Characterization of uncertainties in leaf traits through a Bayesian inversion of the PROSPECT model

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Objectives

1. To develop a method for determining leaf structure and biochemistry from spectral data that characterizes and partitions sources of variability and uncertainty
2. To investigate the relative contributions of species, canopy position, location, climate, and individual leaves to variability in leaf traits

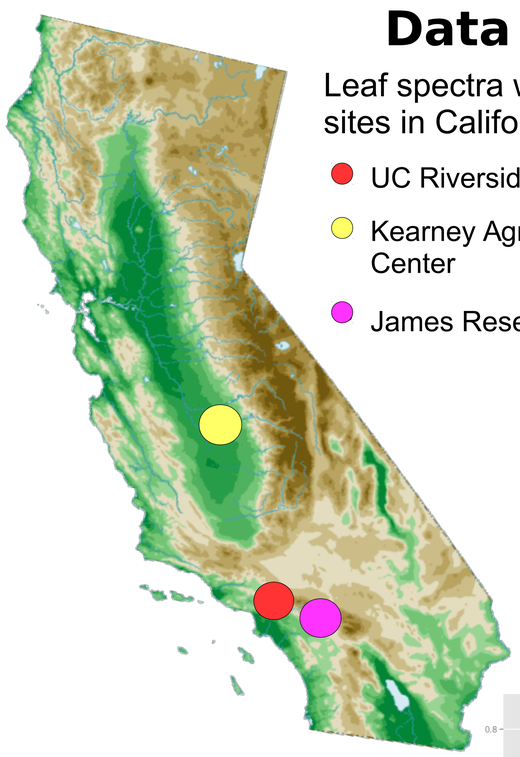
Background

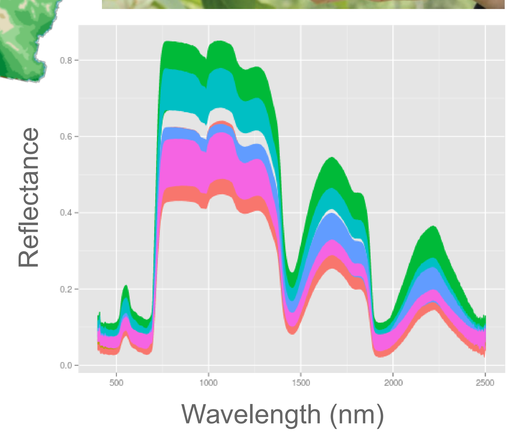
- Leaf parameters drive carbon exchange, hydrology, and energy balance in vegetation models
- Spectral data are easy to collect and have high information content
- The PROSPECT model simulates leaf reflectance and transmittance based on biophysical parameters

Data

Leaf spectra were collected from three sites in California in June 2013-2014:

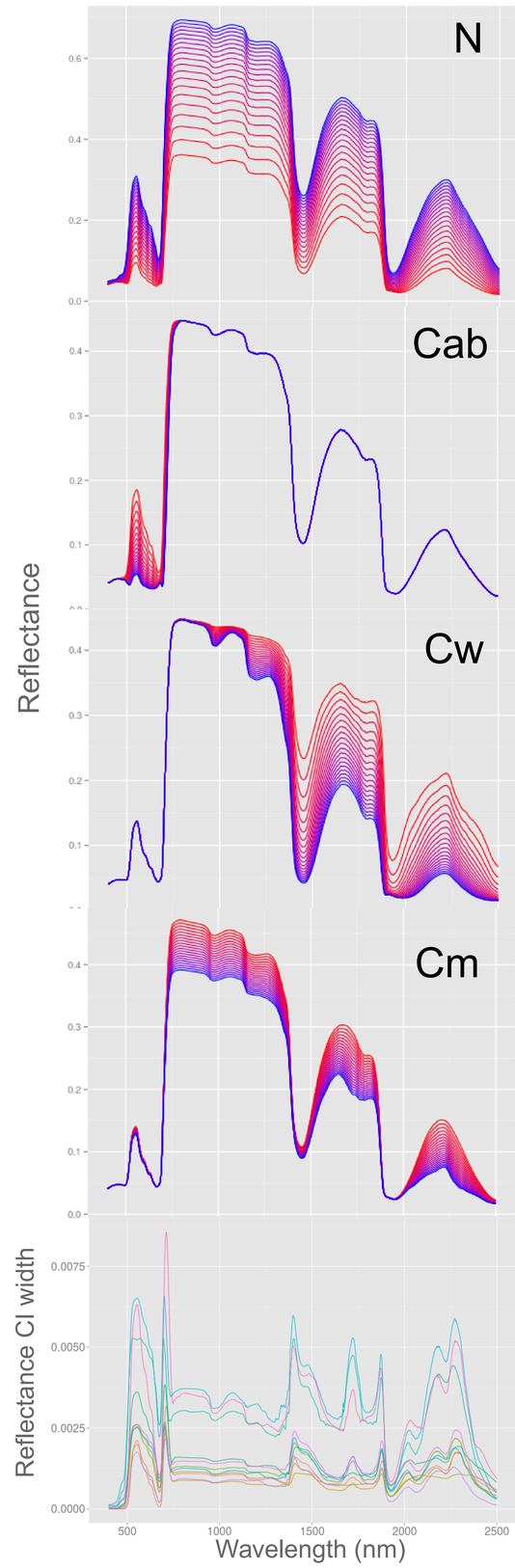
- UC Riverside Agricultural Research Station
- Kearney Agricultural Research and Extension Center
- James Reserve, San Jacinto Mountains



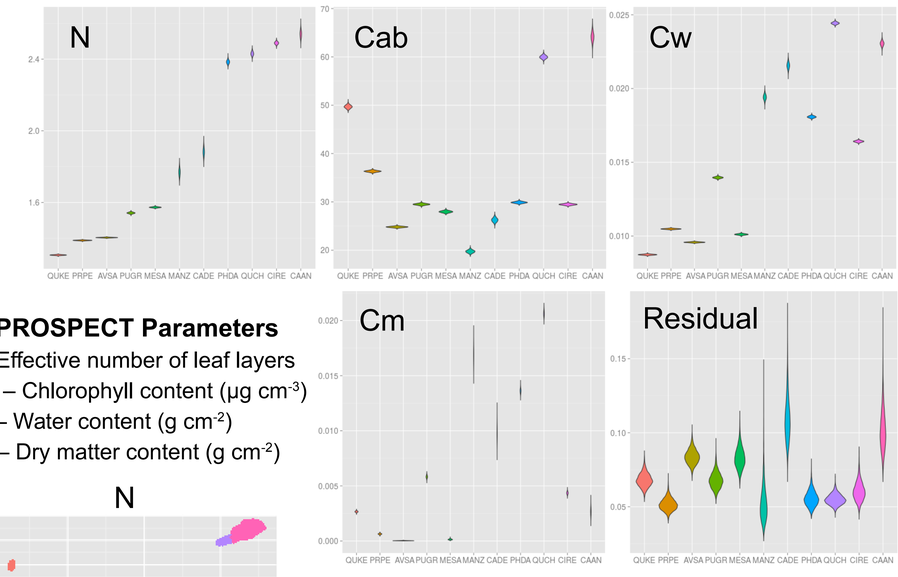


(***Right***) Observed leaf-level reflectance of *Capsicum annuum* (Red Pepper). Colors correspond to individual leaves. Line girth corresponds to observation uncertainty for each leaf.

PROSPECT



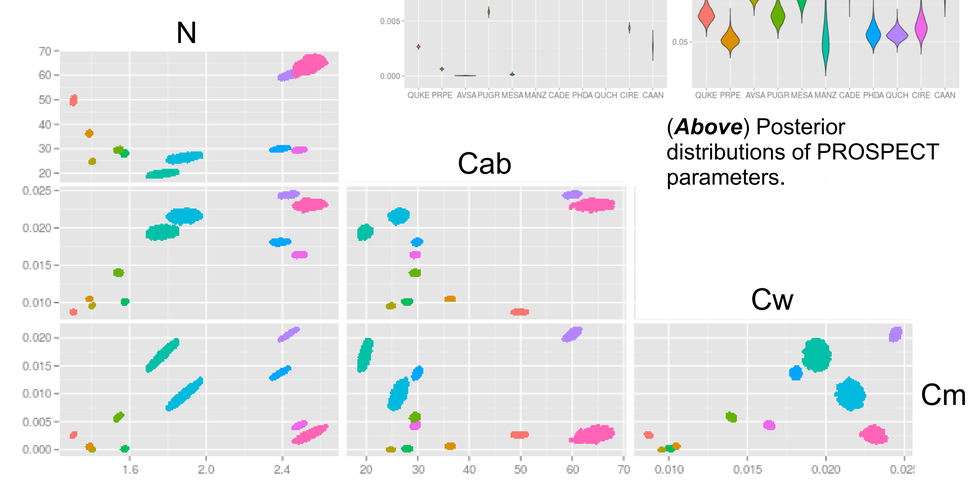
(***Above***) *Top 4 panels*: Sensitivity of PROSPECT model to leaf biophysical parameters. *Bottom panel*: Bayesian credible interval (CI) width of simulated spectra over resulting parameter distribution ranges.



PROSPECT Parameters

N – Effective number of leaf layers
Cab – Chlorophyll content (μg cm^{-3})
Cw – Water content (g cm^{-2})
Cm – Dry matter content (g cm^{-2})

(***Above***) Posterior distributions of PROSPECT parameters.



(***Above***) Covariance in posterior distributions of PROSPECT parameters.

Conclusions

- Reflectance data alone provide substantial information about leaf properties
- PROSPECT inversion efficiency is species and parameter-dependent
- Covariance between PROSPECT parameters is promising for constraining future inversions

Looking Forward

- Partitioning variance and uncertainty into different sources
- Linking to trait databases
- Scaling up to canopy level
- Assimilation of spectral data into ecosystem models

Acknowledgements

This work is supported by NASA Grant NNX14AH65G, the NASA HyspIRI spectral library, and the Boston University Department of Earth & Environment.