NEON 2013 AIRBORNE CAMPAIGN AT DOMAIN 17 TERRESTRIAL AND AQUATIC SITES IN CALIFORNIA

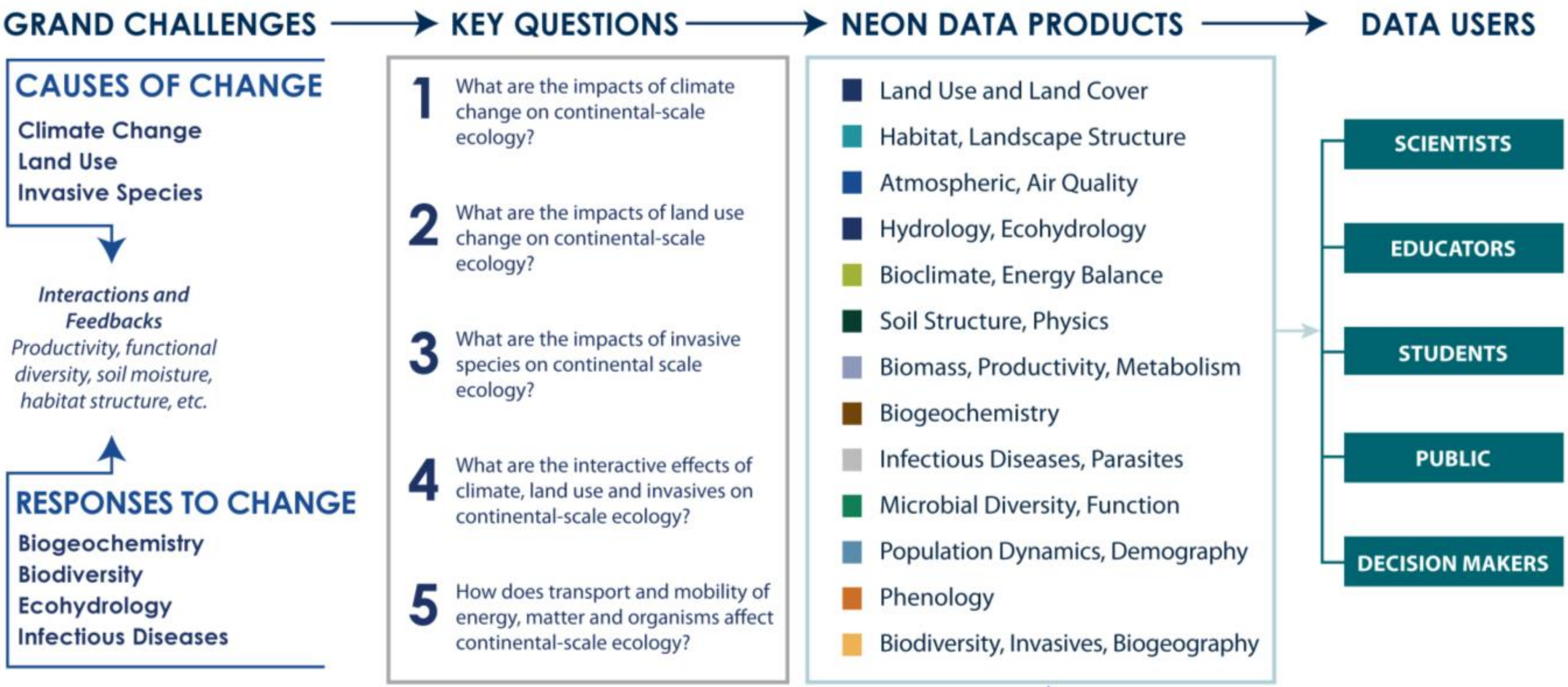
2013 HyspIRI Science Workshop
Pasadena, CA
October 15-17, 2013

What is NEON?

- **Large science facility fully funded by the National Science Foundation**
- **A continental-scale ecological observatory that:**
  - Collects and provides data on the drivers/responses of ecological change
  - Serves as an experimental infrastructure/backbone for research and experiments
  - Develops and provides educational resources to engage communities in working with scientific data
- **Project Timeline**

CONCEPT & DESIGN	SITES BUILT OUT	DATA COLLECTION
2004-2011	2012 - ~2017	~2017 - 2046

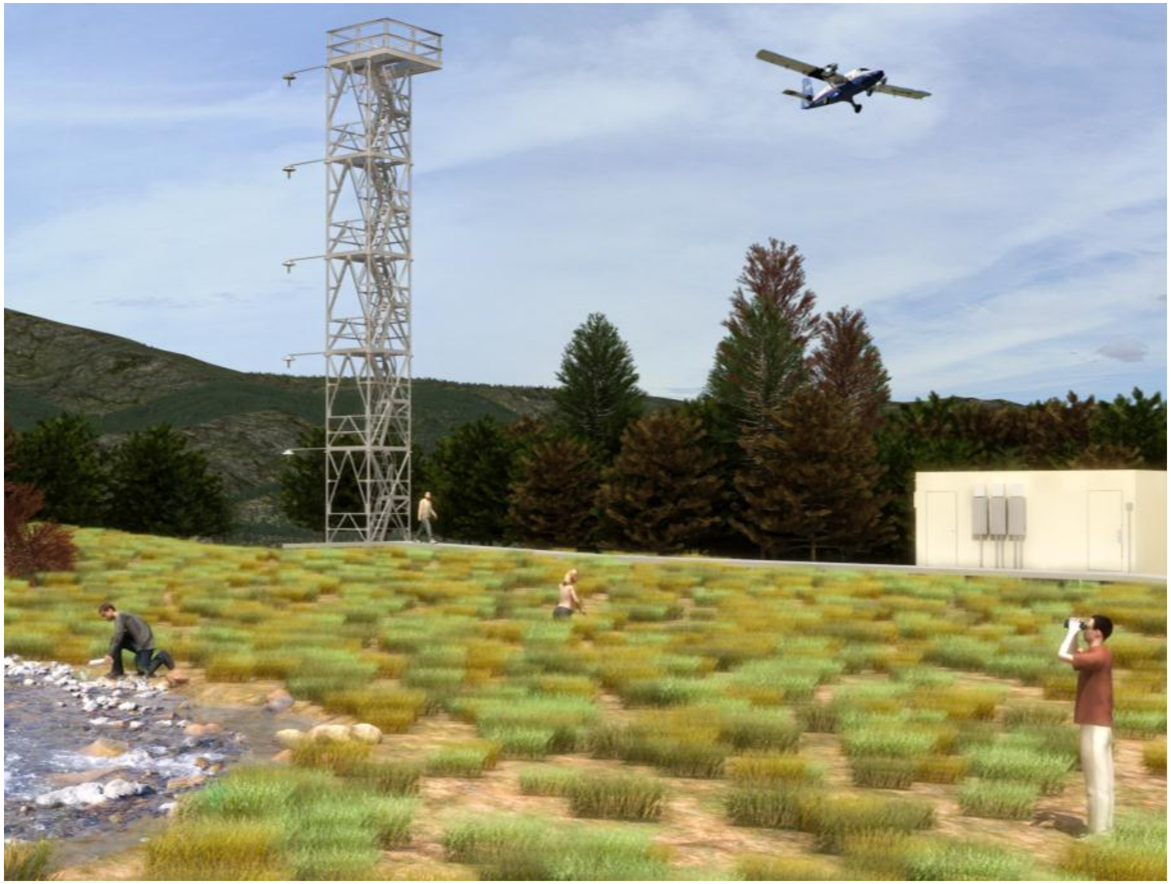
The NEON Project: Designed to Address Science Challenges



A Continental-Scale Design

1. **Core sites:** Located in unmanaged wildland conditions
2. **Relocatable sites:** Representative of human land management effects on ecosystems
3. **Aquatic sites:** Measure changes in aquatic systems over time

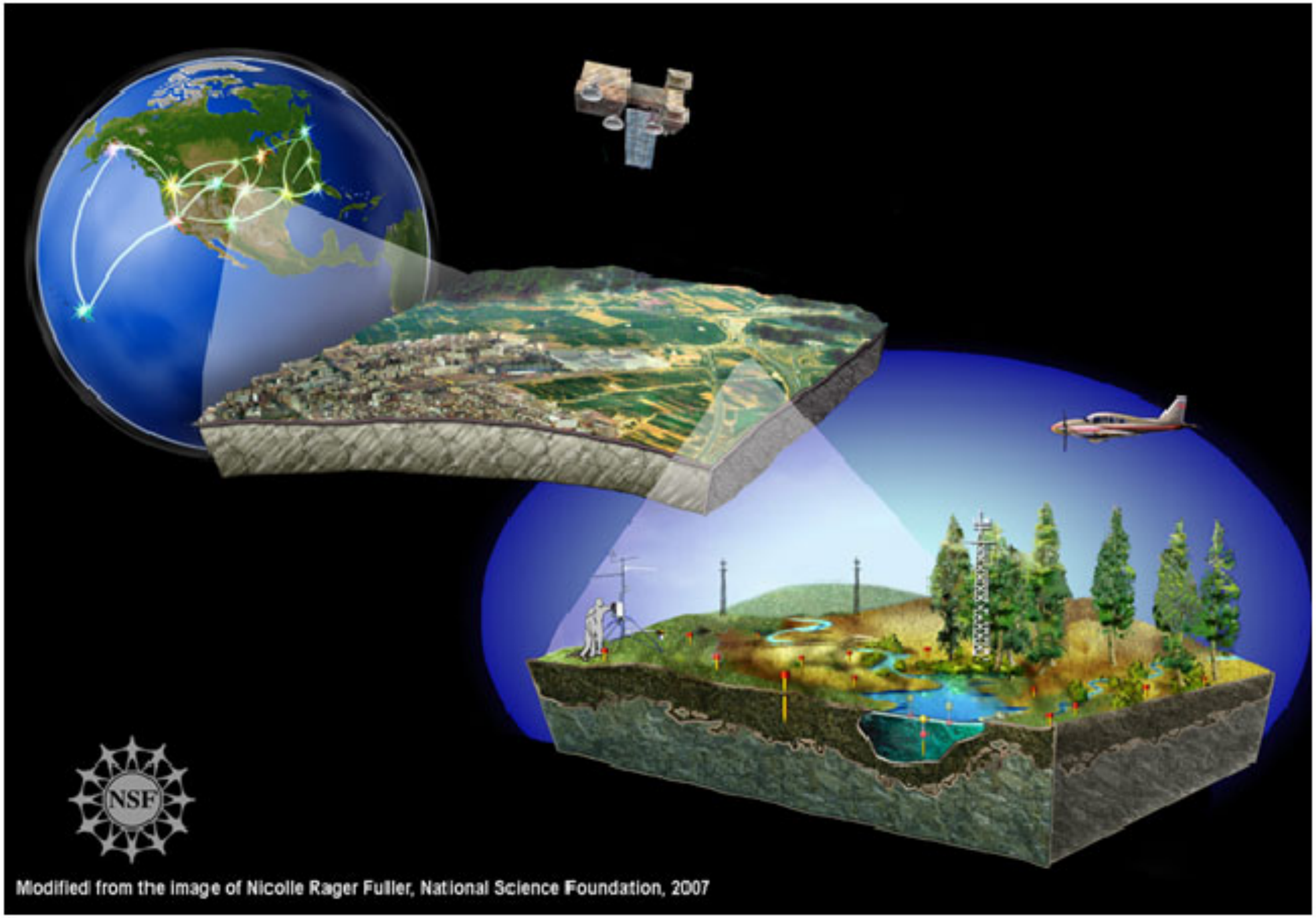
The NEON Site: From Ground to Sky



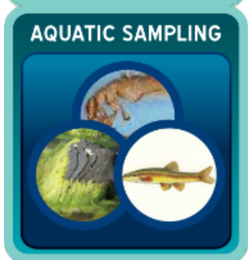
A digital rendering of a NEON site

- Representative sampling
- Replication of gradients
- Detecting/attributing change over decades
- Comprehensive set biological observations
- Sentinel taxa -- terrestrial and aquatic
- Field and lab analyses state-of-the-art
- Standardized and transparent protocols
- QA/QC -- data quality and uncertainty

Integrated Data Sampling



NEON Integrated Sampling Strategy



Biological Sampling

- Plant biodiversity
- Plant biomass, leaf area, and chemical composition
- Plant phenology
- Birds
- Ground beetles
- Mosquitoes
- Small mammals
- Infectious disease
- Biogeochemistry
- Soil microbes

Airborne Observations

- Canopy chemistry
- Canopy moisture
- Leaf area
- Canopy structure
- Canopy height
- Land cover
- Diversity
- Disturbance

Aquatic Sampling

Sensor measurements

- In-stream/In-lake
- Micrometeorology
- Groundwater

Field Sampling

- Chemistry / Isotopes
- Biological diversity
- Microbes
- Algae
- Aquatic Plants
- Invertebrates
- Fish
- Morphology, Bathymetry
- Riparian canopy

Atmospheric Measurements

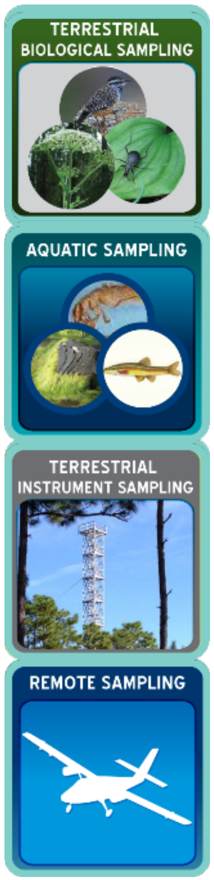
- Key climate inputs
- Bioclimatic variables
- Chemical climate inputs
- Carbon cycle changes
- Water & energy balance

Soil Measurements

- Temperature
- Moisture
- CO_2
- Root growth and phenology

What Users Get

FREE AND OPEN ACCESS TO:



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Land Use Analysis Package

- Combine NEON data with national data suites
- Integrate social and economic data with NEON
- Cross-calibrate NEON data with satellites and in-situ sampling

✓ **All QA/QC information (process and data)**

✓ **Protocols and procedures used to collect data**

✓ **Instrument specifications, characteristics and performance**

✓ **Algorithms used to process data**

- **Data products**
- **Protocols**
- **Educational resources**

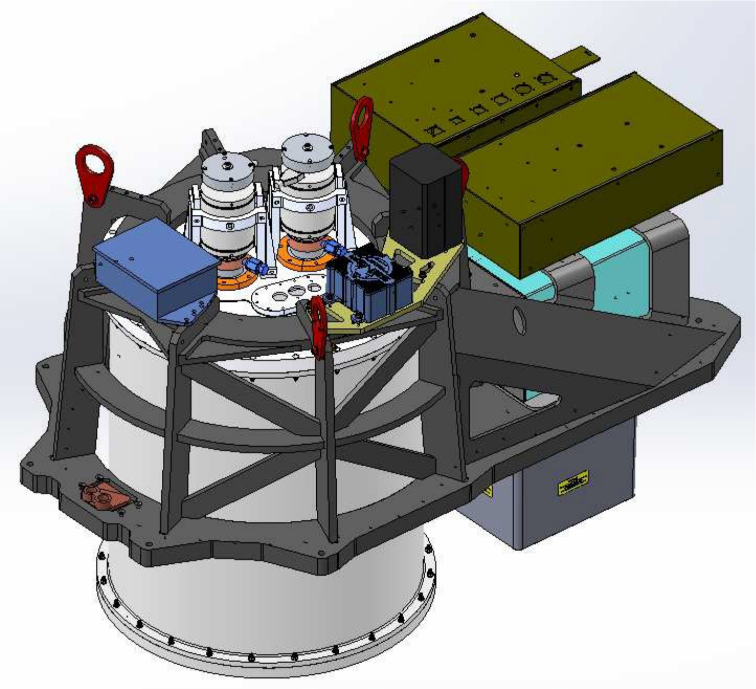
PI users of NEON assignable facilities must comply with the NEON data policy, after a proprietary period, not to exceed 18 months, to validate and prepare data

**Unless legally protected by the Endangered Species Act or other legislation*

NEON Airborne Observation Platform

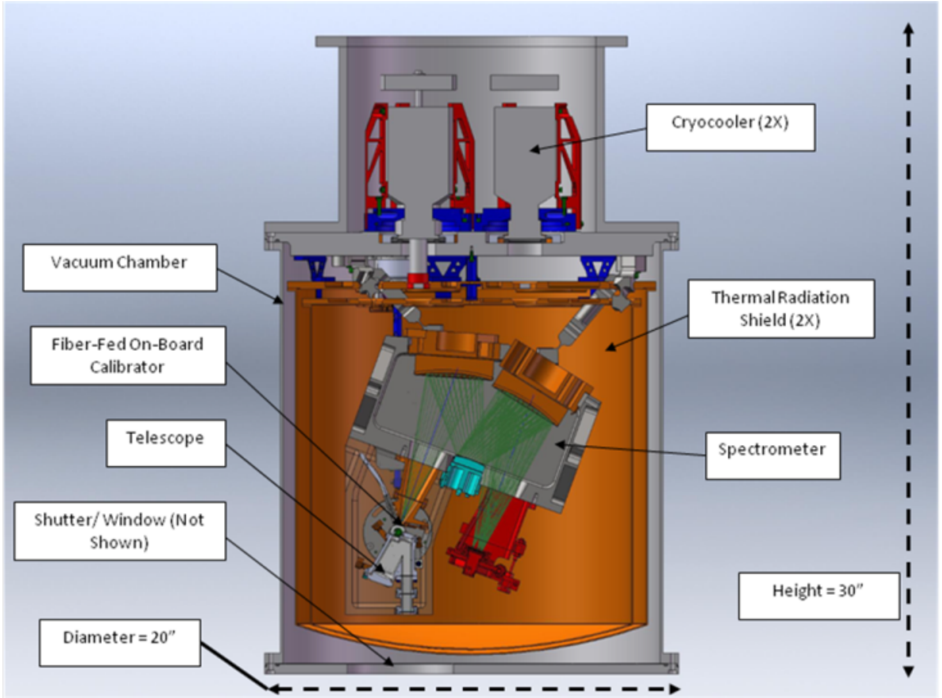
- Tom Kampe, *AOP Director, Assistant Director - Remote Sensing*
- Tanya Ramond, *Systems Engineer*
- Ty Guadagno, *Instrument Engineer, Flight Operations*
- Edwin Penniman, *Optomechanical Engineer*
- Nathan Leisso, *Staff Scientist - Remote Sensing Calibration*
- Keith Krause, *Senior Scientist - Remote Sensing Algorithms*
- Bryan Karpowicz, *Staff Scientist - Remote Sensing Instrumentation*
- Bill Gallery, *Staff Scientist - Remote Sensing Algorithms*
- John Musinsky, *Staff Scientist – Flight Planning and Operations, Science Outreach*
- Ian Crocker, *Airborne Sensor Operations Technician*
- Matt DeVoe, *Airborne Sensor Operations Technician*
- Stephanie Spetter, *Administrative Services Manager*

NEON Airborne Observation Platform



Remote sensing payload designed to be compatible with the low altitude DeHavilland DHC-6 Twin Otter research aircraft

NEON Imaging Spectrometer



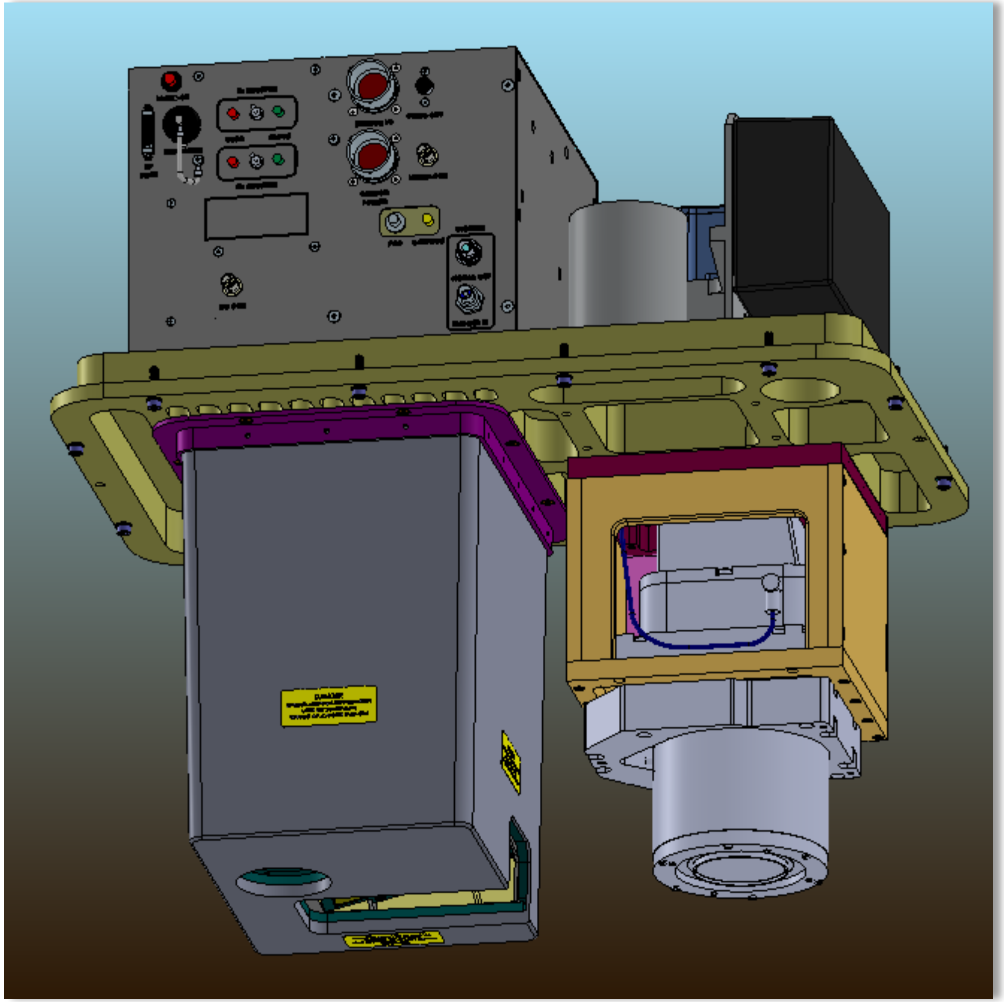
- High fidelity visible-to-shortwave infrared (VSWIR) imaging spectrometer built by JPL

- Based on the AVIRIS Next-Generation Imaging Spectrometer (AVIRISng)

Spectral range	380-2510 nm
Spectral sampling (FWHM)	6 nm
IFOV	1.0 milliradian
X-track FOV	34 degrees
SNR	> 2000 @ 600 nm > 1000 @ 2200 nm
Radiometric accuracy	> 95%
Spectral calibration	+/- 0.1 nm
Spectral uniformity, xtrack	> 95%
Spectral IFOV-variation (in-track)	< 5%
Cross-track pixels	> 600 pixels
Cross-track swath	1.0 km @ 1000m altitude

Waveform LiDAR and High Resolution Digital Camera

Waveform LiDAR		Digital Camera	
Laser wavelength	1064 nm	**Spectral band-pass**	400-700 visible
Laser pulse repetition freq.	Programmable 33-167 kHz	**Field of View**	44 degrees
Laser pulse width	12 nsec	**Ground sampling distance**	0.11 m (@ 1000 m AGL)
Vertical range	65 m nominal	**Dynamic range**	12 bits
Vertical sampling	1 µsec = 0.3 m	**Shutter speed**	1/125 to 1/500
Scan frequency	Programmable 0-70 Hz		
Range of flying altitudes	1,000 to 2,500m		
Scan angle	Programmable 0-50°		
Spatial resolution	< 1 m		



LiDAR Flight Parameters

Site	Date	Mean AGL (m)	Flight Line Overlap (%)	PRF (Hz)	Beam Width	Half Scan Angle (deg)	Scan Freq (Hz)	Photo Overlap (%)	Pixel Res. (m)	Trigger Time (sec)
SJER	6/9/13 6/11/13 6/13/13	1000	37.2	100	Wide	18.5	50	50	8.5	5.7
BRDF (SJER)	6/11/13	1000	37.2	100	Wide	18.5	50	50	8.5	5.7
Soaproot Saddle	6/12/13	1000	37.2	100	Wide	18.5	50	50	8.5	5.7
Providence Creek	6/12/13	1000	37.2	100	Wide	18.5	50	50	8.5	5.7
Teakettle	6/14/13 6/15/13	1500	39.7	70	Wide	19.2	33.3	50	12.7	8.6
BRDF (Soaproot)	6/15/13	1000	37.2	100	Wide	18.5	50	50	8.5	5.7
Elevation Gradient Transect	6/12/13 6/14/13	1500	39.7	70	Wide	19.2	33.3	50	12.7	8.6

Combining Imaging Spectroscopy and Discrete & Waveform LiDAR

Many land processes readily observed and quantified using combination of biochemical and structural information provided by spectroscopy and waveform LiDAR

- native and invasive plant canopy biogeochemistry and habitat structure
- pest and pathogen outbreaks
- changes in competitive relationships
- responses to disturbances like wildfire

Route Plans for Three NEON AOP Payloads

Payload 1

Payload 2

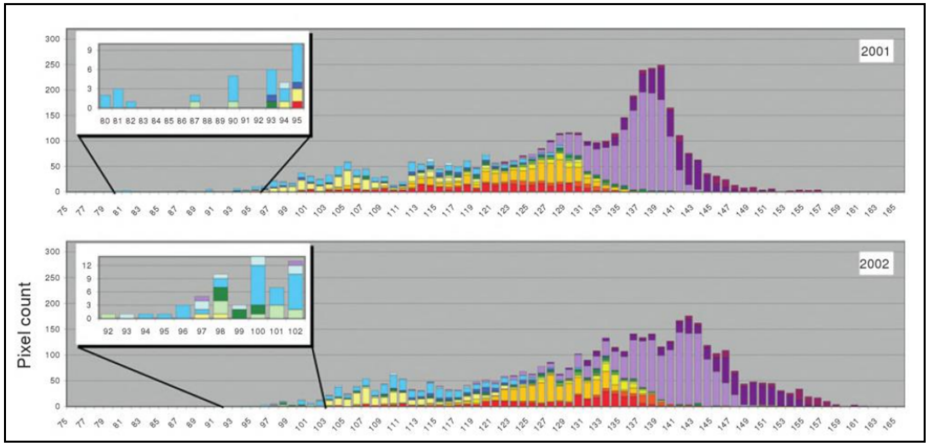
- 2 aircraft with identical payloads to cover NEON sites
- 7-months, 1,100 flight hrs flight season
- **3rd Payload for PI-driven science, Rapid Response, Targets of Opportunity**

Airborne Survey Constraints

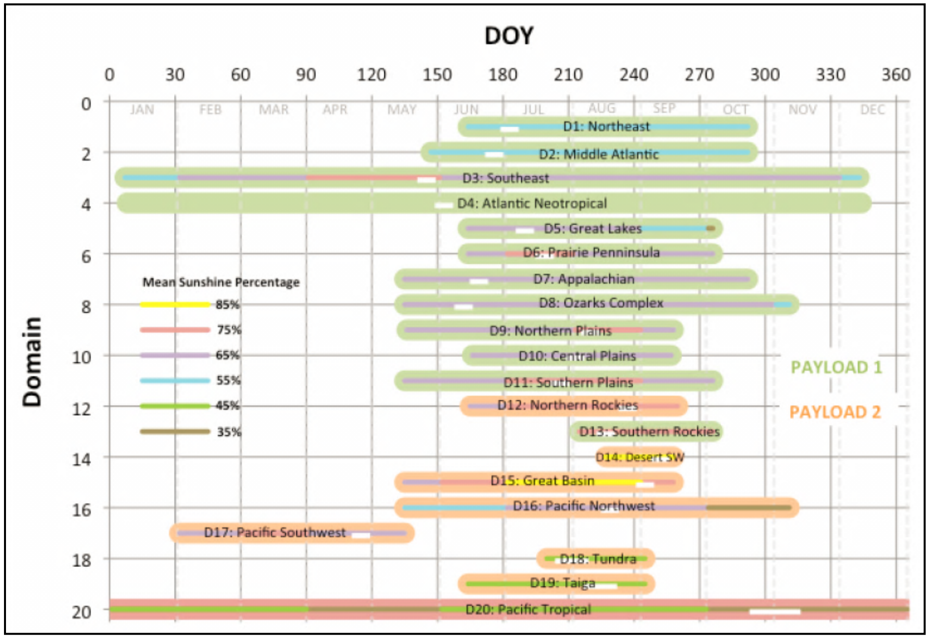
- Peak greenness (maximum leaf cover)
  - phenology varies among species and by elevation
  - must accommodate inter-annual variability

- Minimum cloud cover
  - high cirrus clouds acceptable?

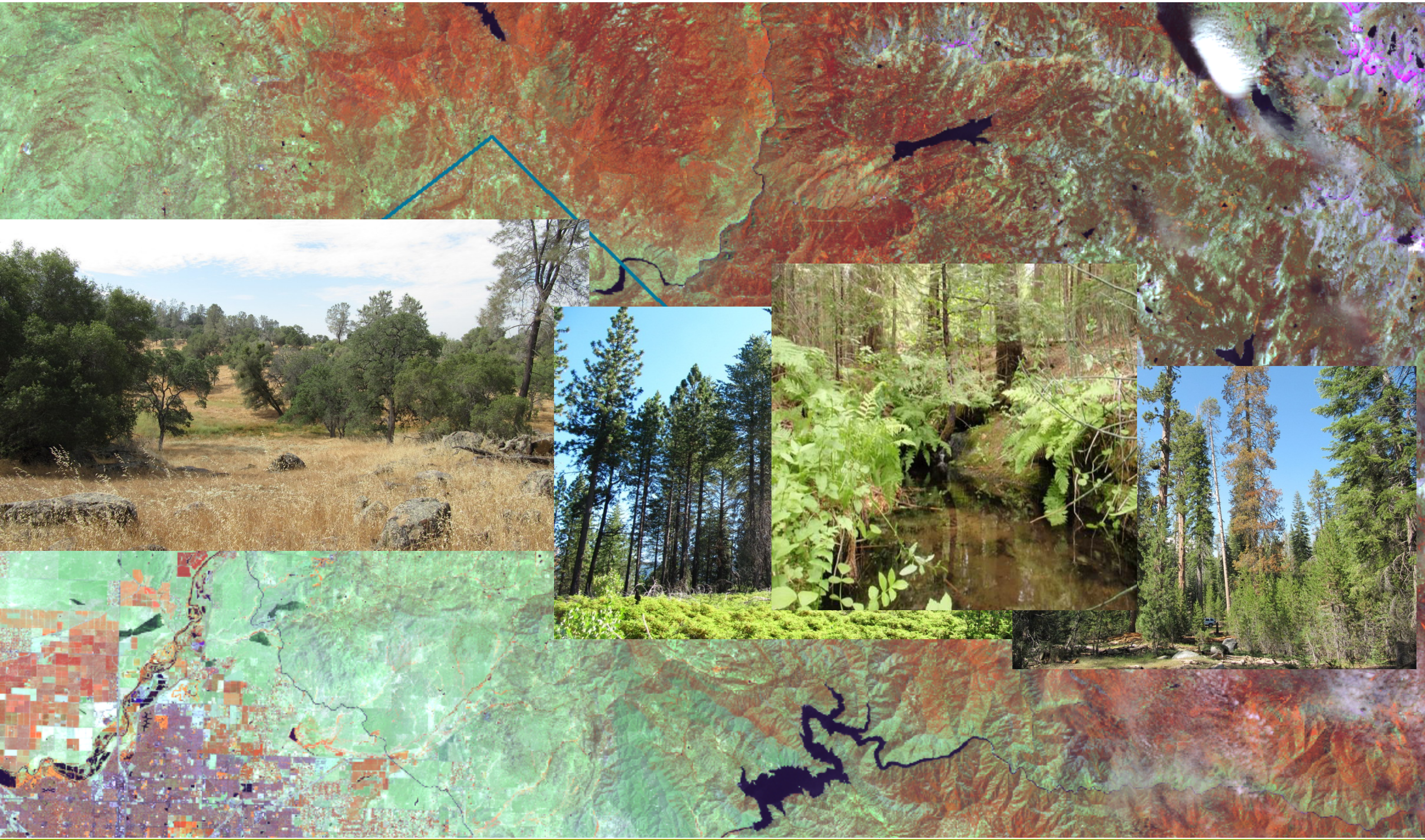
- Minimize solar angles, topographic shadowing
  - ~10 am – 2 pm



(Garrot et al 2008)

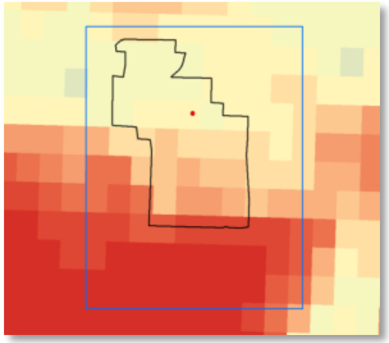


NEON D17 Terrestrial and Aquatic Sites

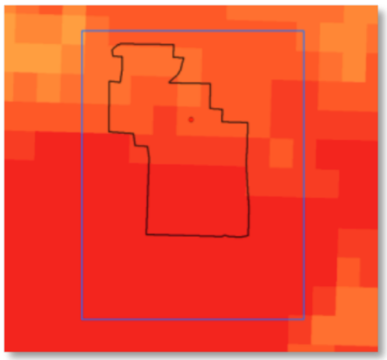


San Joaquin Flight Box Definition

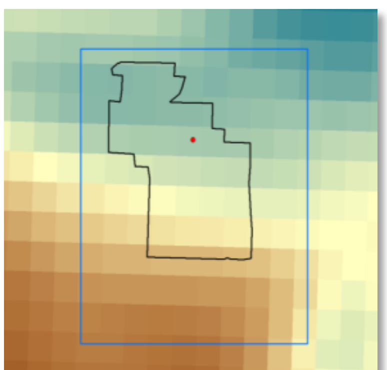
Average Annual Minimum Temperature (1981-2010)



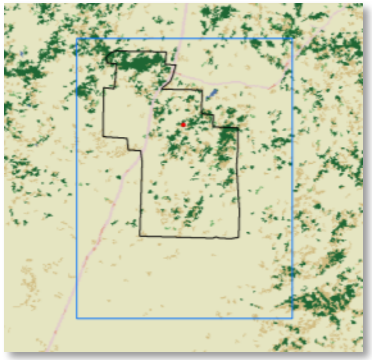
Average Annual Maximum Temperature (1981-2010)

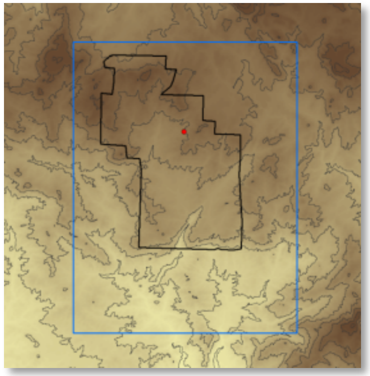


Average Annual Precipitation (1981-2010)

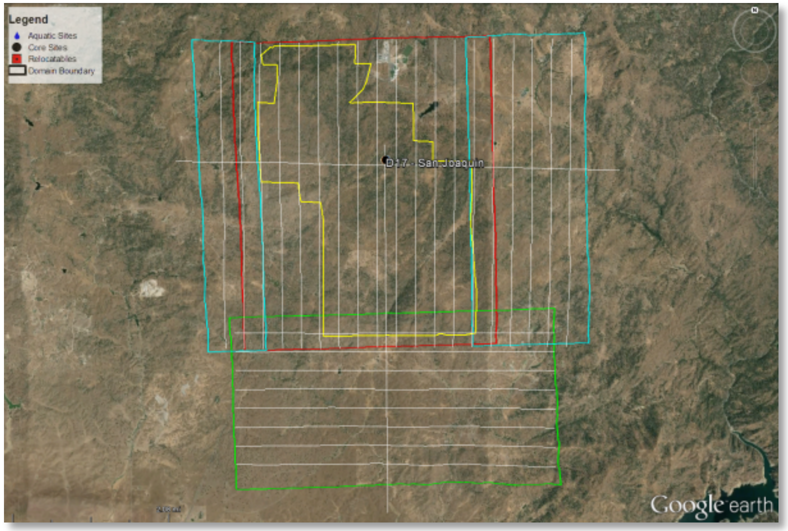


Vegetation Types



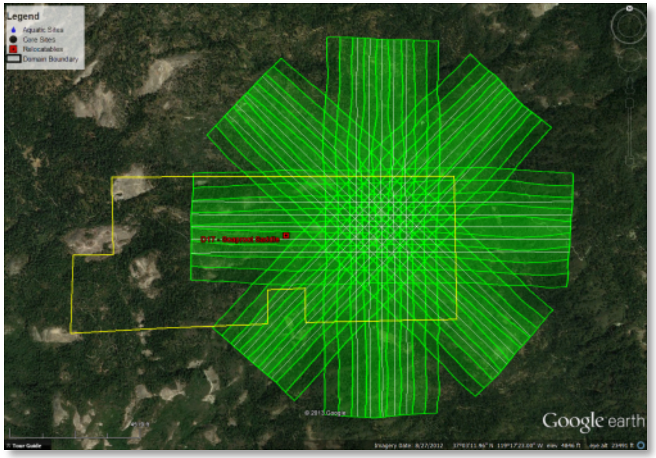


Topography

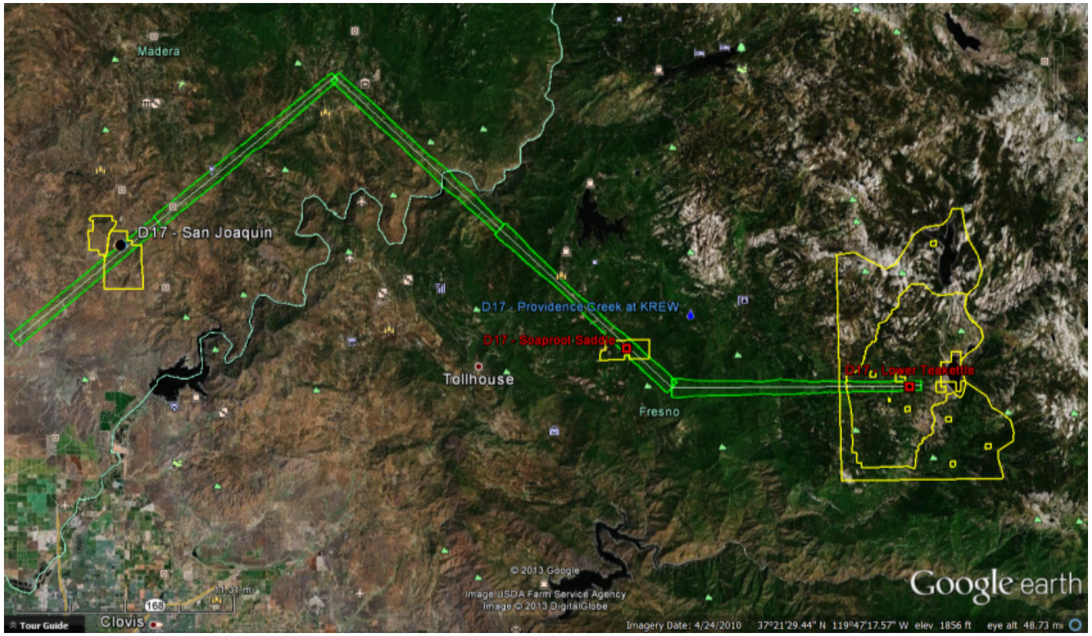


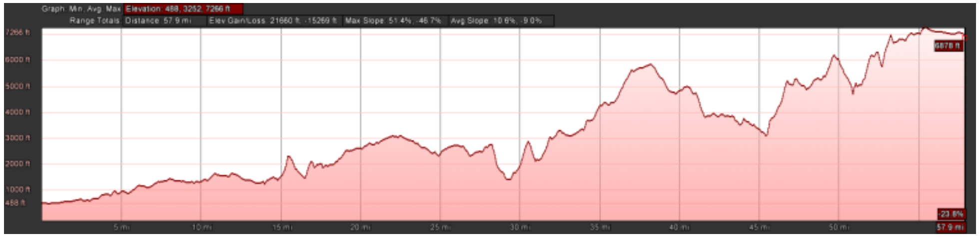
Flight box design must result in robust datasets that:
1) address primary science themes
2) enable scaling to continental scale modeling

BRDF & Elevation Gradient Flights



Soaproot Saddle BRDF Flight

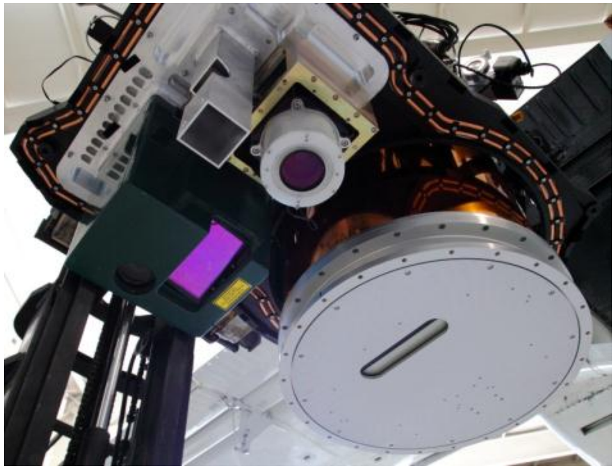




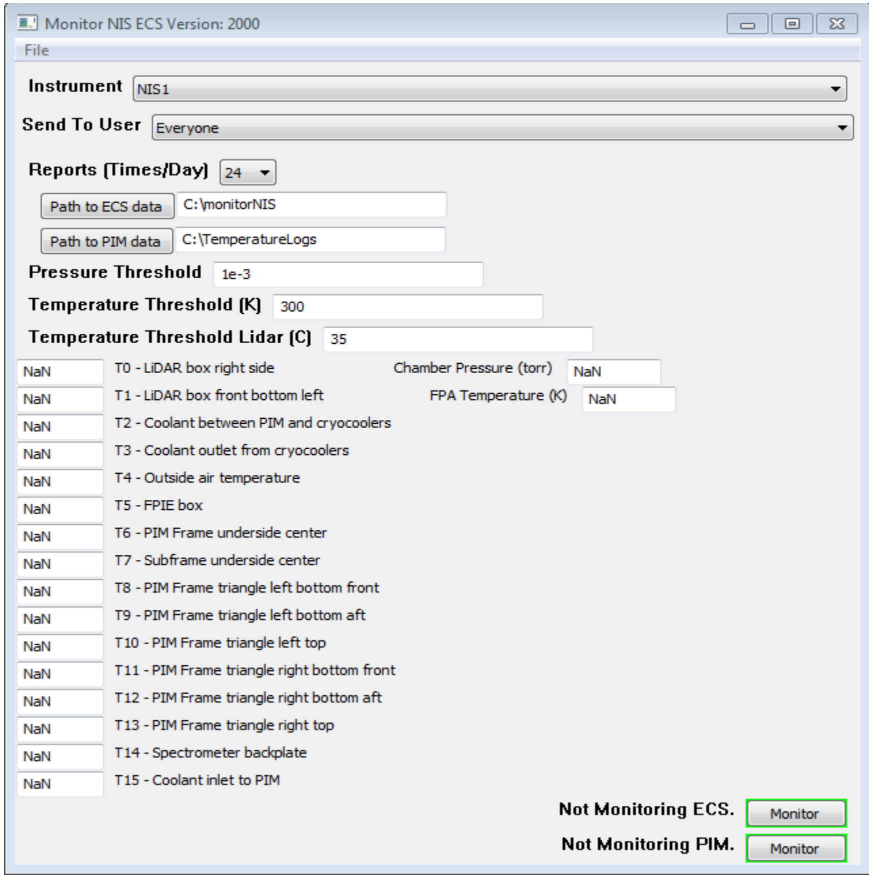
Elevation change along gradient transect from SJER (left) to Teakettle (right)

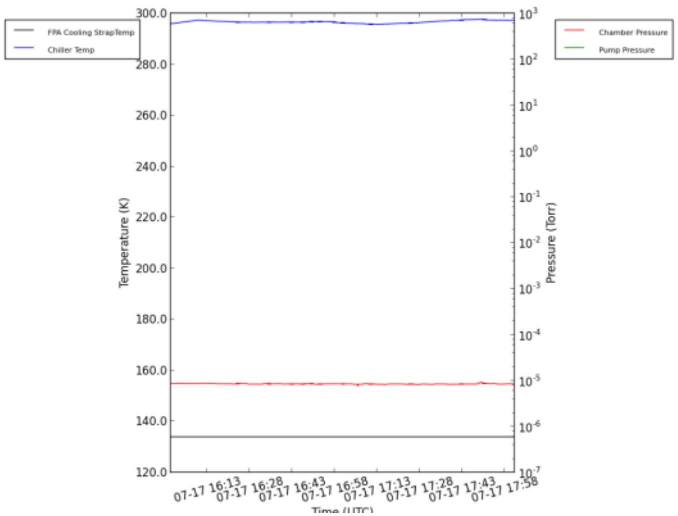
Pre-Campaign Engineering Improvements

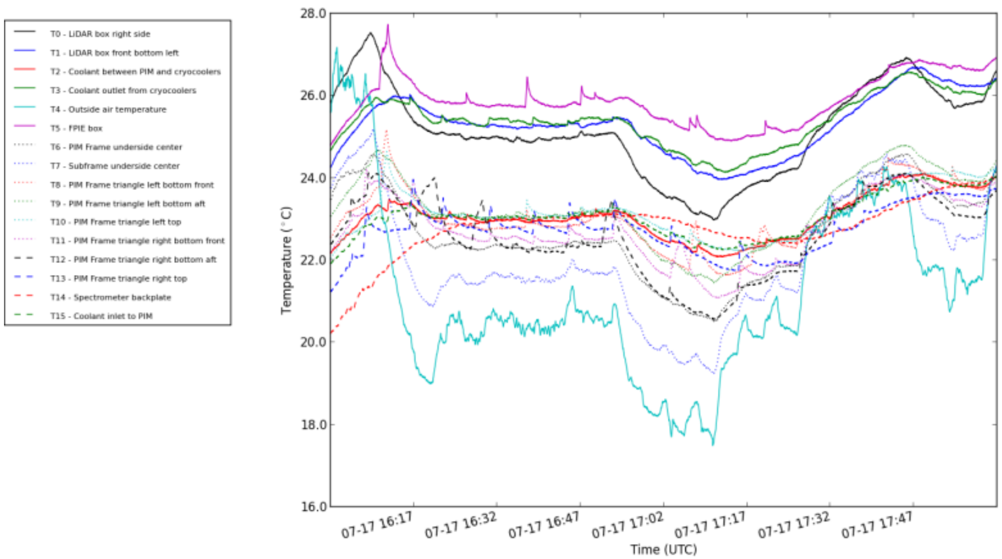
PIM Improvements	Value Added
Lighter	Increase flight time
Stronger	Meet FAA requirements, add safety
Rigidity	Improve boresight rigidity, leading to better NIS/LiDAR/camera co-registration of features on ground
Thermal control	Improve boresight stability Prevent instrument over-heating Control noise on FPIE (focal plane electronics) box
Modular aft section	Increase flexibility for mounting instruments Eliminate loss of boresight alignment during testing and maintenance
OBC and SOBC now attached to PIM	Minimize variation in OBC (on-board calibration) illumination



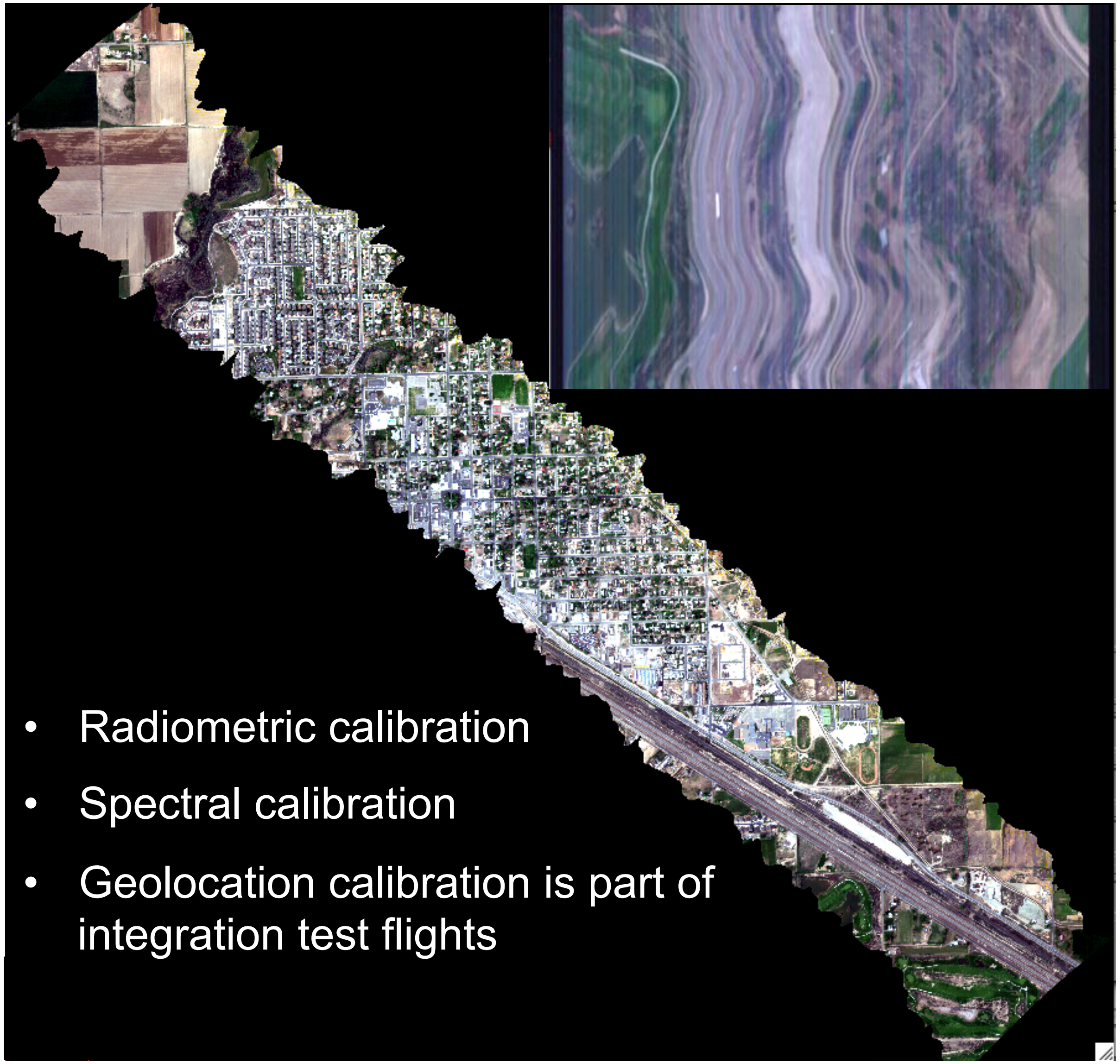
Remote AOP Instrument Monitoring





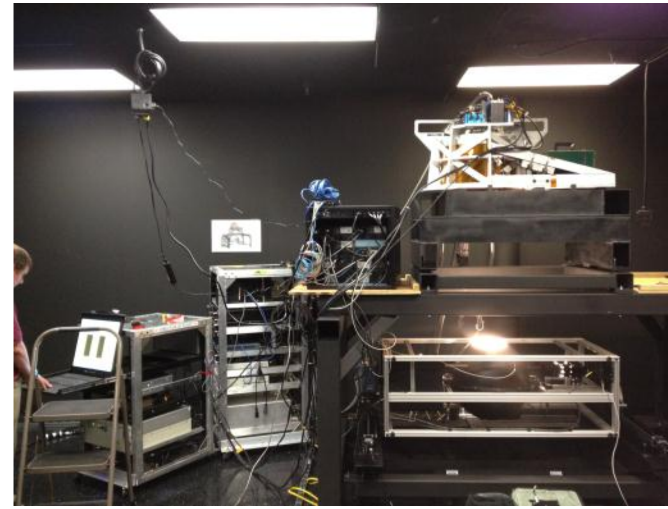


Calibration of the NEON Imaging Spectrometer

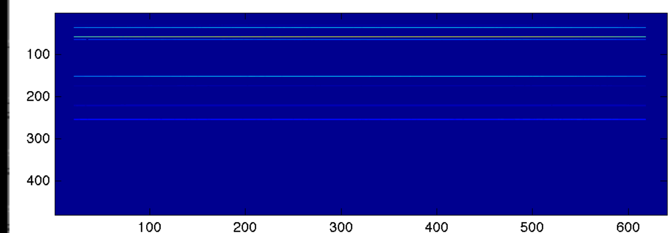


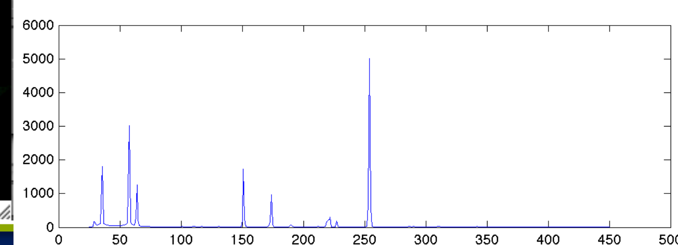
- Radiometric calibration
- Spectral calibration
- Geolocation calibration is part of integration test flights

NIST traceable source

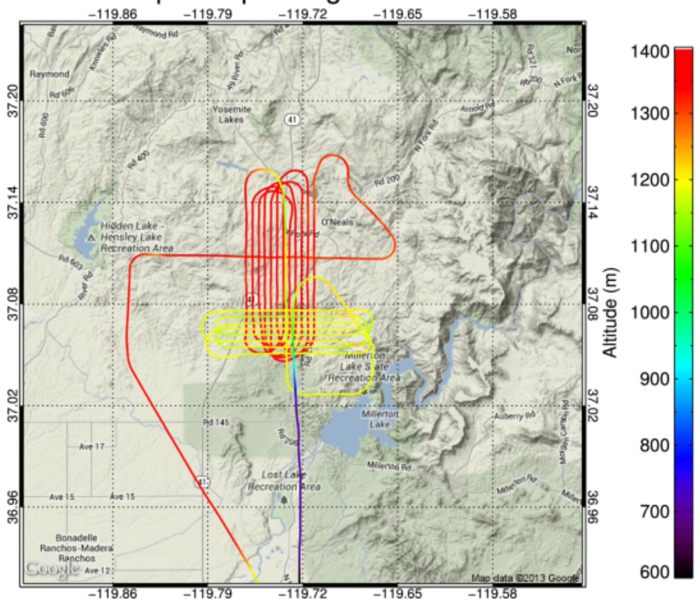


Use Lines sources for Wavelength

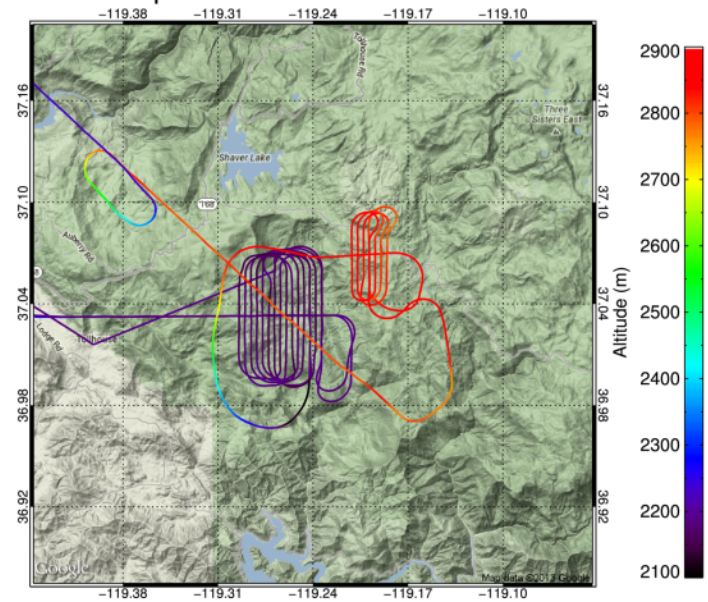




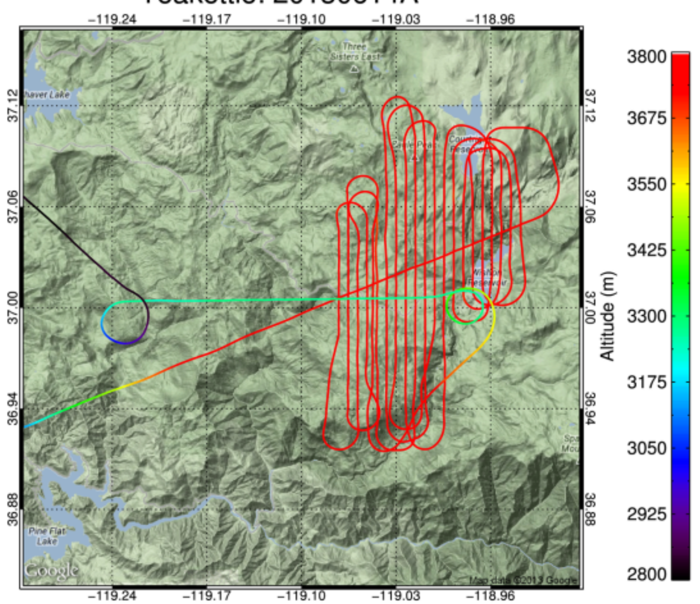
San Joaquin Exp. Range: 20130613B



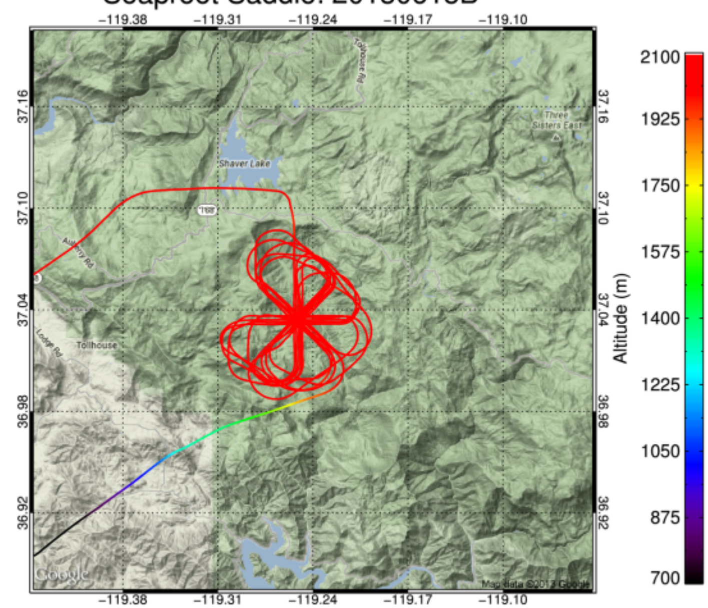
Soaproot Saddle: 20130612A

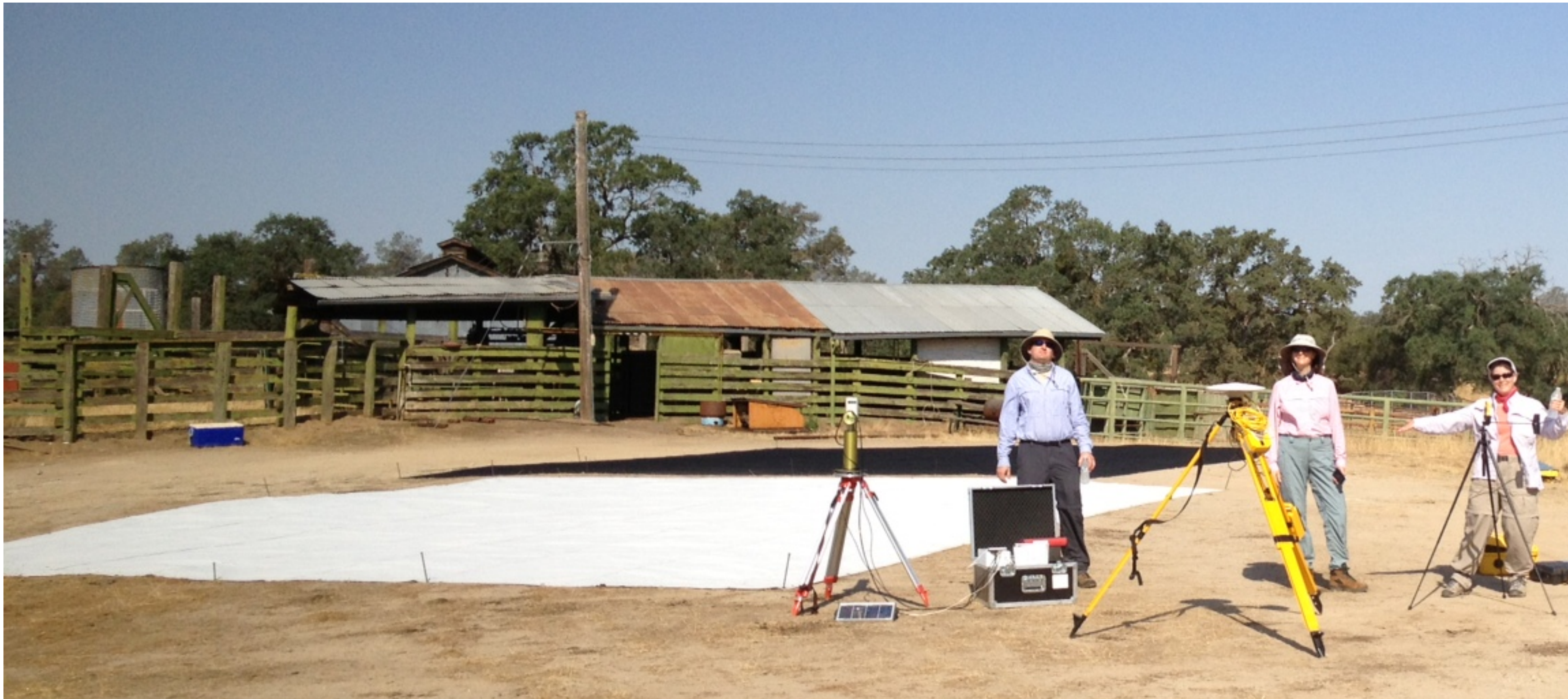


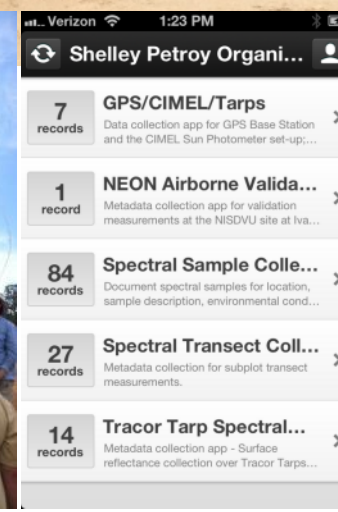
Teakettle: 20130614A



Soaproot Saddle: 20130615B

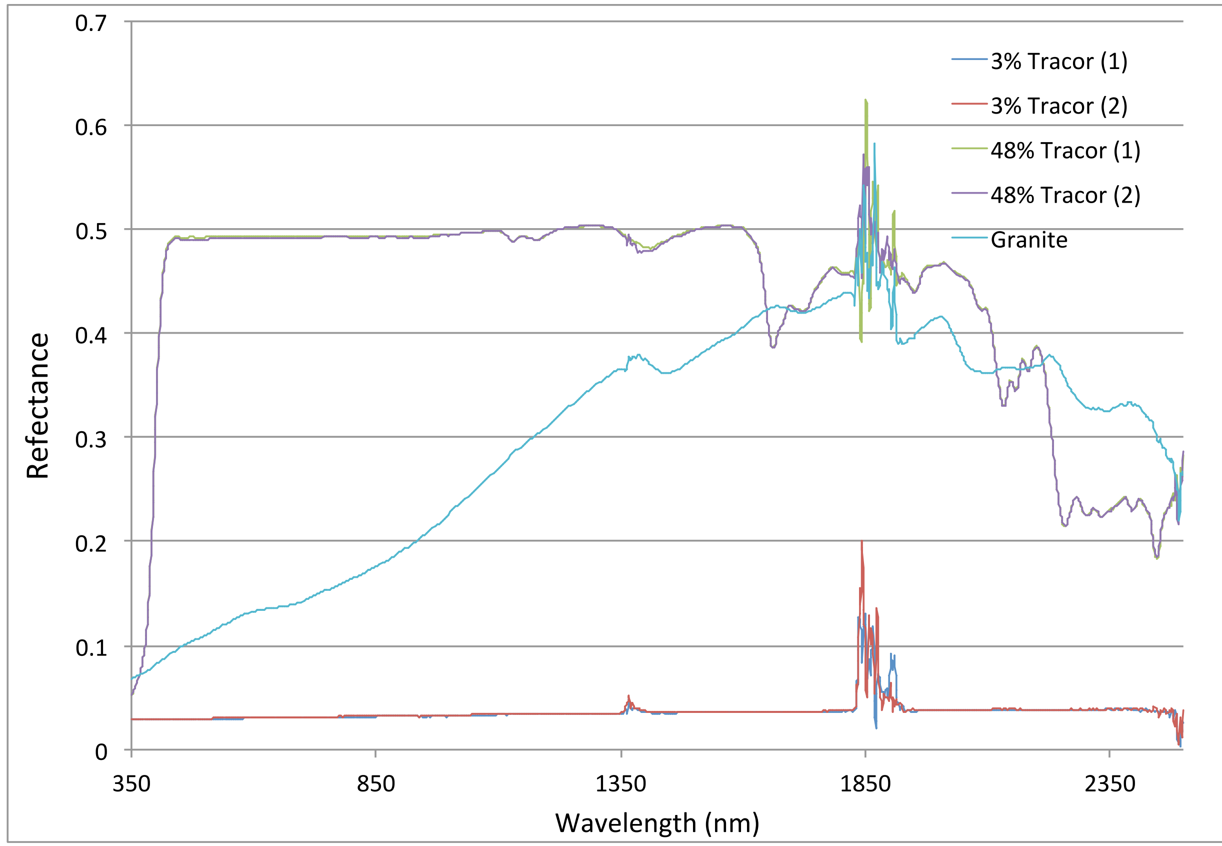




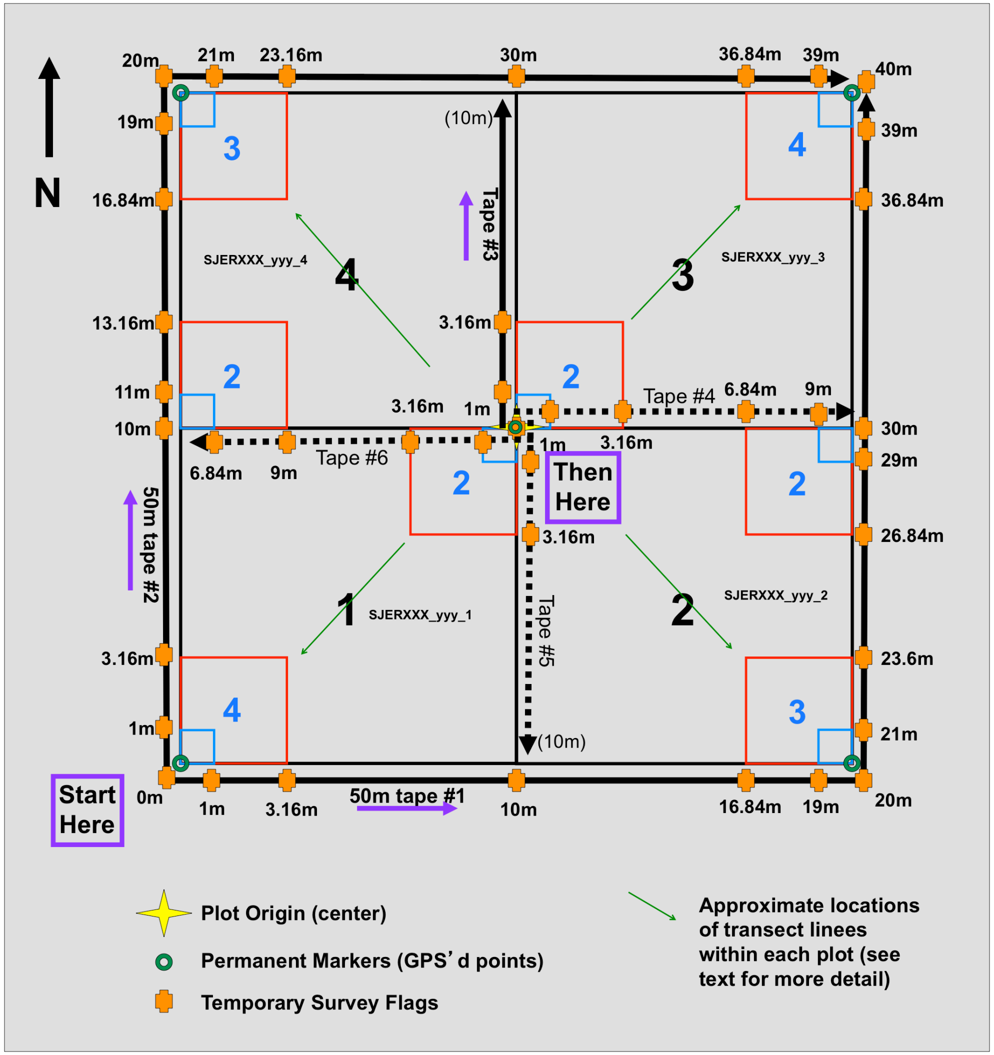


Verizon
1:23 PM
Shelley Petroy Organi...
7 records
GPS/CIMEL/Tarps
Data collection app for GPS Base Station and the CIMEL Sun Photometer set-up;...
1 record
NEON Airborne Valida...
Metadata collection app for validation measurements at the NISDVU site at Iva...
84 records
Spectral Sample Colle...
Document spectral samples for location, sample description, environmental cond...
27 records
Spectral Transect Coll...
Metadata collection for subplot transect measurements.
14 records
Tracor Tarp Spectral...
Metadata collection app - Surface reflectance collection over Tracor Tarps...

ASD Field Spectrometer Calibration

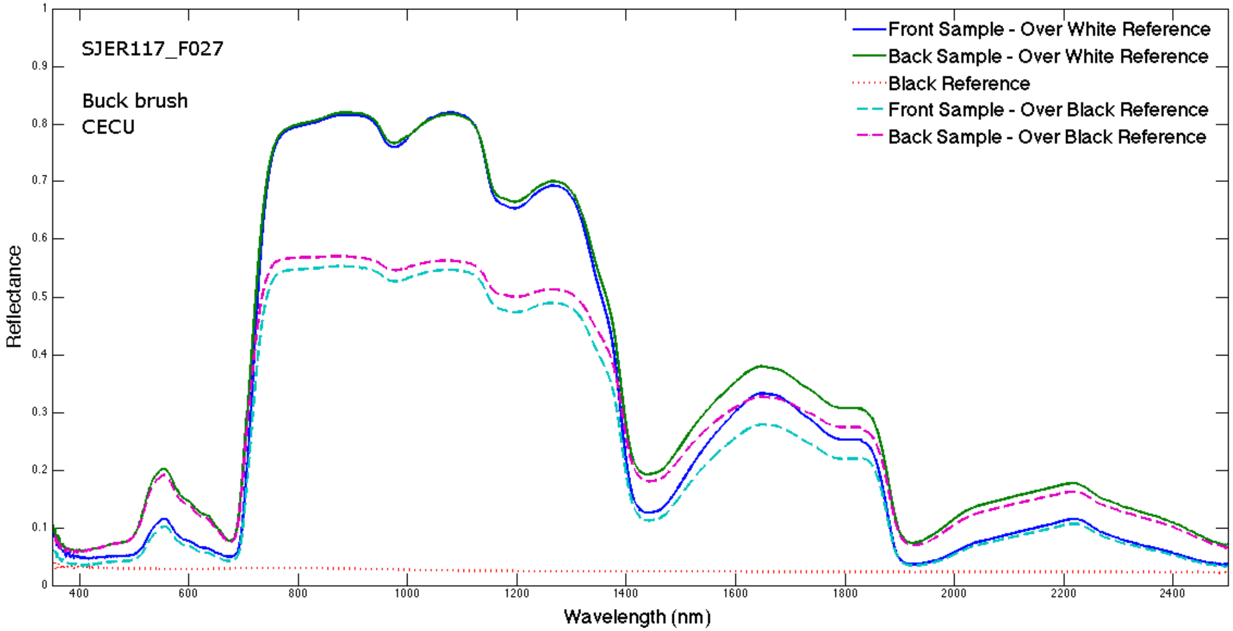


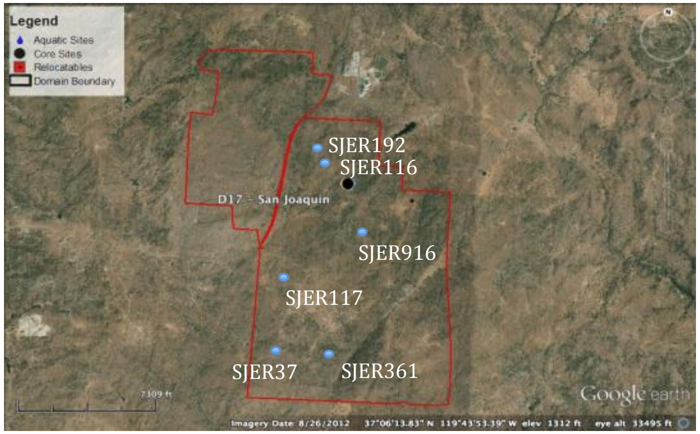
Transect Spectral Data



- Transect spectral data collected at seven NEON subplots in SJER
- Bulk biomass material harvested and bagged from each subplot to derive bulk N from grasses
- Spectral measurements will be compared to lab data to validate algorithm used to derive the biochemical properties from hyperspectral data
- Validated algorithm will be applied to the NEON NIS data to validate larger scale biomass N maps over SJER

Foliar samples spectra collected at six locations in SJER





- Goal of the plant canopy sampling was to investigate the variation in elemental content (C, N, P, Ca2+, Mg2+, and K+), isotopic composition (C and N), chlorophyll, and lignin across a range of plant community types

- The objective was to collect plant chemistry and structural measurements that could be compared with remote sensing data collected by the Airborne Observatory Platform

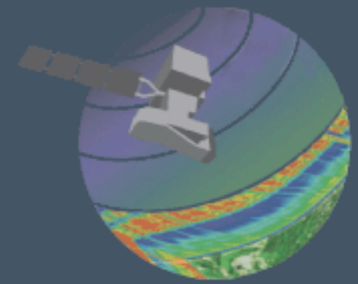
Instrument Comparisons

University of Wisconsin team collected leaf-level reflectance and measured gas exchange

NEON and UW performed instrument cross-comparisons to measure systematic bias within each ASD field spectrometer

DIRSIG

The Digital Imaging and Remote Sensing Image Generation Model



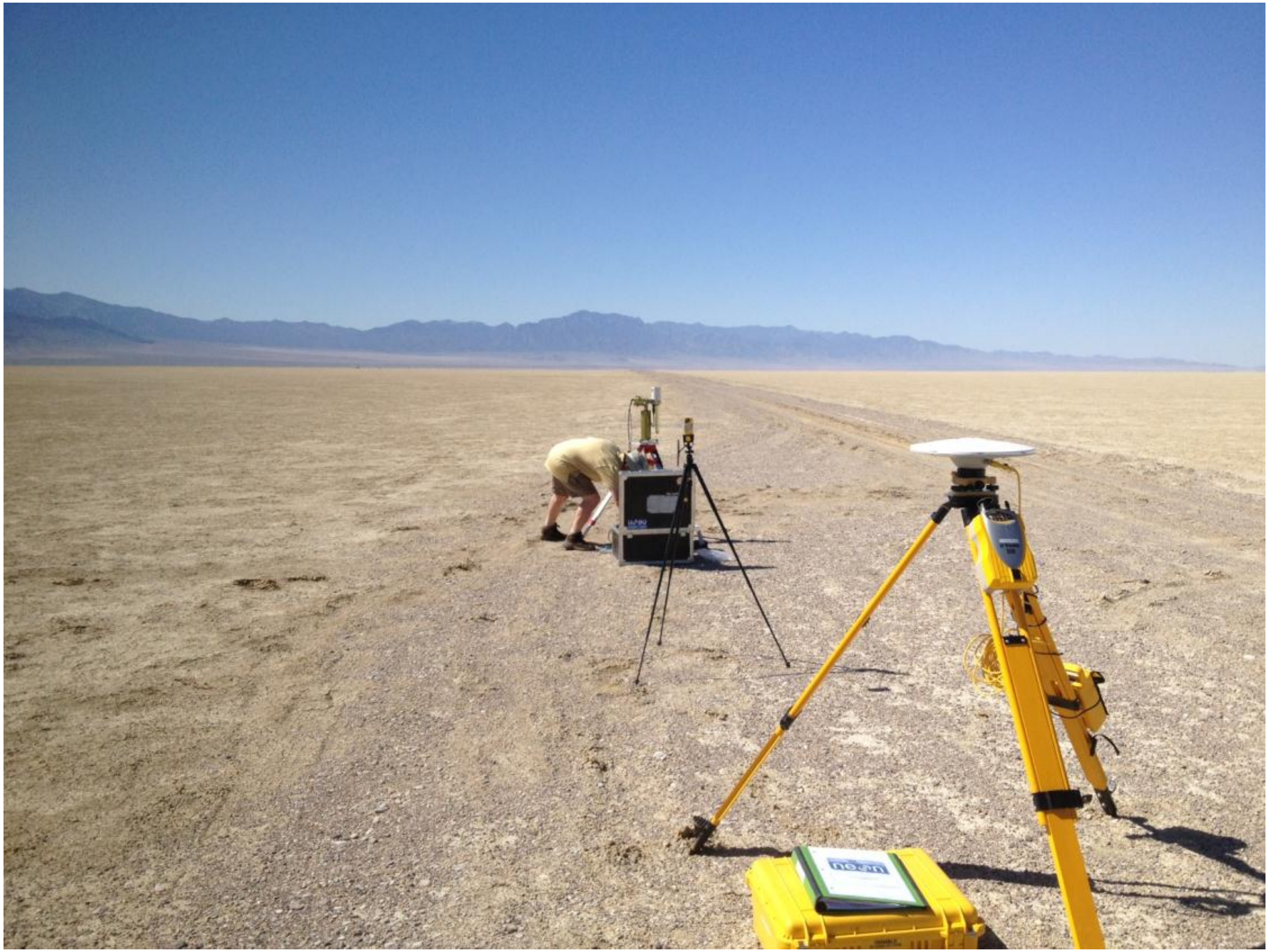
Rochester Institute of Technology

- Conducted ground-based LiDAR scans, LAI, herbaceous biomass measurements, wide-angle photos, spectral measurements at more than twenty sites centered on existing 20x20m NEON plots
- Data will be used for synthetic scene design using DIRSIG to study the impact of sub-pixel structural variation on pixel-level spectral response

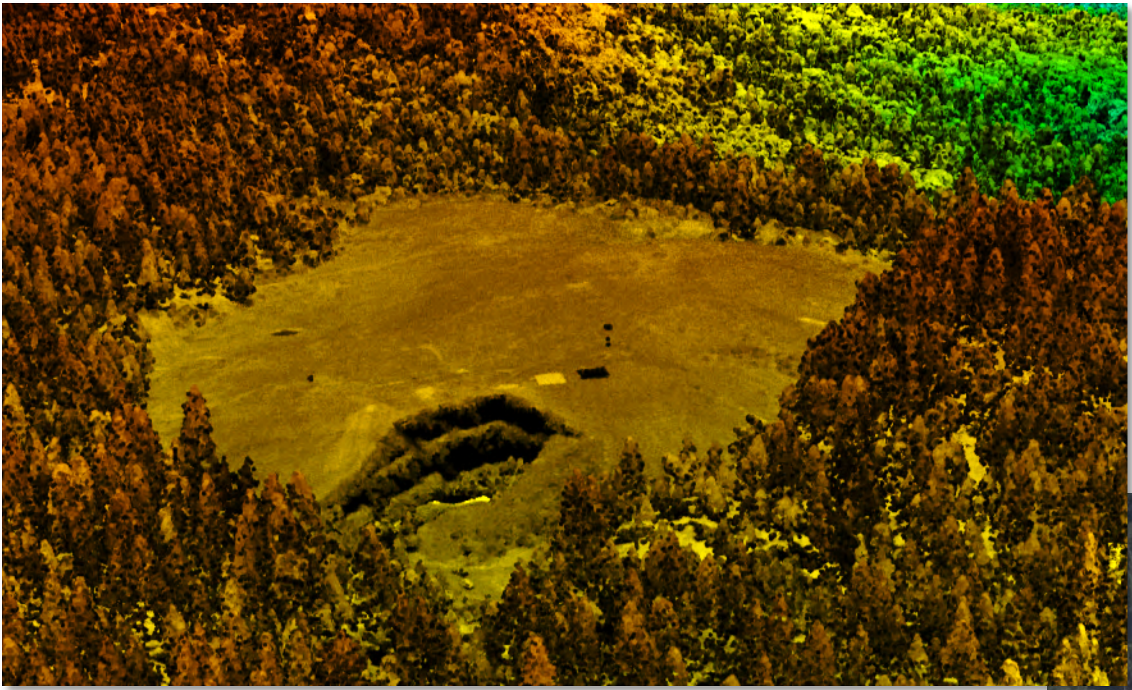
Boston University

- Surveyed three sites with terrestrial waveform LiDAR (DWEL)

Vicarious Calibration at Railroad Valley Playa



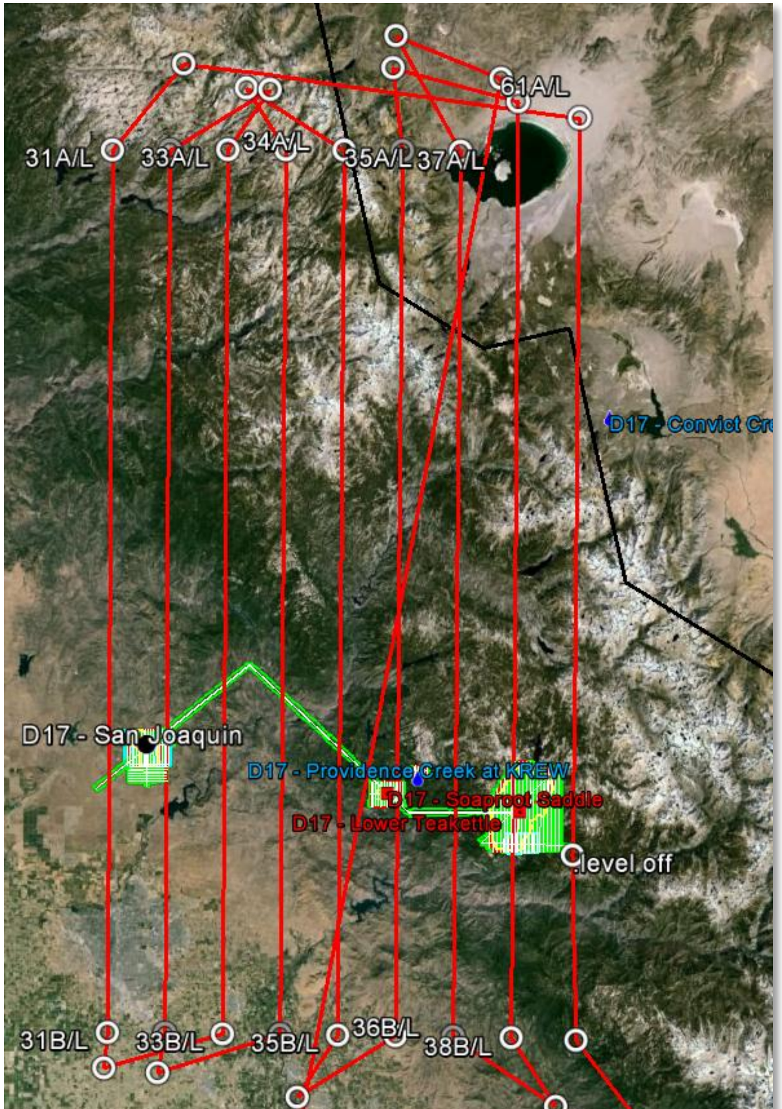
Preliminary Science Data



Discreet LiDAR data for Soaproot Saddle

Aerial photo of field sampling site with Tracor reference reflectance tarps

Collaborations



HyspIRI Preparatory Airborne Campaign

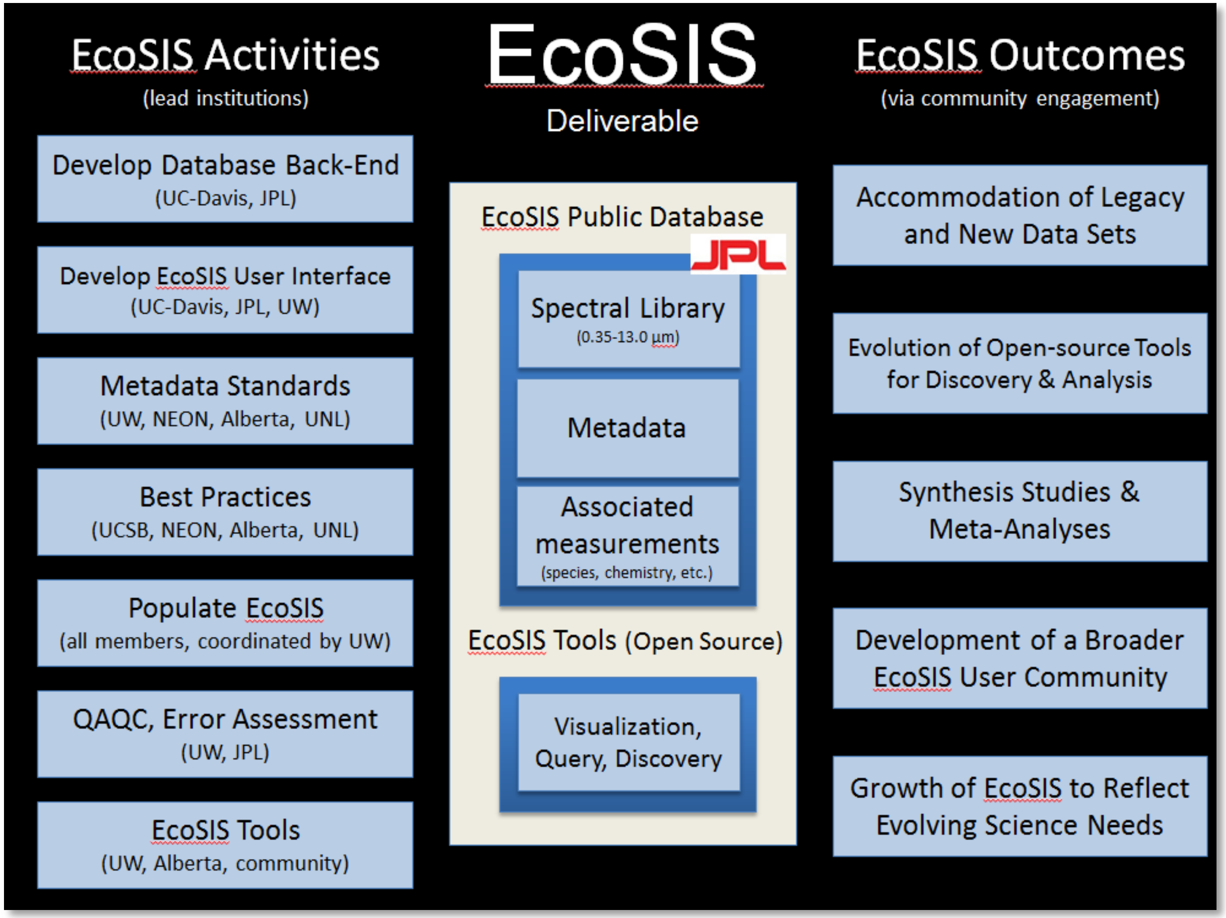
May/June 2013 HyspIRI airborne preparatory mission AVIRIS-classic survey of flight boxes in coastal/inland California

June 12 AVIRIS flight overlapped with NEON AOP survey of Soaproot Saddle and the elevation gradient transect

Obtained coincident datasets from hyperspectral instruments at different resolutions with linked field measurements

Will enable accurate calibration/validation and a range of ecological studies across multiple scales

Collaborations



University of Wisconsin - Ecological Spectral Information System (EcoSIS)

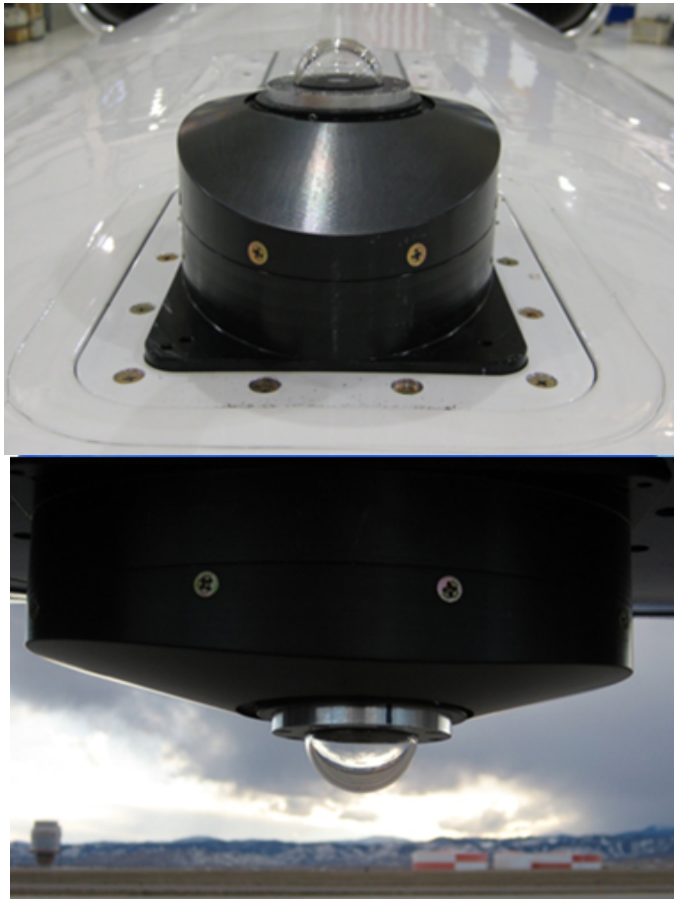
Designed to enhance the accessibility and utility of new and existing spectral vegetation data

Collaborations

Collaboration with University of Colorado's Laboratory for Atmospheric and Space Physics to incorporate airborne irradiance monitor into payload

Measures aerosol optical depth above and below aircraft

Should help with cirrus cloud assessment



For Illustration Purposes Only

Moving Forward

- Preliminary calibrated radiance and orthorectified reflectance products, discrete and waveform LiDAR, co-registered photography expected January 2014
- ATBD's for all data processing will be available online
- Spring 2014 science workshop on application of NEON airborne data
- Annual airborne surveys of D17 begin in 2016
- 52 page Technical Memo on 2013 Airborne Campaign at Domain 17 Terrestrial and Aquatic Sites at http://www.neoninc.org/sites/default/files/tms/TM-005.pdf

NEON.DOC.001298
NEON Technical Memo 005

neon
NATIONAL ECOLOGICAL OBSERVATORY NETWORK

The NEON 2013 Airborne Campaign at Domain 17 Terrestrial and Aquatic Sites in California

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ABSTRACT

The National Ecological Observatory Network (NEON) conducted a series of airborne remote sensing surveys and supporting ground measurements in June 2013 at three NEON terrestrial sites and one NEON aquatic site located in NEON Domain 17 (Pacific Southwest) in California. These sites extend over diverse ecological regions and climate and elevation gradients ranging from open woodland at 200 to 520 m elevation dominated by oaks (blue and interior live oaks) and digger pine in the San Joaquin Experiment Range (NEON core site) to mixed conifer/deciduous forest at 1100 m elevation at the Soaproot Saddle relocatable site, red fir dominated forest at elevations of 1775 to 3038 m at the Teakettle relocatable site, and mid-to-high elevation mixed-conifer riparian forest between 1500 and 2120 m elevation at the Providence Creek aquatic site. The primary objectives of the combined airborne and field campaign were to test the nominal data collection parameters for these sites, evaluate data processing techniques, and obtain an initial data set that supports spatial/temporal scaling studies currently underway as part of the NASA HyspIRI Preparatory Airborne Project. Airborne remote sensing measurements were made using the full NEON Airborne Observatory Platform instrument payload (AOP-1), which includes a high-resolution NEON imaging spectrometer (NIS), a small-footprint waveform-recording LiDAR and a high-resolution digital camera integrated onboard a DeHavilland DHC-6 Twin Otter aircraft. Supporting ground measurements of vegetation spectra and structure, plant species identification and measurements of key atmospheric variables were made in conjunction with the NEON airborne observations at San Joaquin and Soaproot Saddle and in collaboration with field research teams from the University of California, Davis, the University of Wisconsin, Madison, and Rochester Institute of Technology. NEON's airborne observations of Soaproot Saddle were also coincident with the airborne observations of the western Sierra Nevada Mountains made by NASA JPL using the AVIRIS-classic instrument onboard an ER-2, and field measurements acquired to support the ongoing NASA Ecological Spectral Information System (EcoSIS) Project.

Keywords: Airborne remote sensing, imaging spectroscopy

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