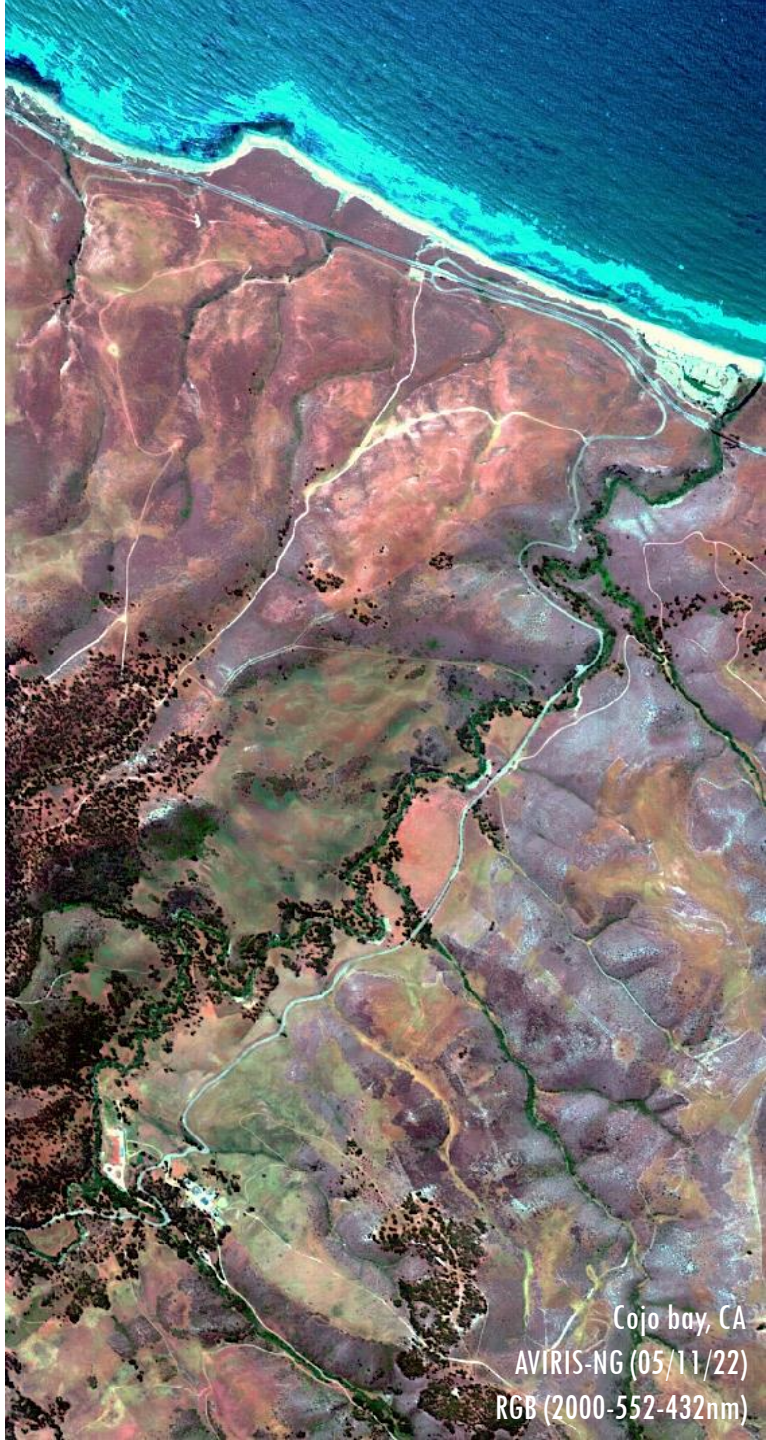
# Functional ecology in the SBG Era:
## An assessment of the state of plant trait retrieval from imaging spectroscopy


Alexey N. Shiklomanov[1], Yoseline Angel[1,2], Dhruva Kathuria[1,3]

[1] NASA Goddard Space Flight Center

[2] University of Maryland – ESSIC

[3] Morgan State University – GESTAR II

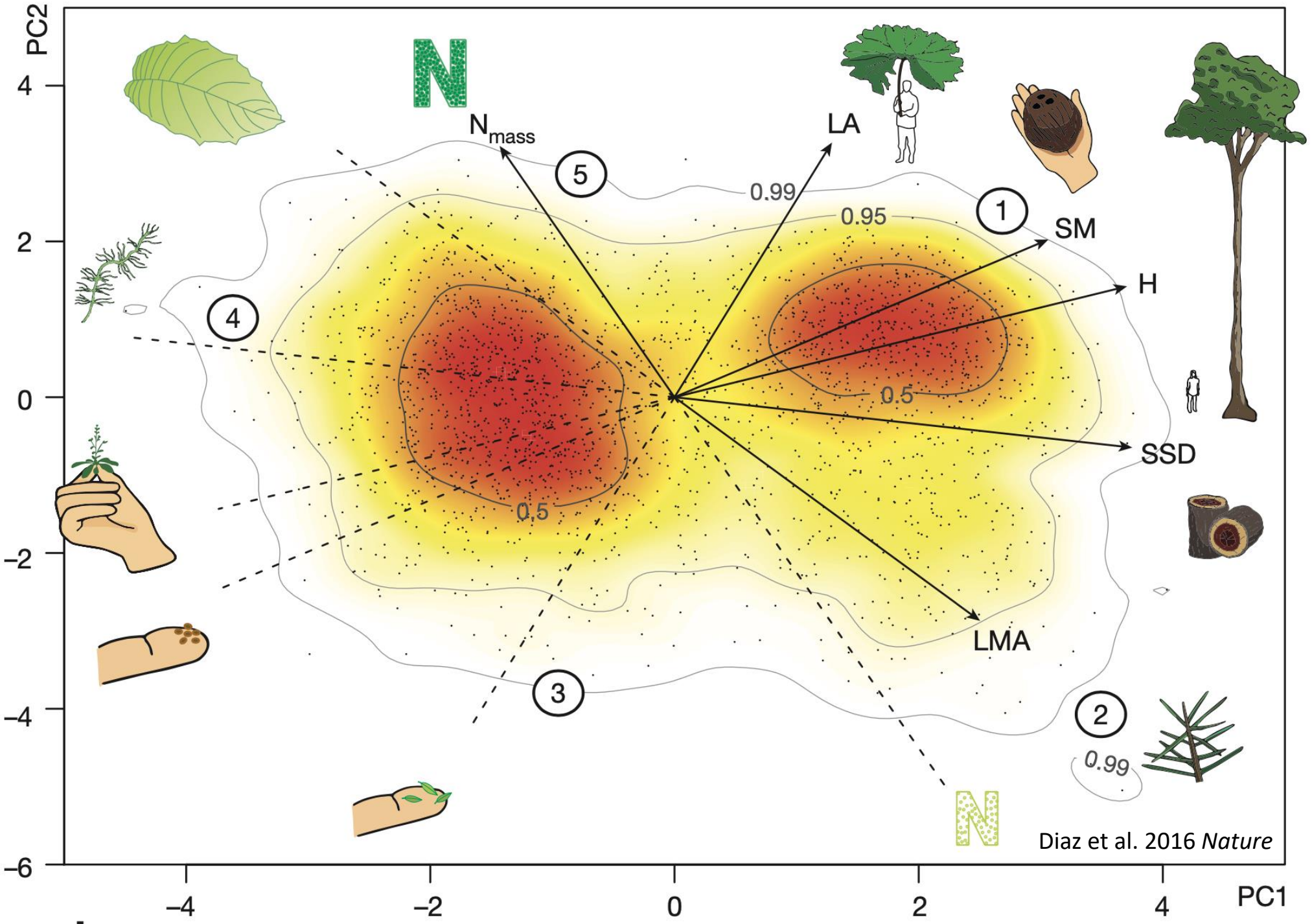





*Supported by the NASA ROSES 2020 New (Early Career) Investigator Program in Earth Sciences.*

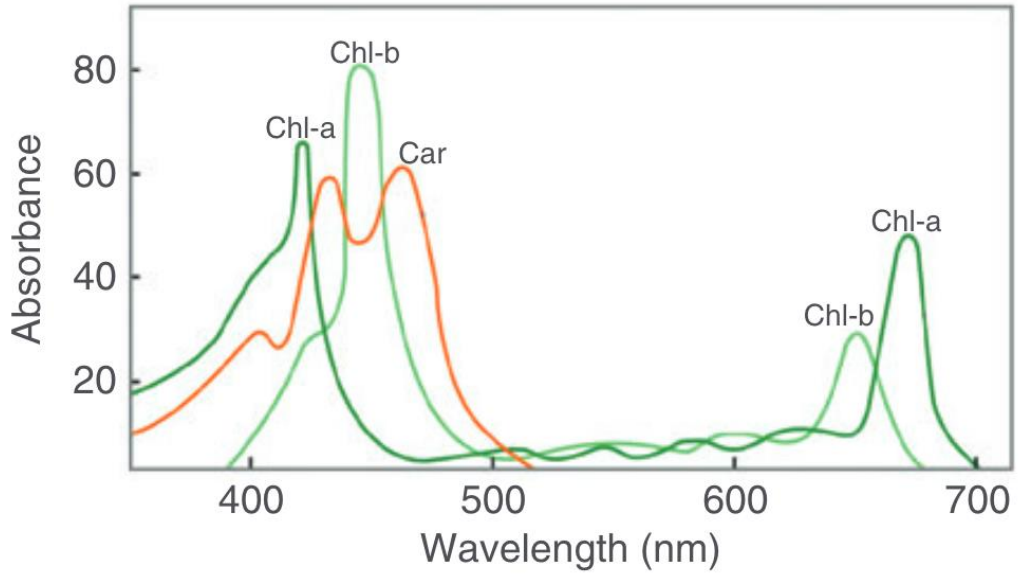
# Plant functional traits

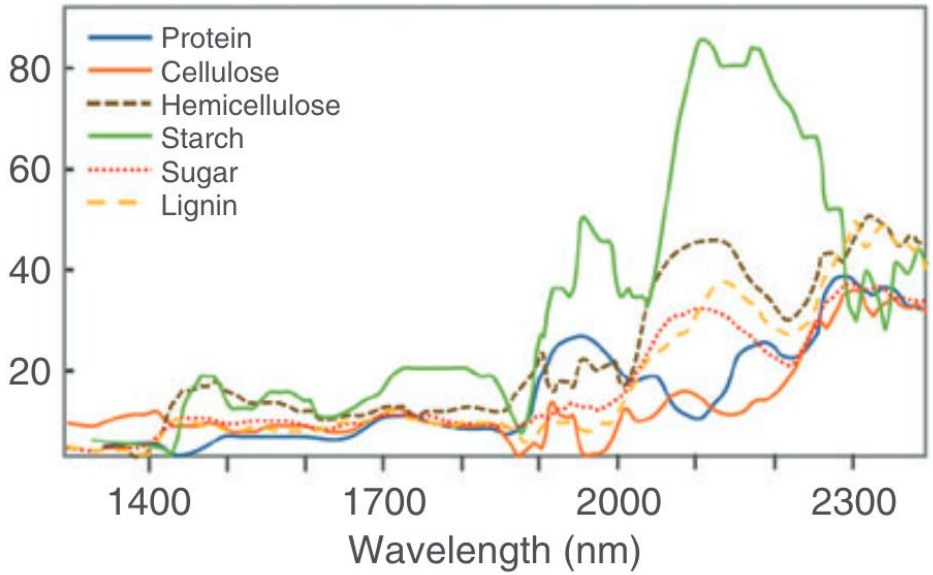
Measurable characteristics of plants that are closely related to function and fitness.

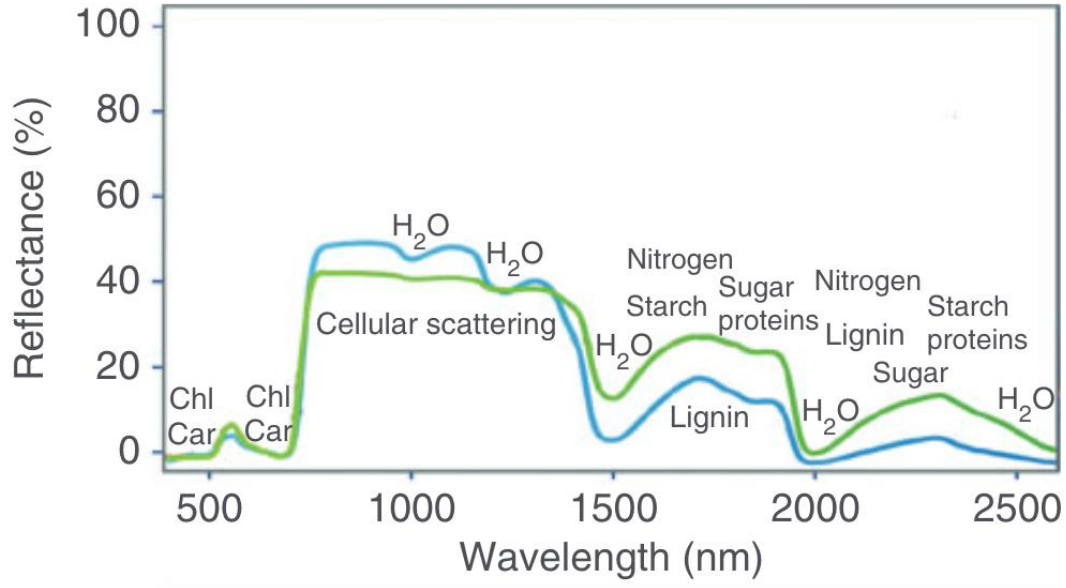



Diaz et al. 2016 *Nature*

# Leaf traits affect leaf optical properties (reflectance, transmittance, and absorption)…

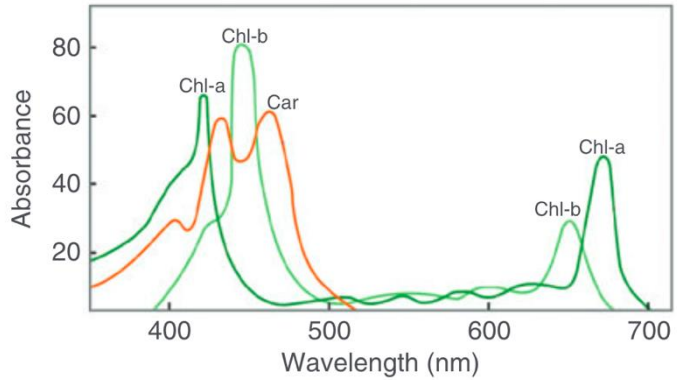


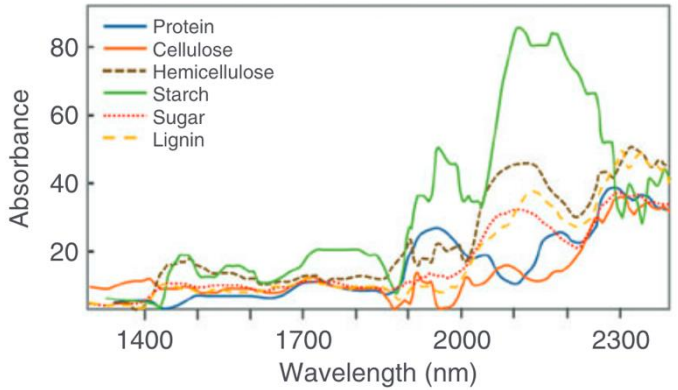



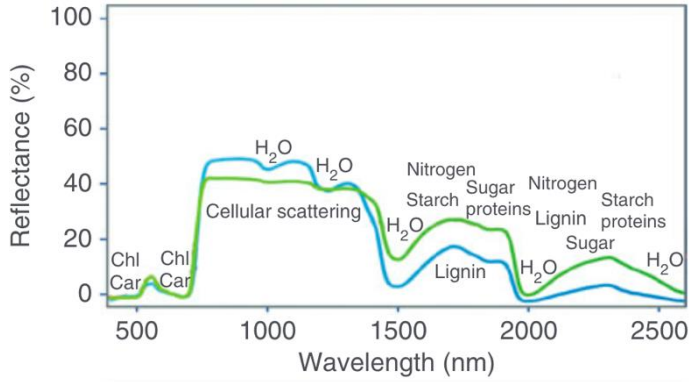




Angel & Shiklomanov 2022 *APRO*

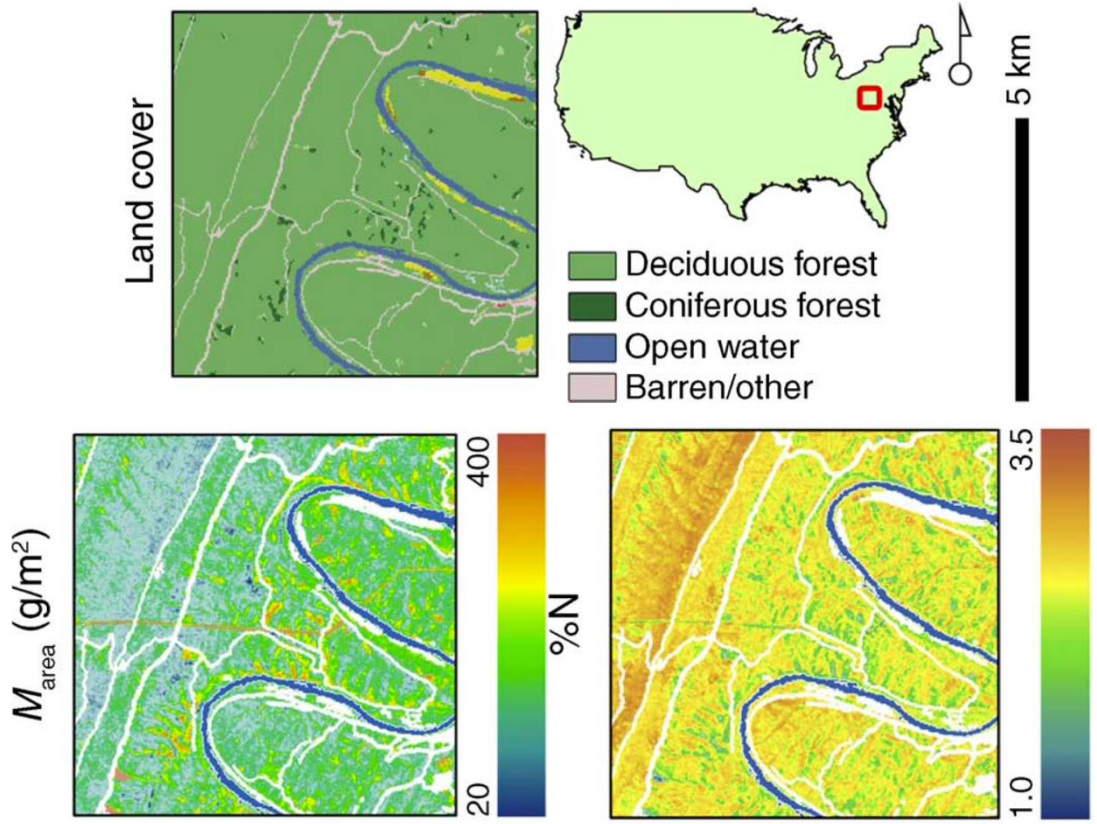
# …allowing us to estimate leaf traits from remote (e.g., tower, UAV, airborne, satellite) measurements of reflectance ("imaging spectroscopy").




Trait retrieval algorithm

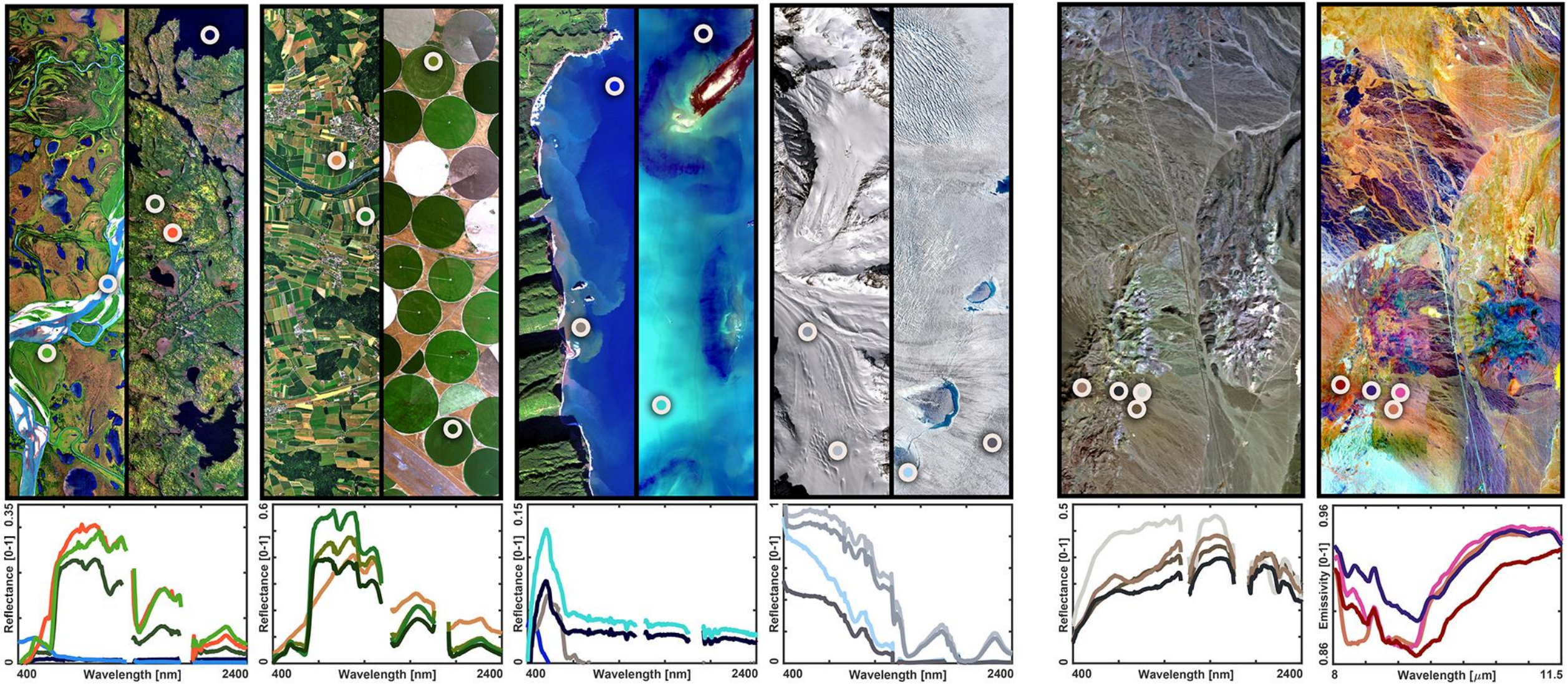



Singh et al. 2015 *Ecological Applications*

# SBG provides data for many focus areas ...

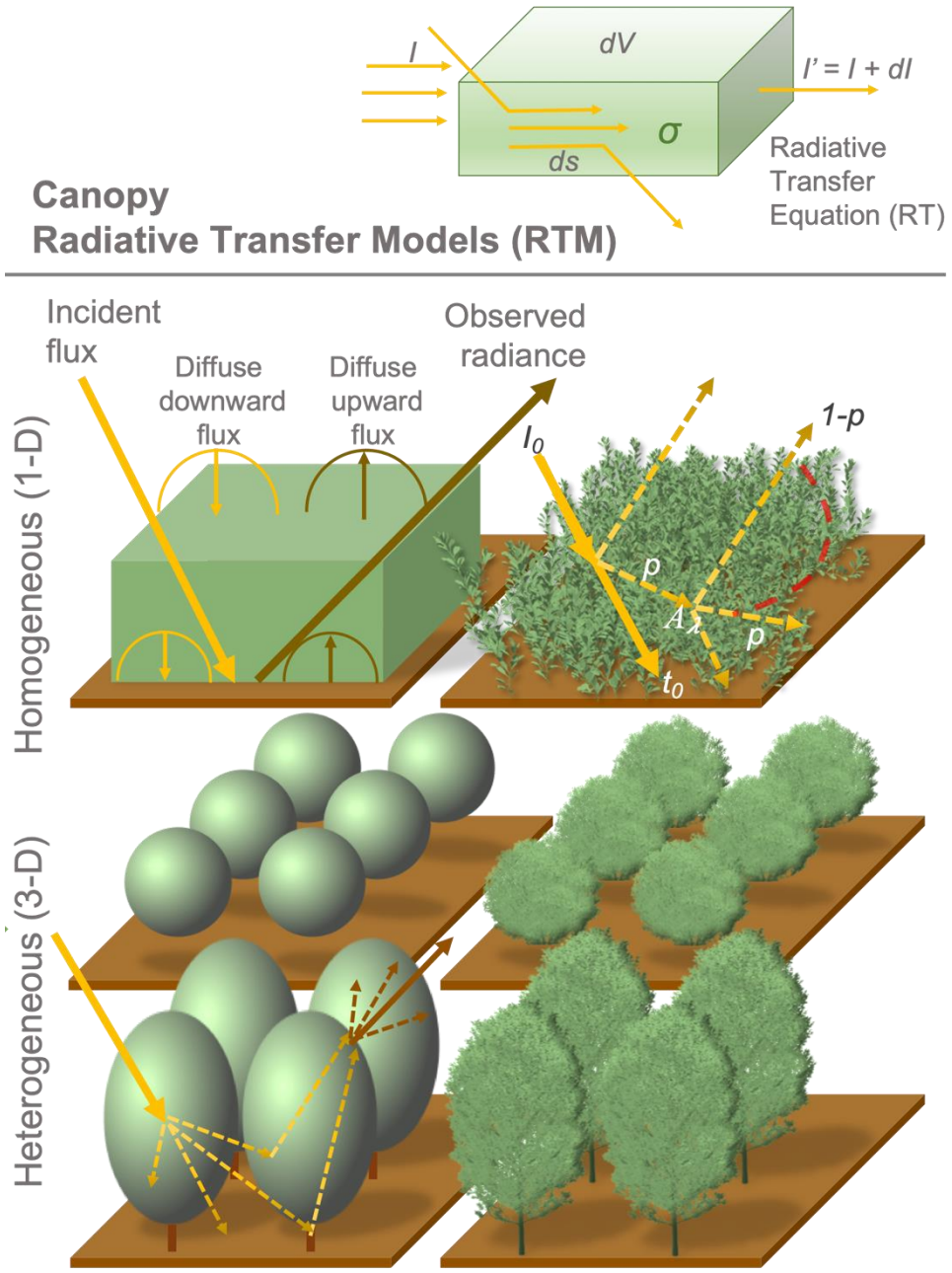
## ... and will see the world in two critical spectral regions

Ecosystems | Agriculture | Coastal Zones | Snow and Ice | VSWIR | Minerals | TIR



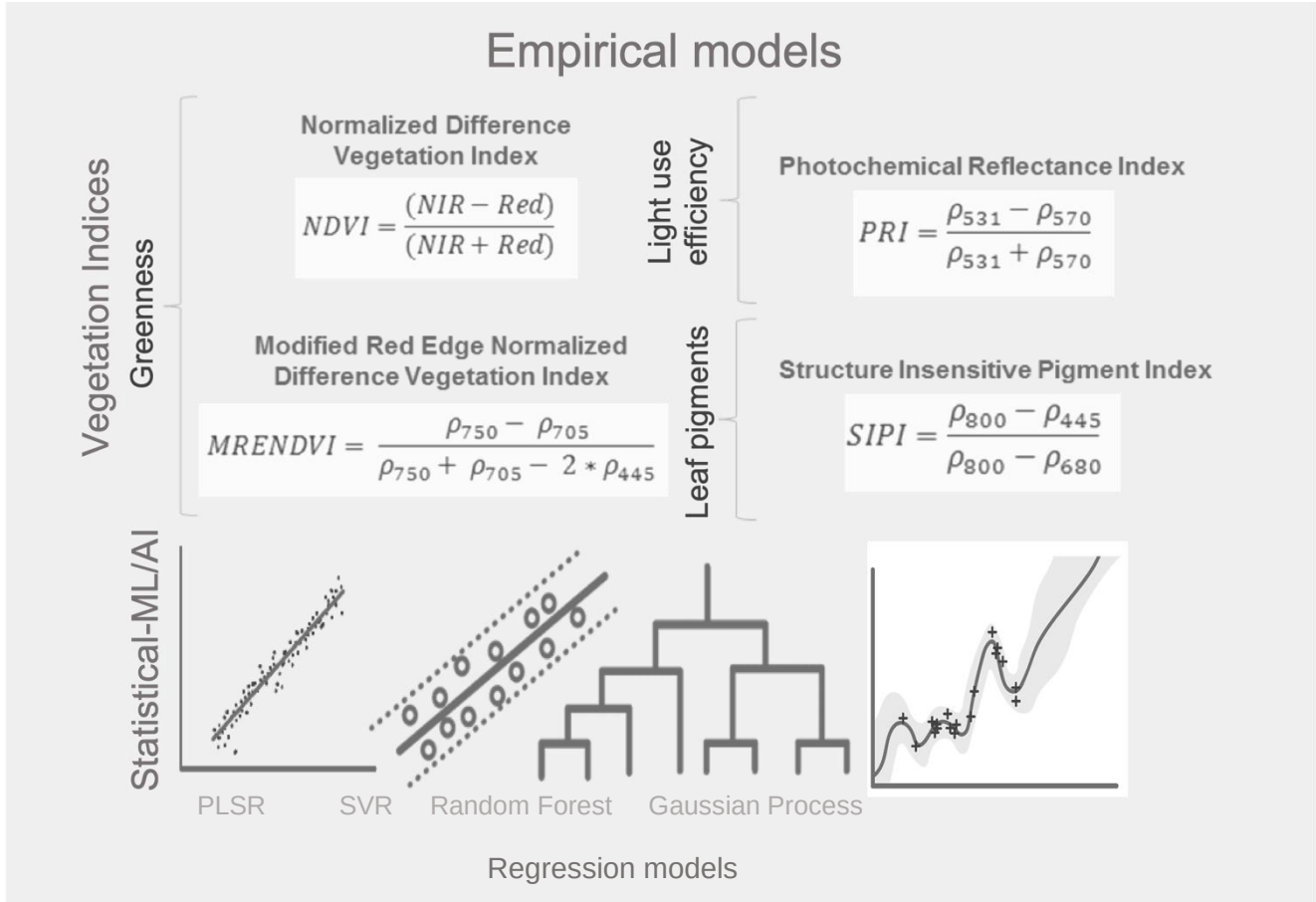

**SBG will be one of the first satellites to acquire regular, global imaging spectroscopy data**

Schneider et al. 2019 *Eos*




Angel & Shiklomanov 2022 *APRO*

# Many methods exist for estimating traits from spectra. Most have only been developed and tested at site scales. *Will they work globally?*



(1) What are the ”best” algorithms, at both leaf and canopy scales?

(2) Why do these algorithms succeed (or fail), and under what conditions?

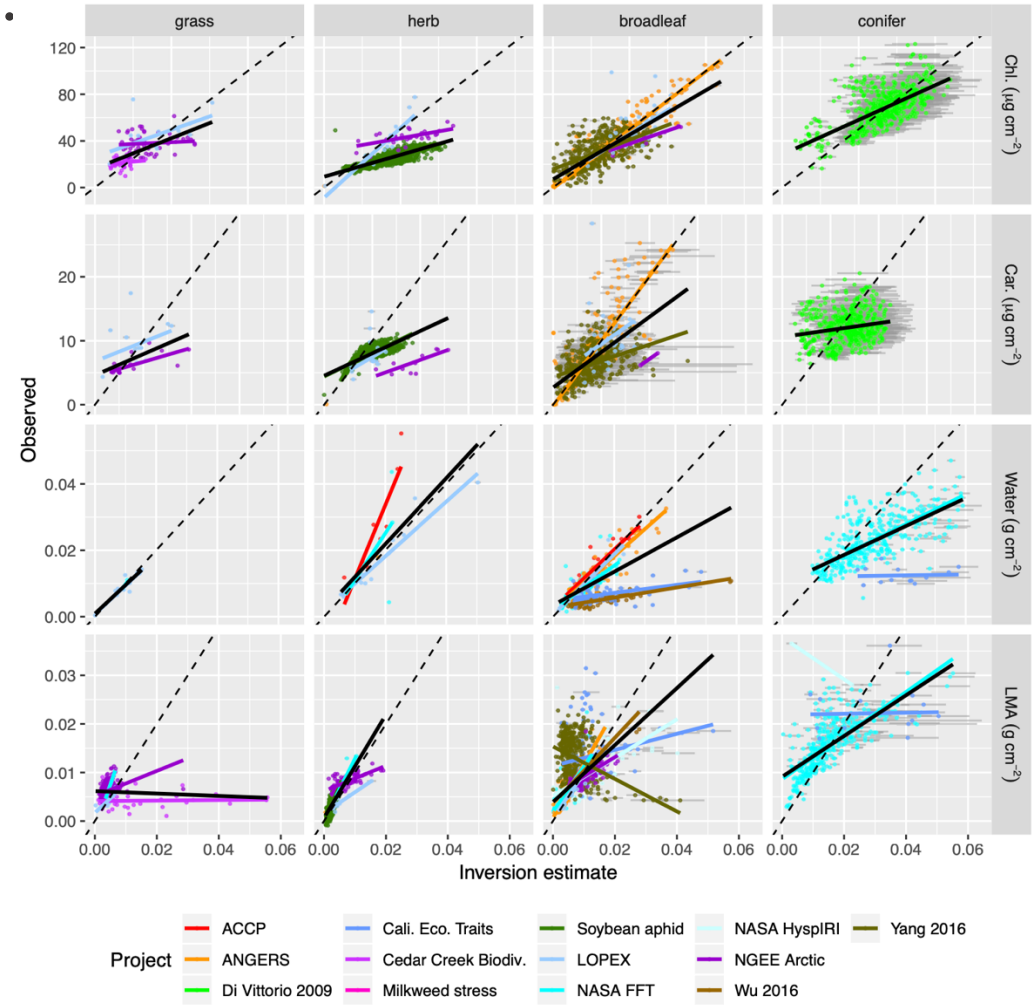
~~(3) How should we measure spectra to get the best trait estimates?~~

“Too late / nobody cares!”
- NASA review panel

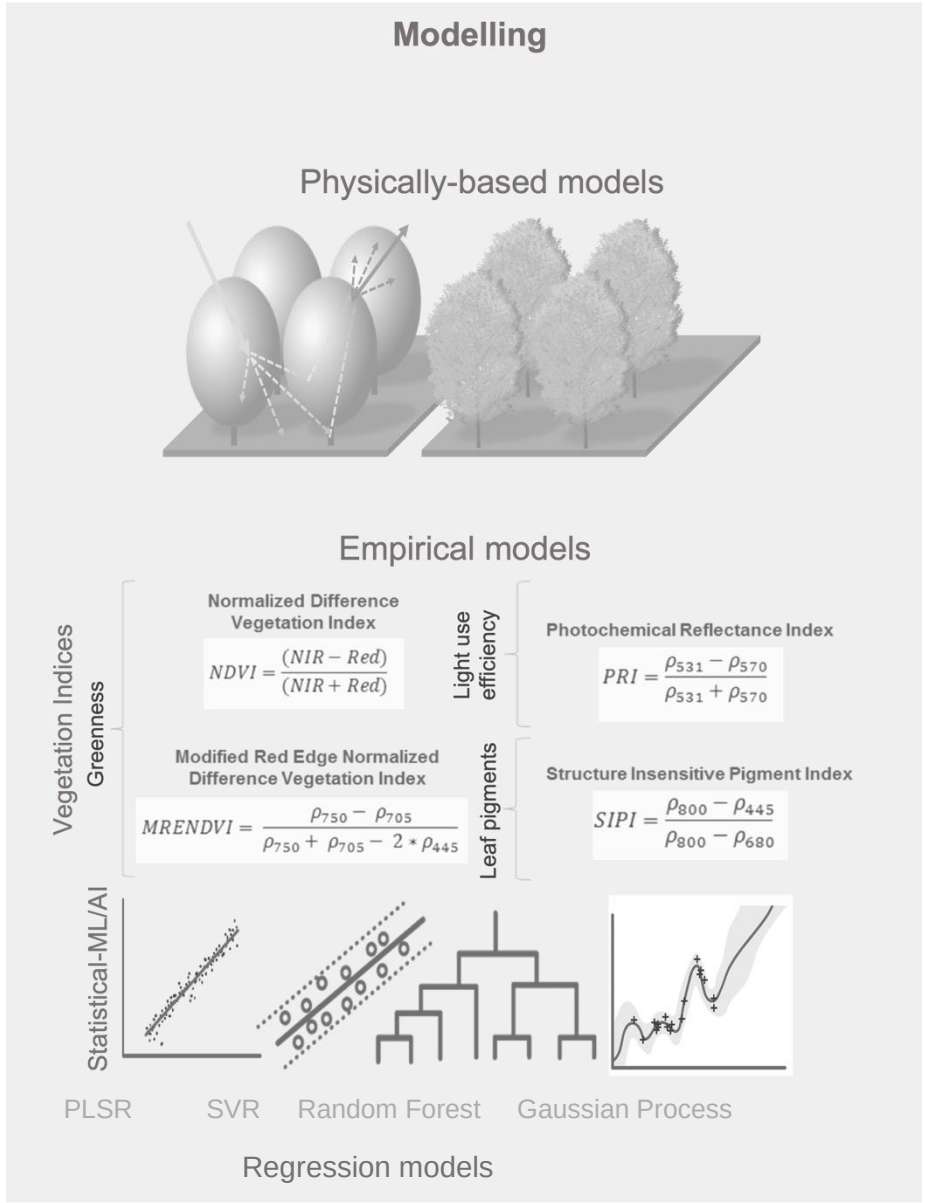
Fine, we’ll look at pretty flowers instead!
- Shiklomanov et al.

# (1) What are the ”best” algorithms, at both leaf and canopy scales?

Evaluate a variety of leaf and canopy trait algorithms against all the leaf and canopy spectral data we can get.



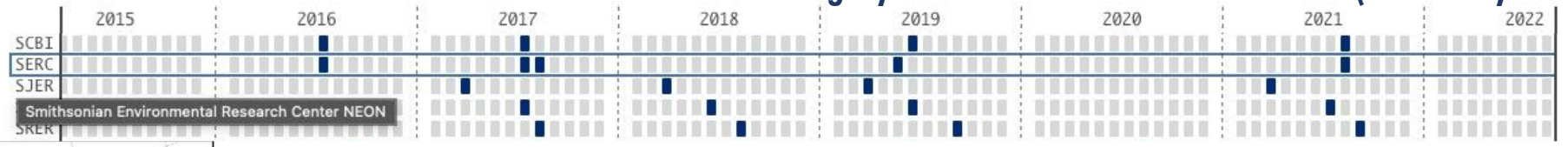

Shiklomanov 2018 Dissertation

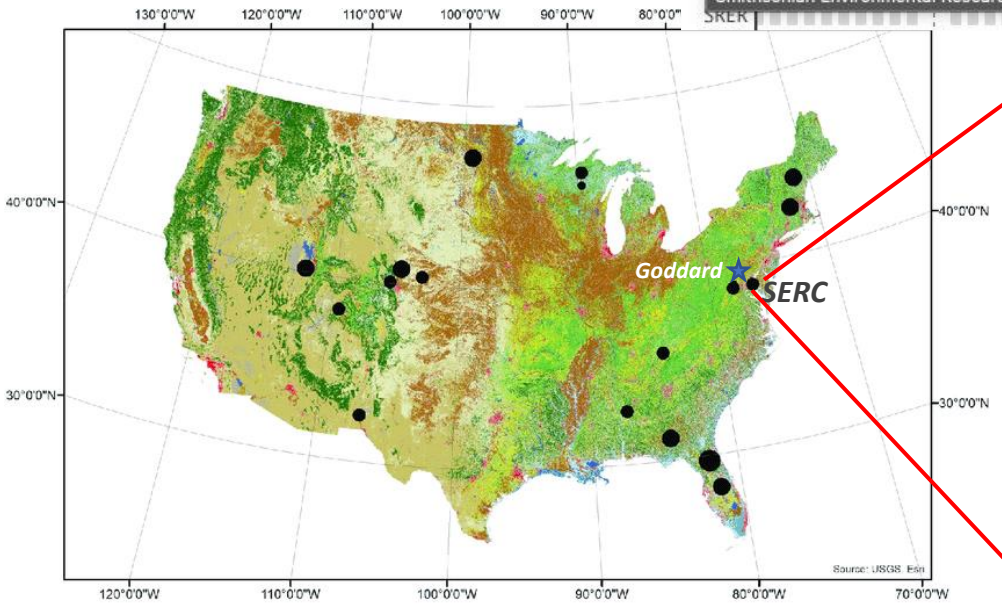


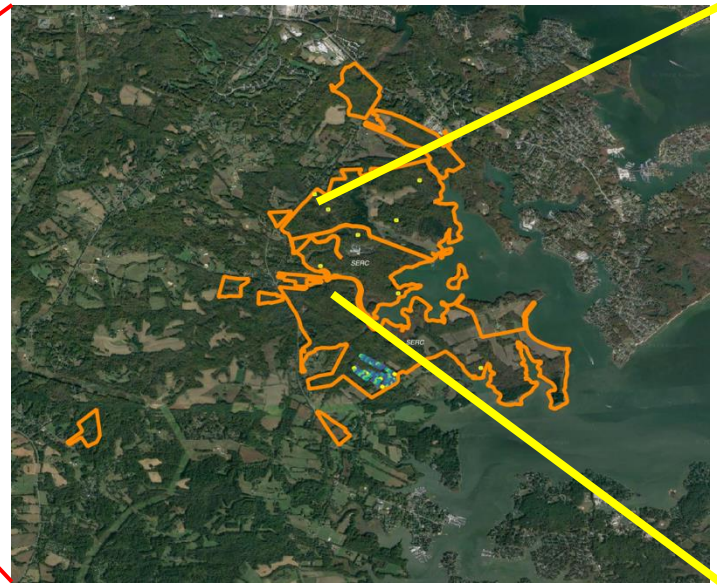
Site

Airborne Imagery

(Total : 4 years)



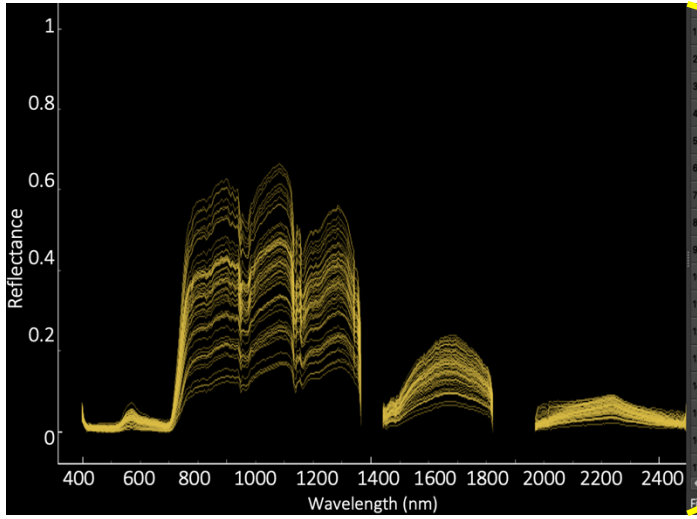



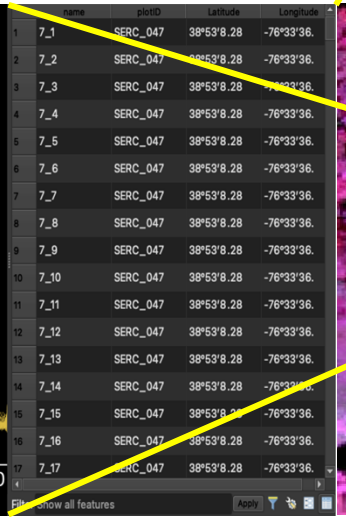



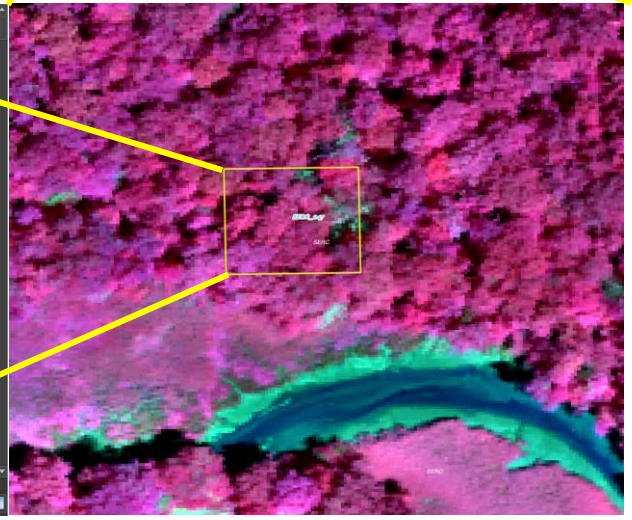
## Field Data (samples per plot)

Chl-a, Ch-b, Chl-ab, Car, LAI, LMA, Taxon, Healthy_status, Age, Exposure, Biome, Location, FieldSpectra

## Canopy Spectra per pixel/plot





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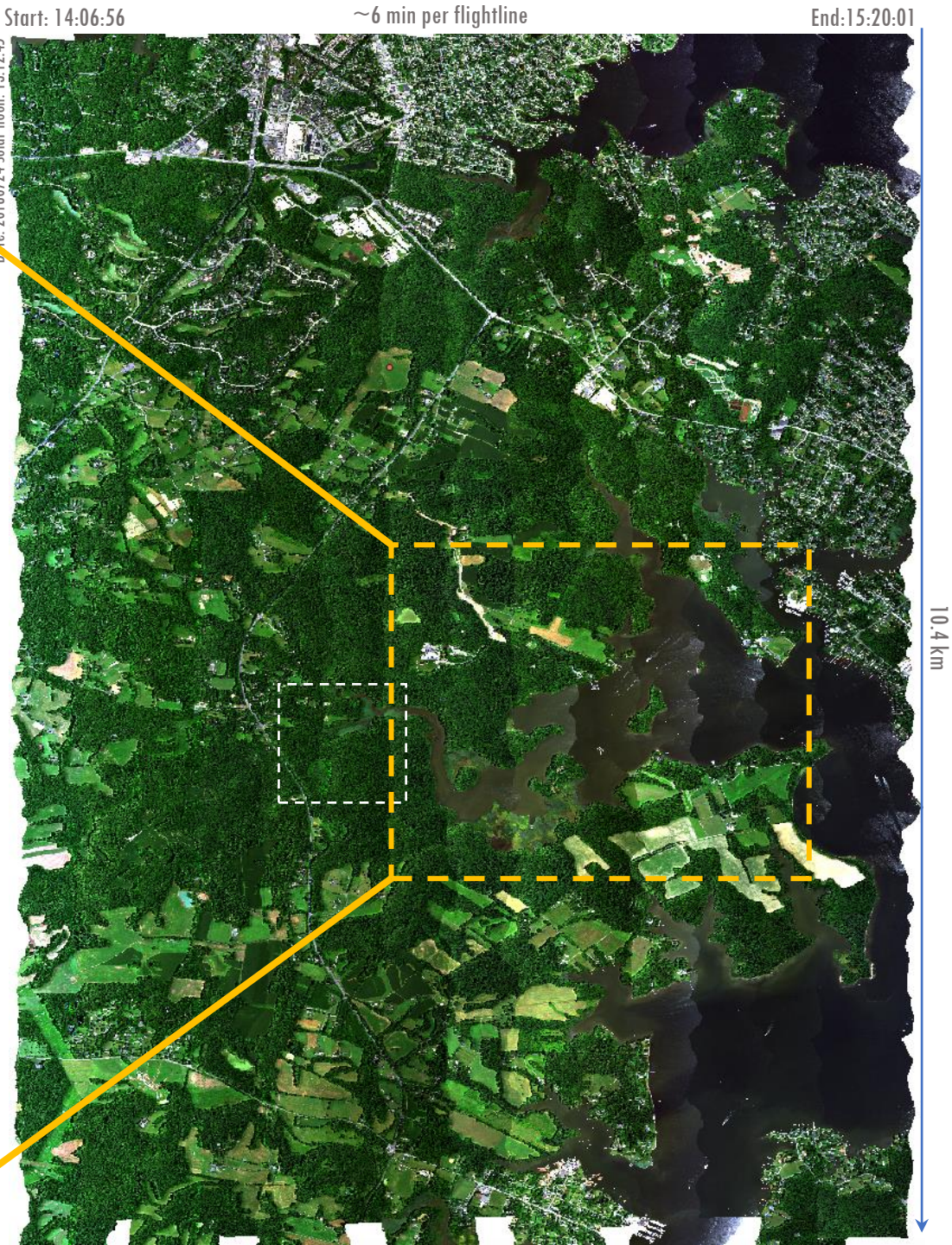
# Troubling artifacts in NEON Reflectance data

Reflectance before correction

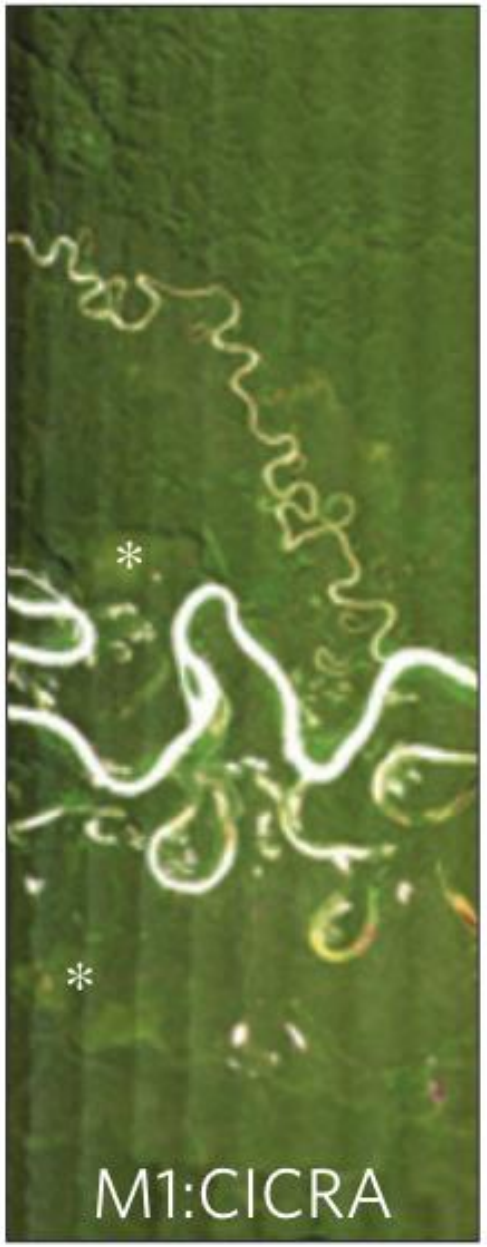
After topo-brdf(flex) correction

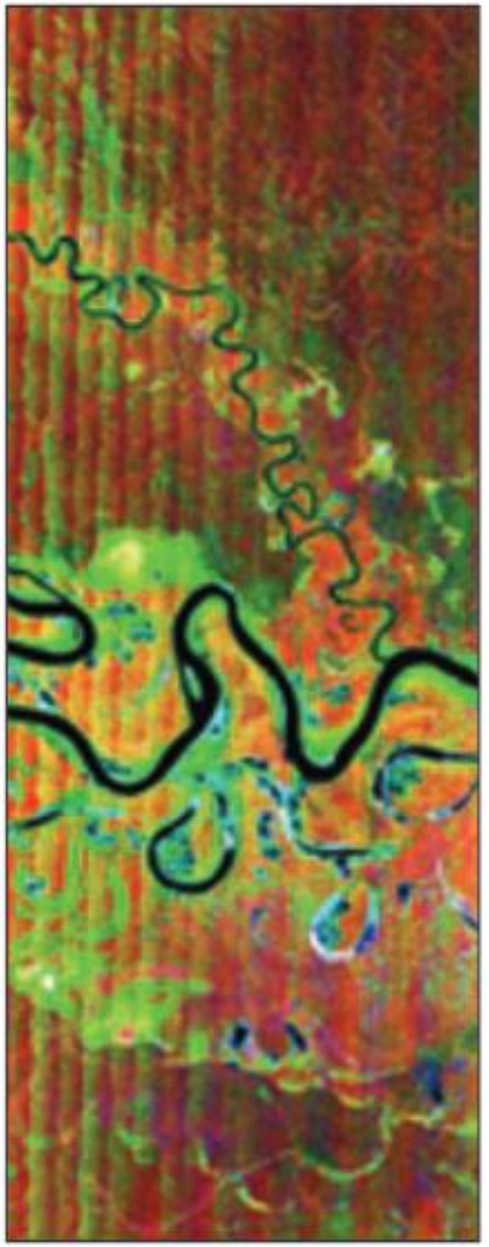
**Artifacts in reflectance data lead to artifacts in trait estimates.**

**These artifacts are *especially* important to resolve for time series analyses.**

**True-color**




**Composite:**
**Ca (red), P (green), Mg (blue)**



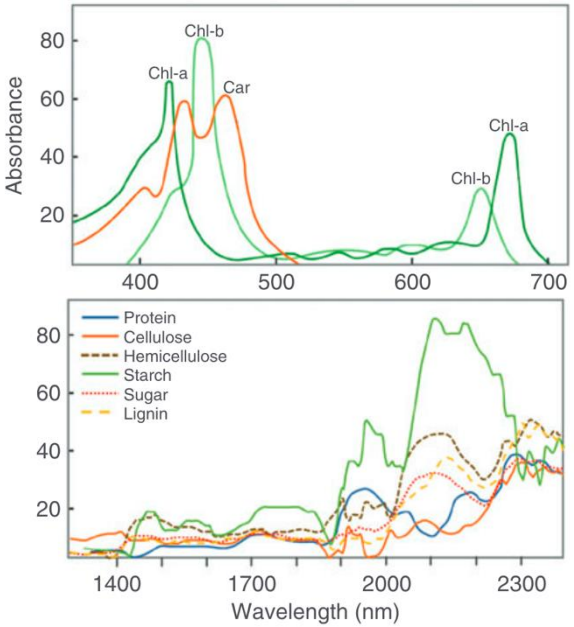
Asner et al. 2015 *Nature Geoscience*

# (2) Why do these algorithms succeed (or fail), and under what conditions?


"Visible"
Clear physical basis

"Invisible"
No direct physical basis

Water
Chlorophyll
Cellulose
Protein
Starch
Phenols
LMA
%N
%C
Mg
Ca
P
K
B
Fe
Vcmax
Jmax
∂13C




All these traits have been successfully mapped using imaging spectroscopy. **Why does this work? What are we *really* seeing** when we see "invisible" traits, in terms of correlations with other traits, structure, etc.

# (3) Flowers!

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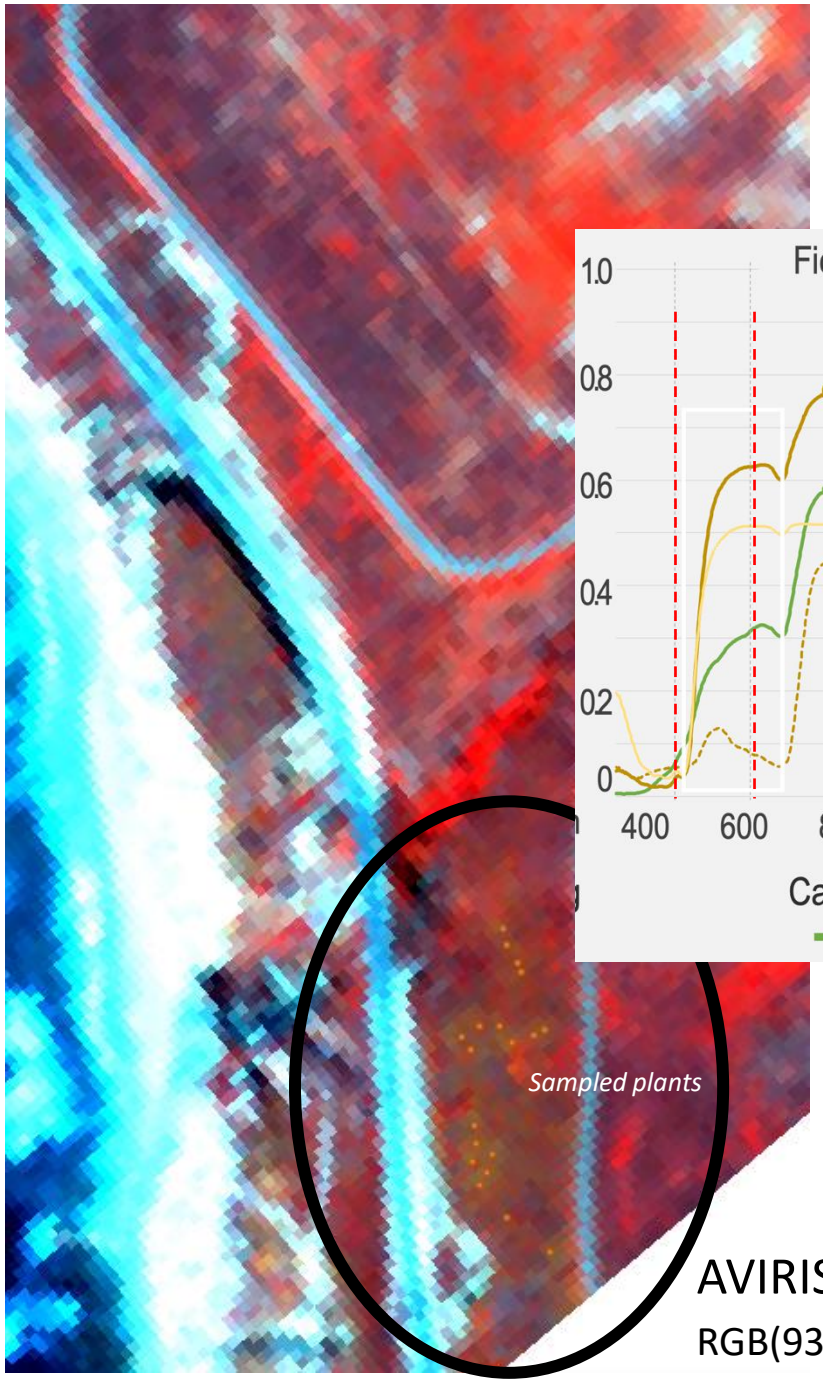
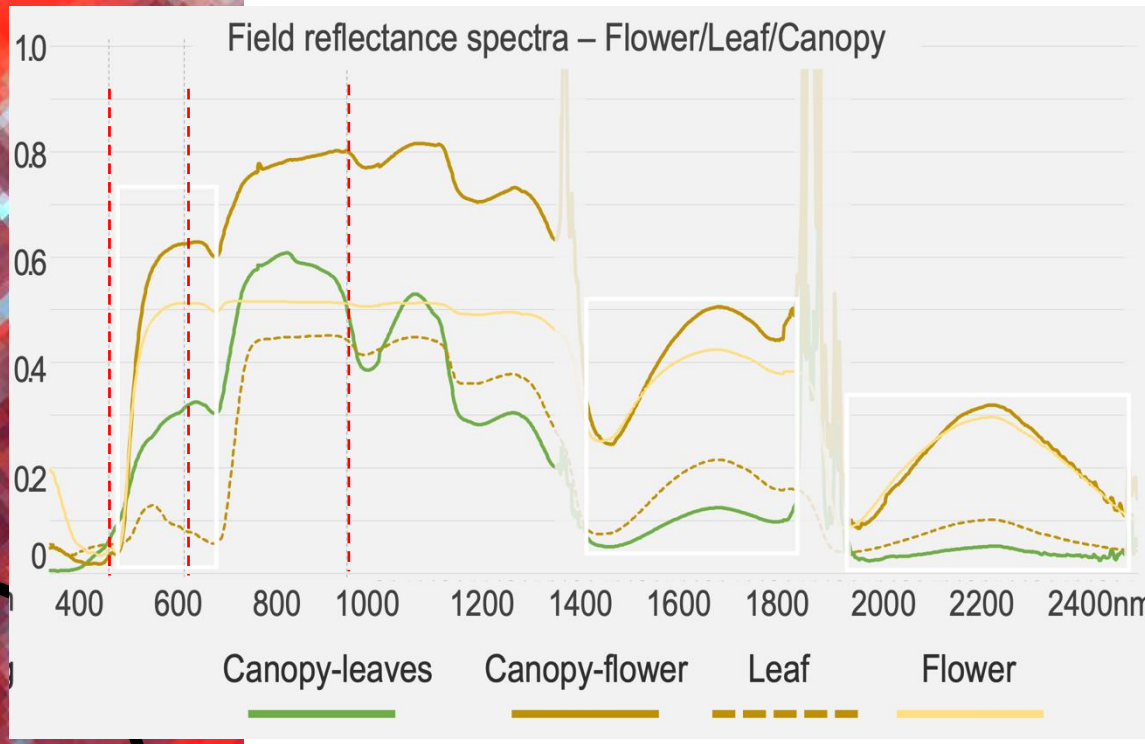
SBG High-Frequency Time series (SHIFT) — Weekly AVIRIS-NG flights during spring/summer 2021, with coordinated field sampling.

# Trying to create a flower vegetation index


AVIRIS-NG

RGB(933-612-467nm)

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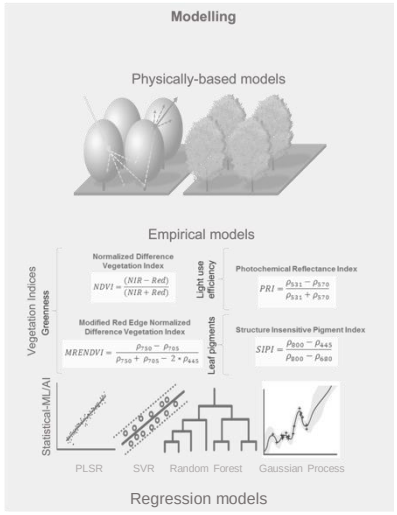
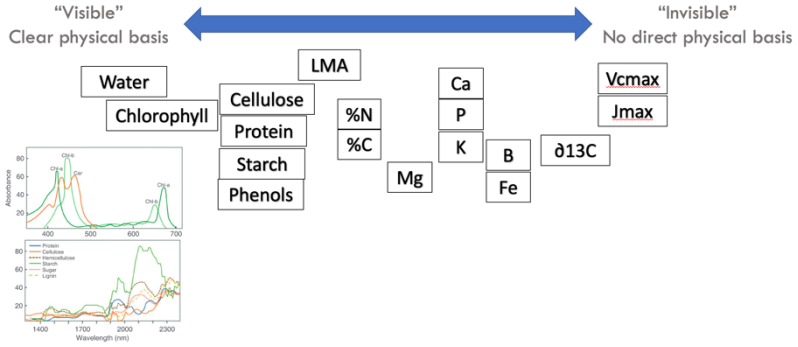
# (1) What are the ”best” algorithms, at both leaf and canopy scales?




# (2) Why do these algorithms succeed (or fail), and under what conditions?

# (3) Flowers!