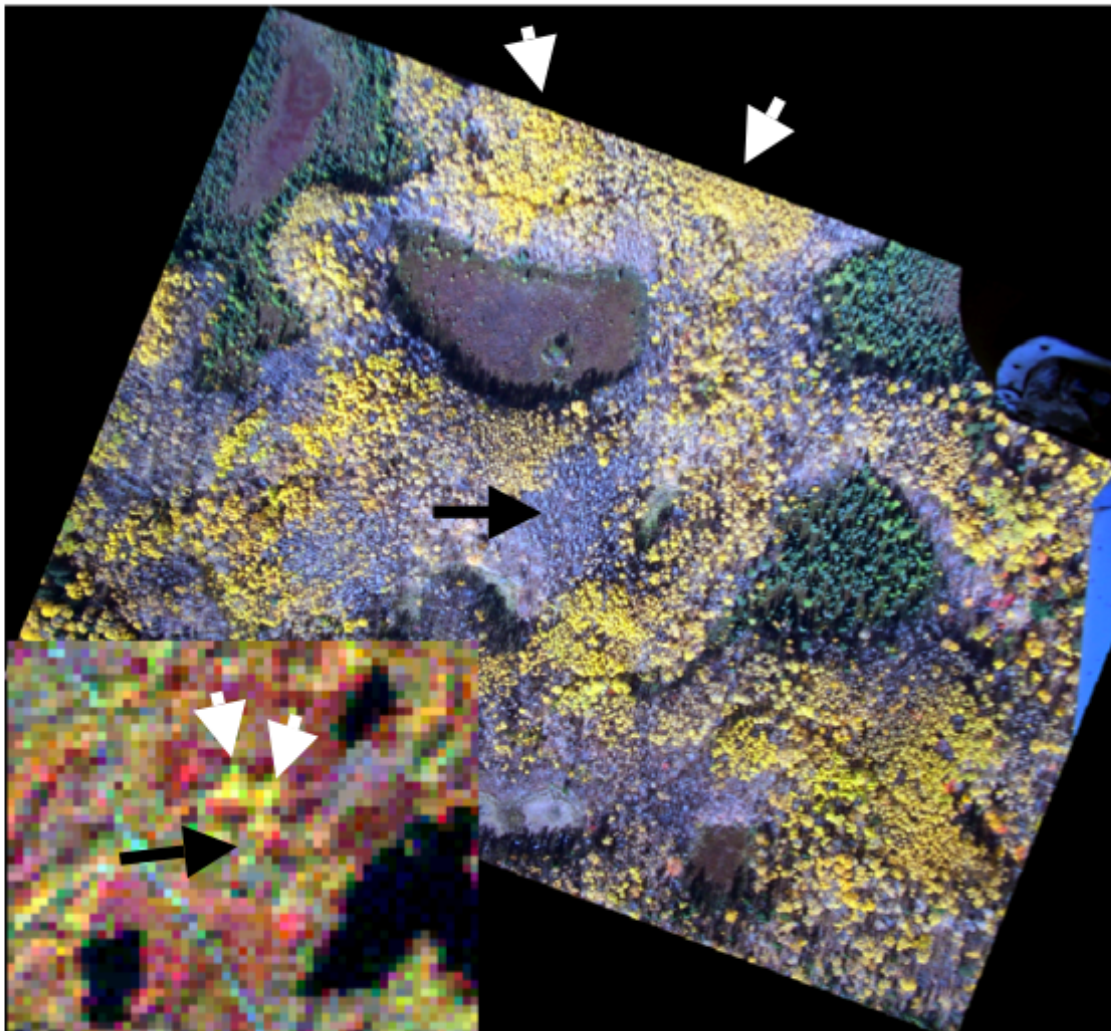
HyspIRI Research: Photosynthesis and Genetics of Aspen

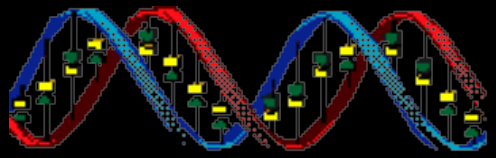
Phil Townsend, Shawn Serbin, Dylan Dillaway, Eric Kruger, Mike Madritch

Quaking aspen (*Populus tremuloides*) as a model system

Remote sensing of genetic diversity in aspen



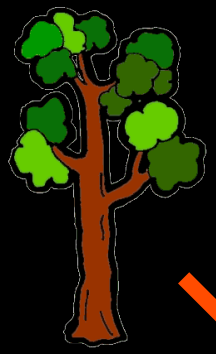
Early October Landsat and true color aerial photo
Differing senescence among genotypes

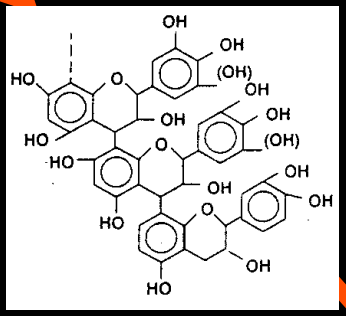


Genotype

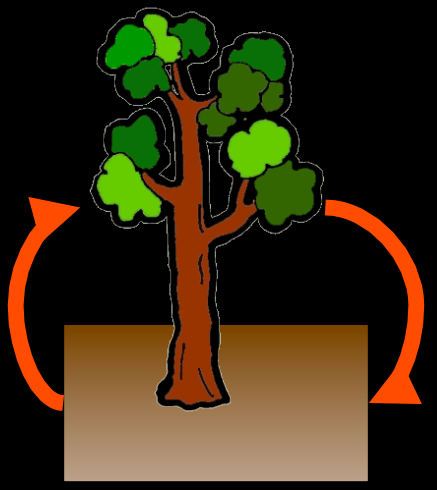
Environment

Phenotype



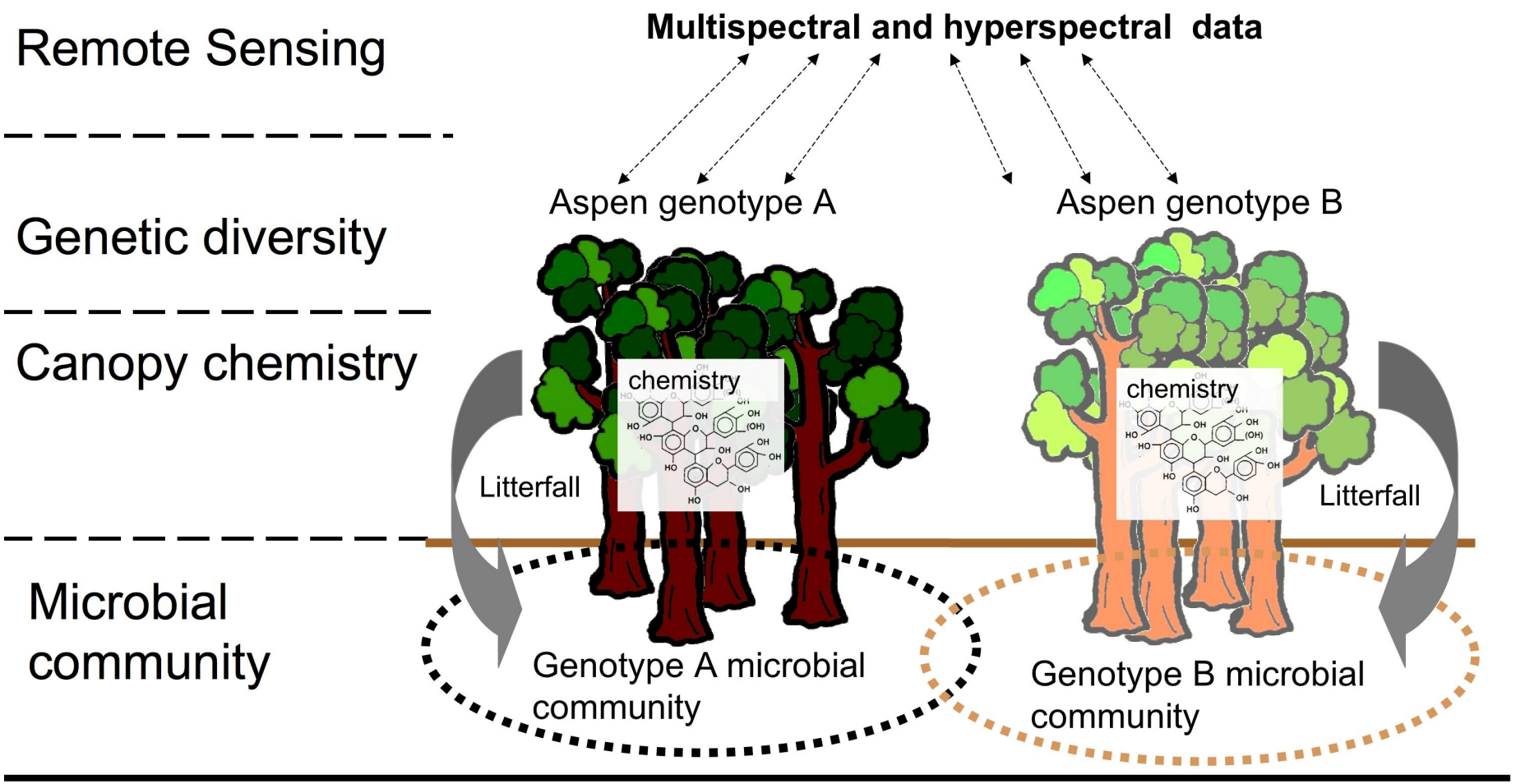


Litter
Chemistry

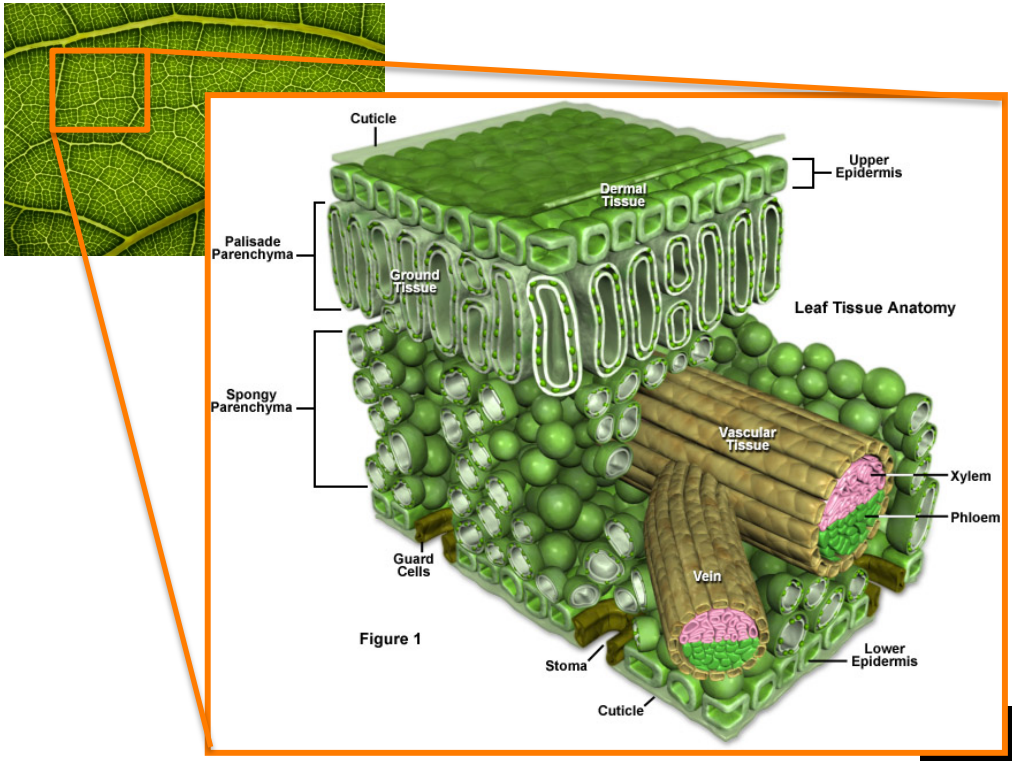


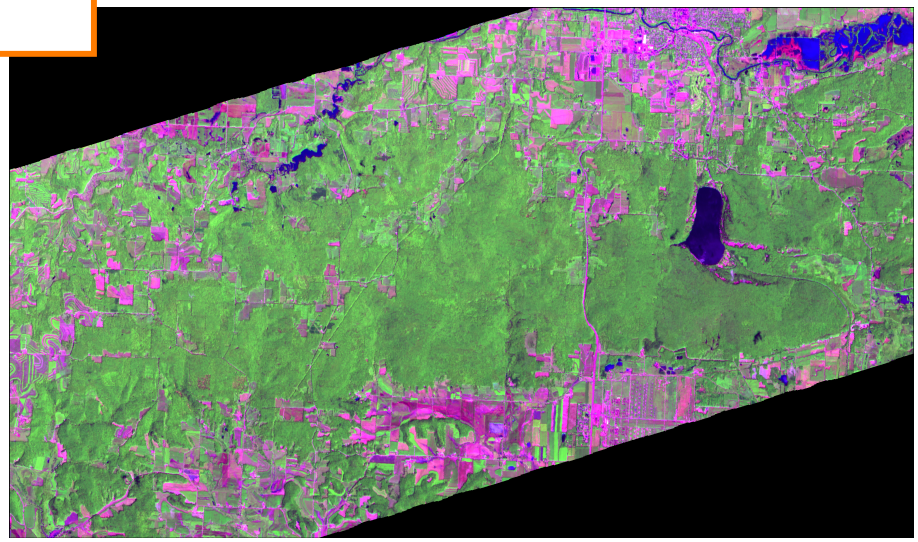
Nutrient
Cycles

Remote sensing of genetic diversity in aspen

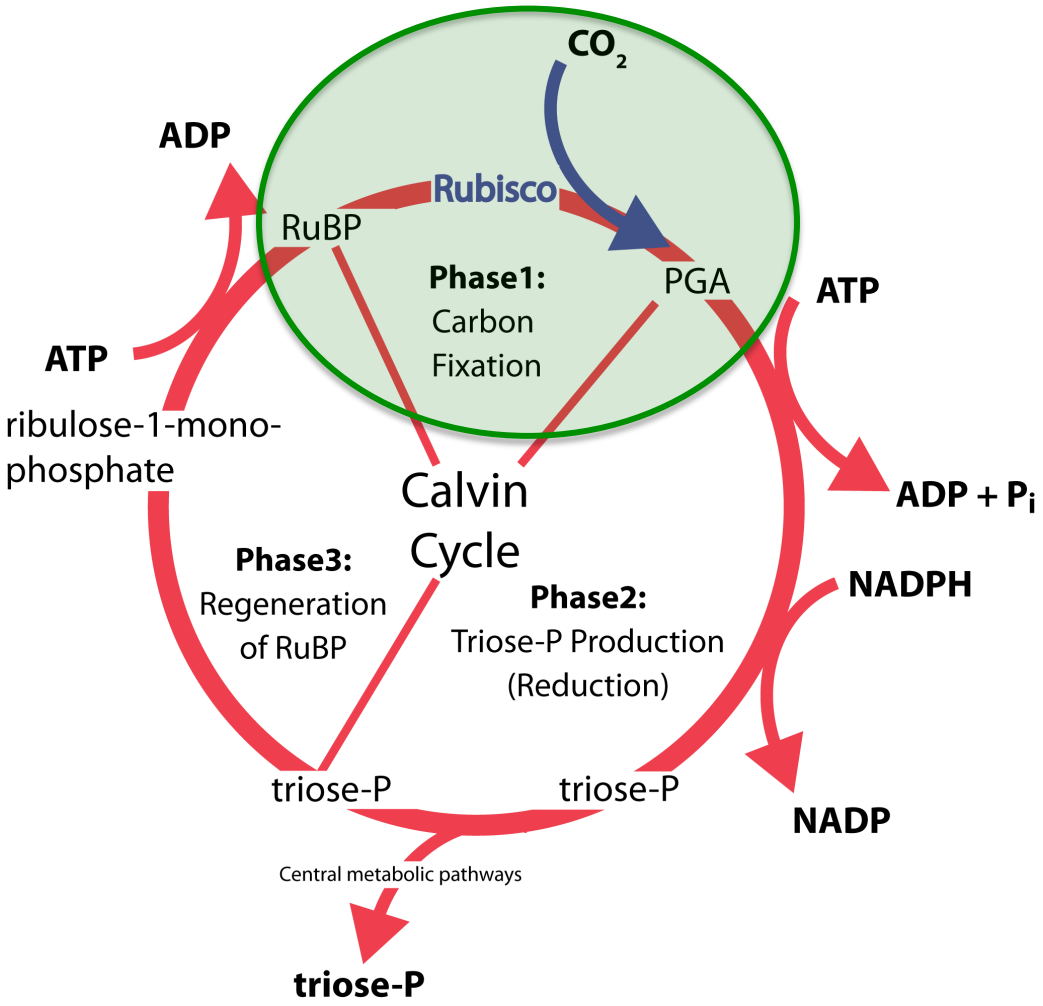


Detection of leaf metabolic rates using spectroscopy





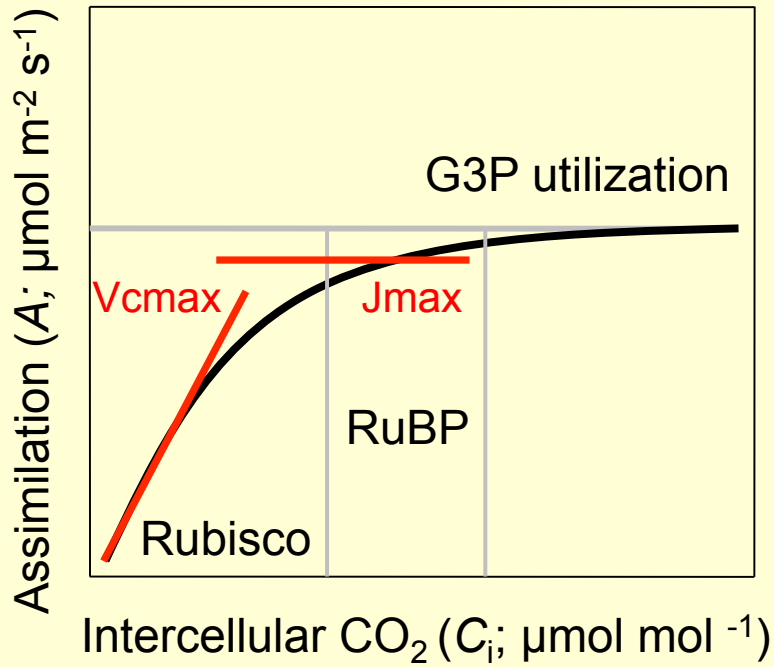
V(c)max – maximum rate of carboxylation



Carboxylation – initial addition of CO_2 to RuBP (catalyzed by RuBisCO). Energy from ATP and NADPH → triose phosphate

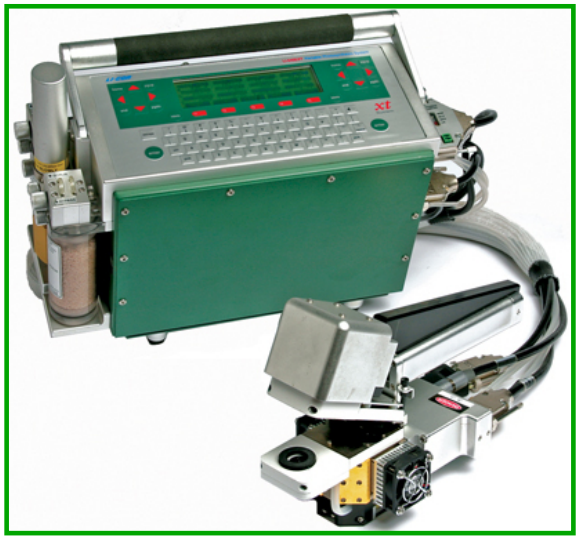
Biochemical modeling of photosynthesis

$$A_n = \min(A_c, A_j, A_p) - R_d$$



- Limited by
  - Rubisco
  - RuBP regeneration
  - triose phosphate utilization (G3P)
- Determine key metabolic variables
  - **Vcmax**: Rubisco activity
  - **Jmax**: Electron transport

Physiological data in glasshouse study

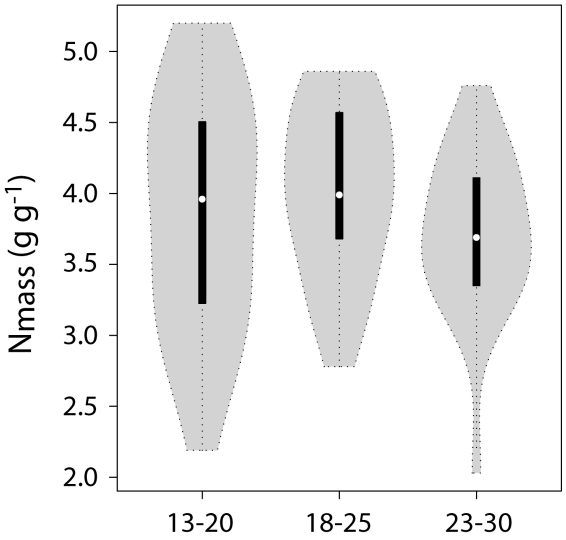


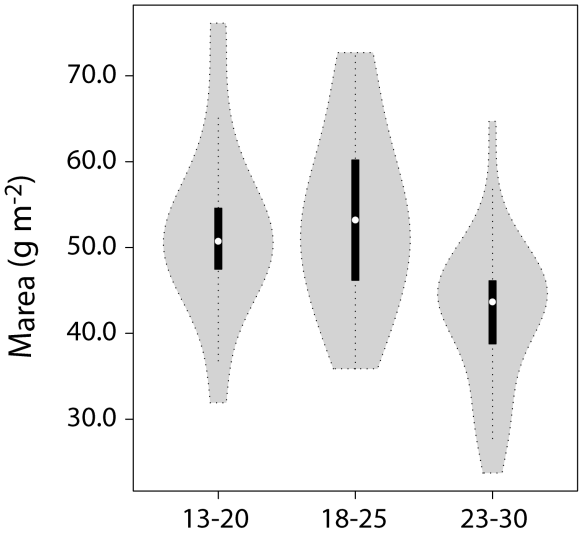
- Three temperature regimes
  - 13/20 °C, 18/25 °C, 23/30 °C
- Leaf gas exchange
  - Vcmax, Jmax, A_{mass}, A_{area}
- Structure and chemistry
  - SLA, Leaf N
- Leaf optical properties (350-2500 nm)

FERST
FOREST ECOSYSTEM REMOTE SENSING TEAM
DEPARTMENT OF FOREST AND WILDLIFE ECOLOGY
UNIVERSITY OF WISCONSIN - MADISON

Physiological measurements across temperature regimes

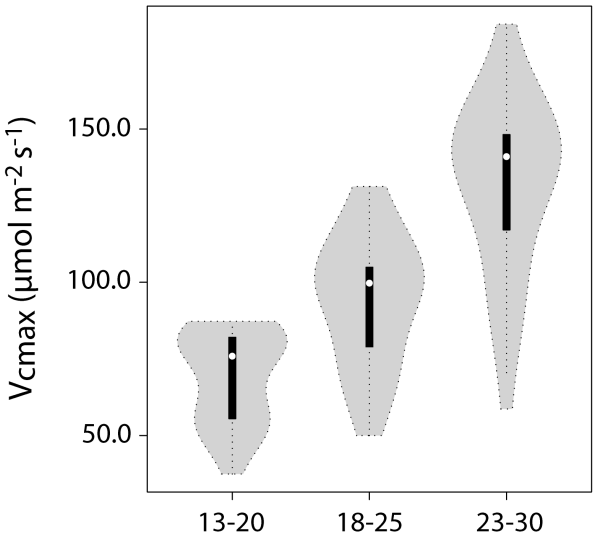
N (mass)

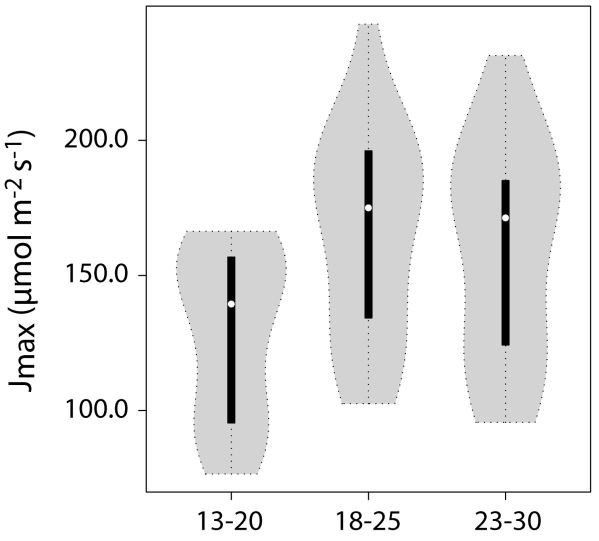




LMA

V(c)max

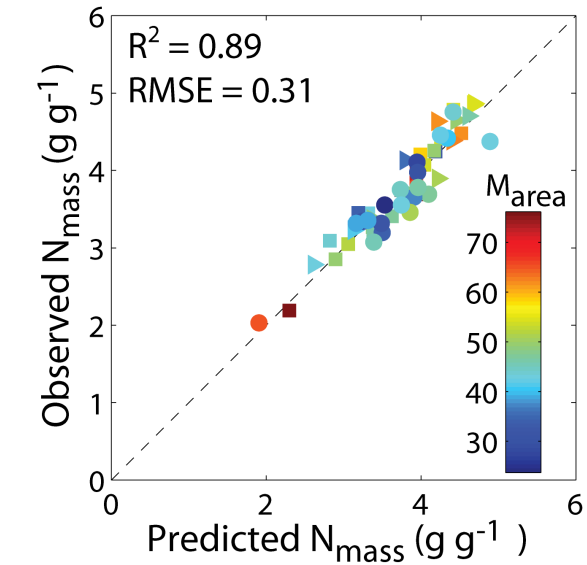


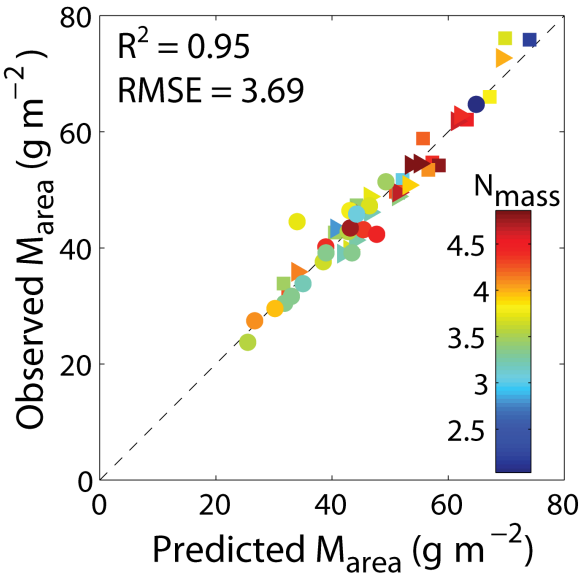


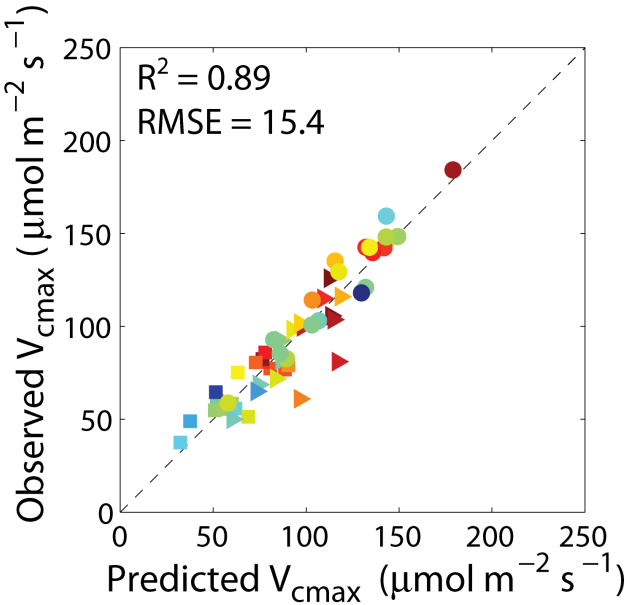
Jmax

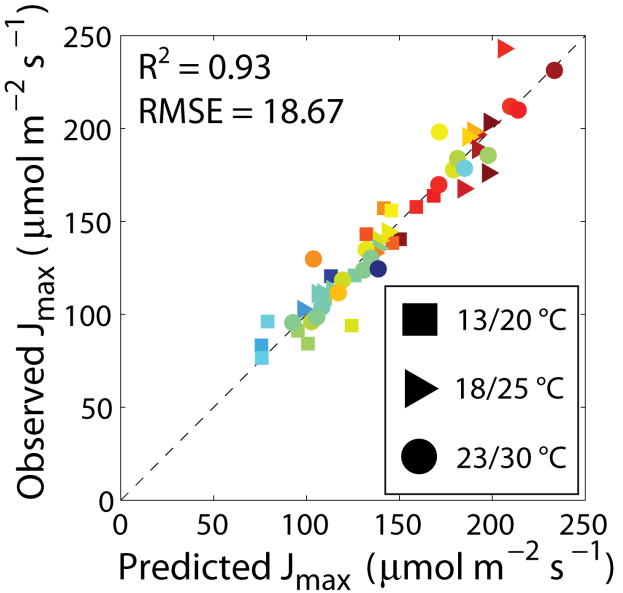
Night – Day Temperature

Predictions using leaf spectra and PLSR

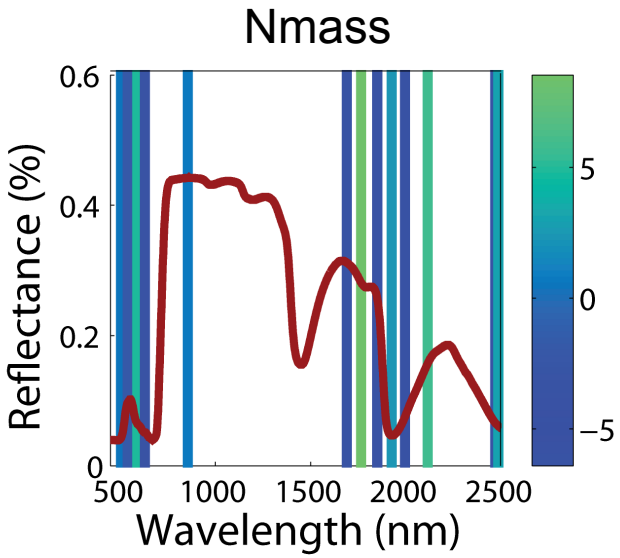


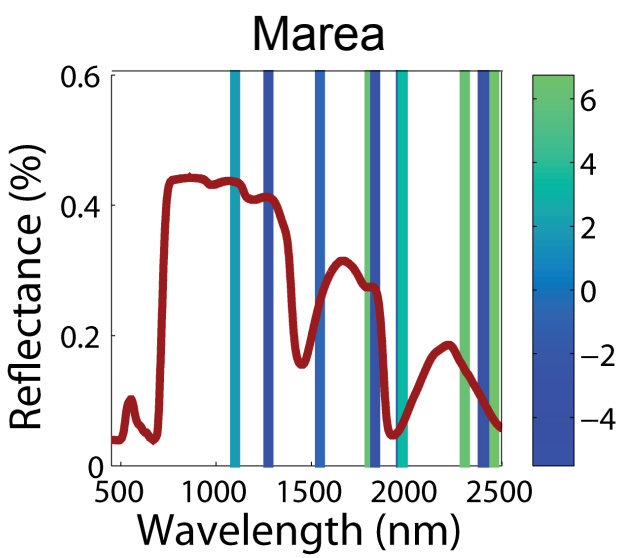


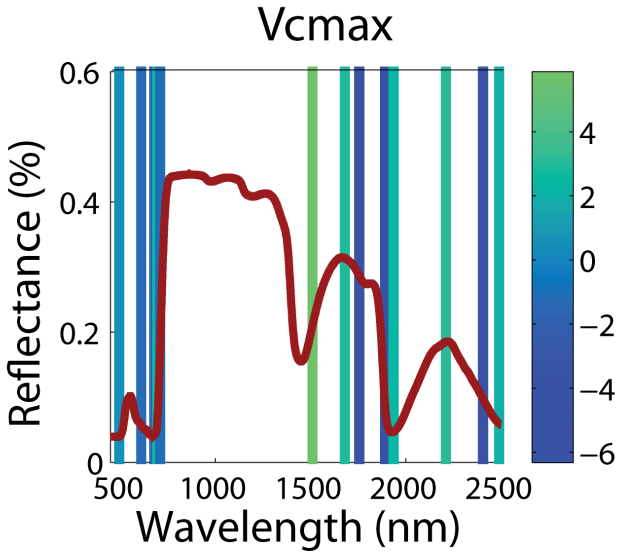


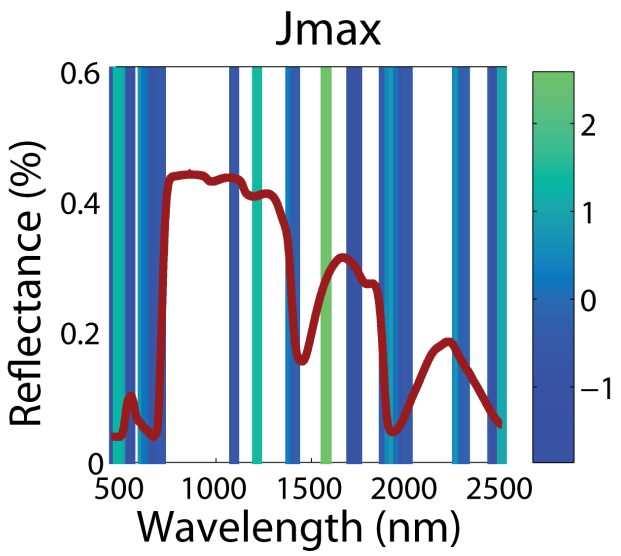


PLSR waveband selection

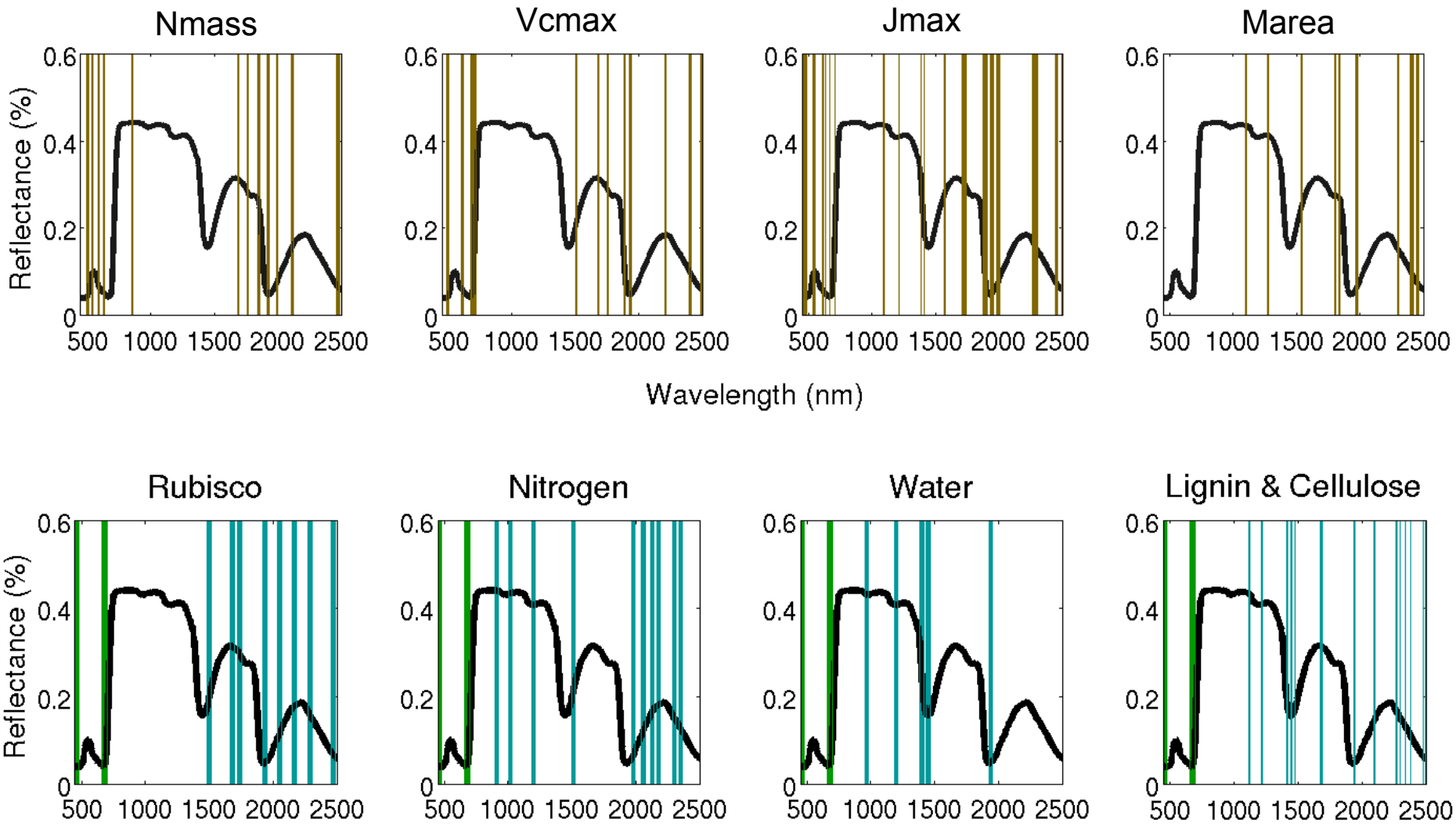






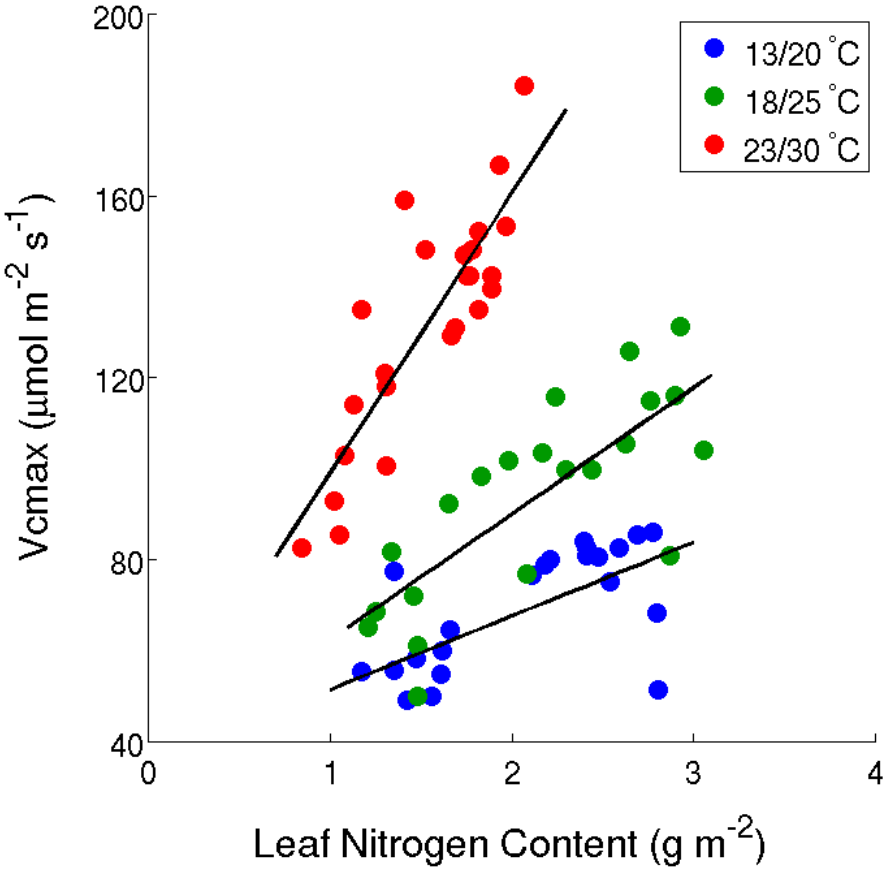


PLSR waveband selection and the state of knowledge

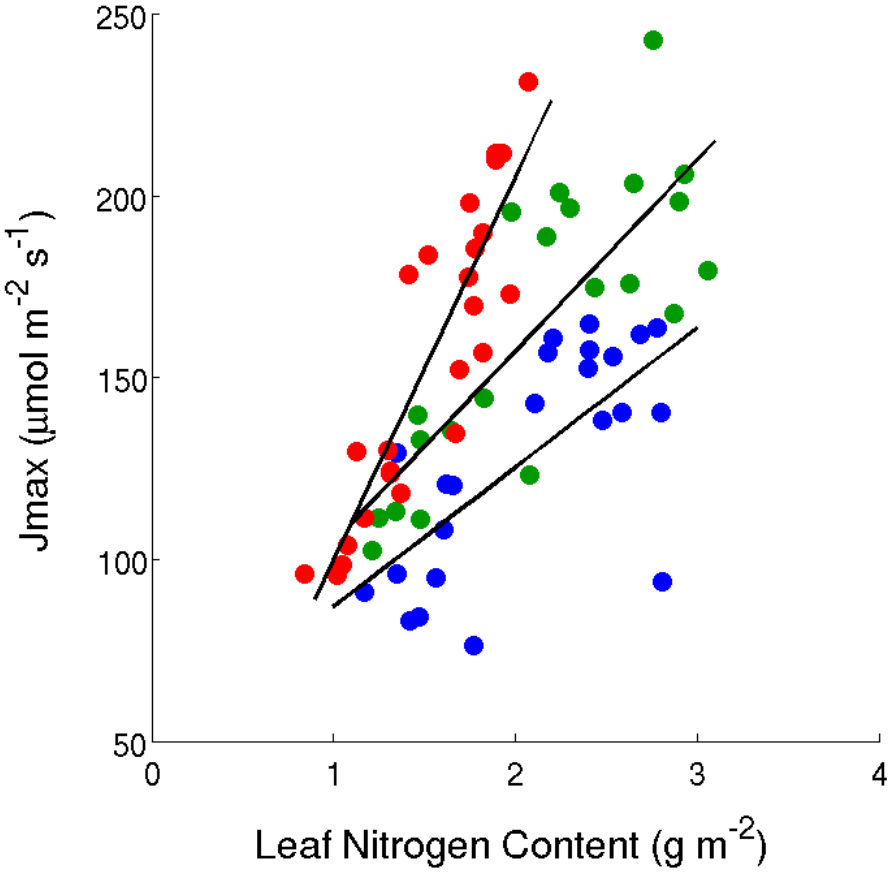


Chl a & b

Biotron measurements show thermal effects on leaf metabolism



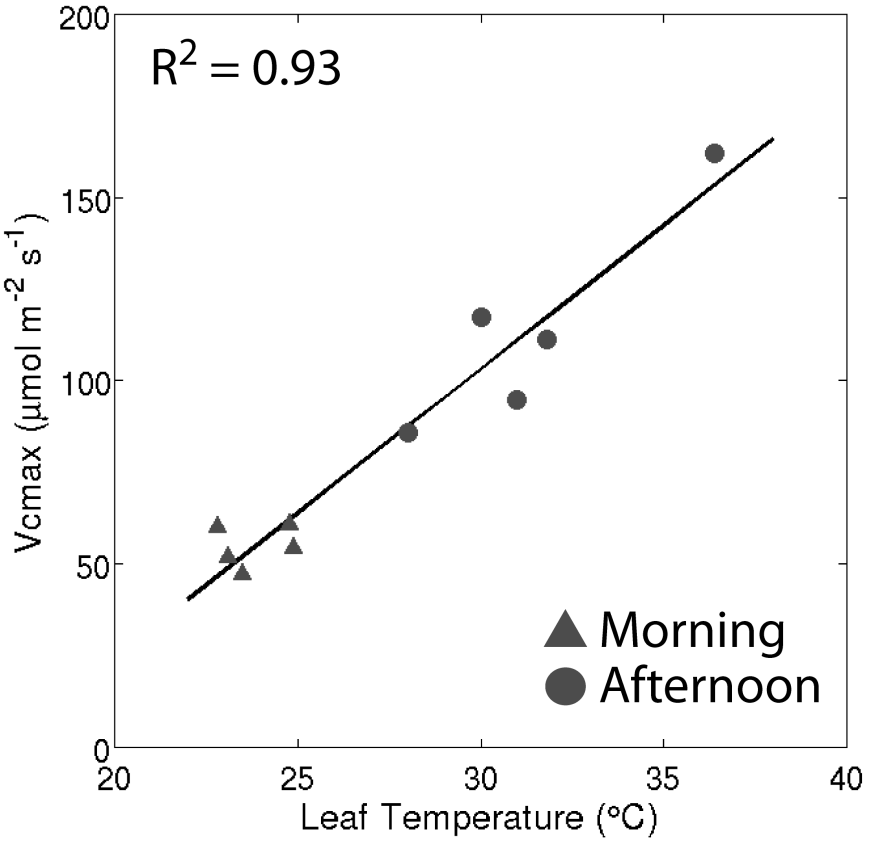
$R^2 = 0.003$

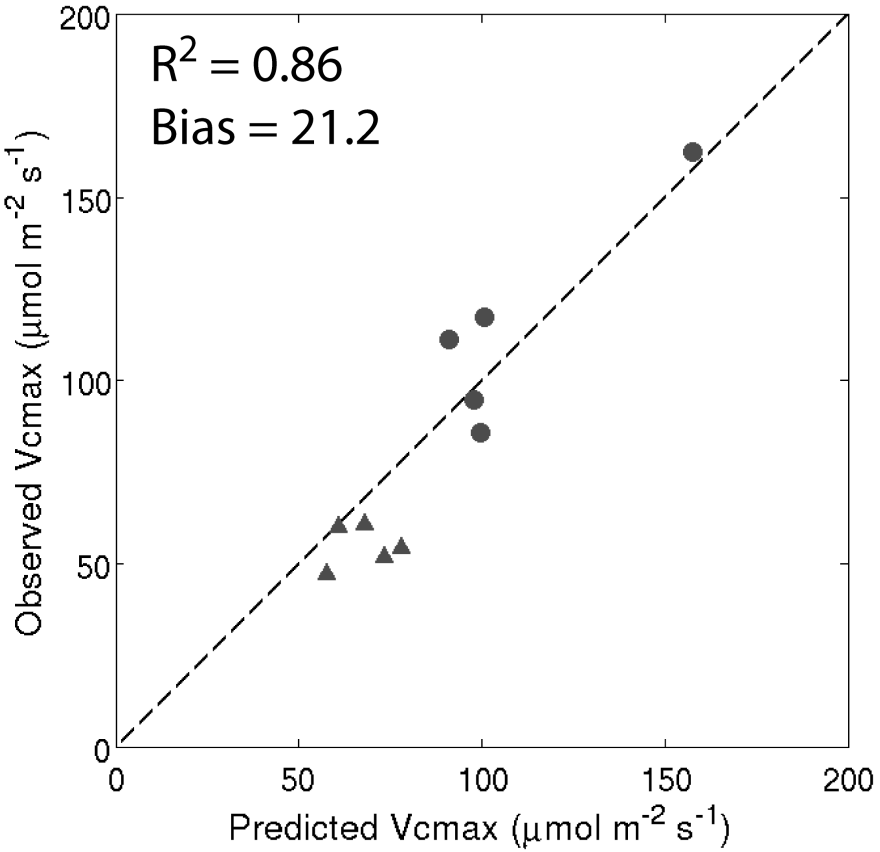


$R^2 = 0.33$

Pooled R^2 between spectra-predicted V(c)max/Jmax and leaf N

Spectra are responsive to temp.-driven variations in metabolism

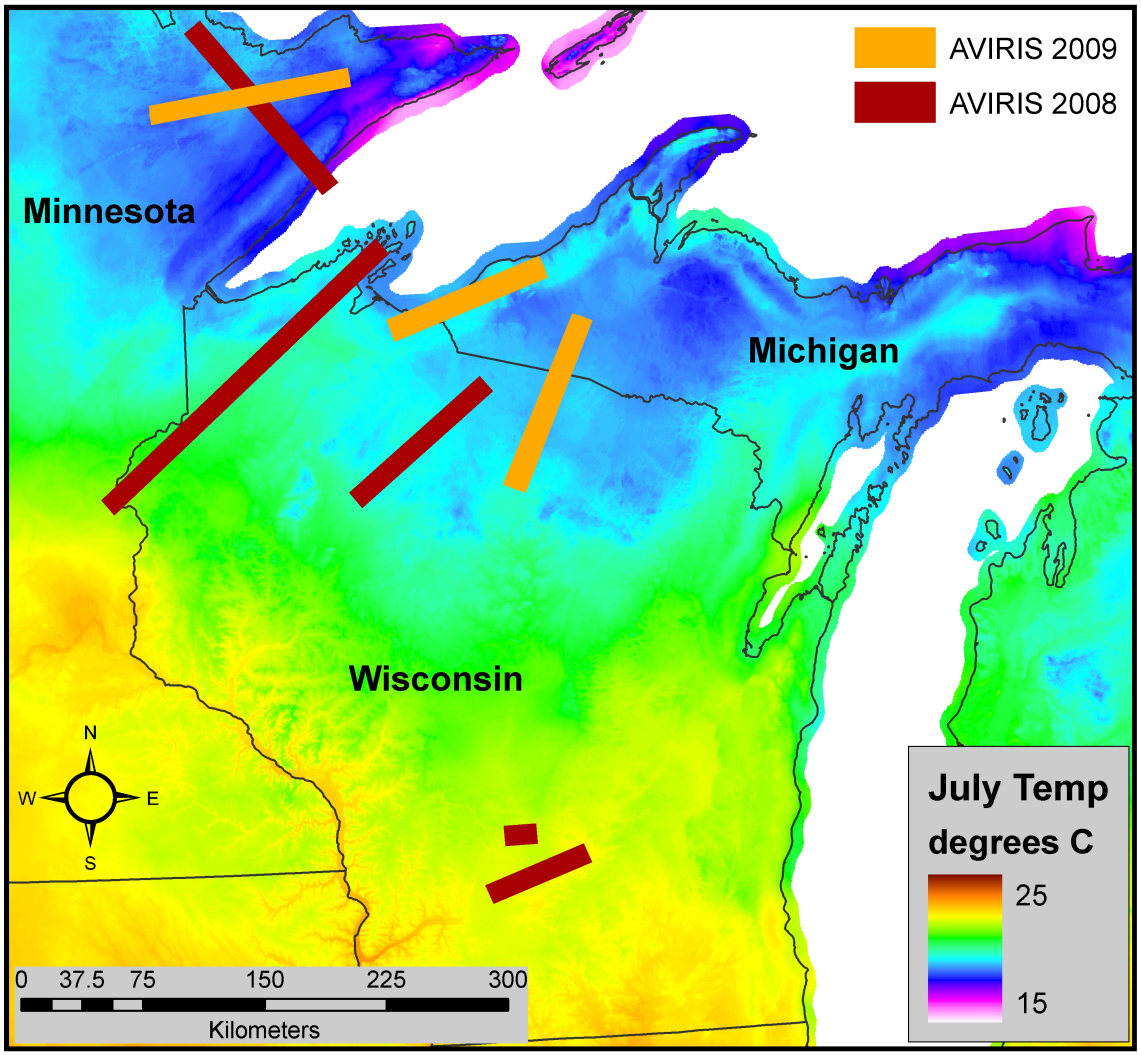




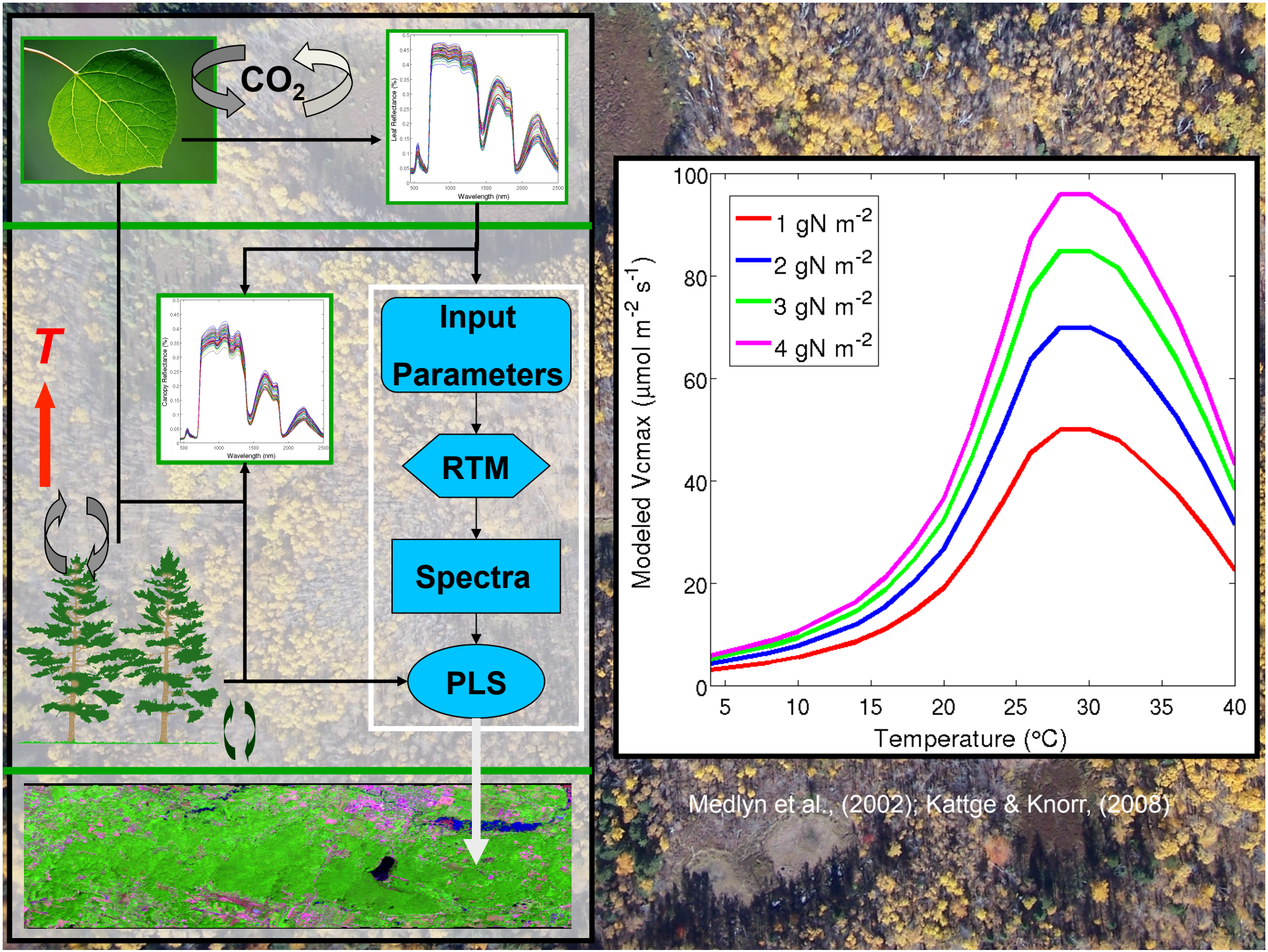
Time	Tleaf (°C)	$Vcmax^{25}$
Morning	23.8	54.8
Afternoon	31.4	114.3

How will climate change affect composition and metabolism?

- Hyperspectral imagery
- Field collection
  - Gas exchange
  - Spectra
  - Canopy temperature
- Examine regional trends
  - Lat/Long variation

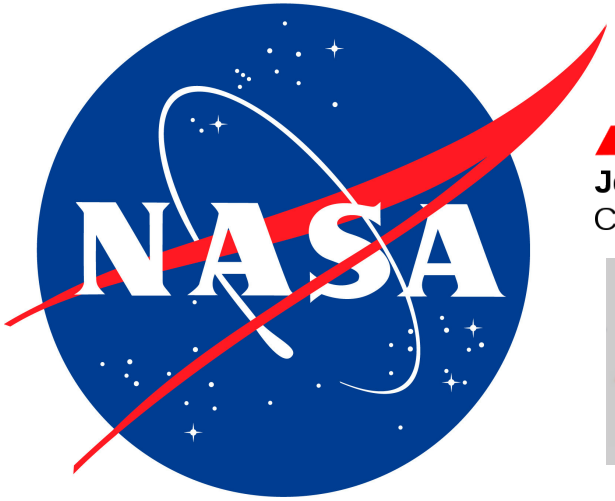


PRISM Data: http://www.prism.oregonstate.edu/


CO_2
Leaf Reflectance (%)
Wavelength (nm)
Canopy Reflectance (%)
Wavelength (nm)
T
Input Parameters
RTM
Spectra
PLS
Modeled Vcmax (µmol m^{-2} s^{-1})
Temperature (°C)
1 gN m^{-2}
2 gN m^{-2}
3 gN m^{-2}
4 gN m^{-2}
Medlyn et al., (2002); Kattge & Knorr, (2008)

Acknowledgments

- Terrestrial Ecology Program
- Earth & Space Science Fellowship
- HyspIRI Preparatory Activities (forthcoming)



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