Synergy of VSWIR and LiDAR for Ecosystem Structure, Biomass, and Canopy Diversity

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VQ1. What is the global *spatial pattern of ecosystem and diversity distributions* and how do ecosystems differ in their composition or biodiversity?

VQ2. What are the *seasonal expressions* and cycles for terrestrial and aquatic ecosystems, *functional groups*, and diagnostic species?

VQ3. How are the *biogeochemical cycles* that sustain life on Earth being altered/disrupted by *natural and human-induced environmental change*?
Challenges to Imaging Spectroscopy

Plant chemical signatures are influenced by canopy structure and shadows.
Spectral Dependence of Leaf and Canopy Properties

- Canopy gaps and shade
- Leaf Reflectance/Chemistry
- Leaf Transmittance/Chemistry
- Leaf Angle Orientation
Carnegie Airborne Observatory (CAO)
3-D functional imaging of ecosystems

LiDAR for topography, canopy structure, LAI, etc.

\[ \text{CROSS-TRACK LASER PULSES} \]

\[ \text{RETURN PULSE WAVEFORM} \]

\[ \text{RETURN ENERGY} \]

\[ \text{TRAVEL TIME (\text{ns})} \]

\[ \text{CANOPY TOP RETURN} \]

\[ \text{GROUND RETURN} \]

\[ \text{height} = 15 \text{ m} \]

\[ \text{height} = \text{travel time} \cdot \text{light speed} / 2 \]

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Hyperspectral for species, chemistry, etc.

\[ \text{EACH SPATIAL ELEMENT HAS A CONTINUOUS SPECTRUM THAT IS USED TO ANALYZE THE SURFACE AND ATMOSPHERE} \]

\[ \text{224 SPECTRAL IMAGES TAKEN SIMULTANEOUSLY} \]

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Fusion for estimates of biodiversity, biomass, sun/shade fraction, habitat suitability, etc.
Biological Invasion Fronts
Canopy chemistry and biodiversity in tropical forest canopies
High-Temporal Tower-Based Studies

1) Thermal + LiDAR/Hyperspectral

2) Correcting hyperspectral observations for shadow fraction
Pan-tilt mount

Continuous Sun/Shade Measurements

Thermal imager (NEW!)

SERC Flux Tower
Photosynthetic light-use efficiency ($\varepsilon$) from multiple angles can be related to:

1) direct measurements of PRI; and
2) shadow fraction ($\alpha_s$) derived from LiDAR or mixture decomposition.

$\varepsilon = f(\Delta PRI \Delta \alpha_s^{-1})$

PRI = Photochemical Reflectance Index
$\varepsilon = $ photosynthetic light-use efficiency
Conclusions

*Biophysical* information from LiDAR and *biochemical* information from hyperspectral remote sensing provides complementary data for:

1) describing *spatial patterns of vegetation and biodiversity*;

2) characterizing relationships between *ecosystem form and function*; and

3) Detecting natural/human-induced change that affects *biogeochemical cycles*.