Remote Sensing Observations at Multiple Scales to Define Ecosystem Form & Function

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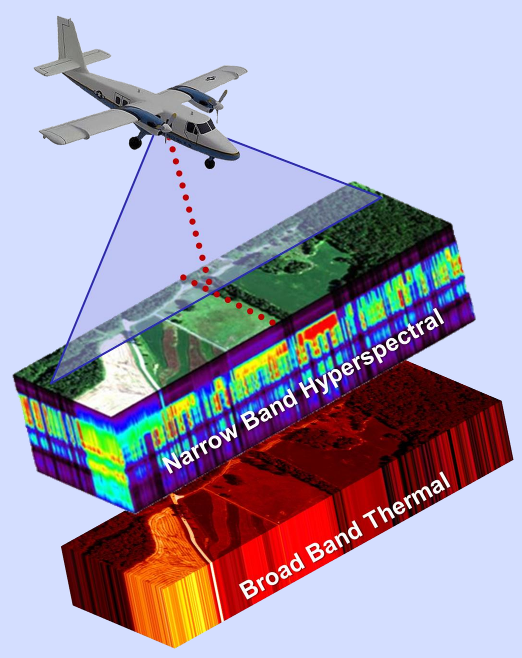
Imaging spectroscopy can provide timely, spatially explicit information for monitoring terrestrial ecosystems. The HyspIRI mission called for by the NRC Decadal Survey identifies the need for a near term space-borne hyperspectral imaging spectrometer to globally map early signs of ecosystem change through altered physiology. The primary instrument on the proposed NASA HyspIRI mission is a hyperspectral (10 nm FWHM) mapper with a 60 m ground resolution and a 19 day global revisit, which will enable imaging spectroscopy with high temporal repeat to capture the impact of environmental perturbations on ecosystem productivity. The goal of these efforts is to further spectroscopic techniques for ecosystem assessments using a comprehensive suite remote sensing observations.

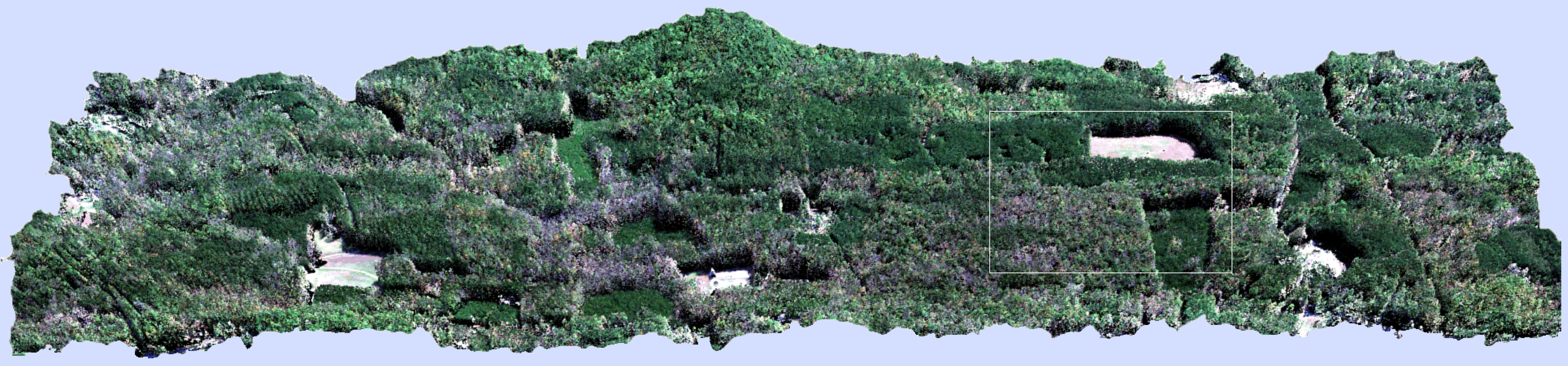
The specific objectives of this research are:

- Indentify spectroscopic techniques that consistently track biophysical changes indicative of productivity.
- Establish the performance of spectroscopic techniques across observation levels and through time.
- To further define algorithms and products applicable to future satellite missions.

The Duke Forest research site is managed by Duke University and is located at the edge of the Piedmont near Durham, North Carolina. Much of the Forest exhibits rolling terrain with an elevation range from 300 to 500 feet above sea level. Over 100 species of trees have been identified in the Duke Forest. The major types in descending order of prevalence are pine, pine-hardwood, upland hardwood, and bottomland hardwood.



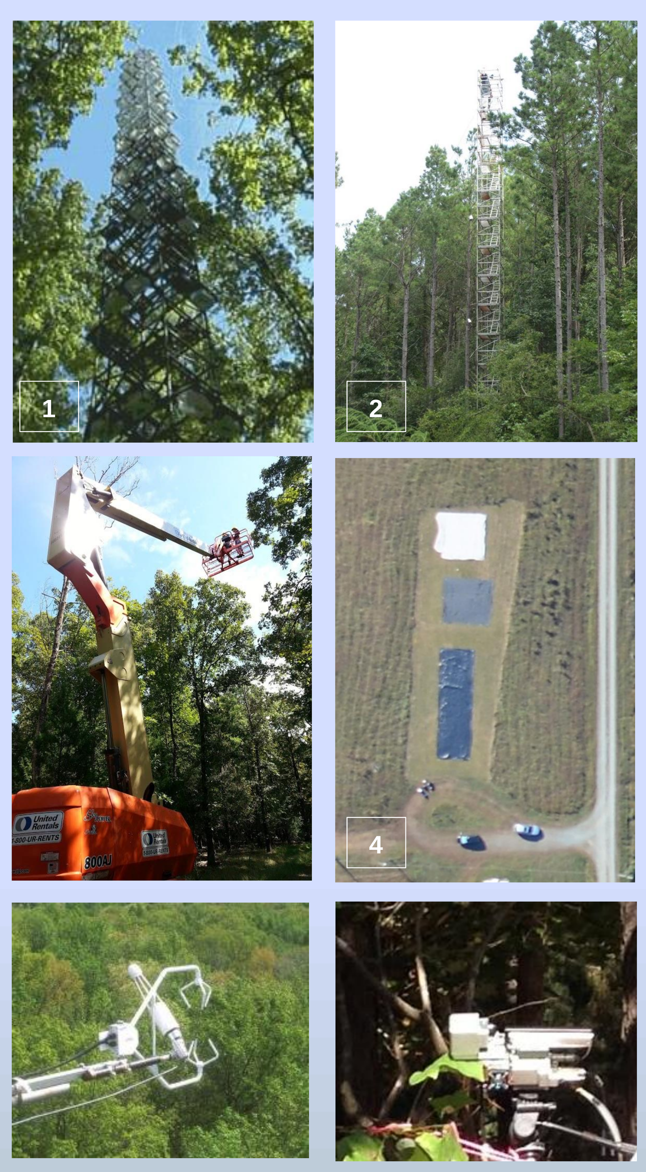
Goddard's Lidar Hyperspectral Thermal Airborne Imager (G-LiHT) was flown over this site from Sept-Oct 2013 configured with a VNIR imaging spectrometer, a scanning LiDAR operating at 150 kHz, a broadband thermal imager, and a high resolution DSLR camera. For further information on G-LiHT visit: *http://gliht.gsfc.nasa.gov*



This study focused on the Blackwood division of Duke Forest where a 10 km^2 area was flown with a series of 8 equally spaced flight lines at 600 m AGL. The above RGB composite of the study area is overlaid on the LiDAR DEM as an example of one of G-LiHT's co-registered data products at a gridded 2 m ground resolution.

The site contains two instrumented forest towers:

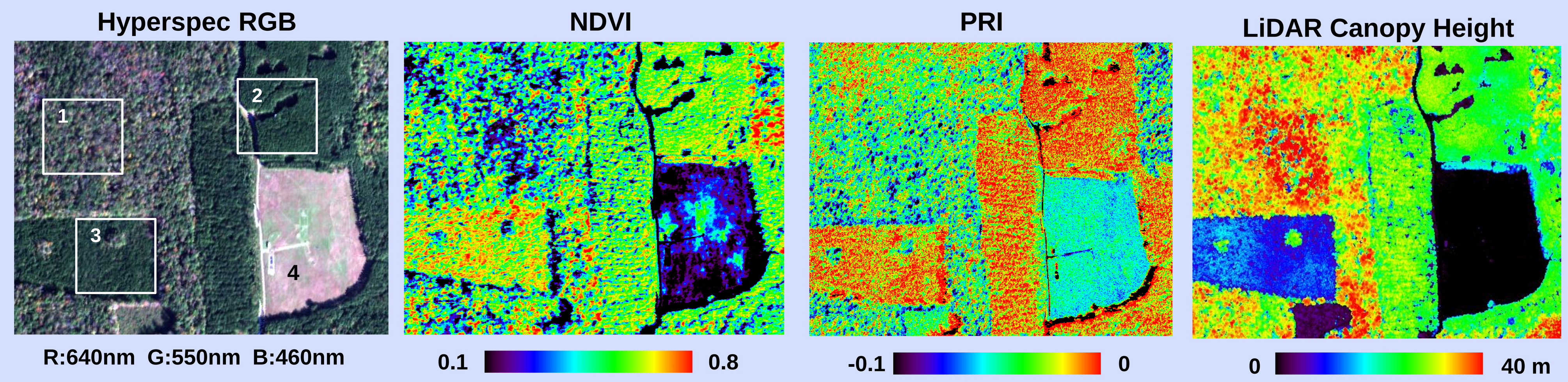
- The Hardwood Forest tower [1] footprint consists of an oak-hickory forest that represents a later stage of a post-agricultural succession.
- The Loblolly Pine tower [2] with a footprint that has a diverse understory composition below a nearly homogeneous over story.



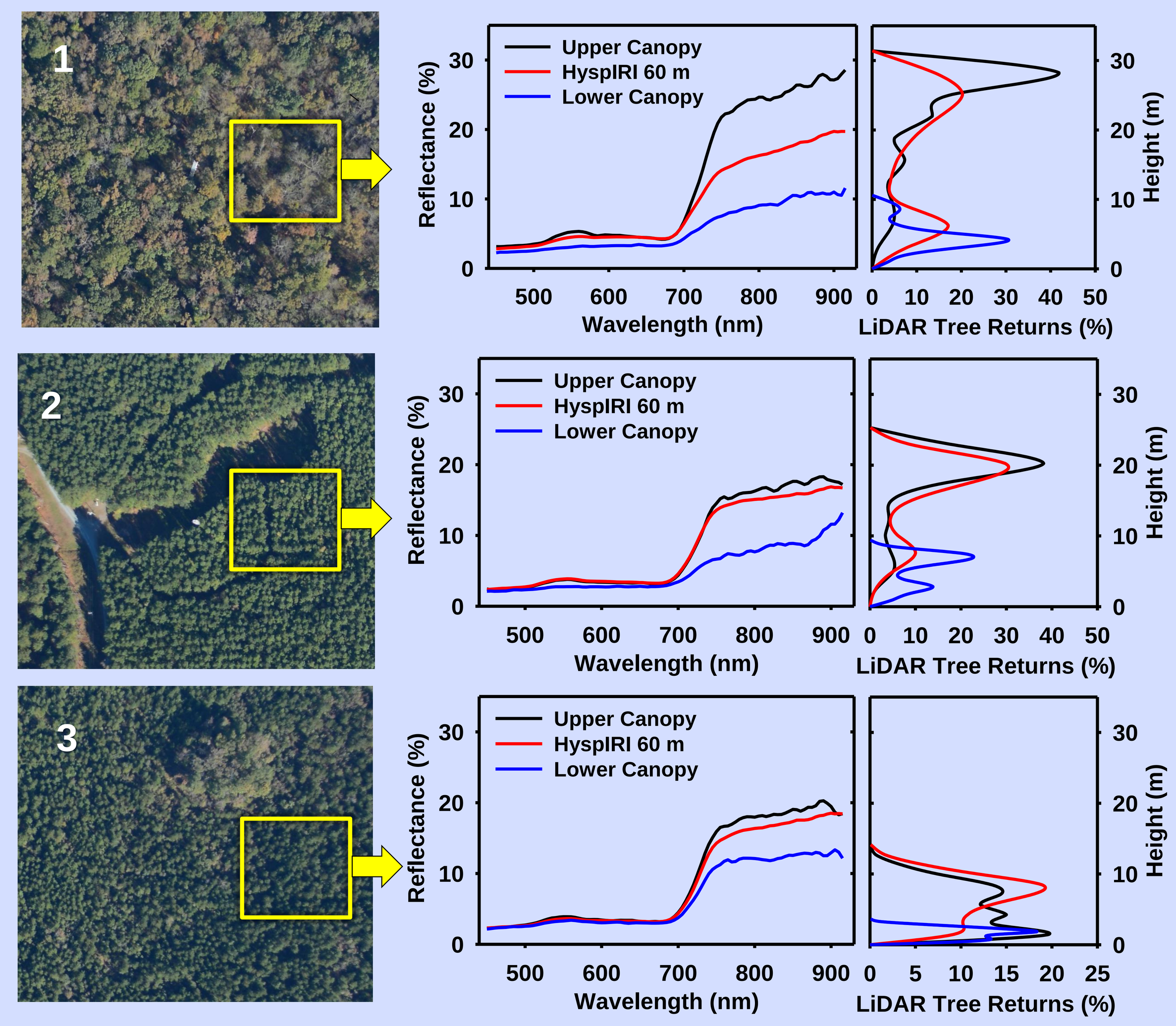
Both towers were configured with automated data acquisition systems to capture multi-angular observations of surface reflectance and temperature. For further information on the FUSION tower based observing systems visit: *http://gliht.gsfc.nasa.gov/fusion/*

Additional supporting observations include:

- Leaf & canopy optical properties
- Calibration site with aerial targets [4]
- Micrometeorological & CO_2 flux observations
- Foliar pigment contents & photosynthetic measurements
- Canopy LAI & species composition
- Additional foliar analysis including C & N contents

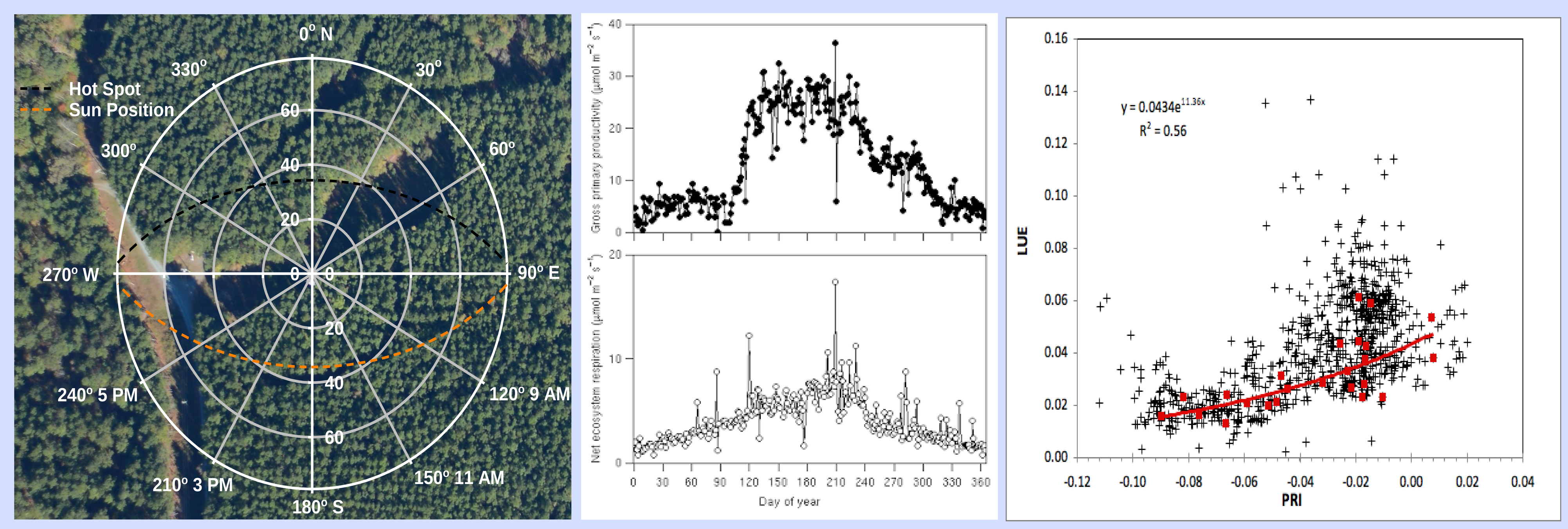


Above RGB image shows the relative location of; 1) the Hardwood Tower, 2) the Pine Tower, 3) an early succession Pine stand, and 4) the open field calibration site. Several spectral vegetation indices are calculated from the imaging spectrometer data with NDVI & PRI shown in the middle two false color images with the LiDAR derived canopy height to the right.



Left aerial photos from G-LiHT's high resolution DSLR camera are shown for each of three specific regions of interest. In red are HyspIRI (60m) aggregated reflectance spectra averaged from each region of interest (900 pixels) along with corresponding LiDAR derived distributions of canopy elements. Upper canopy (black) and lower understory (blue) spectral end members were identified based on a hybrid approach using multiple layers of remote sensing information. This strategy can use high resolution multi-sensor airborne data to aid in the development of spectral algorithms for HyspIRI.

FUSION's multi-angular capability maps complete hemispherical surface reflectance every half hour with a 10º sampling resolution. FUSION's FOV from the pine tower is shown below (left). A sample of seasonal data from the CO_2 flux sensors are shown in middle. While the panel to the right, identifies a diurnal relationship between FUSION derived PRI and ecosystem Light Use Efficiency (LUE). The observations in red are near NADIR view angles that correspond to the proposed HyspIRI 10:30 AM overpass time.



Conclusions

Since forests have different phenological cycles, LAI, and other biophysical properties, the vegetation indices and spectral signals within and among forest cover types may not lead to a universal solution for tracking productivity. However, full spectral imaging of high temporal frequency used alone or in combination with additional remote sensing observations such as LiDAR derived canopy structure could offer substantial quantitative improvements in ecosystem assessments. Here, we employ remote sensing observations at multiple scales to enhance our understanding of ecosystem form and function.

References

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