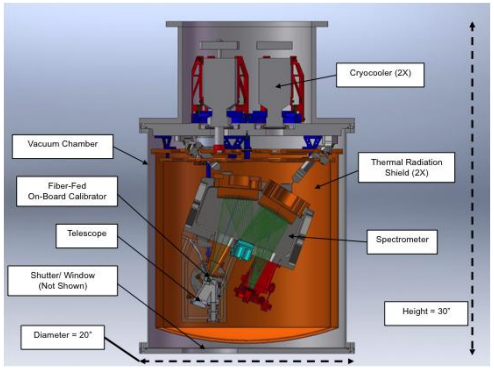
Airborne Operations

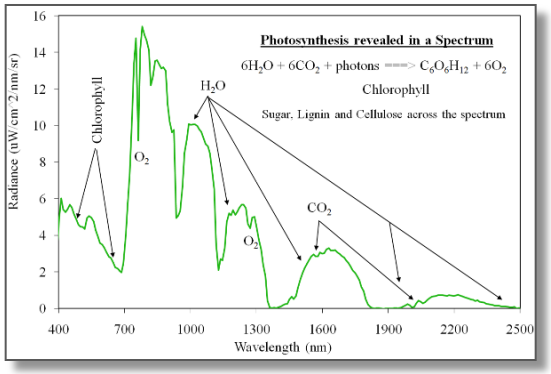
- 2 aircraft with identical payloads to cover sites
- 7-months, 1,100 flight hrs flight season
- 3rd Payload for backup & new science, targets of opportunity



Airborne Observation Platform

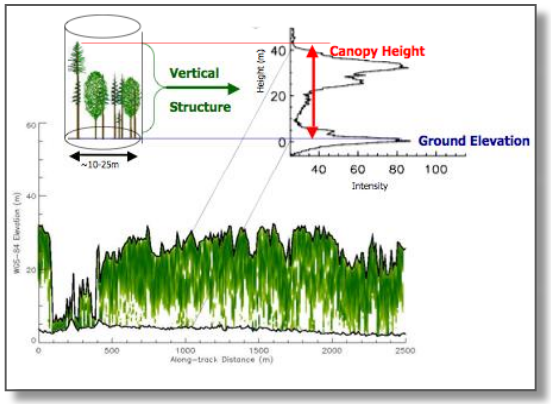
Imaging Spectrometer
JPL



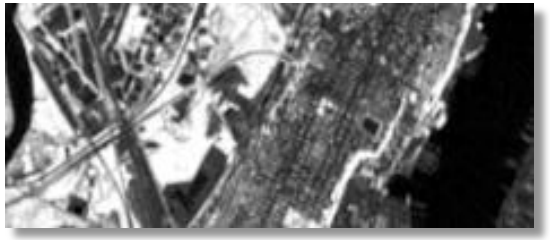


Waveform lidar
Optech ALTM Gemini system

Applanix GPS/IMU

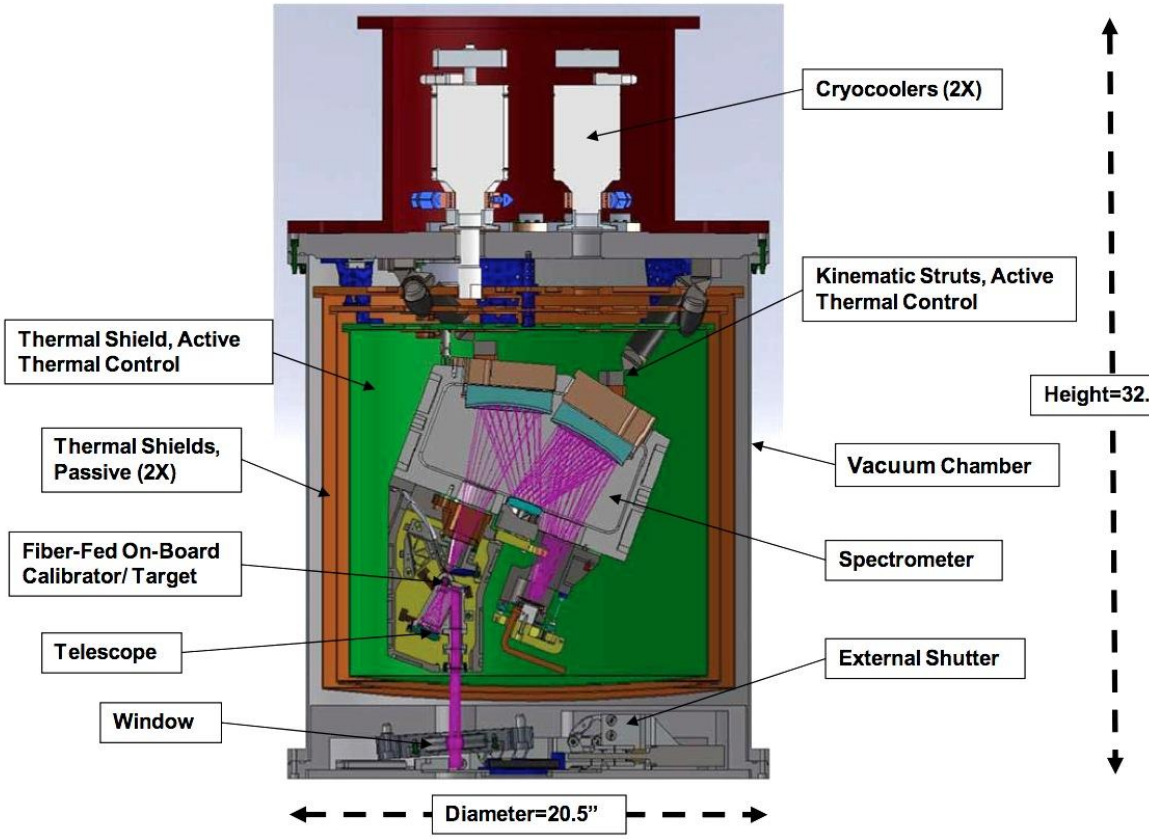


High-resolution digital camera
Applanix digital airborne camera

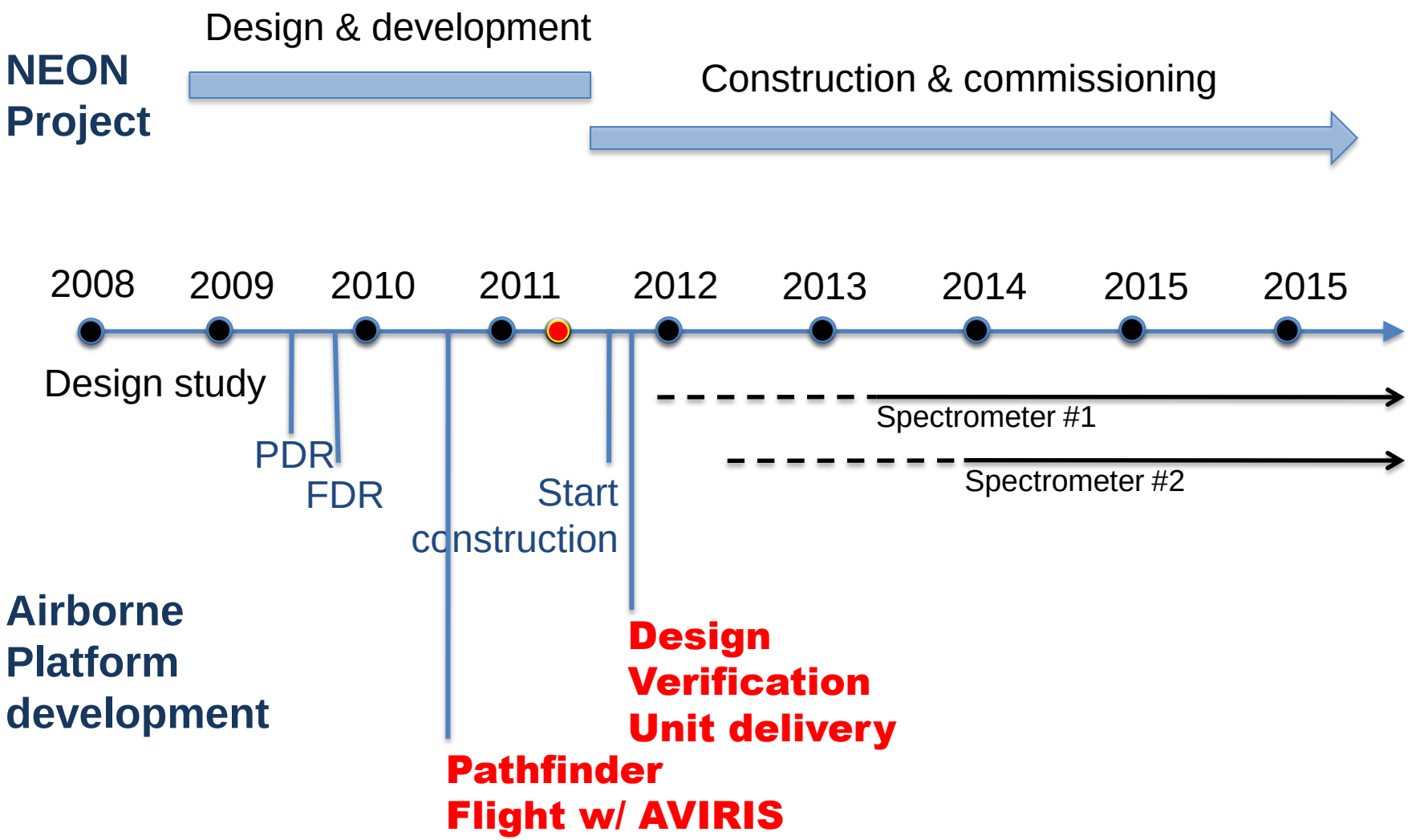


Neon Imaging Spectrometer Design Verification Unit (DVU)

- Pushbroom imaging spectrometer
- Spectral range: 380 – 2510 nm
- Spectral sampling: 5 ± 0.5 nm
- FOV: 34 ± 1 degrees
- IFOV: 1 ± 0.1 mrad
- Radiometric sampling: 14 bit
- Crosstrack swath: 1 km @ 1 km AGL
- Spectral-cross-track uniformity: >95% uniformity
- Spectral-IFOV: > 95% uniformity
- Configuration: Two-mirror off-axis telescope, single Offner spectrometer with multi-blaze grating, mechanical coolers

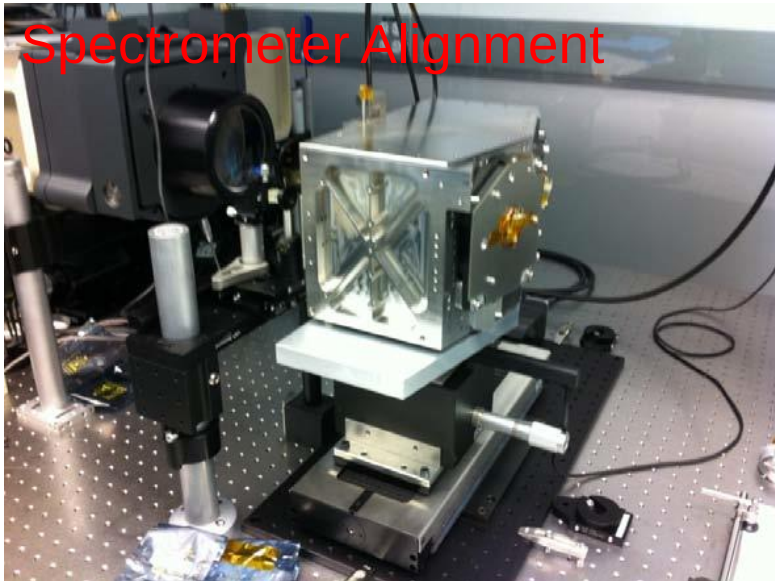


Status of Airborne Observation Platform

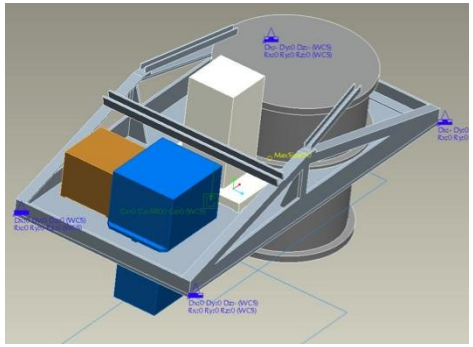


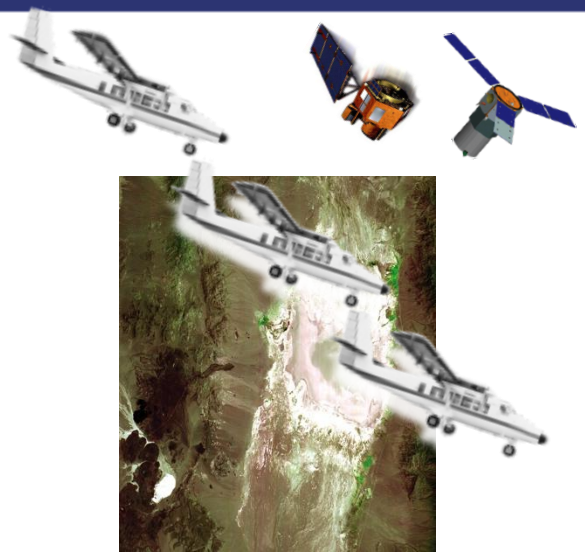
DVU Development status

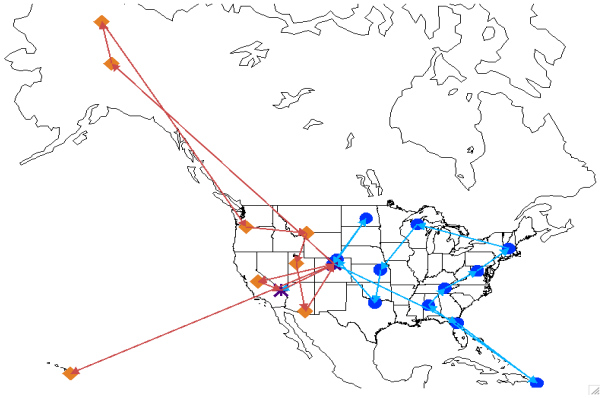
- **2008-Dec** Completed JPL conceptual design study & early risk reduction tasks
- **2009-Feb** Subsystem design reviews
- **2009-Oct – 2012-Apr**
  - Spectrometer design verification unit (DVU)
  - Prototype algorithms
  - Flight campaigns (inc. 2010 pathfinder)



Calibration timeline for airborne platform







Winter → *Spring* → *Fall*

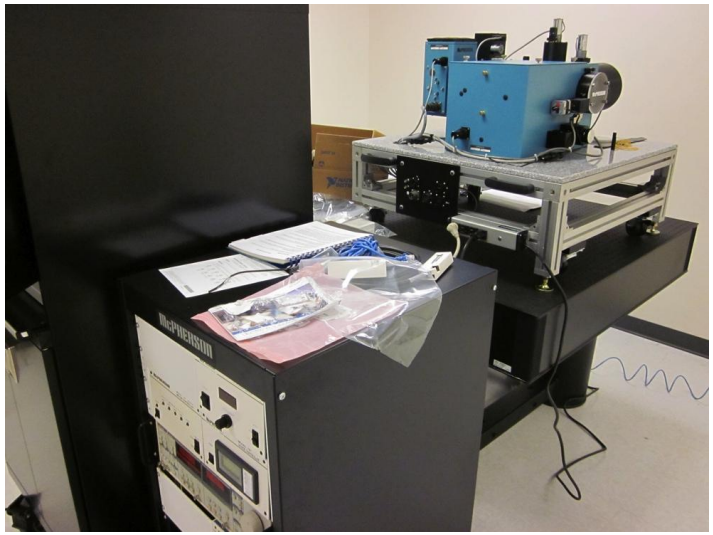
Pre flight season laboratory characterization at NEON HQ in Boulder, CO

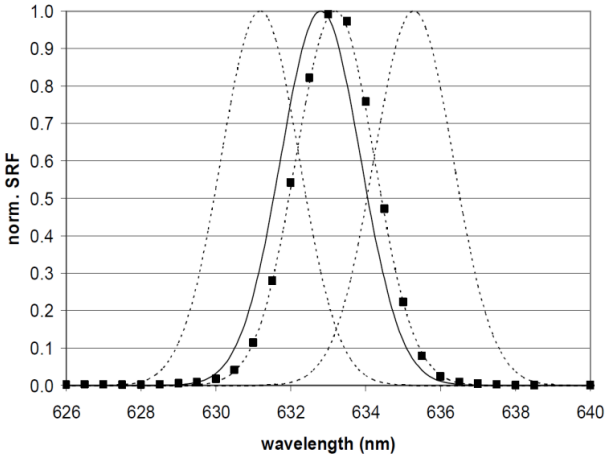
Pre flight season operational test. Coincident measurements of:
- -3 airborne platforms
- -Satellite sensors
- -Ground-based reflectance and atmosphere

Flight season characterization:
- -On-board calibrator
- -Known test sites
- -Solar radiation based calibration

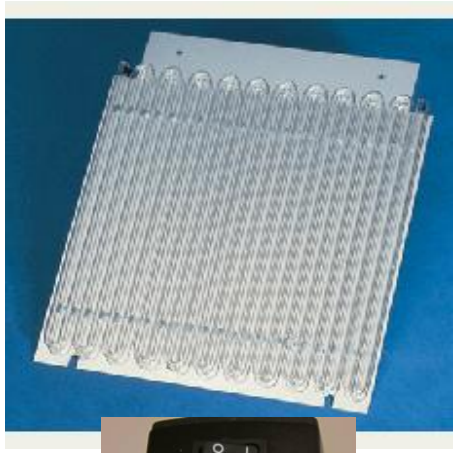
Calibration Facility – Spectral

Monochromator



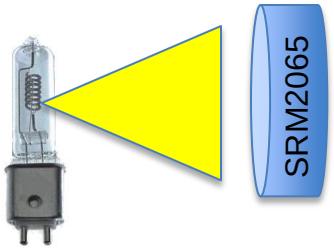


Rare gas spectra



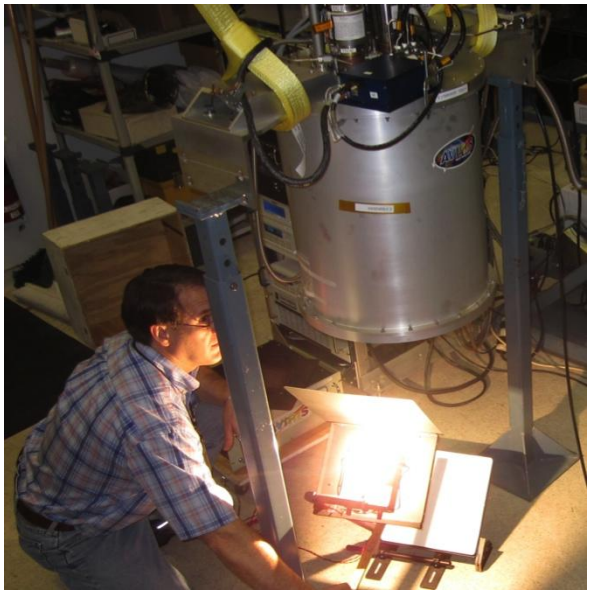
Laser sphere

SRM 2065 - Ultraviolet-Visible-Near-Infrared Transmission Wavelength/Vacuum Wavenumber Standard

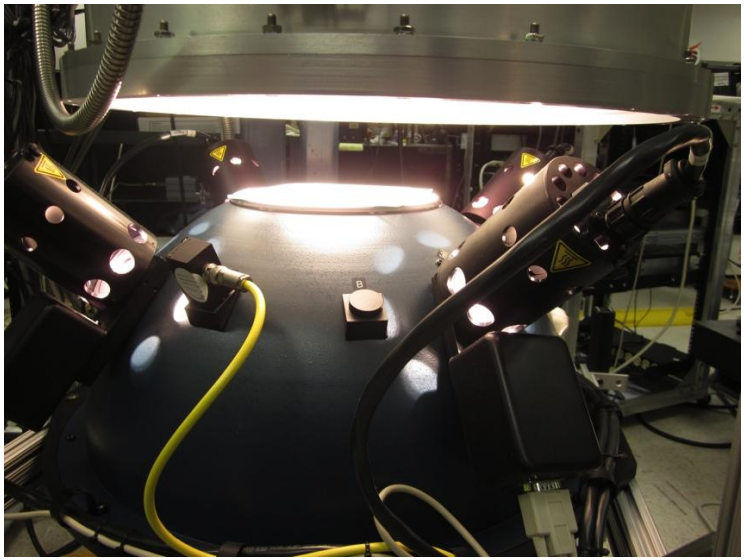


Calibration Facility – Radiometric

NIST irradiance standard



Integrating-sphere source



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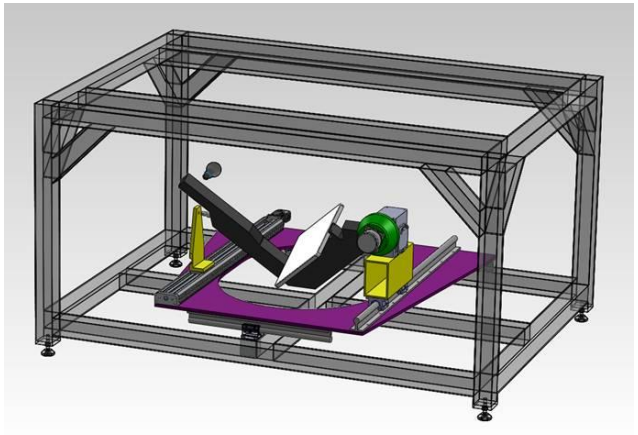
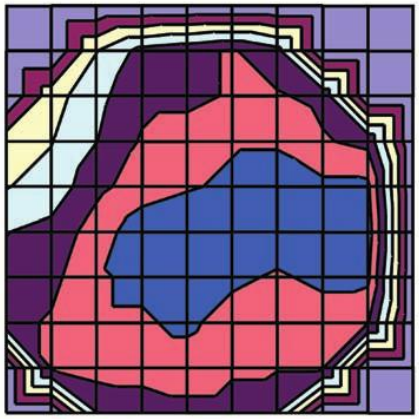
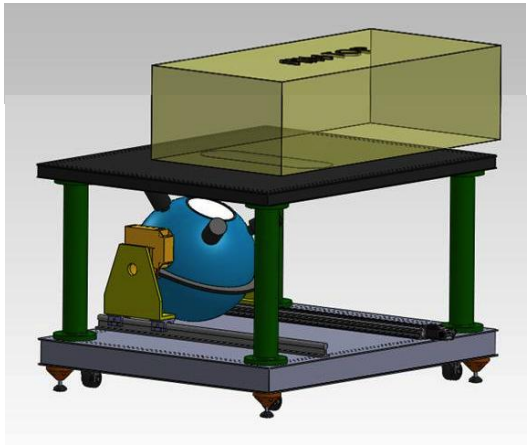






NEON Domain 3 core site: Ordway-Swisher Biological Station, Florida

Prototype to incorporate multiple NEON data-streams to

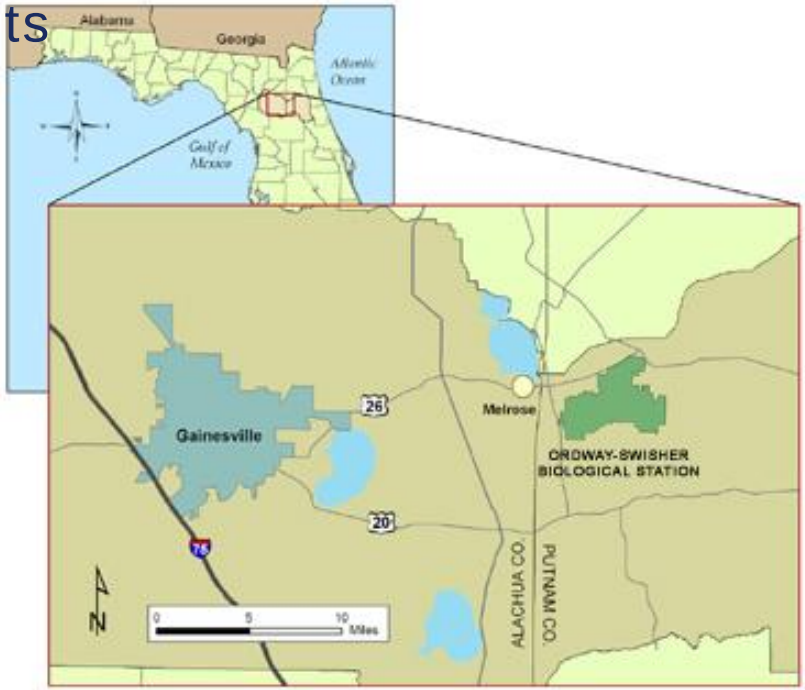
- Develop scaling strategies
- Ground-truth airborne measurements

Field sampling measurements

- Tree diversity
- Vegetation structure
- Leaf Area Index (LAI)

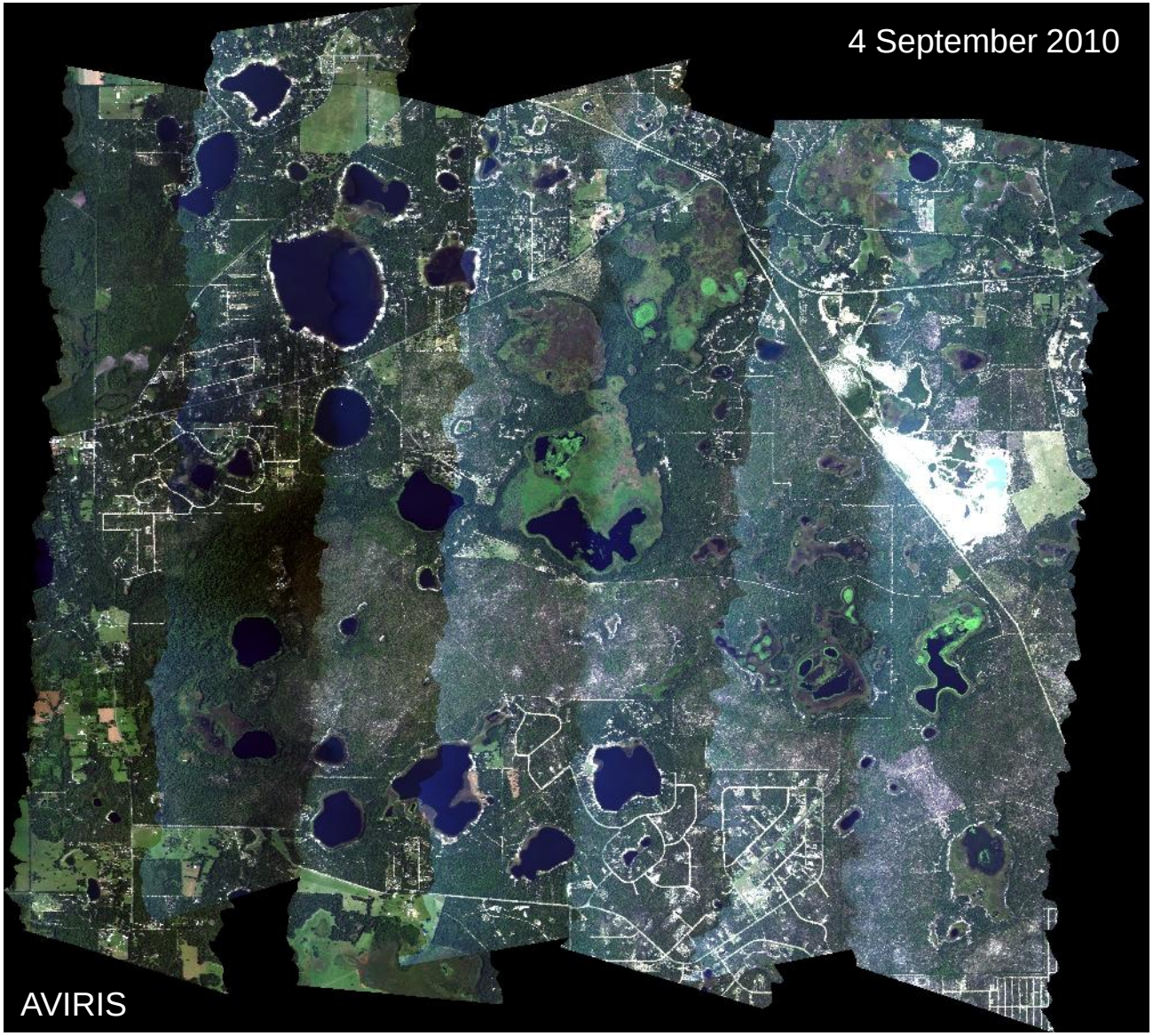
Airborne measurements

- Imaging spectroscopy
- Waveform lidar

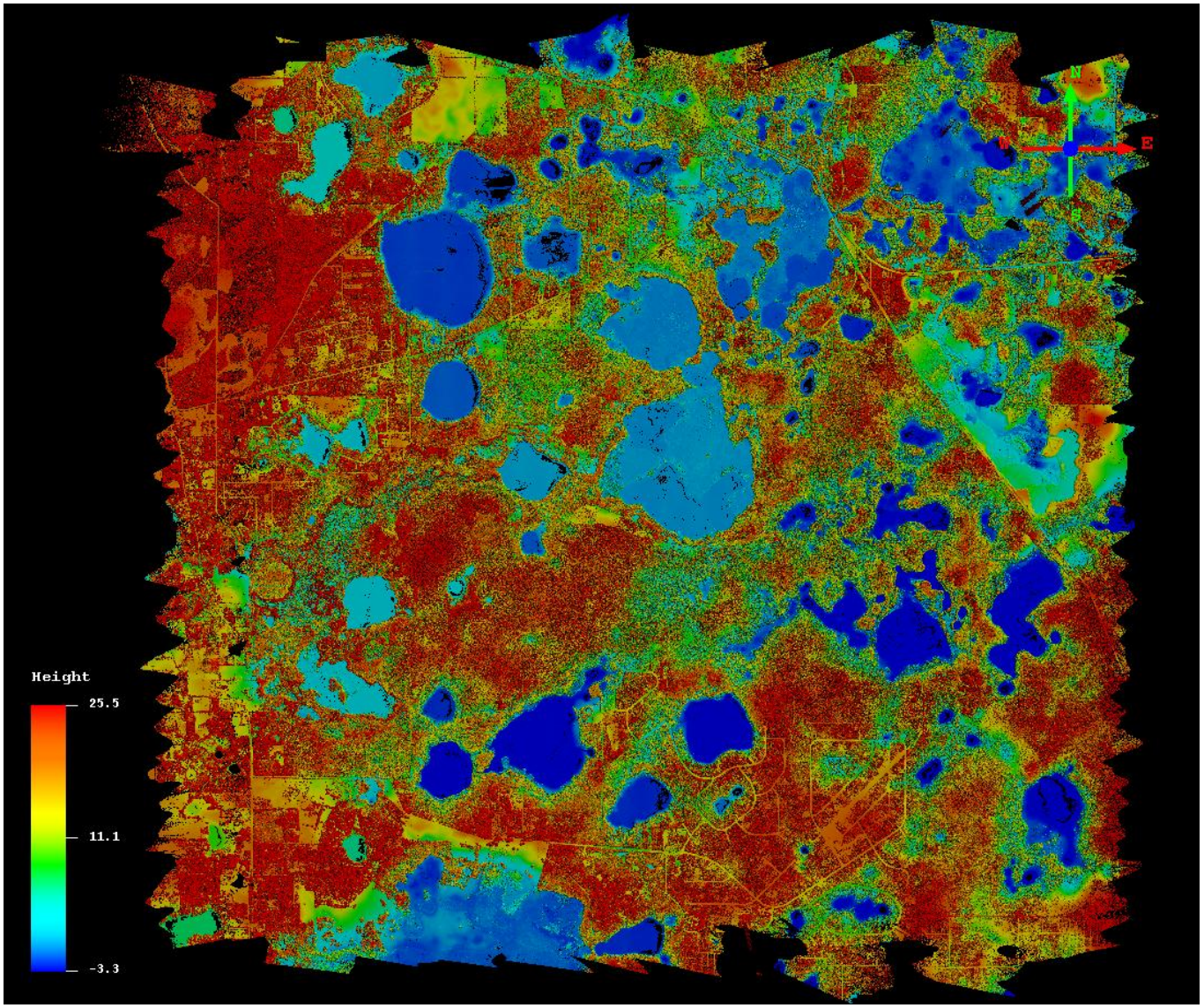


Pathfinder 2010 photos

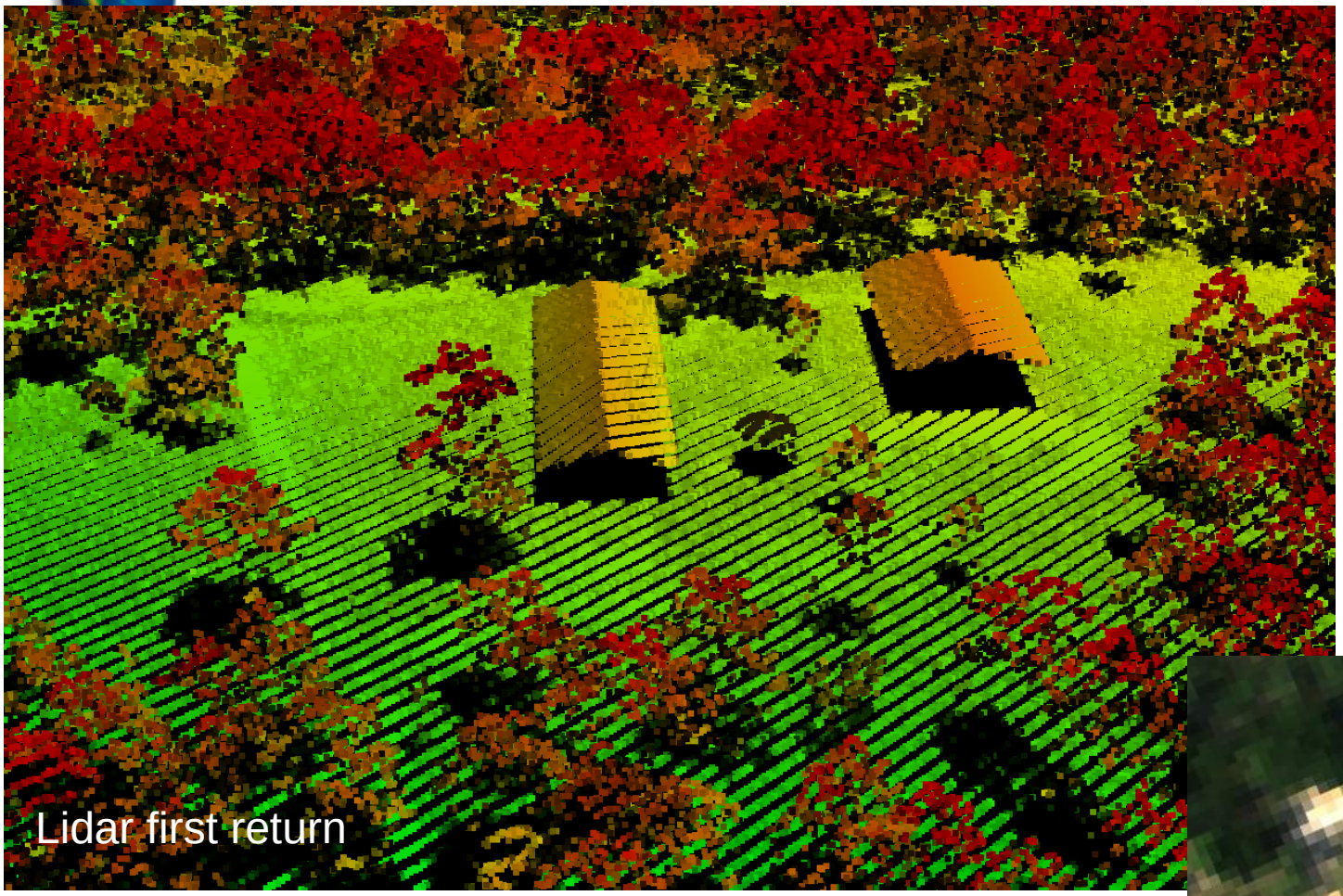
Pathfinder 2010 – Imaging Spectrometer

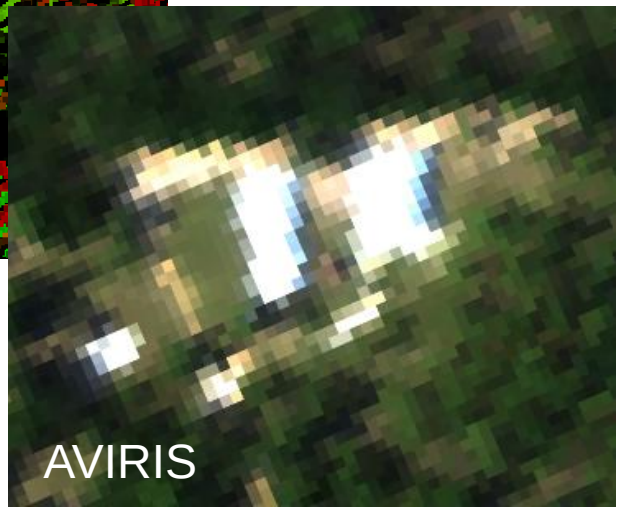


Pathfinder 2010 – Waveform lidar

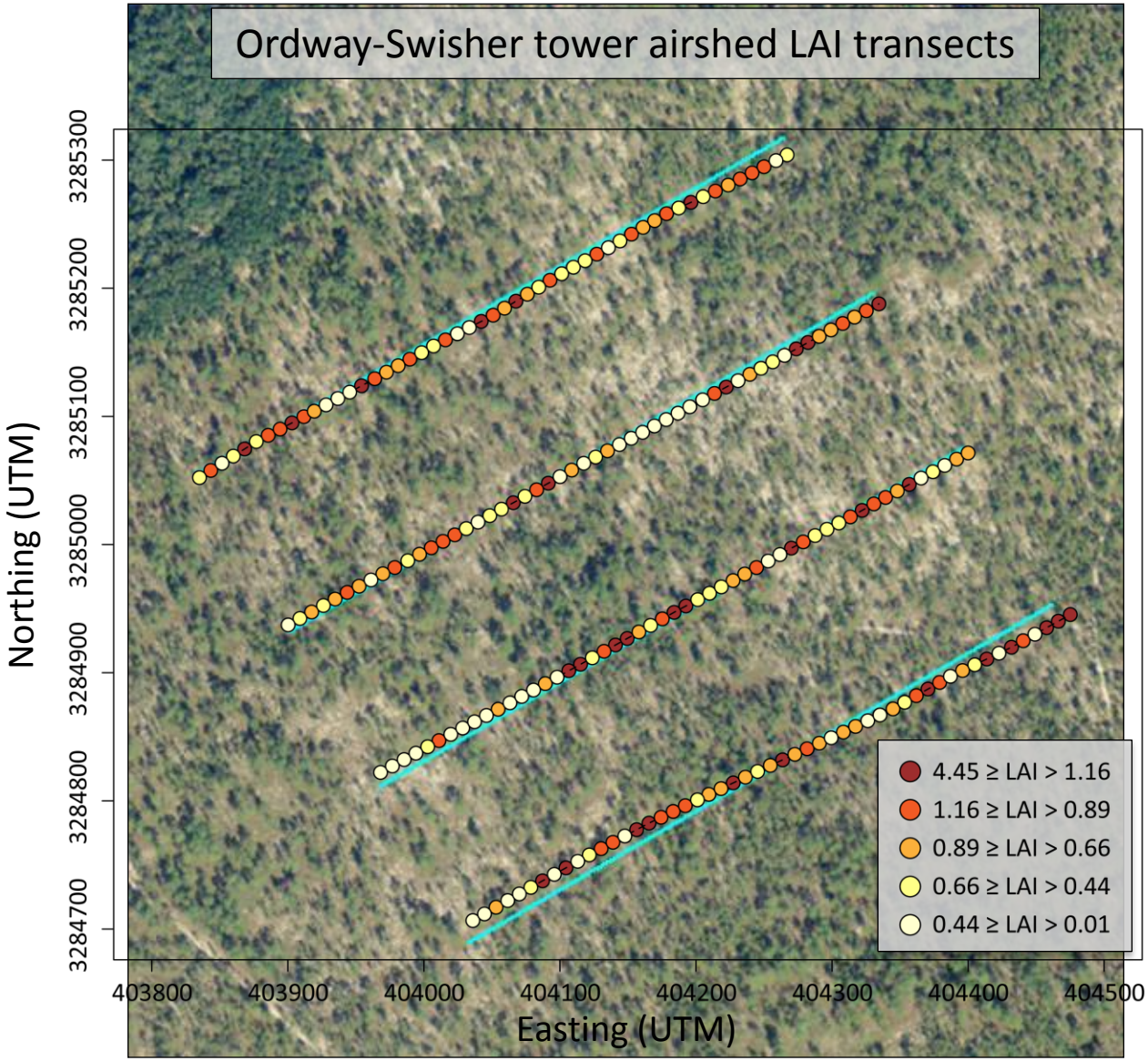


Lidar

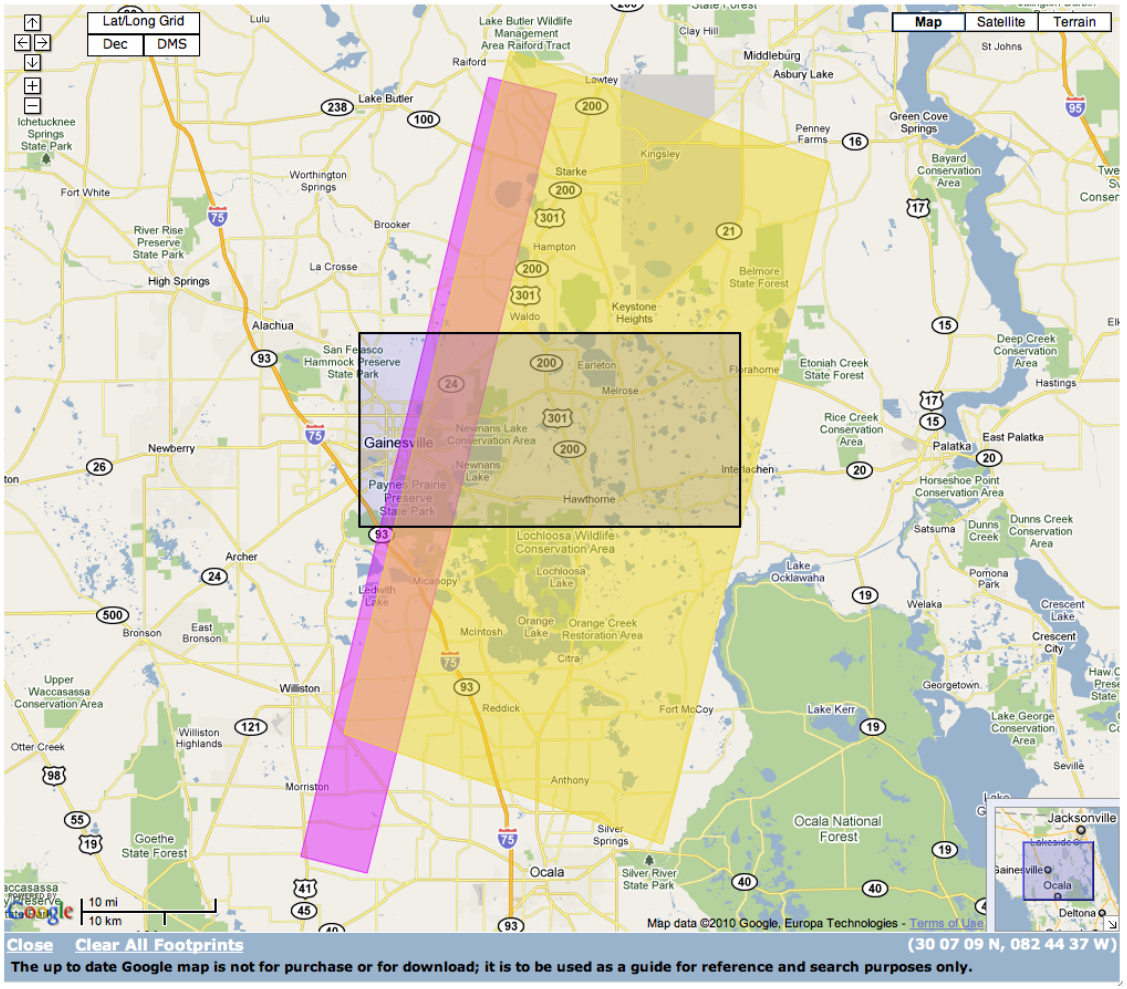


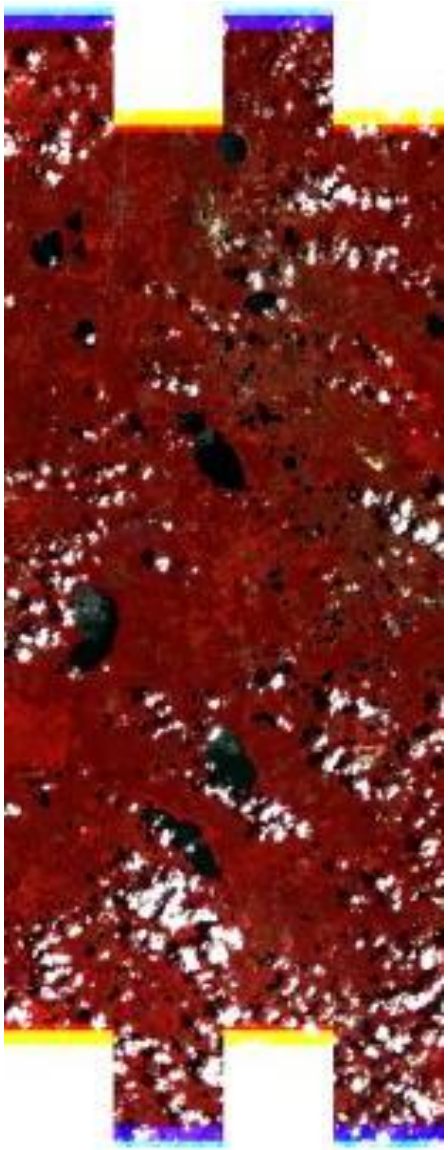


Leaf Area Index data



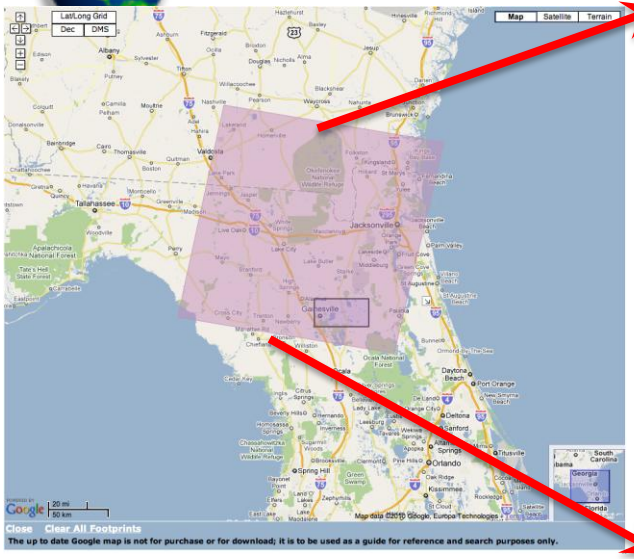
EO-1 on September 3, 2010

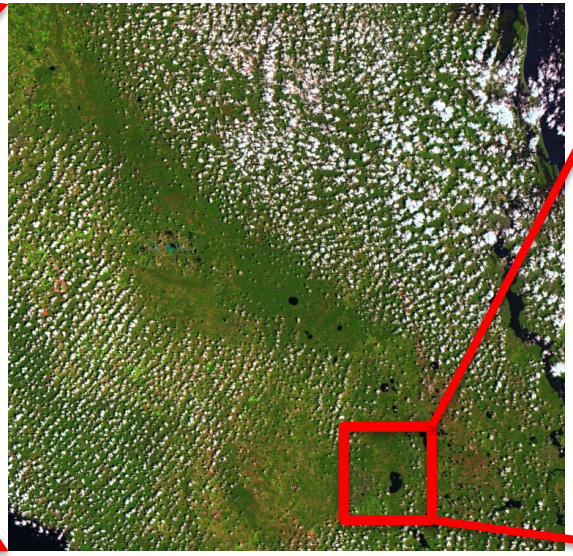


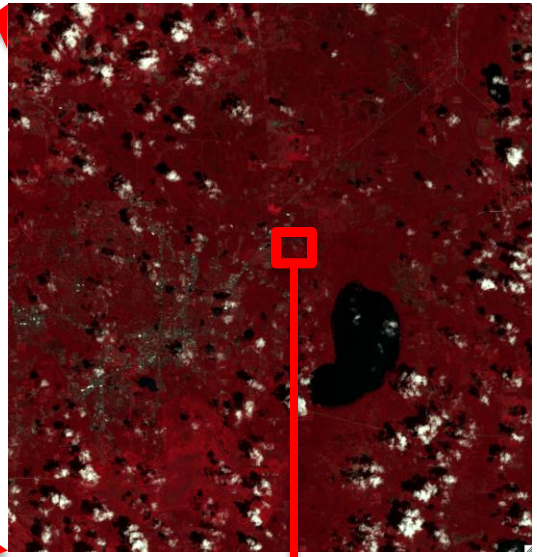


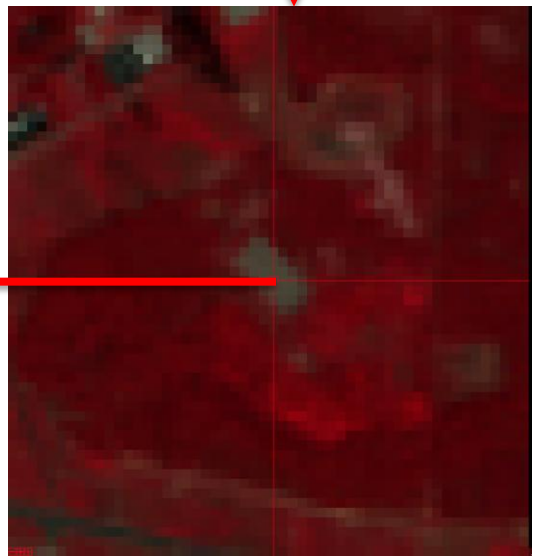
Hyperion = pink footprint
Advanced Land Imager = yellow footprint
Campaign area = Black outline

Radiometric Cal site - Landsat 5TM

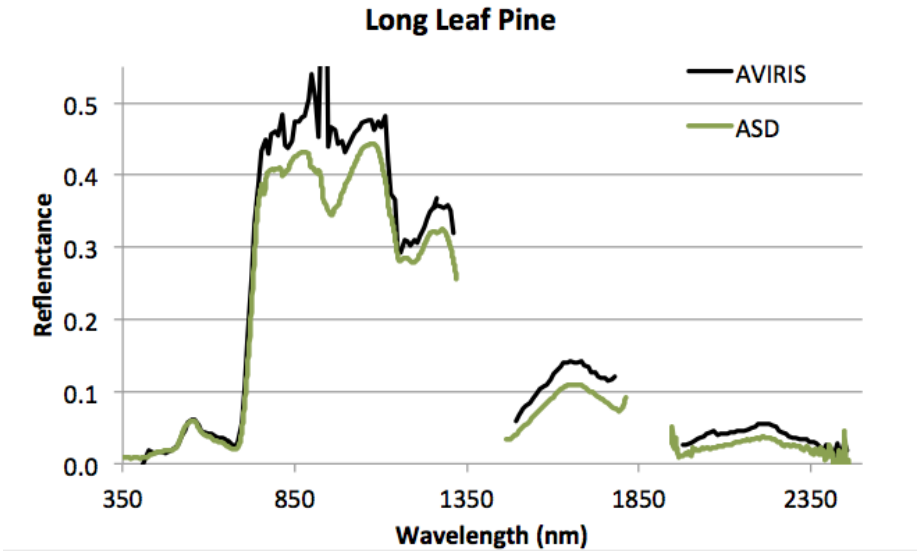


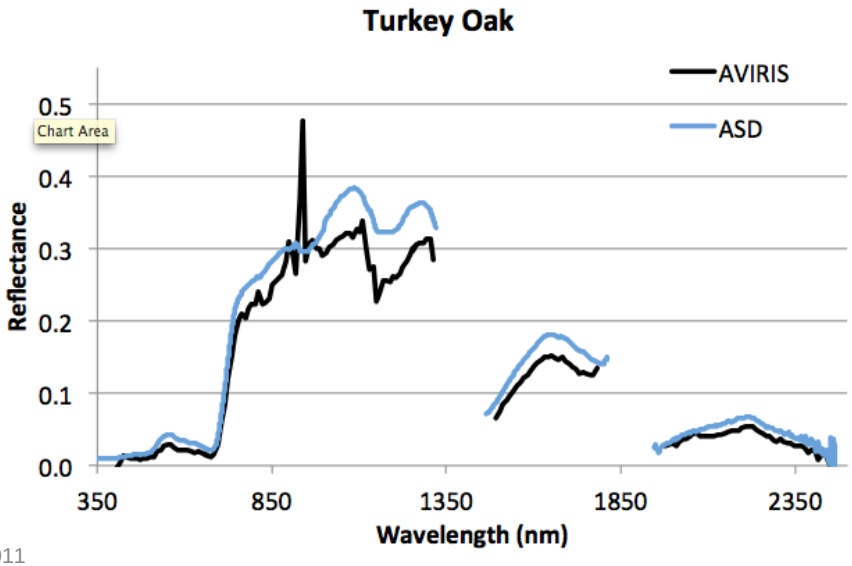






AVIRIS and ground spectra



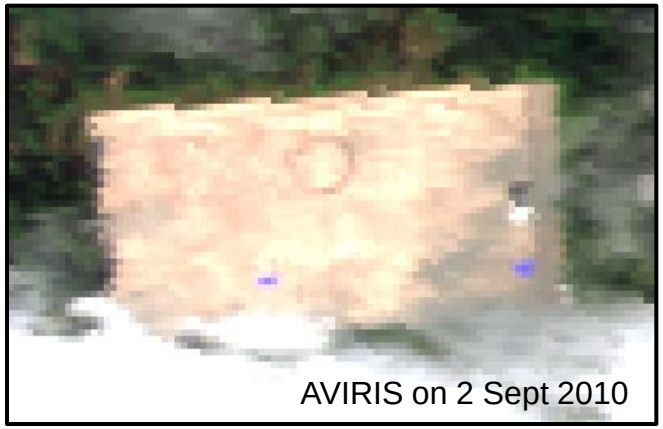


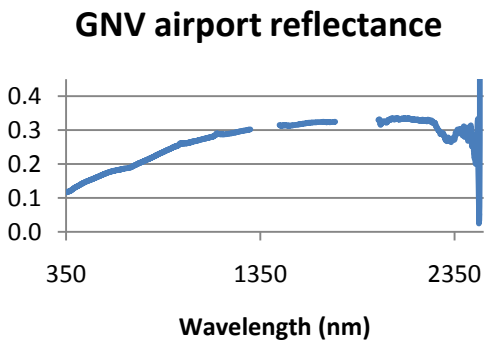
Measurements for vicarious calibration

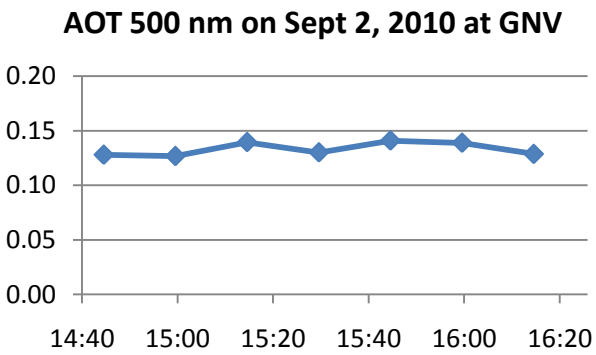
Ground reflectance

Atmospheric characterization

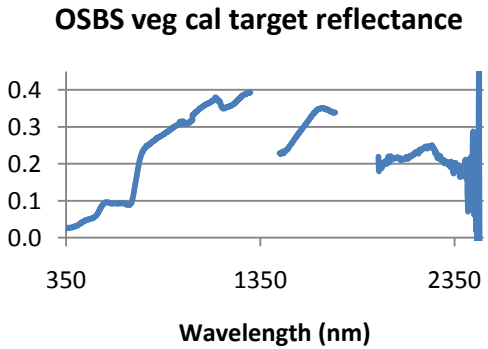
Gainsville Airport Test Site

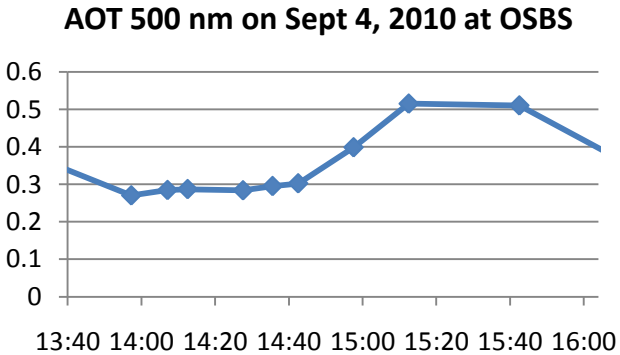






Ordway Test Site





Summary

- NEON airborne remote sensing will provide a remote sensing capability beyond existing systems in its ability to produce quantitative information about ecosystems drivers and responses with annual coverage

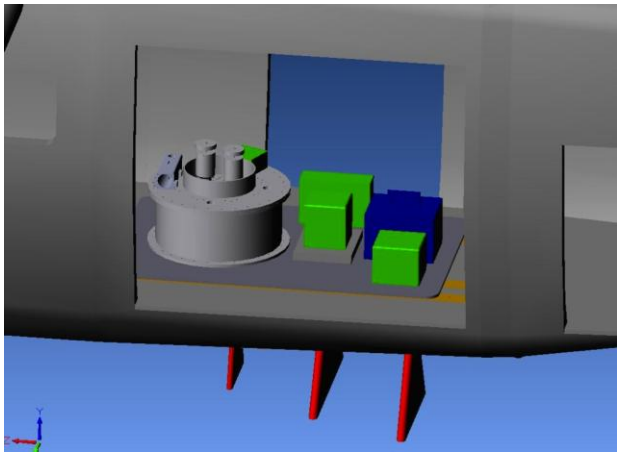
- Airborne instrumentation will provide sub-meter/meter scale measurements to bridge scales from organism and stand scales to the regional scale

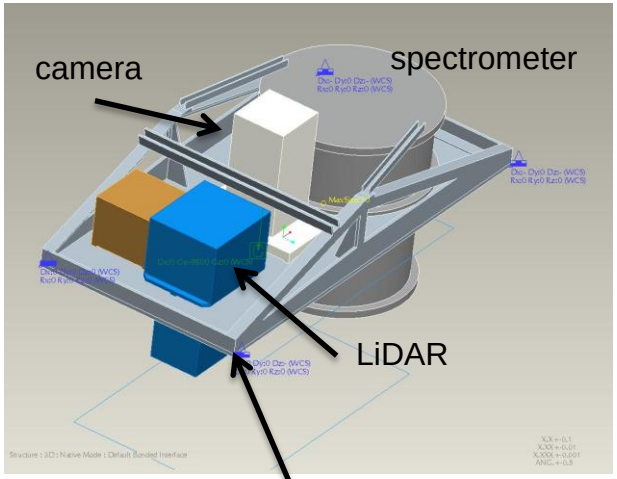
- NEON data system will enable free and open exchange of scientific information from the Observatory

- BACKUP / DELETED SLIDES

Airborne System Description

- Three airborne remote sensing payloads
  - Imaging spectrometer
  - Waveform lidar
  - High-resolution camera
  - GPS-Inertial measurement unit
- Leased Twin Otter aircraft
- Instrument maintenance and calibration facility
- Science and flight operations





Payload Integration Mount (PIM)