CALIBRATION OF NEON’S AIRBORNE IMAGING SPECTROMETERS

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Funded by the National Science Foundation to...

... 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
- Land Use
- Invasive Species

Response to Change
- Biodiversity
- Biogeochemistry
- Ecohydrology
- Infectious Disease
NEON Observation Platforms

AOS/AIS

AOP

TOS

TIS
Capture of Data at Multiple Spatial Scales

- Up-Down Scaling
- Vegetation reflectance / biophysical characteristics
- Leaf Area
- PAR profile
- Canopy architecture
- Ecosystem state
- Habitat states
- Biogeochemical cycles
- Land surface interactions
- Species composition
- Succession
- Vegetation dynamics
- CO₂ flux
- Partitioning
- Phenology productivity
- Metabolic regulation
- CO₂, O₂, H₂O exchange

Radiative Transfer Modeling

- Leaf RT Model: Link leaf (ρ, τ) to absorption of pigments, water, etc.
- Canopy RT Model: Link BRF to LAI, cover, 3D structure, biochemistry, background, non-vegetative surfaces, etc.
- Atmospheric RT Model: Link spectral radiance to scattering and absorption due to varying atm. H₂O & aerosols

Time [s]
AOP Flight Concept

NDVI data determines the annual flight window for each domain.
AOP Data

Aspen & Pine

Dead Grass

Snow
The NEON Imaging Spectrometer

- Vacuum Chamber
- Fiber-Fed-On-Board Calibrator
- Telescope
- Shutter/Window (Not Shown)
- Diameter = 20"
- Cryocooler (2X)
- Thermal Radiation Shield (2X)
- Spectrometer
- Height = 30"
- Window
- OSF/FPA
- TM1
- TM2
- Slit
- SM1
- SM2 (DG)
- SM3
- 640 Cross-track Spatial pixels
- 1000 km altitude
- Swath = 611 m
- Ground Speed = 51,446 m/sec
- Flight line = ~15 km
- 426 Spectral Samples per FOV
- 1 m GSD
Why Calibration?

Solar Radiation Spectrum

Visible, near infrared, shortwave infrared

leaf pigments

chlorophyll & other pigments

water content, leaf biochemicals, lignin, cellulose

water absorption bands

water, leaf, canopy structure

leaf pigments

cell structure

water content, leaf biochemicals, lignin, cellulose

water absorption bands

water, leaf, canopy structure
NIS Raw Flight Line Sequence

Dark Frame is taken prior to science collection. Science data is taken of the flight line target. In this case, Soaproot Saddle in NEON's Domain 17 collected in 2013. Reflectance tarps are visible in the uncorrected image.

On-board calibrator (OBC) data is taken at a low light level immediately after second dark collect. On-board calibrator (OBC) data is taken at a higher light level to improve signal at short wavelengths. Laser data is taken to provide a spectral check and to conclude the sequence.

Dark Frame is taken after science collection.
Spectral Calibration

For EACH Pixel (All 255,944 of them),

We need to know or model the

• Location
• Shape

of the spectral response functions (SRF)

Where

Shape

Normalized Response

Measured
Modeled
Residual

Wavelength (nm)

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Spectral Calibration
Spectral Calibration

- Pixel = 253.96, Std of peaks = 0.003
- Pixel = 151.00, Std of peaks = 0.004
- Pixel = 57.62, Std of peaks = 0.003
- Pixel = 35.62, Std of peaks = 0.005

Wavelength of pixel = 5.0095 * Pixel # + 257.4293
Spectral Calibration

Raw NIS-1 image collected on BIP/SCIP

- BIP/SCIP illuminates 5 spatial pixel locations
- Zero-order light collected at start
- RGB show up in RGB image of collect

Algorithm selects spatial columns, in this case [35, 177, 314, 457, 596]
Spectral Calibration
Development of NEON code for SRF

Band Center
FWHM
Spectral Calibration

Fitted Gaussians for Spatial Position 314

FWHM of Fitted Gaussians for all 5 Spatial Positions
Radiometric Calibration

![Radiometric Calibration Diagram]

- **FEL 653 Interpolated**
- **NIST FEL 653**

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Irradiance</th>
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<tr>
<td>350</td>
<td>0.93</td>
</tr>
<tr>
<td>550</td>
<td>0.94</td>
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<tr>
<td>800</td>
<td>0.95</td>
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<td>0.96</td>
</tr>
<tr>
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<td>0.97</td>
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<td>2300</td>
<td>1.01</td>
</tr>
<tr>
<td>2550</td>
<td>1.02</td>
</tr>
</tbody>
</table>

- **VNIR**
- **SWIR < 1000-nm**
- **SWIR 1100-nm -> 2100-nm**
- **SWIR 2125-nm -> 2300-nm**
- **SWIR 2325-nm -> 2400-nm**
- **2425-nm -> 2500-nm**
Radiometric Calibration

Integrating Sphere Test Station
Radiometric Calibration

20130506 Sphere measurements: all light levels

- 40%
- 40%, KG-2
- 30%
- 30%, KG-2
- 20%
- 20%, KG-2
- 10%
- 15%
- 100%, KG-2
- 100%, KG-2, OPT
- 50%, OPT
- 50%, KG-2
Vicarious Calibration at Railroad Valley
Vicarious Calibration at Railroad Valley
Vicarious Calibration at Railroad Valley

Cirrus Band = ~30% Difference
Conclusions

• Next steps
  • Improve Spectral Calibration
  • Continue calibration test set development
  • Incorporate precision Transfer Radiometers in calibration process
  • Continue development of QA/QC verification and reporting
Back-up slides