B42A-04: Detection of Extreme Climate Event Impacts to Terrestrial Productivity From Airborne Hyperspectral Imagery

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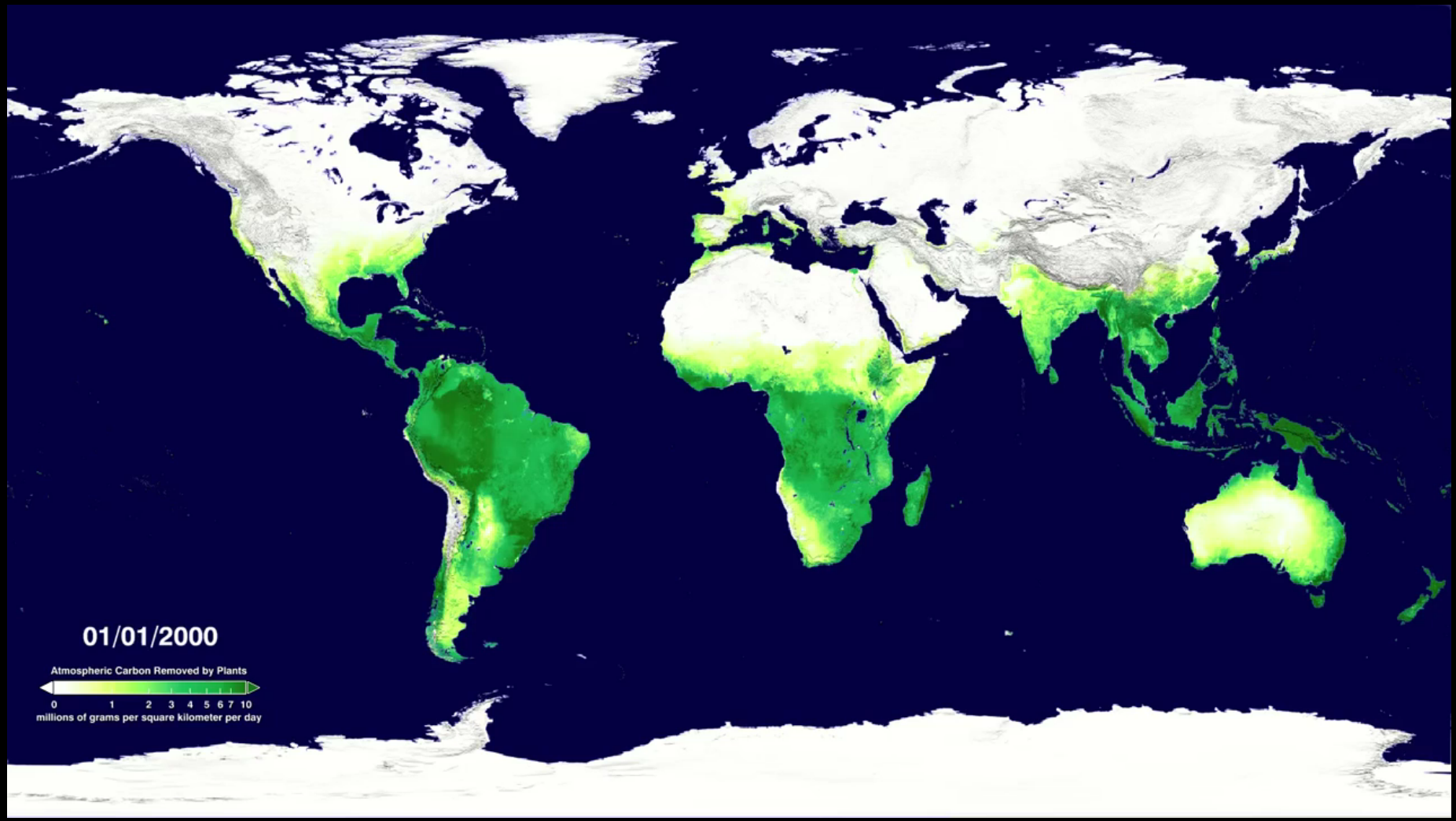
Thu 17 Dec 2015 11.05-11.20 MW 2006
Integrating Remote Sensing Observations and Eddy Covariance I

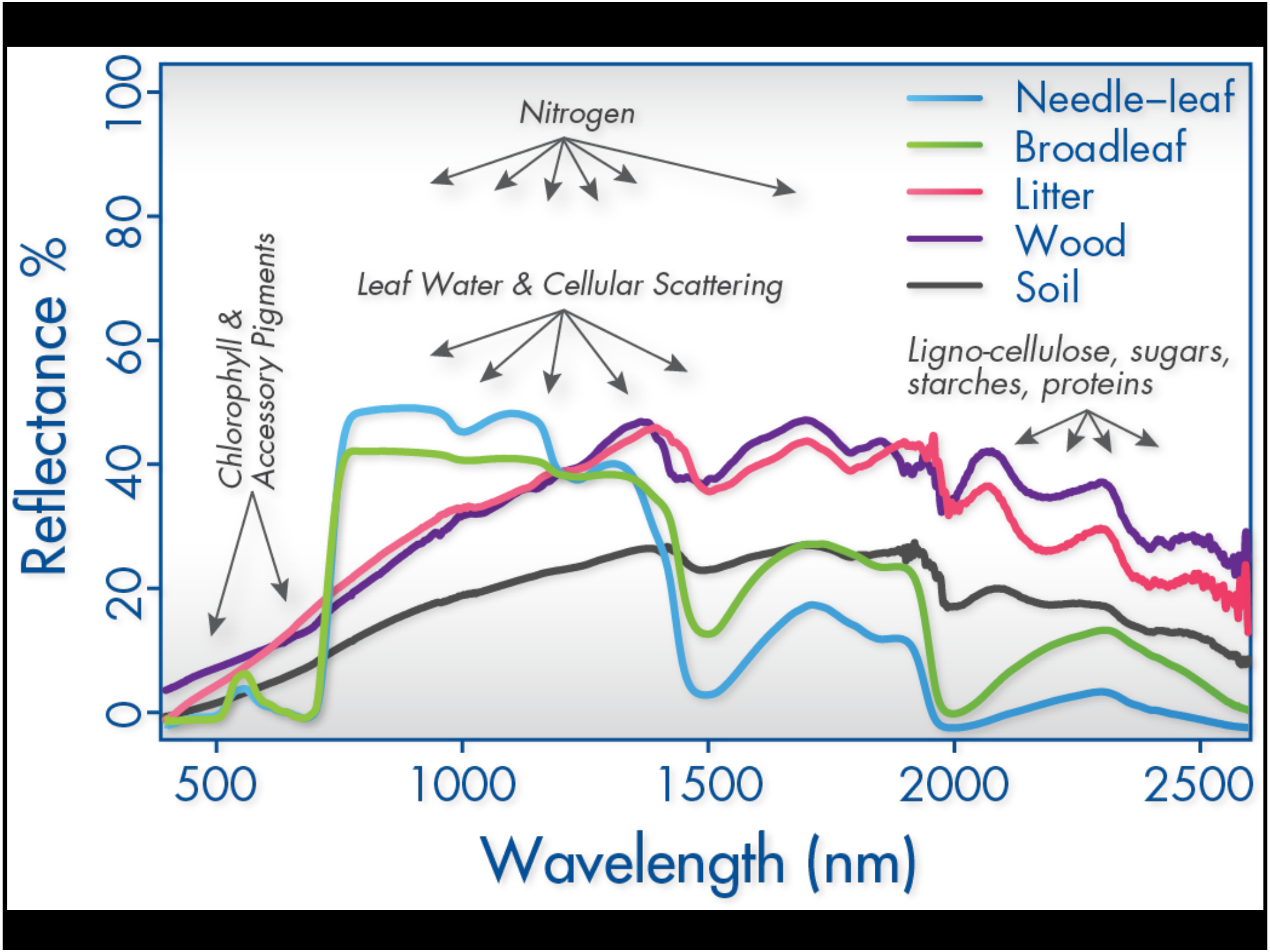


GPP = Gross Primary Productivity

UMT NTSG

Moral: Spectral resolution matters

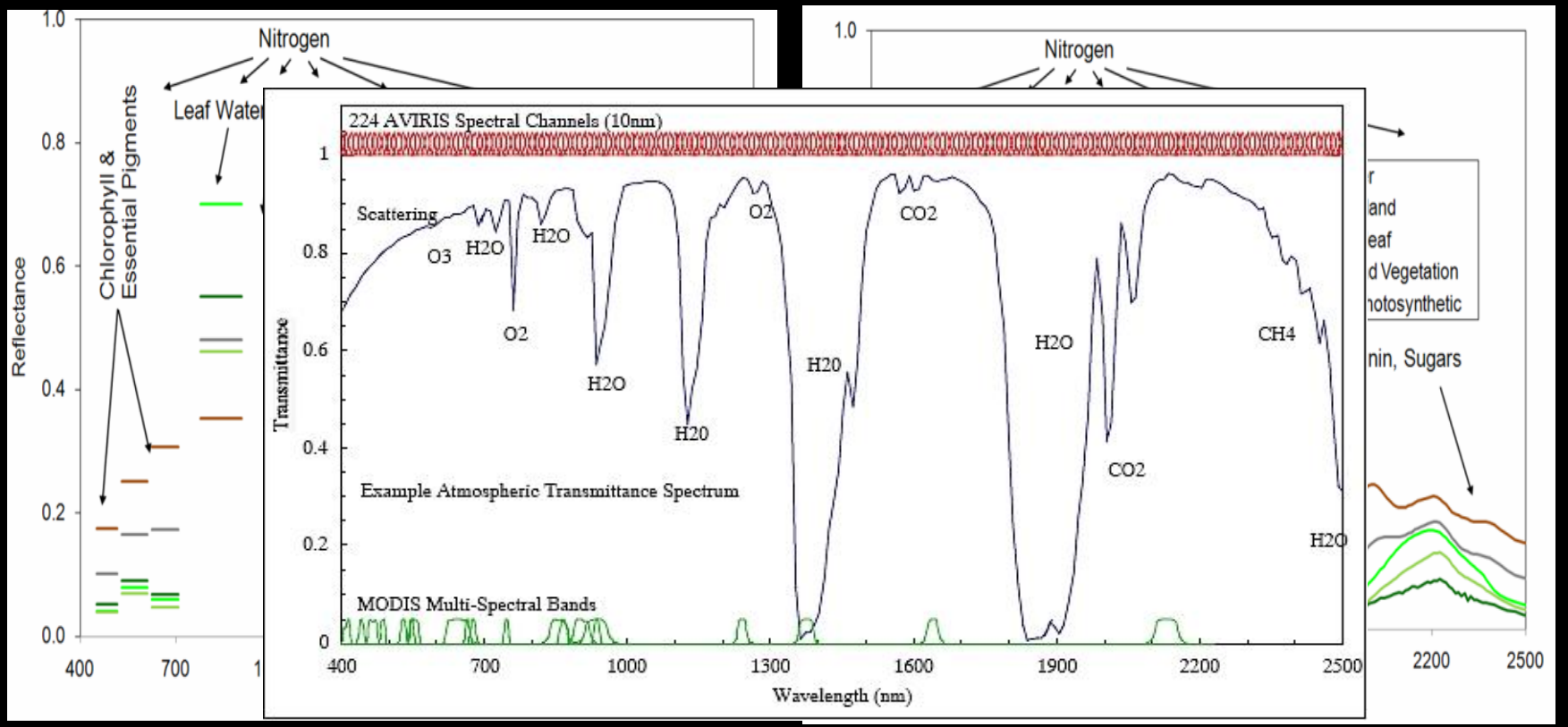
- Pretty pictures are great, but how can we use these observations to inform us about GPP response to drought?
  - We've had a paradigm that works at large spatial scales, but no so much at picking up variation in regions or over time, limiting our ability to detect extreme climate impacts
- Turns out, we can't capture drought sensitivity with current broadband satellite sensors
  - Hyperspectral sensors can, and therefore we should focus on spectral resolution and algorithms over spatial resolution enhancement


Reflectance %
0
20
40
60
80
100
500
1000
1500
2000
2500
Wavelength (nm)
Nitrogen
Leaf Water & Cellular Scattering
Chlorophyll & Accessory Pigments
Ligno-cellulose, sugars, starches, proteins
Needle–leaf
Broadleaf
Litter
Wood
Soil

Spectroscopic Measurements for Ecosystem Measurement

20th Century Multi-Spectral Measurements

21st Century Spectroscopic Measurement

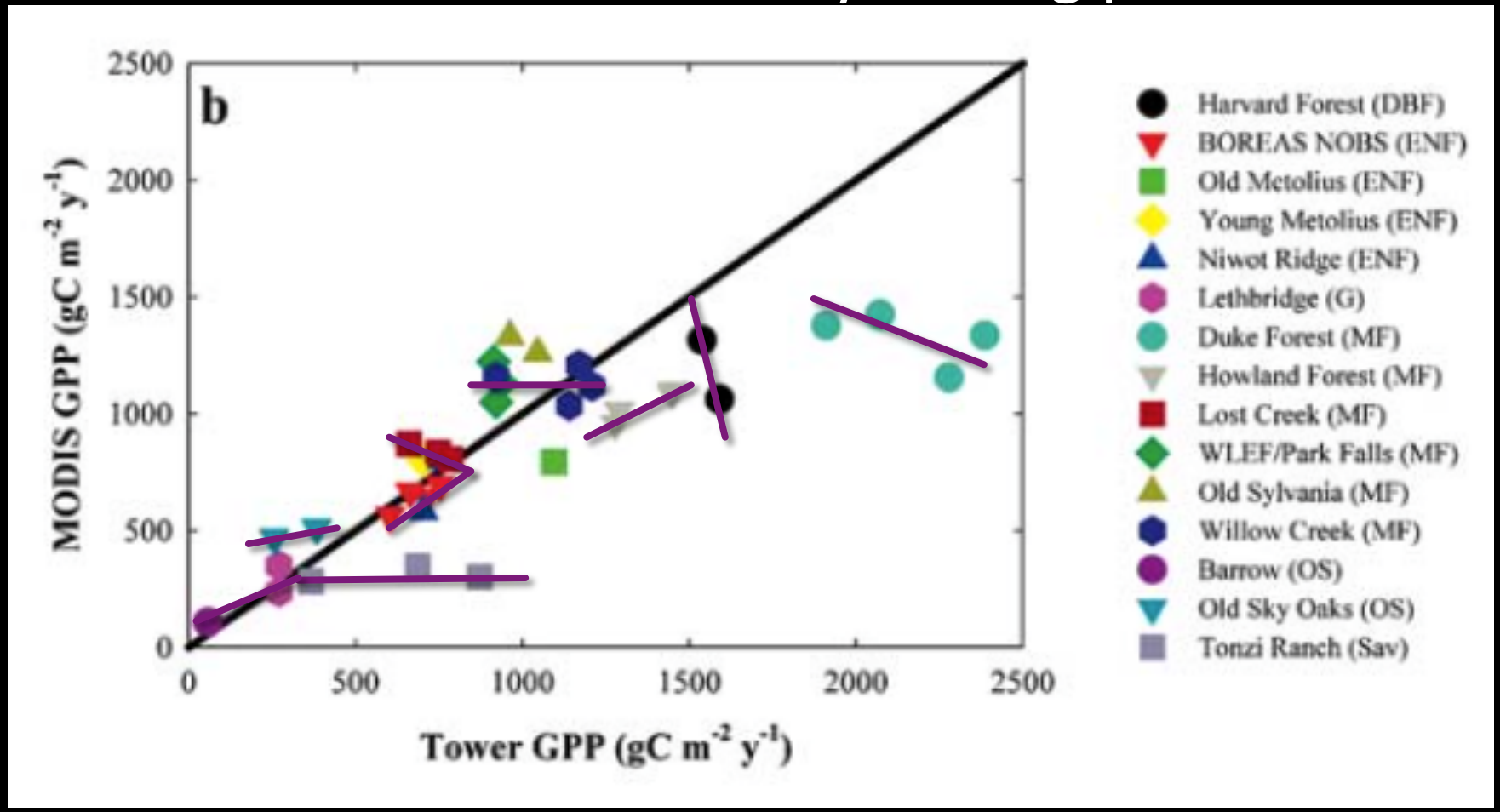


Multi-spectral imaging: insufficient to derive some important terrestrial parameters

Full range imaging spectroscopy: composition, chemistry, health and change of ecosystems.

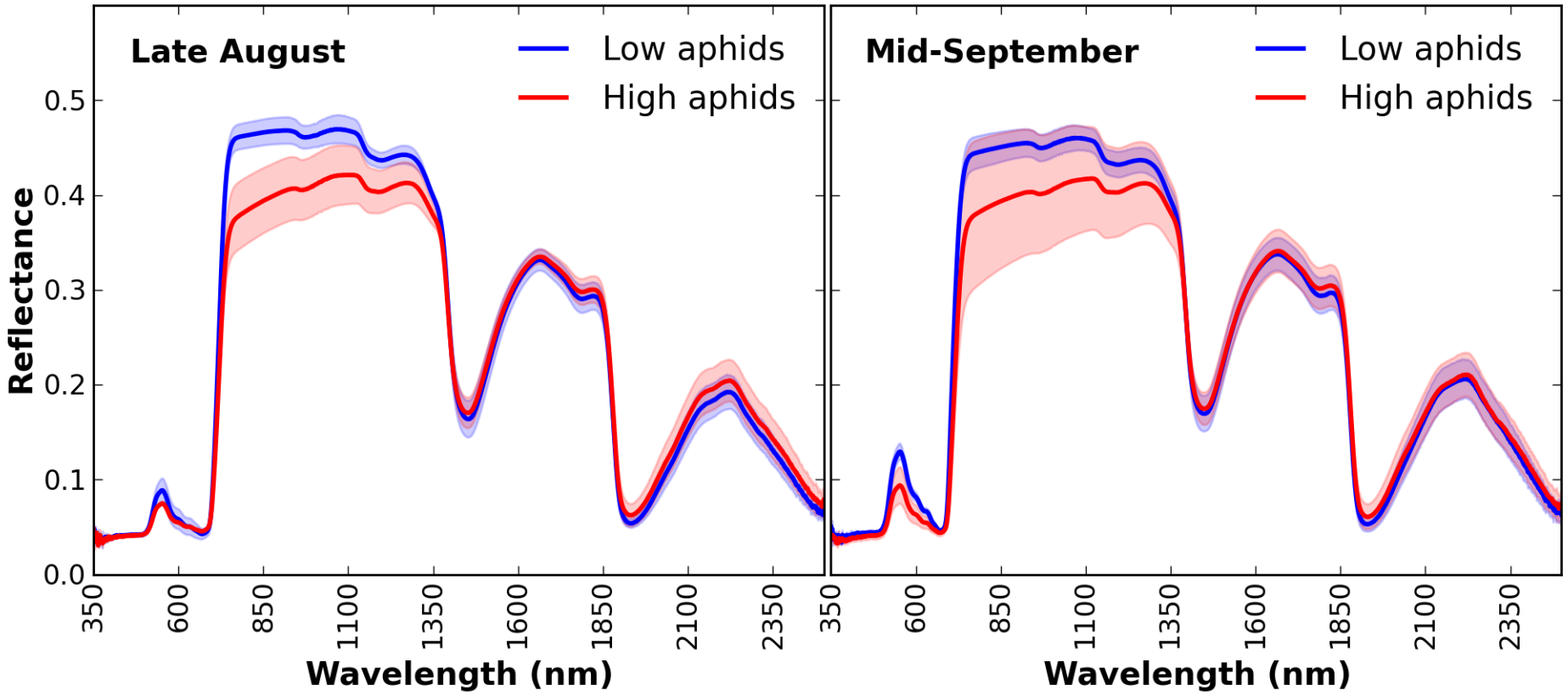
c/o Rob Green, NASA JPL

Seeing trees for the forest: Broadband sees mostly the big picture



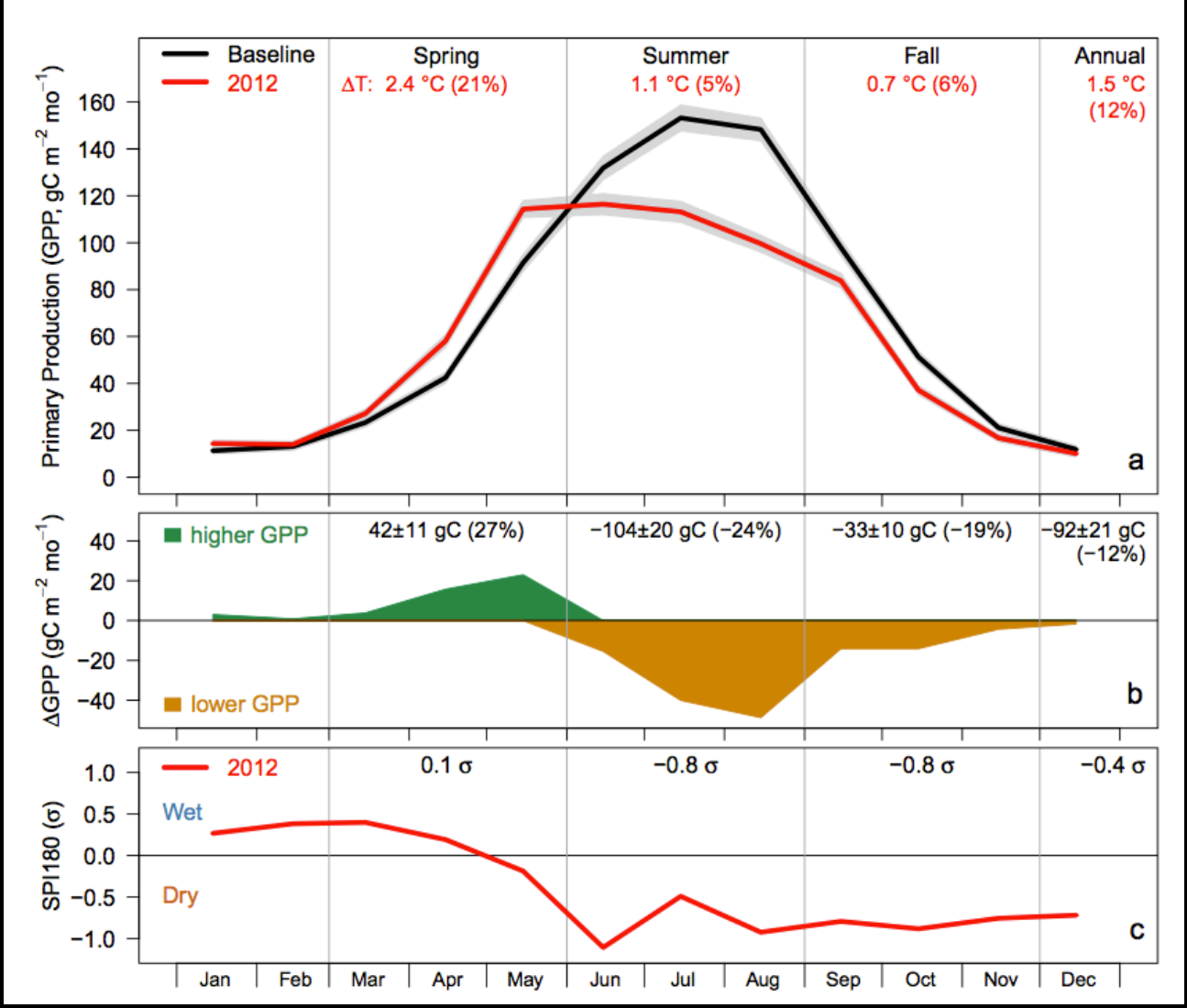
Heinsch et al., 2006

Stress is in the details



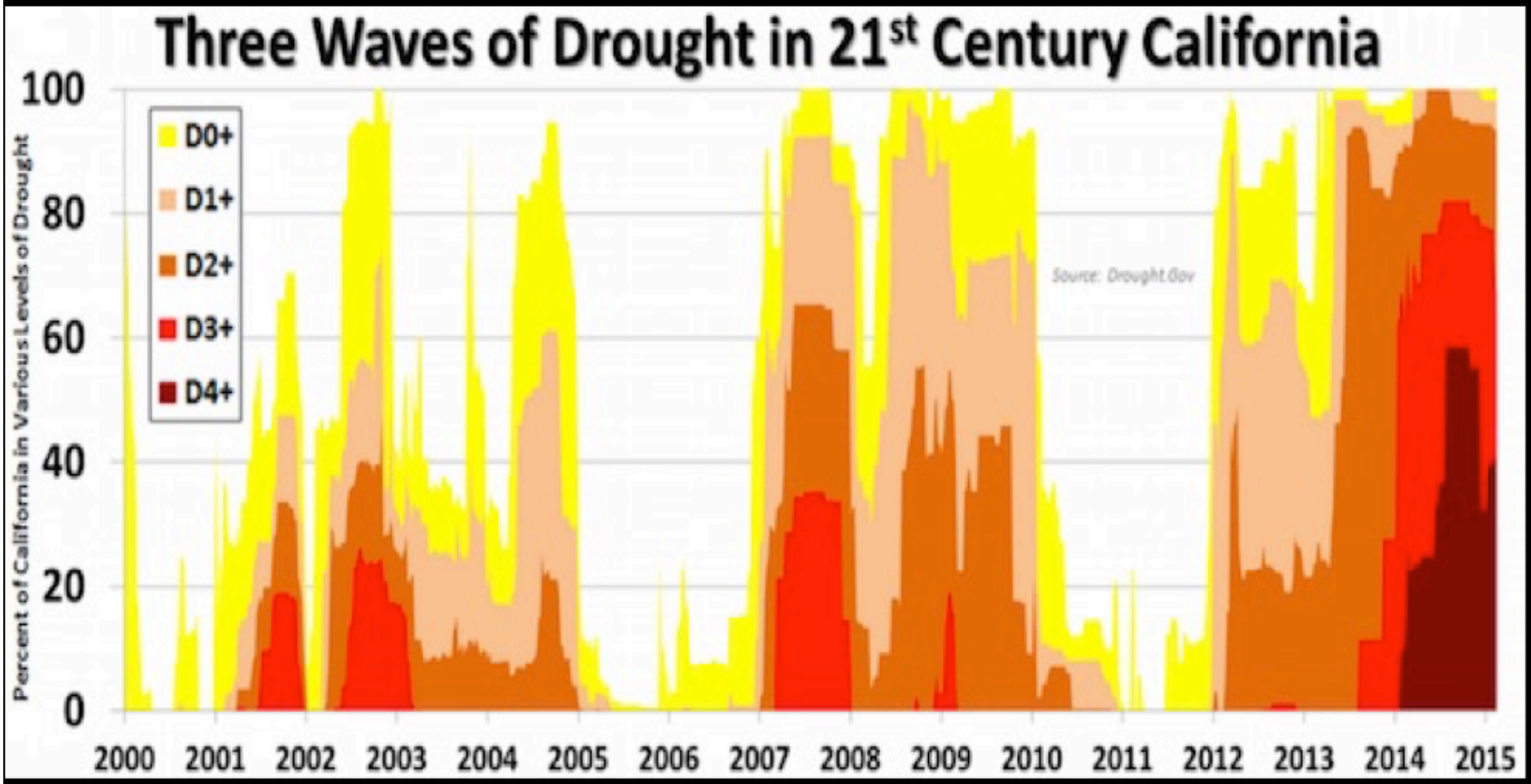
Courtesy of A. Singh

Flux towers show a variety of responses of GPP to drought



Wolf et al., in review

California is a good place to study climate extremes

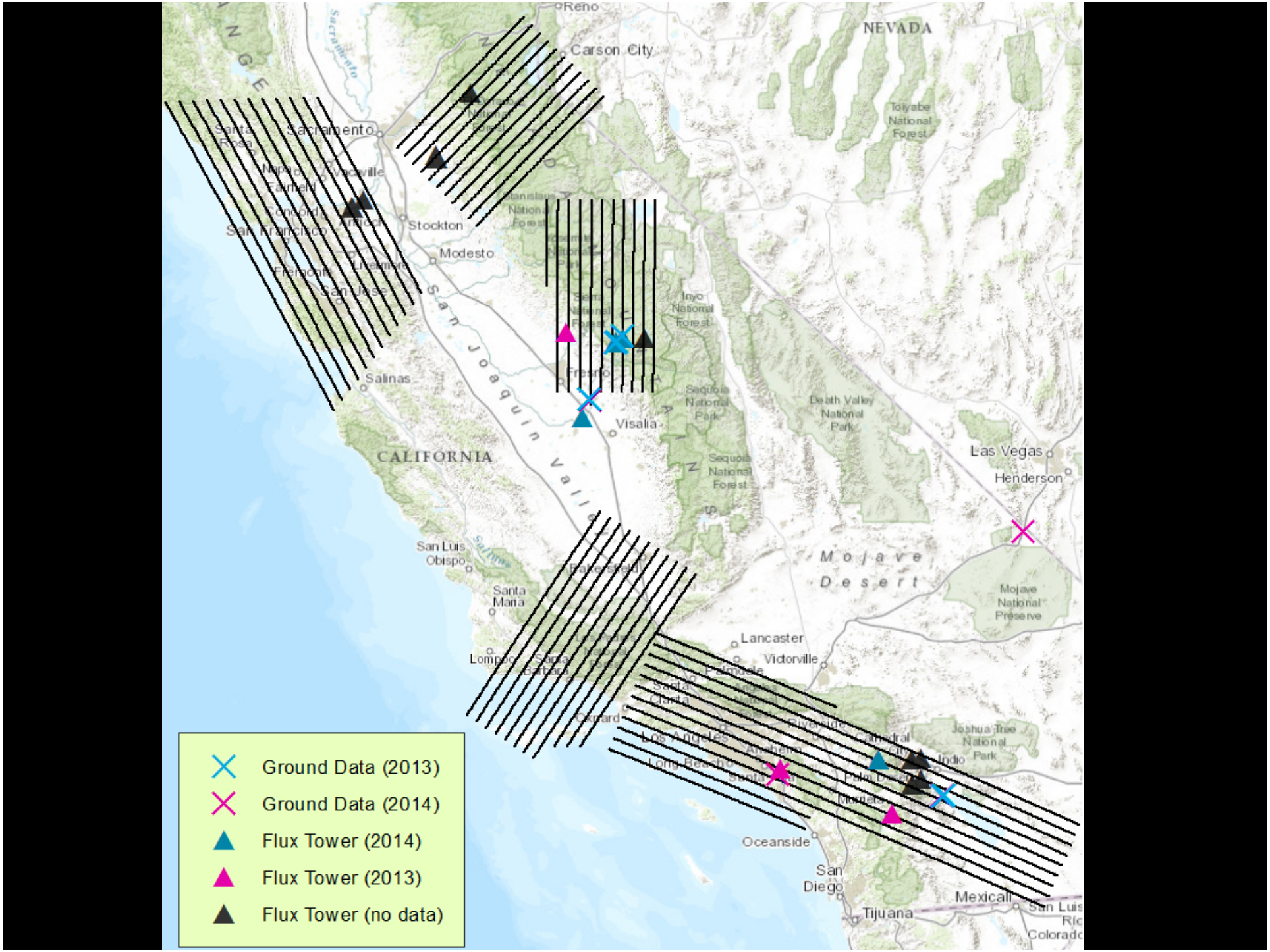


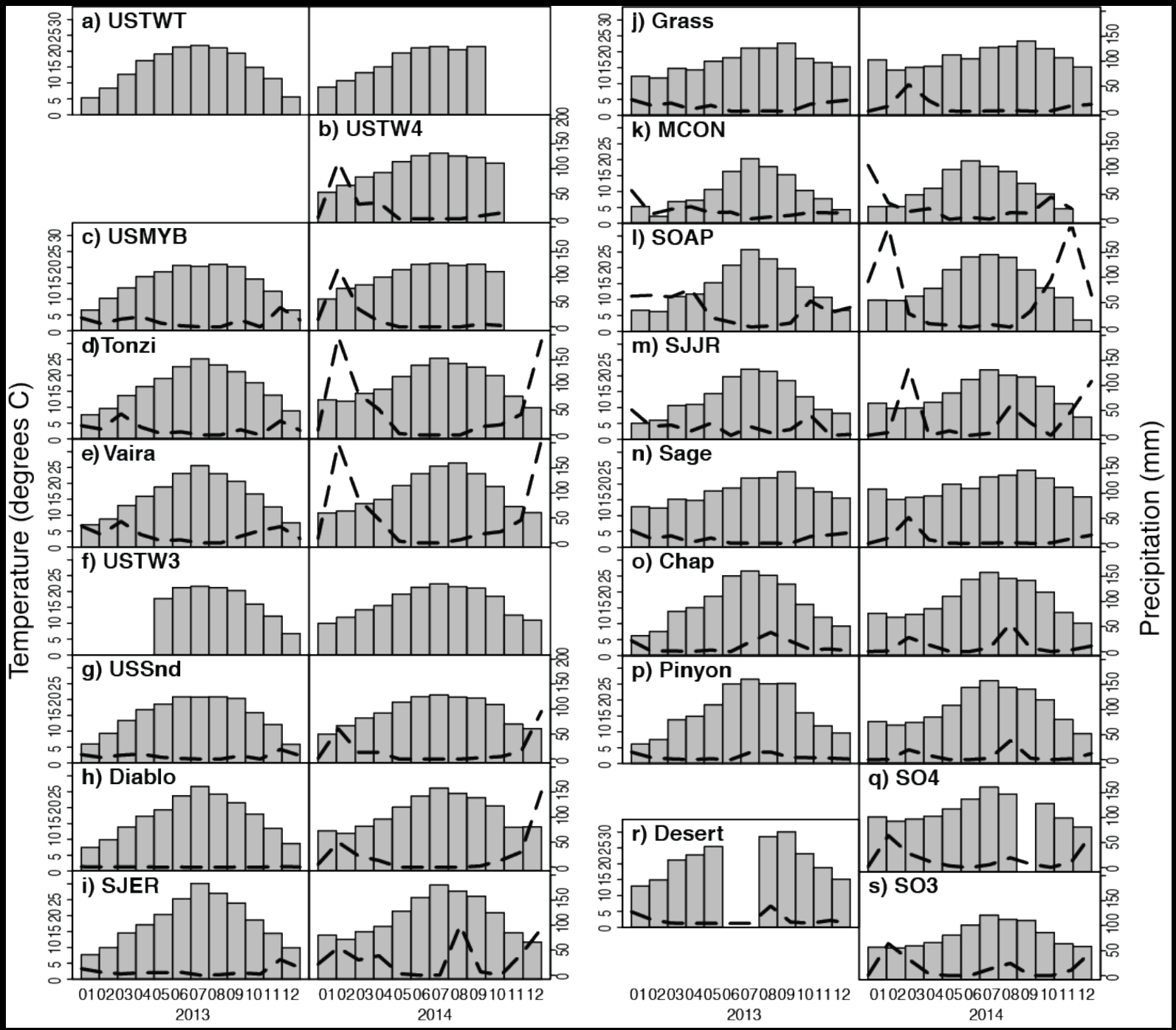
https://twitter.com/NWSHanford/status/570690853167112193

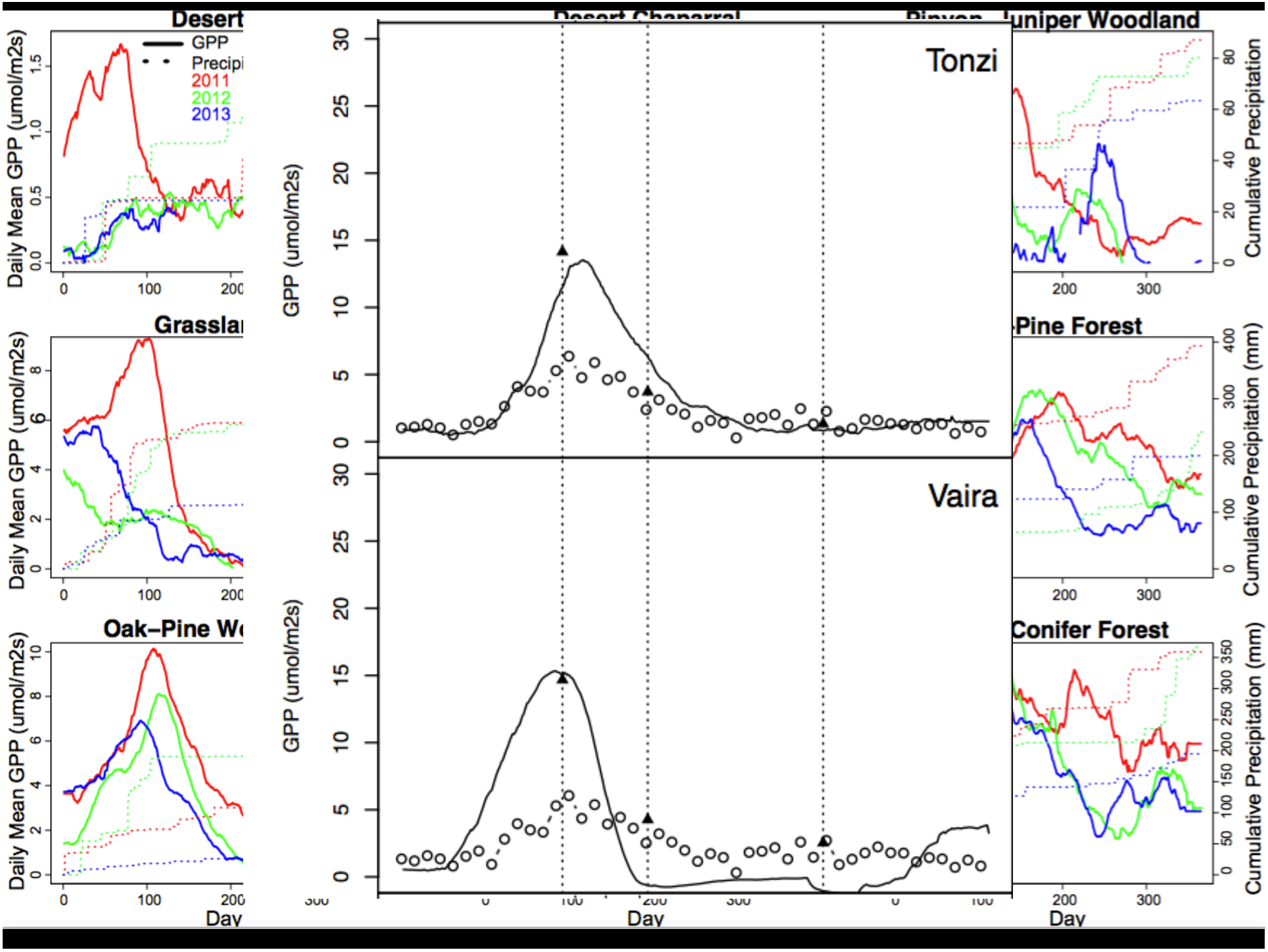
Building a better drought-trap

- Eddy covariance flux towers provide anchor points for evaluation of relationships between spectra and photosynthesis parameters or magnitude.
  - Tower PIs shared carbon, water, and energy fluxes for region across elevation, precipitation, and land cover gradients during drought period

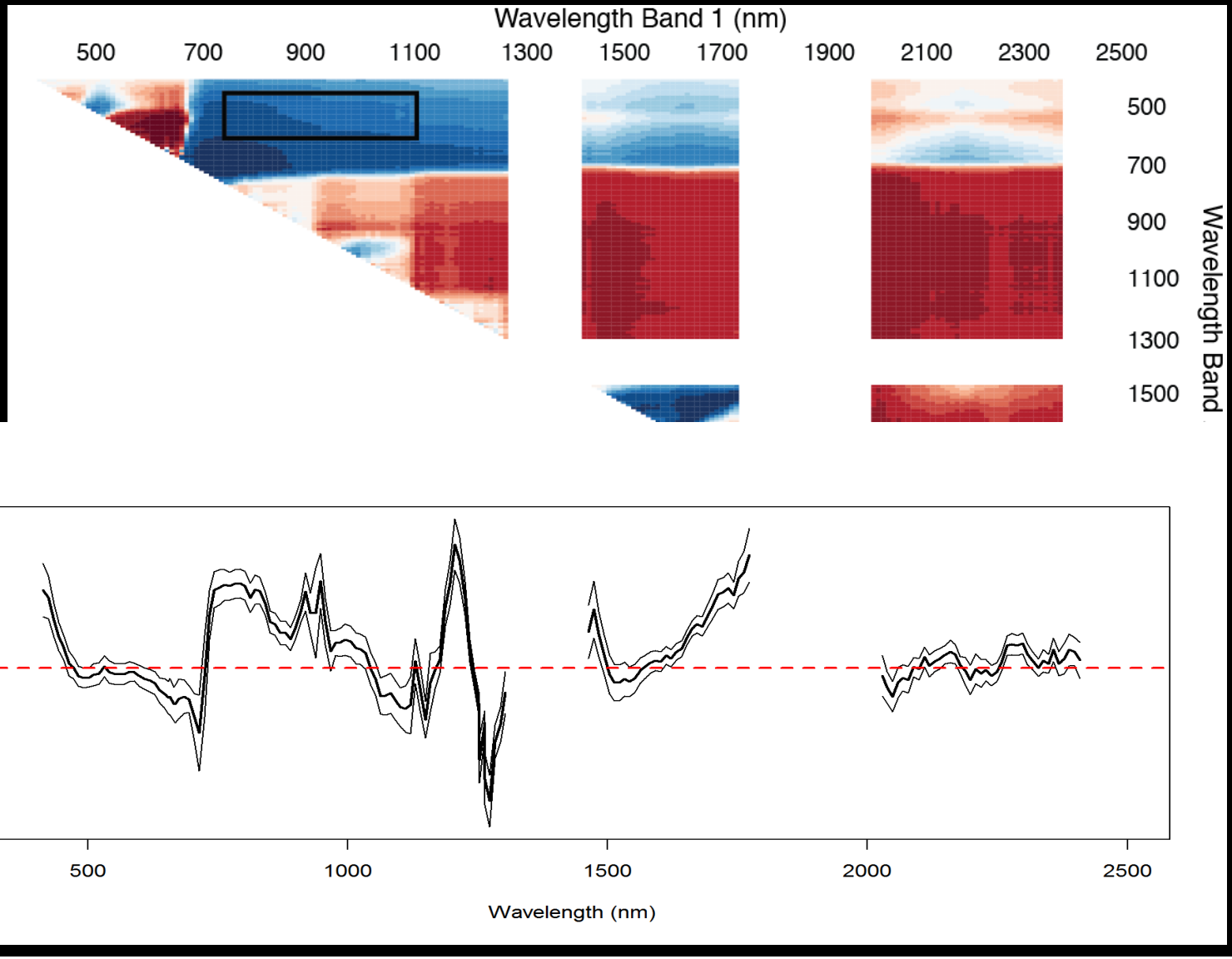
- Applied single flux partitioning (Desai-Cook model) and flux footprint (Kljun) model for 20 towers to extract Gross Primary Productivity estimates during exact time of HysplRI overflights.
  - GPP compared to footprint weighted spectra and 2-band indices
  - Total 104 tower footprint spectra extracted

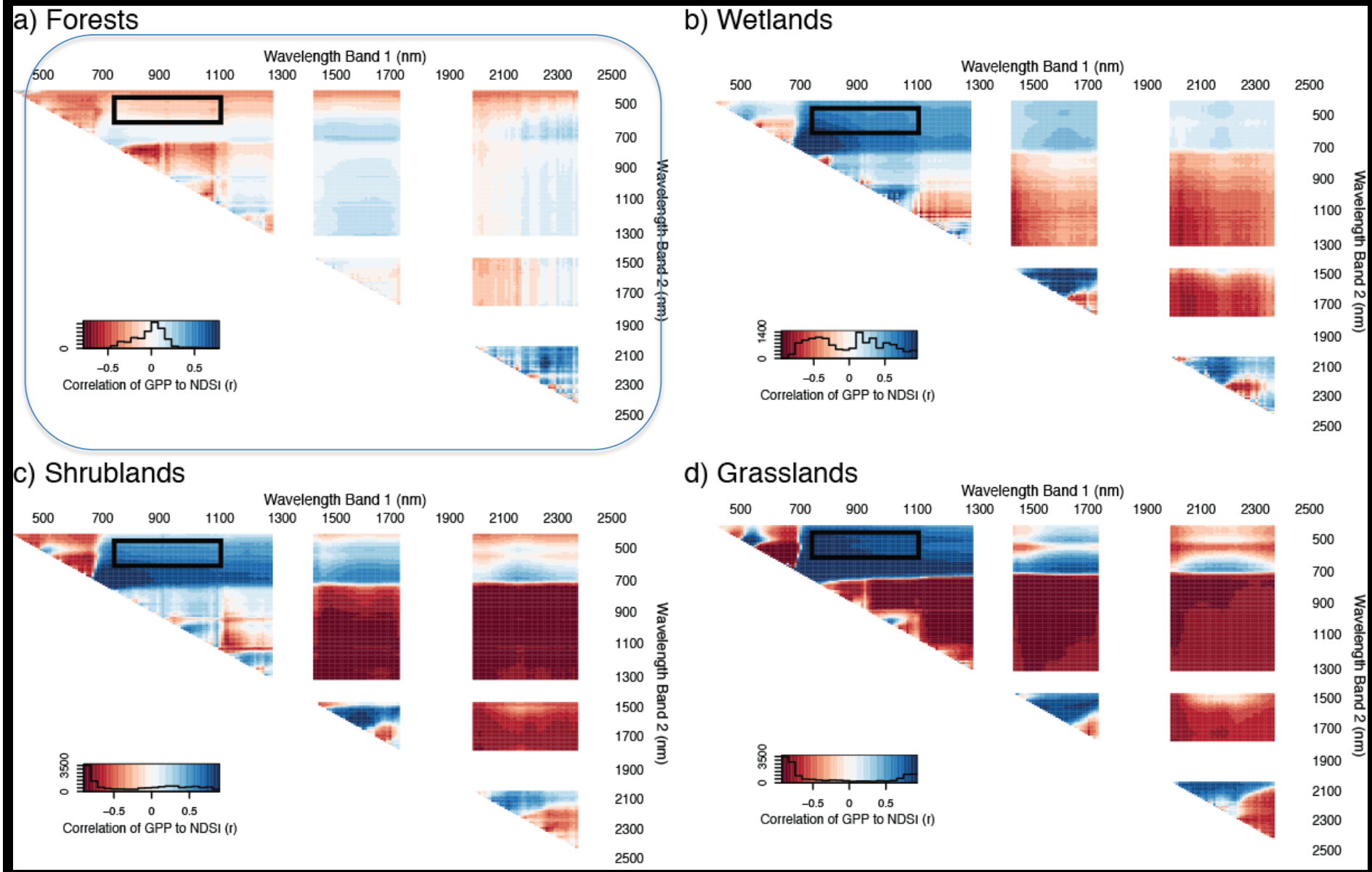

Ground Data (2013)
Ground Data (2014)
Flux Tower (2014)
Flux Tower (2013)
Flux Tower (no data)
NEVADA
CALIFORNIA
Reno
Carson City
Sacramento
Stockton
Modesto
Fresno
Visalia
Salinas
San Luis Obispo
Santa Maria
Lancaster
Victorville
Las Vegas
Henderson
Oceanside
San Diego
Tijuana
Mexicali
Indio
Mojave Desert
San Joaquin Valley


a) USTWT
b) USTW4
c) USMYB
d) Tonzi
e) Vaira
f) USTW3
g) USSnd
h) Diablo
i) SJER
j) Grass
k) MCON
l) SOAP
m) SJJR
n) Sage
o) Chap
p) Pinyon
q) SO4
r) Desert
s) SO3
Temperature (degrees C)
Precipitation (mm)
0 5 10 15 20 25 30
0 50 100 150 200
01 02 03 04 05 06 07 08 09 10 11 12
2013
2014

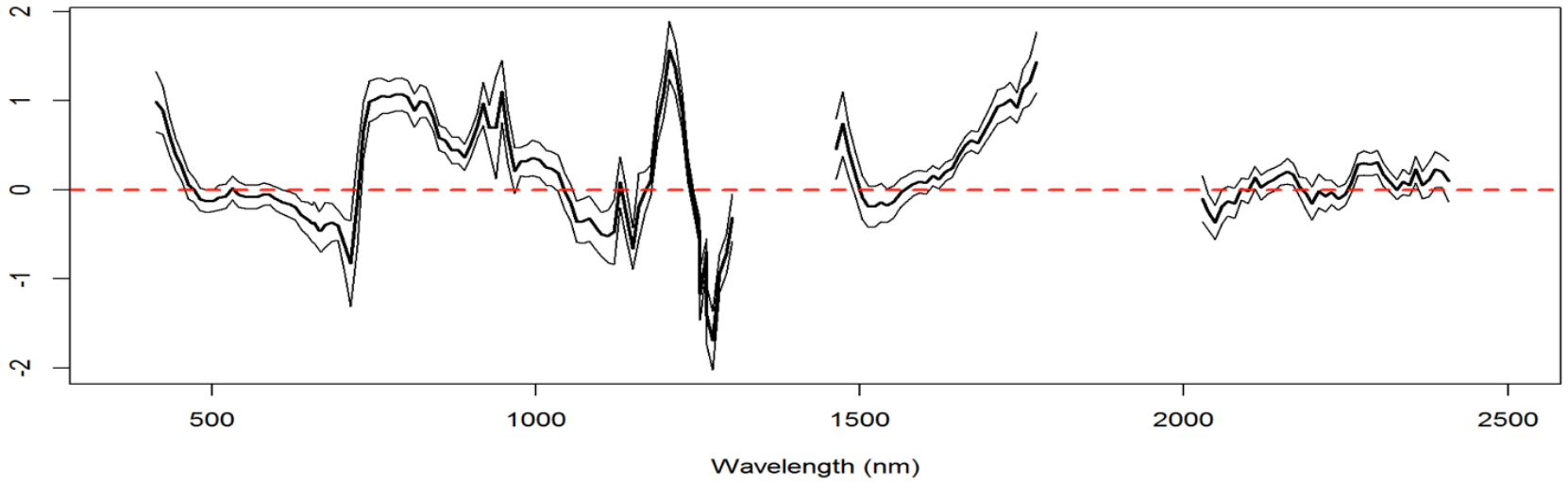

Desert
Grassla
Oak–Pine W
Desert Chaparral
Pinyon
Juniper Woodland
Pine Forest
Conifer Forest
Tonzi
Vaira
GPP
Precipi
2011
2012
2013
Daily Mean GPP (umol/m2s)
GPP (umol/m2s)
Cumulative Precipitation
Cumulative Precipitation (mm)
Day

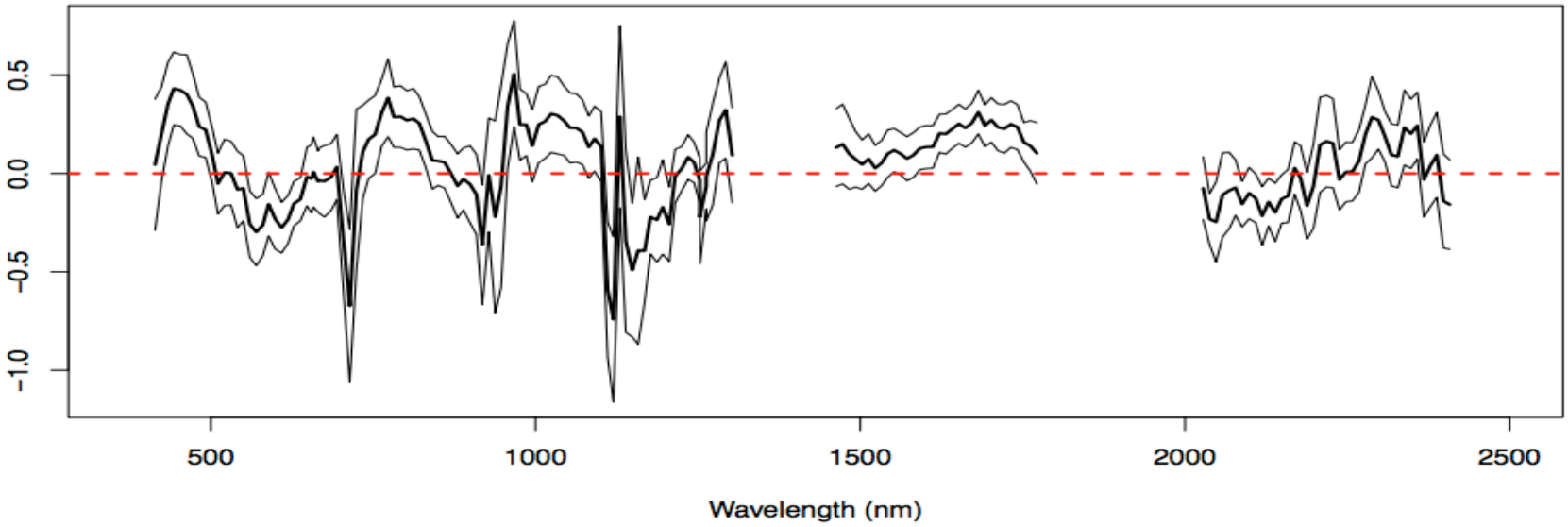
Band ratios across all sites reveal strong correlations across a number of broad and narrow features




a) Forests
Wavelength Band 1 (nm)
500 700 900 1100 1300 1500 1700 1900 2100 2300 2500
Wavelength Band 2 (nm)
500 700 900 1100 1300 1500 1700 1900 2100 2300 2500
0
−0.5 0 0.5
Correlation of GPP to NDSI (r)
b) Wetlands
Wavelength Band 1 (nm)
500 700 900 1100 1300 1500 1700 1900 2100 2300 2500
Wavelength Band 2 (nm)
500 700 900 1100 1300 1500 1700 1900 2100 2300 2500
0 1400
−0.5 0 0.5
Correlation of GPP to NDSI (r)
c) Shrublands
Wavelength Band 1 (nm)
500 700 900 1100 1300 1500 1700 1900 2100 2300 2500
Wavelength Band 2 (nm)
500 700 900 1100 1300 1500 1700 1900 2100 2300 2500
0 3500
−0.5 0 0.5
Correlation of GPP to NDSI (r)
d) Grasslands
Wavelength Band 1 (nm)
500 700 900 1100 1300 1500 1700 1900 2100 2300 2500
Wavelength Band 2 (nm)
500 700 900 1100 1300 1500 1700 1900 2100 2300 2500
0 3500
−0.5 0 0.5
Correlation of GPP to NDSI (r)

BUT: When looking for variation within a single biome





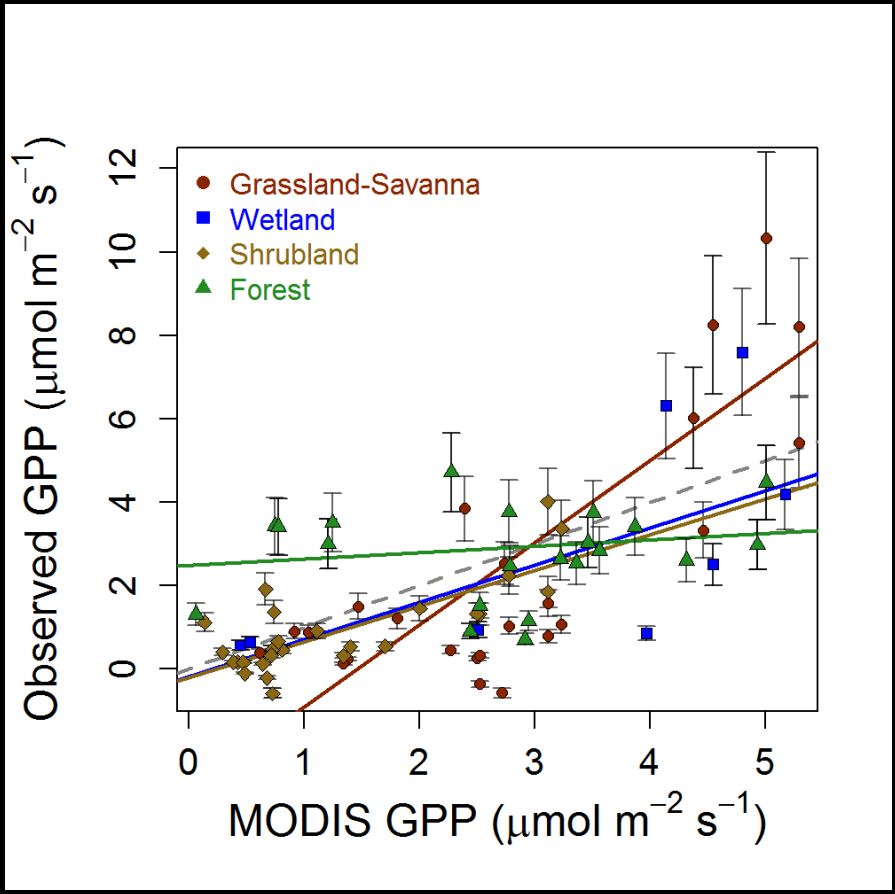
ures

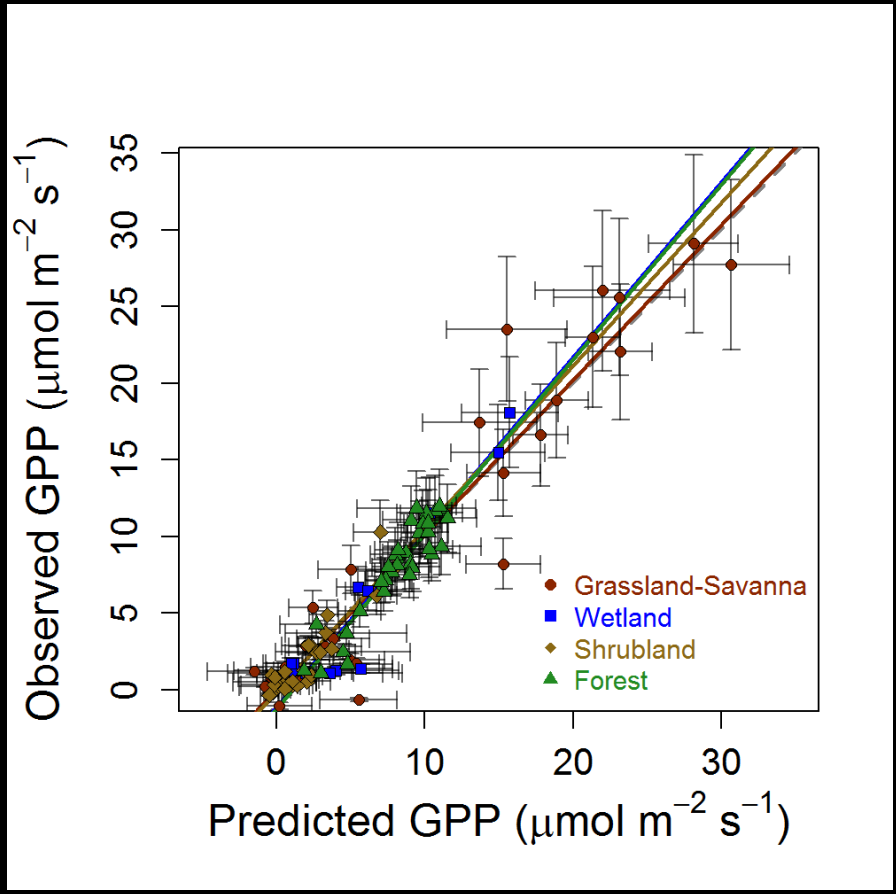
1300

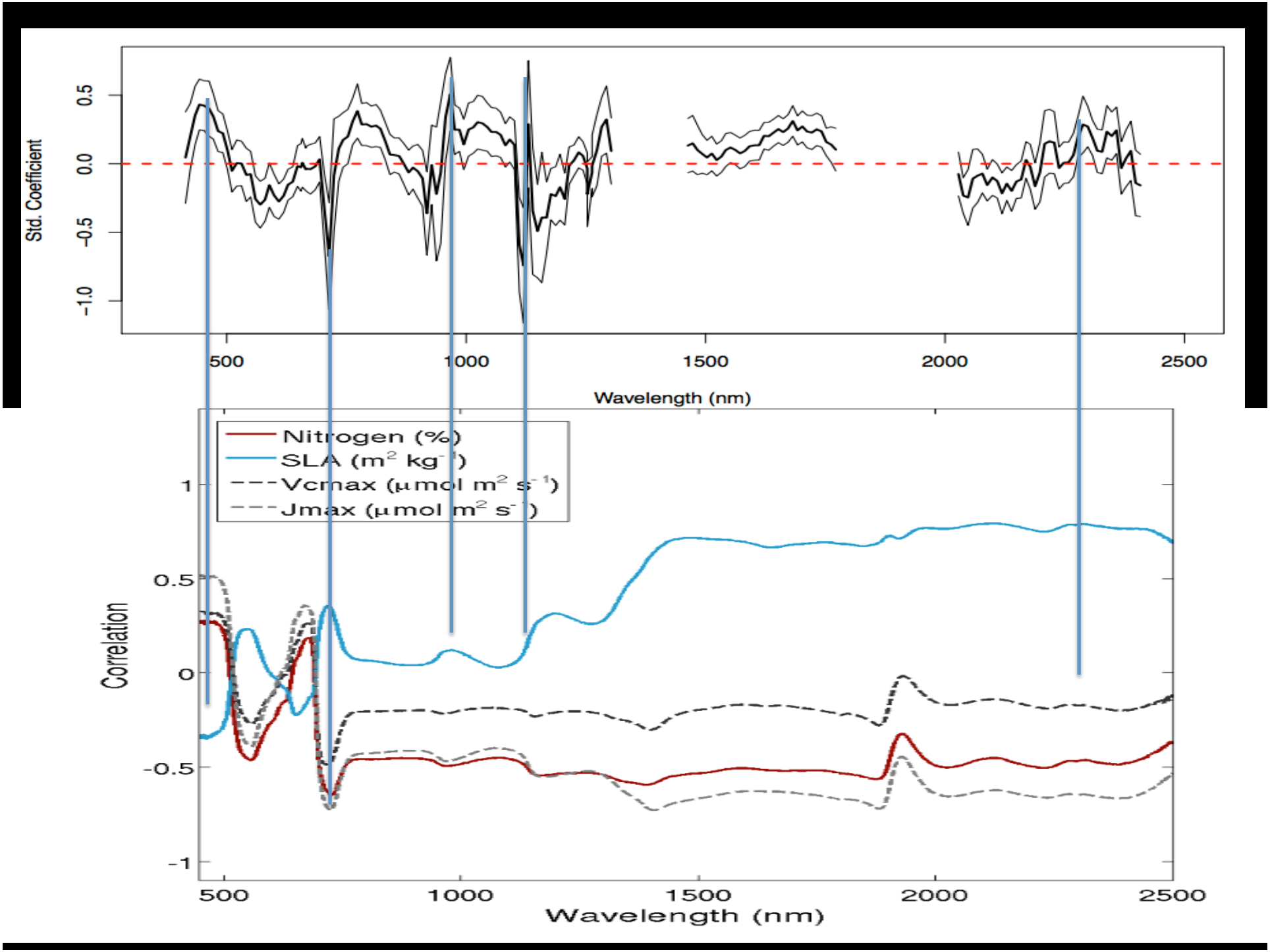
Wavelength Band 2 (nm)

s

PLSR uses multiple bands to better capture both intra- and inter-site variation in GPP across time and space during drought



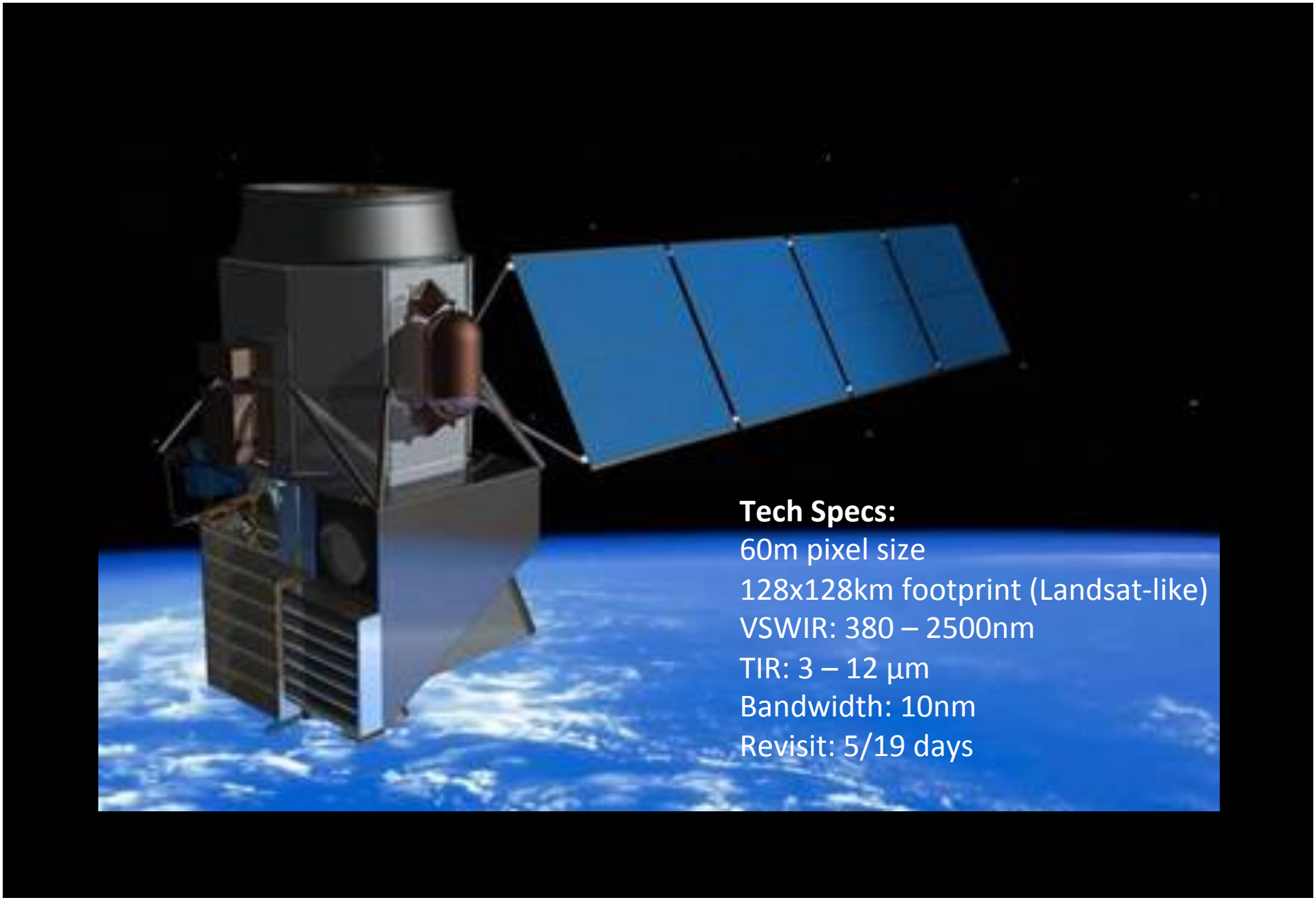



Std. Coefficient
0.5
0.0
-0.5
-1.0
500
1000
1500
2000
2500
Wavelength (nm)
Nitrogen (%)
SLA (m² kg⁻¹)
Vcmax (µmol m² s⁻¹)
Jmax (µmol m² s⁻¹)
Correlation
1
0.5
0
-0.5
-1
500
1000
1500
2000
2500
Wavelength (nm)

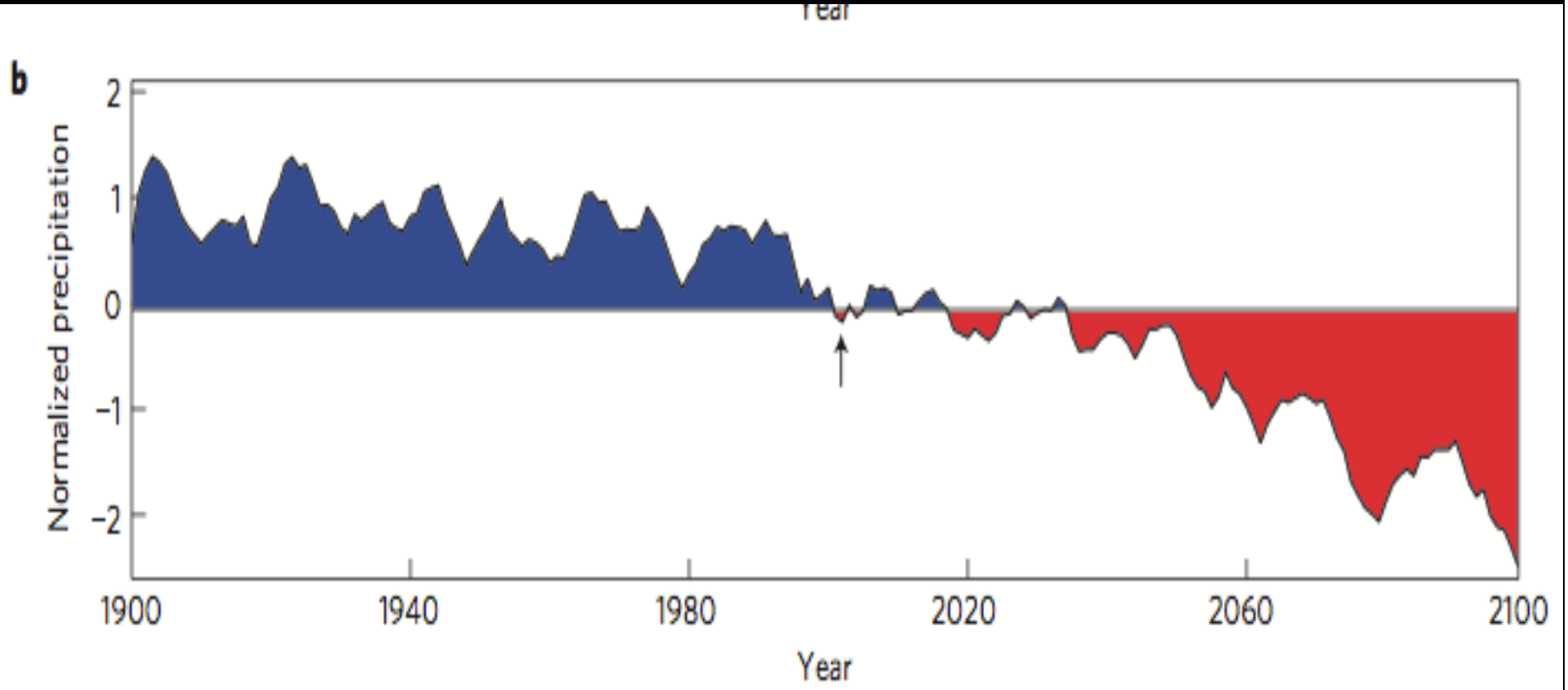
Main points

- Narrowband features detect response of plants to extreme climate stress that broadband cannot
- Satellites now being considered – need for mechanistic algorithm development
- Where are we going from here:
  - Mapping photosynthesis parameters and inverting ecosystem models radiative transfer
  - Paper (Dubois, Desai et al) on this project to be submitted soon
  - Also see: Serbin, S.P., Singh, A., Desai, A.R., DuBois, S.G., Jablonski, A.D., Kingdon, C.C., Kruger, E.L., and Townsend, P.A., 2015. Remotely estimating photosynthetic capacity, and its response to temperature, in vegetation canopies using imaging spectroscopy, *Rem. Sens. Environ*.,167, 78-87, doi:10.1016/j.rse.2015.05.024.

Future Missions: HysplRI



Drought is going to be a common climate extreme



Schwalm et al., 2012, Nature Geosci.

Thank you!
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Also see:

Support:
NASA Hyspiri Grant
NNX12AQ28G

GC22D-06 HyspIRI Measurements of Agricultural Systems in California: 2013-2015 (TOWNSEND)

TUE 1135 MW 3014

B53B-0544 Linking vegetation structure, function and physiology through spectroscopic remote sensing (SERBIN)

FRI 1340 MS Posters

B54D-01 Mapping Variation in Vegetation Functioning with Imaging Spectroscopy (TOWNSEND)

FRI 1600 MW 2006

B53D-0594 Applications of spectral inversion to understanding vegetation functional trait relationships (SHIKLOMANOV)

FRI 1340 MS Poster