The Use of Hyperspectral Imagery to Assess the Sensitivity of Ecosystem Photosynthetic Parameters Along Two California Climate Gradients

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1 Introduction

- Sensitivity of ecosystem parameters essential to estimating the impact of climate change
- We combined imaging spectroscopy (IS) with thermal infrared (TIR) imagery to create spatially explicit estimates of two key photosynthetic traits
- Maximum rates of RuBP carboxylation (Vmax) and regeneration (Jmax) are typically determined through gas exchange (Fig. 1a), but we estimate traits using IS & TIR data
- Hyperpectral remote sensing data used in conjunction with leaf level spectroscopy, gas exchange, and flux tower data are used to characterize ecosystem photosynthetic parameters, CO2 uptake, and climate forcing across land use and cover gradients
- Development of universally applicable remote sensing methods to estimate ecosystem metabolism will enable retrievals from future satellite-based imaging spectrometers

2 Study Area

- Two climate-elevation gradients comprised of 10 ecosystems, including four forests (Fig. 2a)
- Broad vegetation and land use found at field sites allow for robust testing of our methods

Figure 2. (a) The location of the ten eddy covariance tower sites comprising the southern California and Sierra transects that are being leveraged in this project. (b) The range of annual mean temperatures and annual mean precipitation values recorded over the last several years at each site, including desert (D), pinyon/juniper (J), montane chaparral (C), coastal sagebrush (S), oak pine forest (F), Ponderosa Pine (P), oak-pine woodland (O), mixed conifer forest (M), and subalpine forest (A). The variability of annual precipitation is orders of magnitude larger than that of temperature.

3 Results

- Vmax estimates from flux tower data show significantly lower values than from gas exchange and spectral measurements made on vegetation found within the flux tower footprint
- Drought conditions associated with decline in Gross Primary Productivity (GPP)
- Vmax estimates correlated with GPP, indicating decreased photosynthetic capacity during drought conditions
- Variability in precipitation is the main driver for inter-annual variation in productivity for each site

Methods

AVIRIS and MASTER imagery were used to estimate photosynthetic metabolism through implementation of PLSR algorithms (Singh et al. in prep). This allows for the creation of maps depicting the spatial variation of Vmax around the flux tower sites (Fig. 3). Flux tower data were used to estimate Vmax by inversion of Farquhar photosynthesis model, and to model GPP via flux partitioning.

Table 1. Estimates of Vmax from flux tower data, along with correlated LAI estimates. 2012 LAI estimates are similar to those made in the field. A drought induced decrease of Vmax is apparent at the coastal sagebrush site over the last 3 yrs.

4 Conclusion

- Scaling up leaf metabolism and chemistry to the canopy scale using novel algorithms is feasible with remote sensing data
- Correlated decrease in GPP and Vmax demonstrates impact on vegetation of drought and has implications for the future
- Land use change, including transition to agriculture & urbanization, pollution & changing climate have dramatic effects on photosynthesis
- These and other stress events can be monitored on the regional scale by the methods used in this study
- Implementation of a space-borne imaging spectrometer offers the ability to monitor such global changes
- Further research is required to determine an efficient scaling method for Vmax to eliminate discrepancy between flux tower estimates and those from gas exchange estimates & hyperspectral observations

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Acknowledgements

We gratefully acknowledge assistance provided by Dr. Adam Wolf (Princeton) in estimating Vmax through inverse modeling, Dr. Michael Goulden and lab (UC-Irvine) for flux tower observations, and Andrew Jakobson (UW) in generating the maps of ecosystem metabolism. We thank the US National Aeronautics and Space Administration (NASA) for providing financial support of the project (Hypis Preparatory Grant 8NN123A0280), UW Nelson Institute for travel support, the Wisconsin Space Grant Consortium for financial support, and the Alexander Gould Instrument Support Program and PANAlytical Boulder (formerly ASD Inc.) for financial and instrument support. Additional thanks to the AVIRIS/MASTER/ER-2 teams, 2013/14 HypisRfl Airborne Campaign teams, & NCEO airborne group.

References