Diurnal and Seasonal Dynamics in Chlorophyll Fluorescence and Xanthophyll Cycle

in Two Vastly Different Canopies

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OPTIMUS

Innovative Optical Tools For Proximal Sensing Of Ecophysiological Processes

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Outline

- Objectives

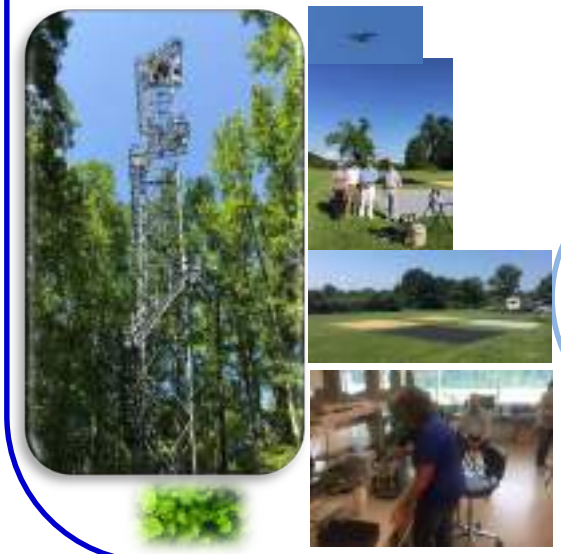
Our goal is to characterize the dynamic diurnal and seasonal dynamics in vegetation fluorescence and reflectance properties, as they relate to photosynthetic function (A_{leaf}, GPP_{canopy}, LUE) and their relationships.

- Study sites and data collections in 2017
- Processing
  - *Filtering, Parameter retrieval and Scaling/Normalization*
- Preliminary Results
  - *Diurnal trends in tulip poplar*
  - *Seasonal trends in corn*
  - *Comparing the diurnal trends in corn and poplar*
- Comparisons across phenology and between sites – normalization or scaling
- Future steps

Study Sites

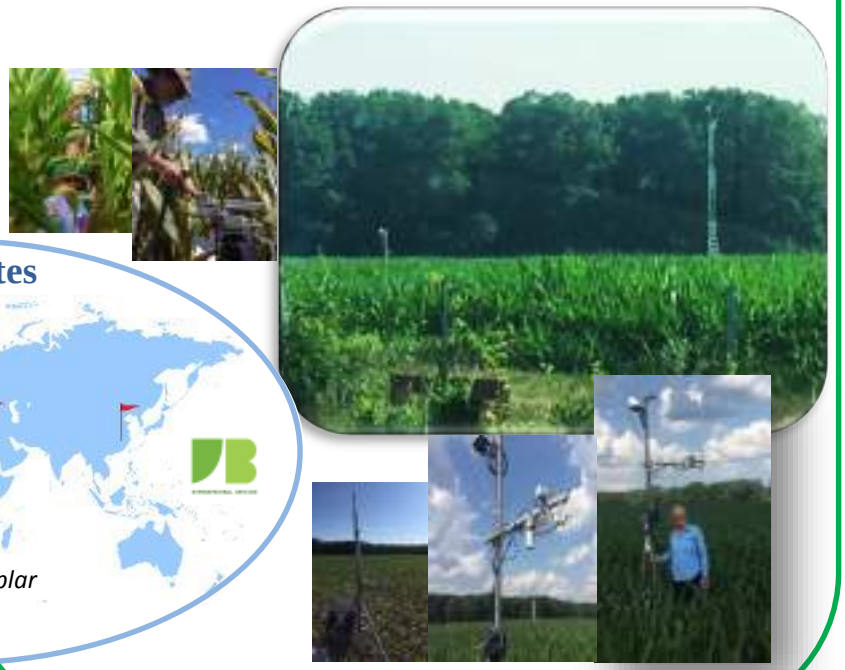
I. Smithsonian Environmental Research Center (SERC), Edgewater, MD

- Mature mixed deciduous forest
- Diurnal FLoX measurements, focused on tulip poplar (*Liroendron tulipifera* L.)
- One week support of NASA/FLARE, PI B. Cook & ESA/FLEX
- Data collection: cal/val for NASA/FLARE; for major species leaf and canopy gas exchange and fluorescence, leaf pigments, LA, SLM, optical properties



II. OPE3, USDA/ARC, Greenbelt, MD

- Corn under optimal nitrogen treatment
- Diurnal and seasonal FLoX measurements capturing phenology changes
- FLoX measured canopy instrumented with FLUX tower and MONIPAM sensors
- Data collection: leaf and canopy gas exchange and fluorescence, leaf pigments, LA, SLM, optical properties; FUSION tower measurements



Methods: FLoX-D Measurements and Processing

Data Filtering

1. solar stability (E)
2. saturation vegetation (L, upwelling)
3. saturation down welling (E)

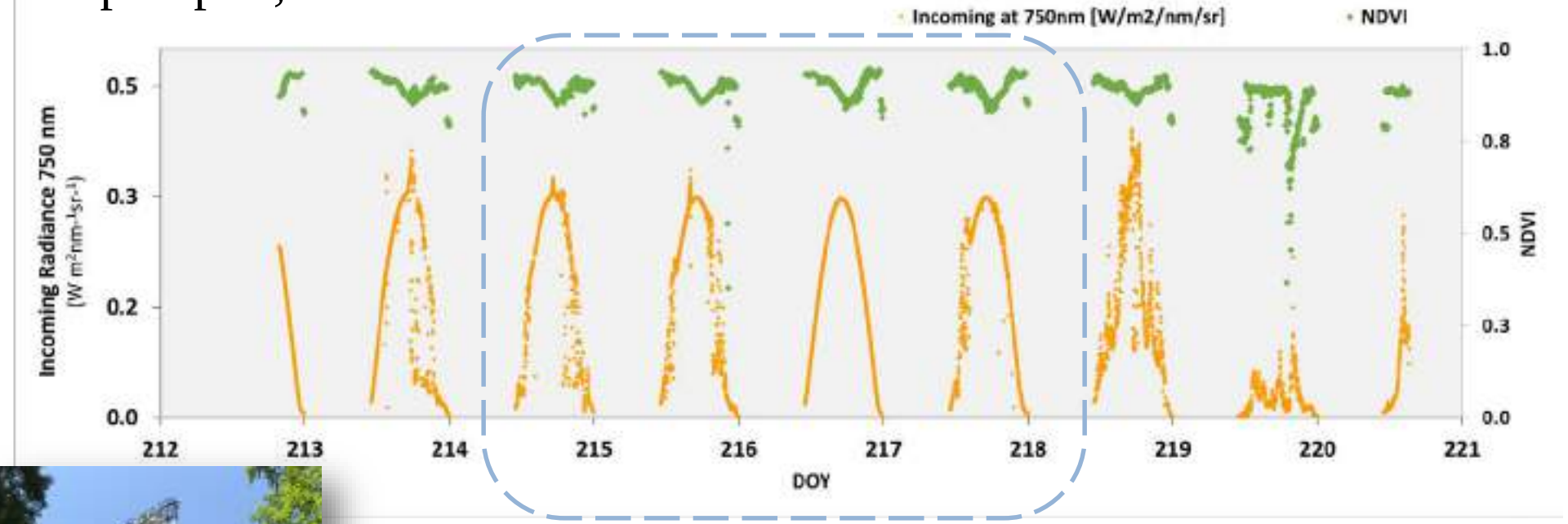
Data Processing

1. calculate reflectance
2. vegetation Indices based on reflectance
3. SIF retrieval (at 685 nm and 760 nm, iFLD and sfm)

Parameter	Spec 1	Spec 2
Spectrometer	QEPro	FLMT
FWHM (nm)	0.3	1
Sampling interval (nm)	0.14	0.3
Spectral range (nm)	650 - 800	400-1000
Data: derived outputs	Radiance, Sun-induced Chl fluorescence at O_2-B and O_2-A	Irradiance, Radiance, Reflectance and VIs

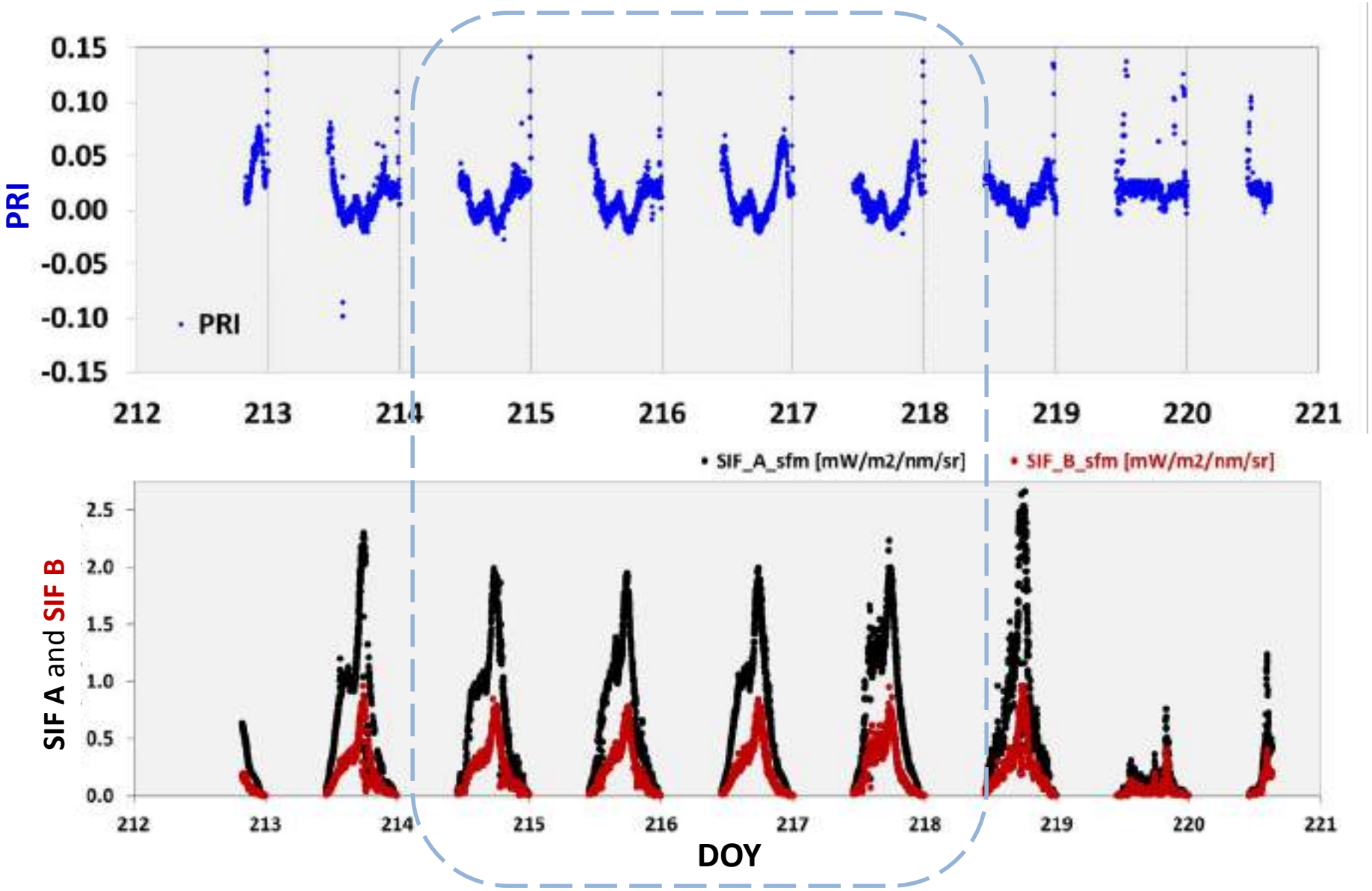
Diurnal Canopy Observations, Mid Season

Tulip Poplar, SERC MD 2017



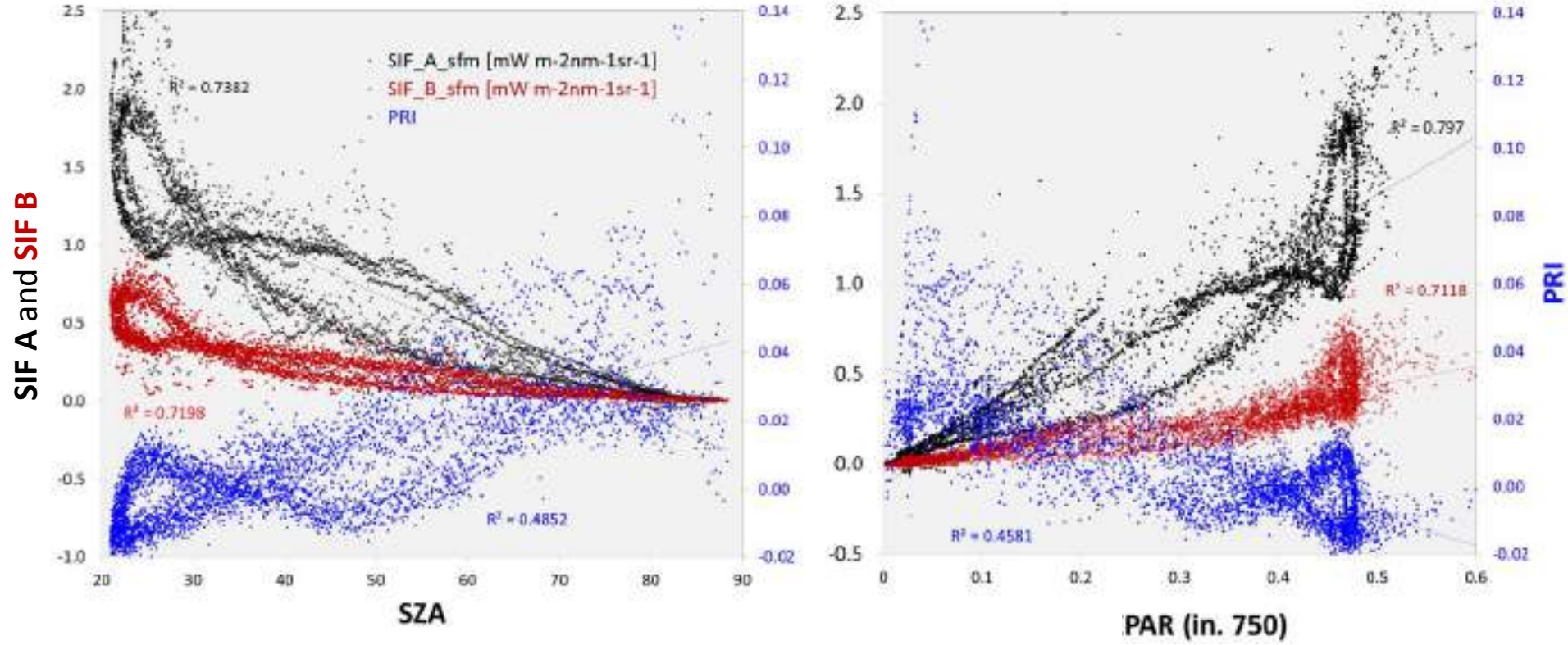
Mid-Season PRI and SIF

SERC, Edgewater, MD



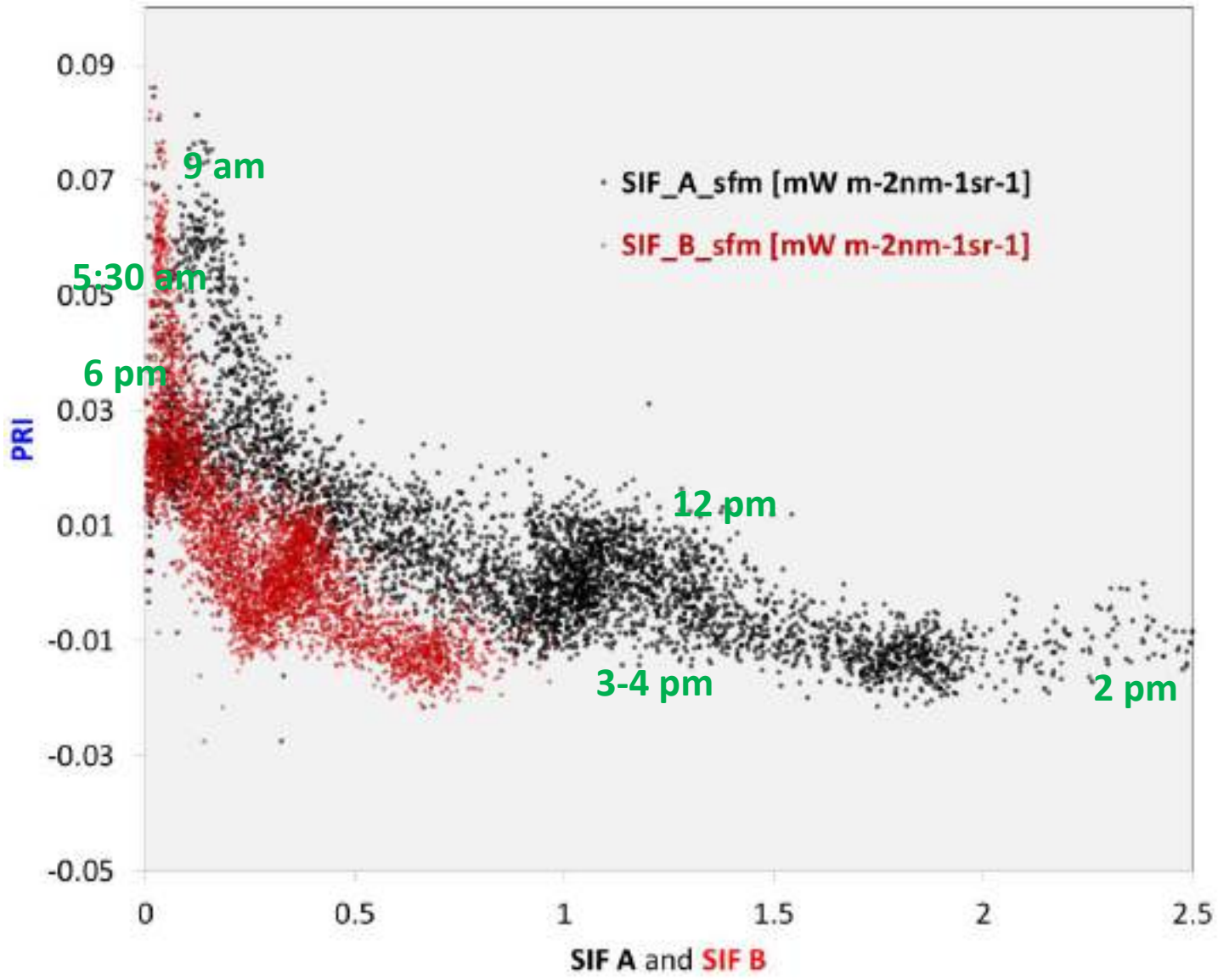
Diurnal Changes in SIF and PRI

Mid-season, Tulip poplar, SERC, Edgewater, MD



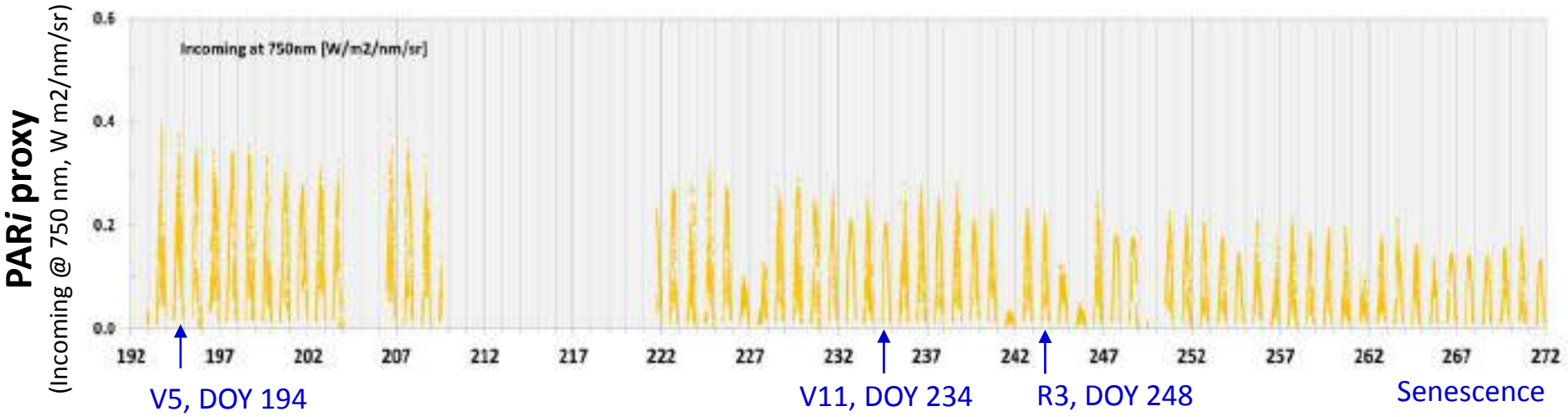
Diurnal Changes in PRI and SIF

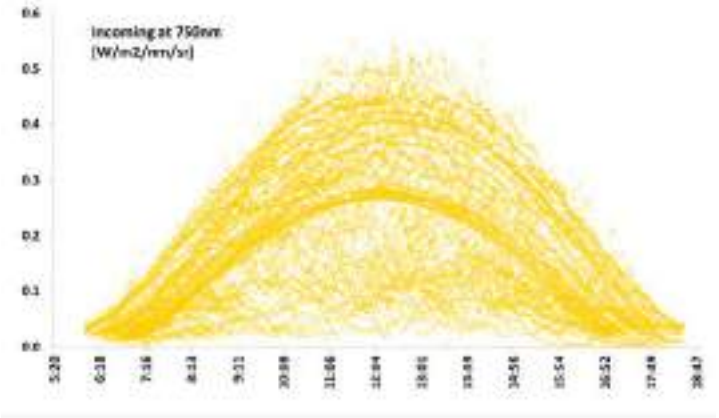
Mid-Season, SERC, Edgewater, MD



Changes in Illumination (incoming at 750 nm)

OPE3, USDA/ARC, Greenbelt, MD

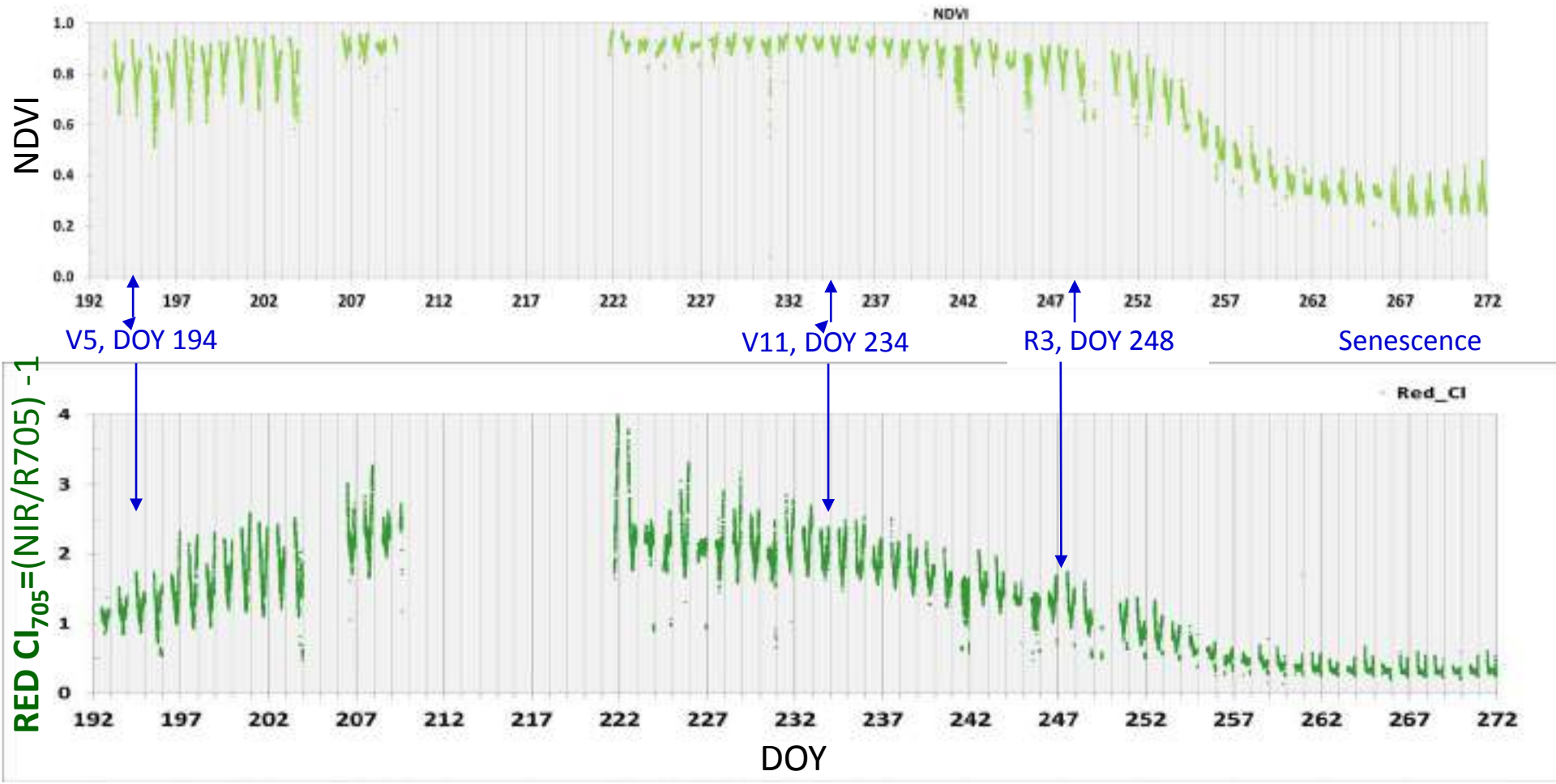




DOY 194 – young, DOY 234 – mature, DOY 248 - senescing

Changes in Chlorophyll&LAI

NDVI and MTCI, OPE3, USDA/ARC, Greenbelt, MD



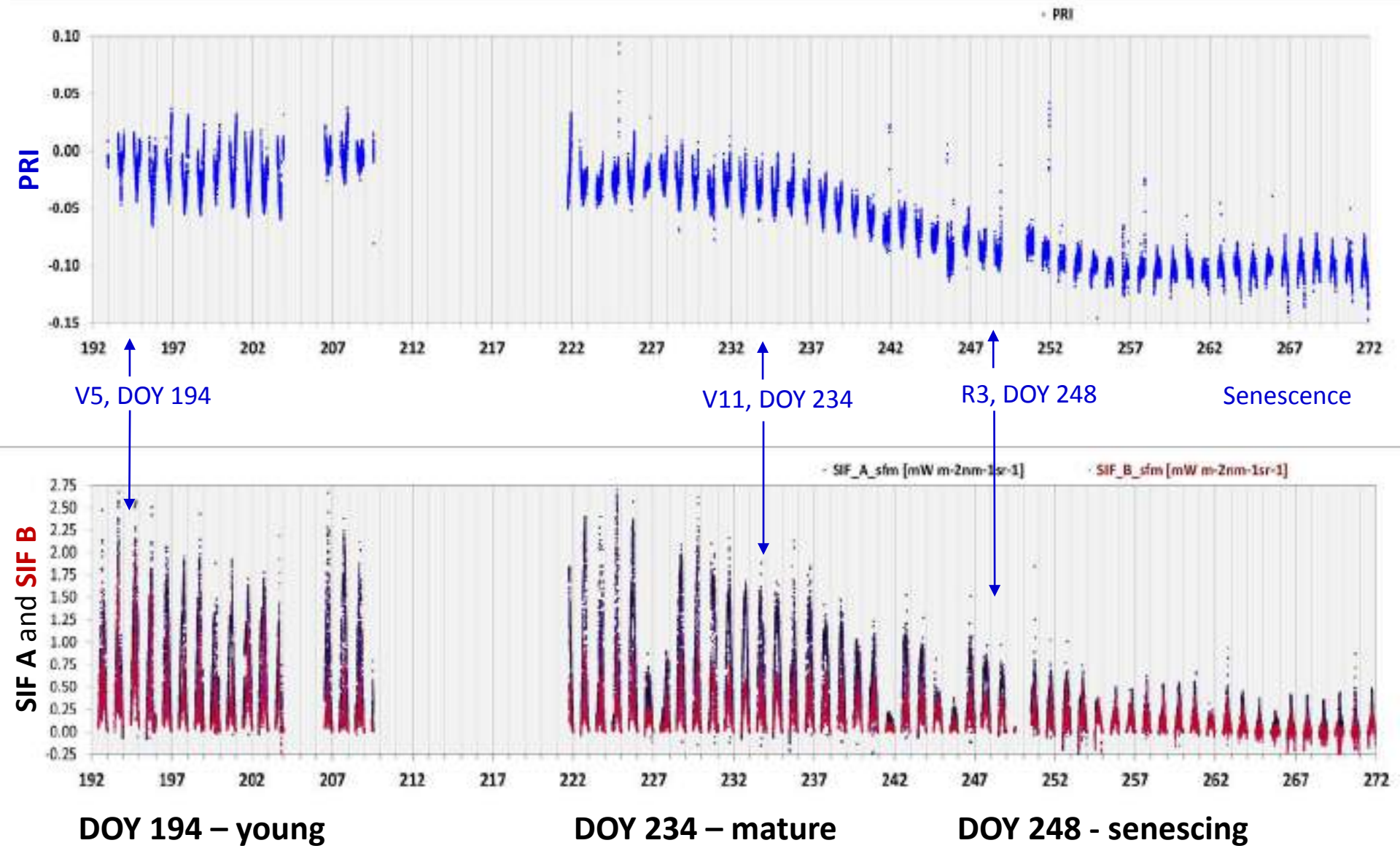
DOY 194 – young

DOY 234 – mature

DOY 248 - senescing

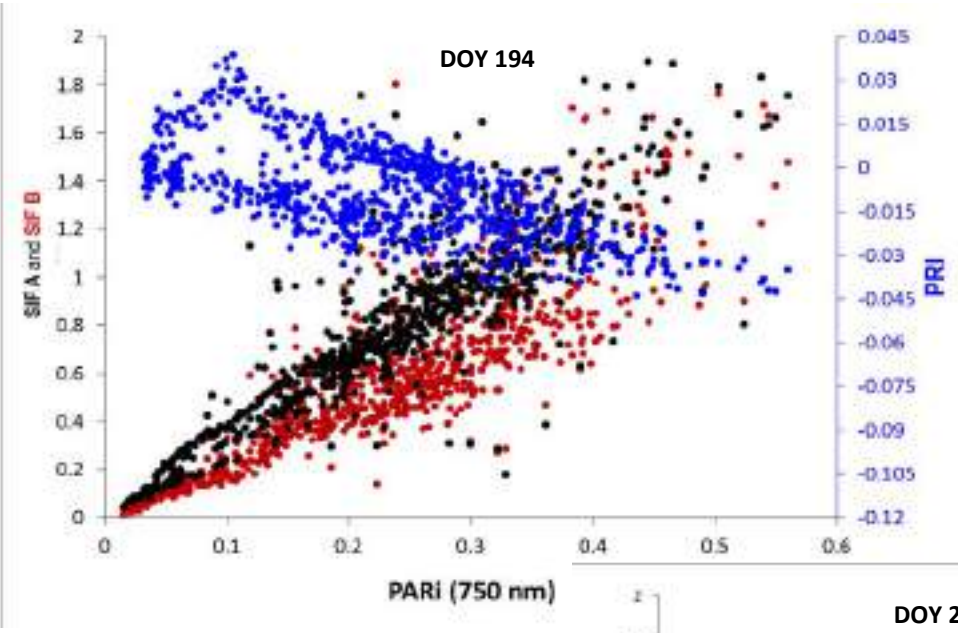
Changes in Photochemistry

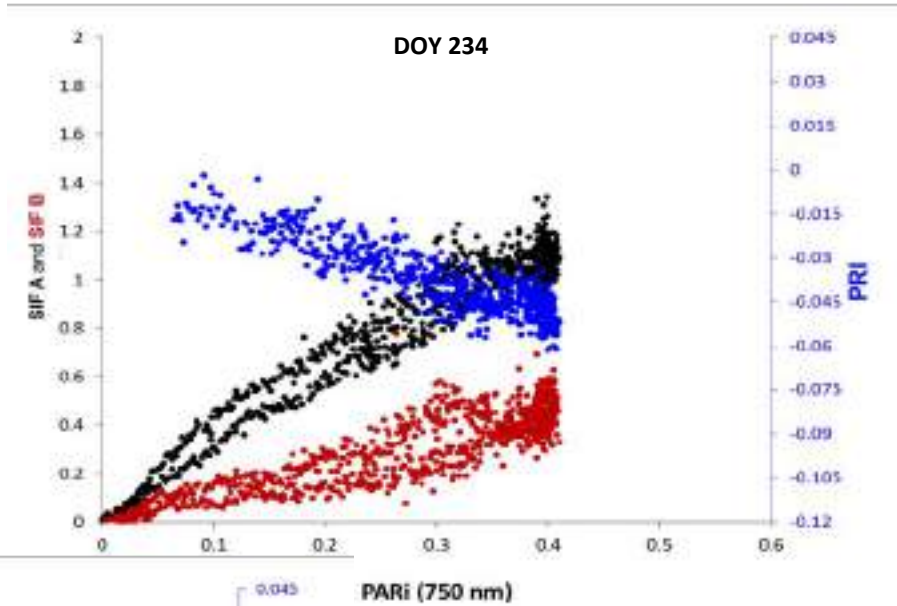
PRI and SIF, USDA/ARC, Greenbelt, MD

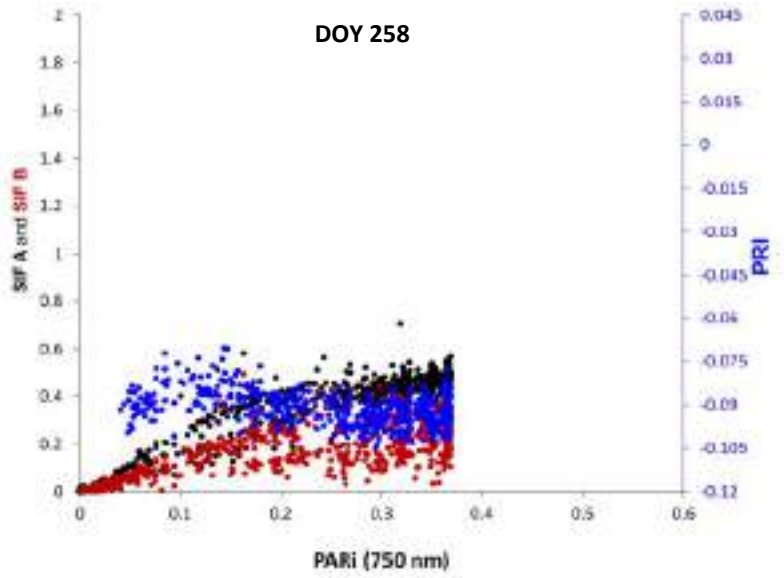


Dynamics in PRI and SIF with PAR

Corn: Young, Mature and Senescing, 2017, OPE3/USDA, MD

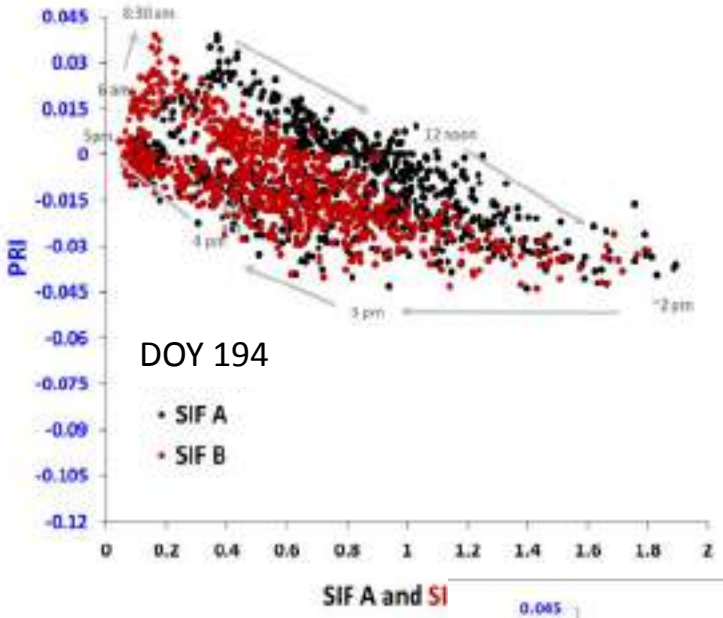


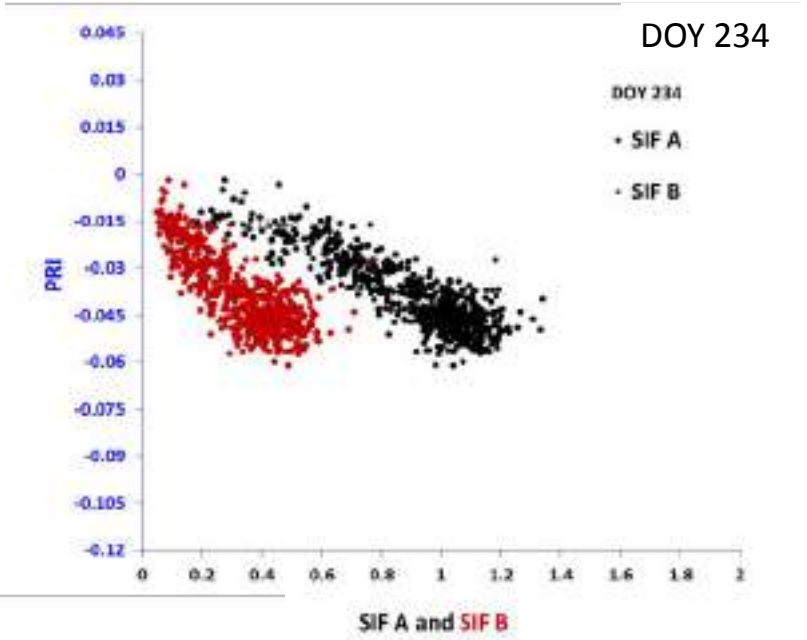


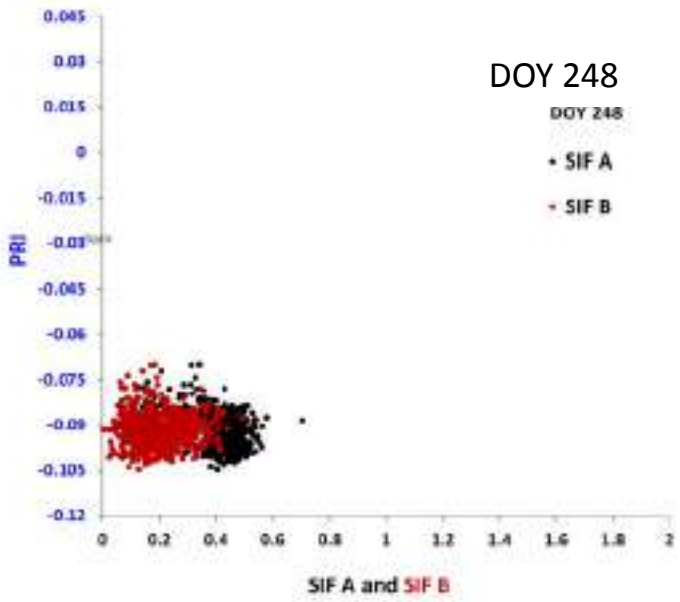


Associated Diurnal Changes in PRI and SIF

Corn: Young, Mature and Senescing, 2017, OPE3/USDA, MD



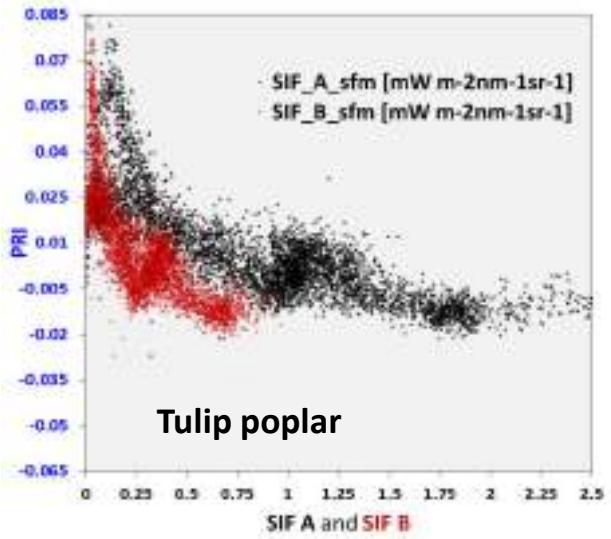




DOY 194 – young
DOY 234 – mature
DOY 248 - senescing

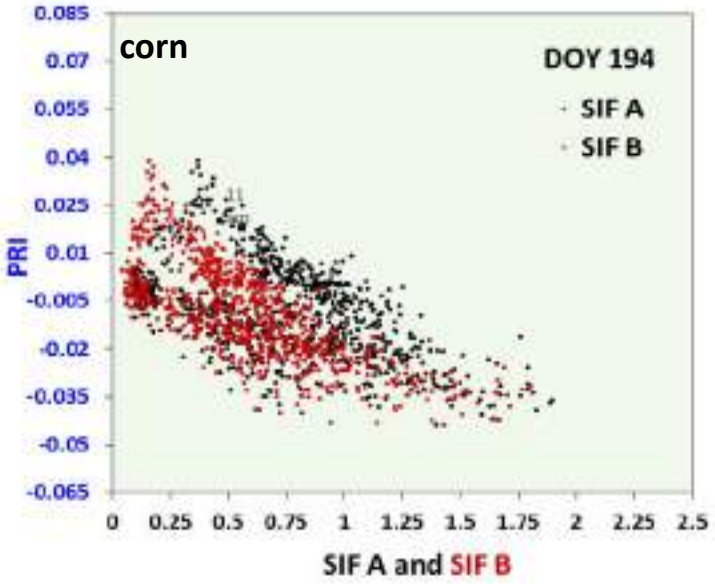
Diurnal Changes in PRI and SIF

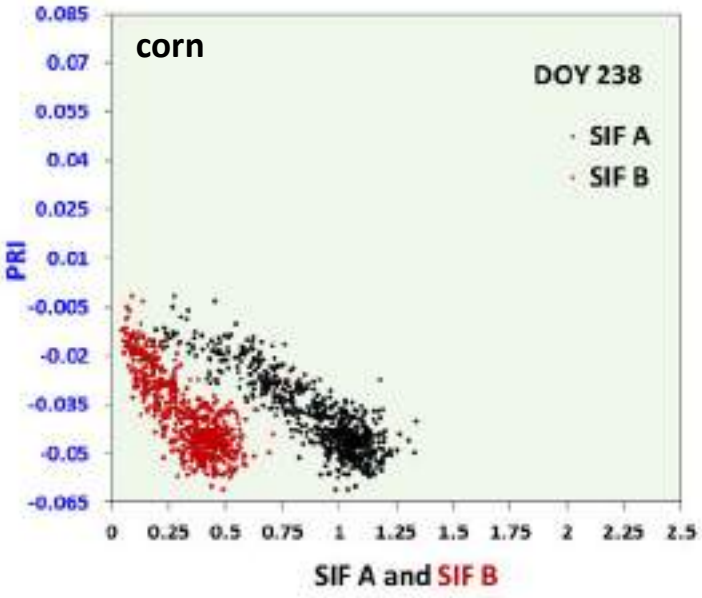
Comparing poplar (SERC) and corn (OPE3/USDA)



In perspective:

- *hysteresis observed for mid-season poplar and younger corn*
- *differences due to chlorophyll content*
- *species differences*
- *canopy and light differ*

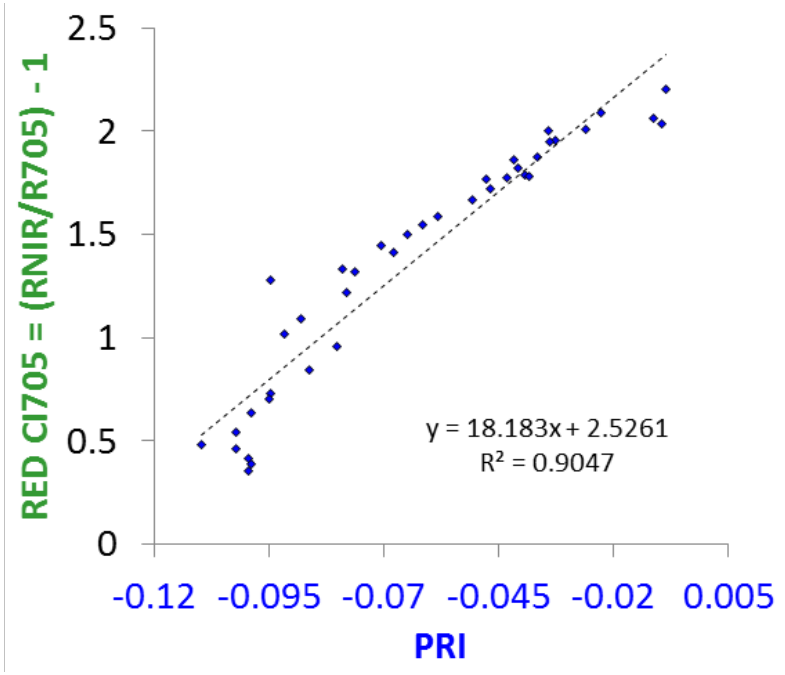


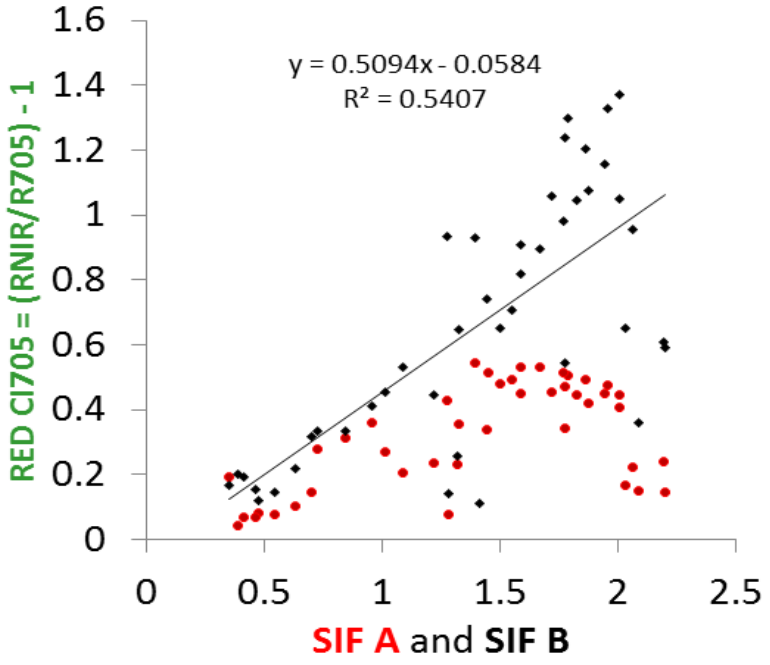


Considering the 'BIG' Drivers of Variation

Drivers of variation, in addition to metabolic changes with phenology:

- Variation in PAR – considered with going to yield
- Changes with Chlorophyll content

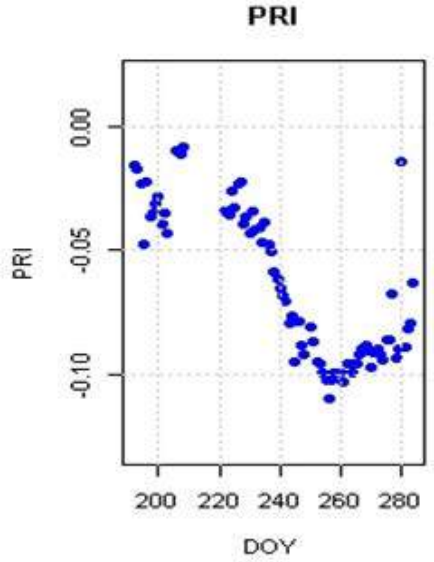


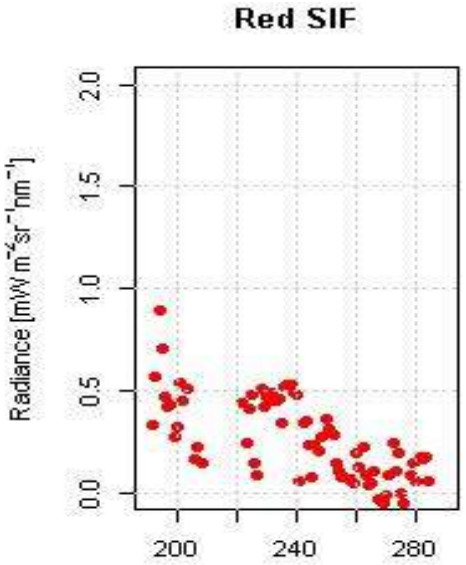


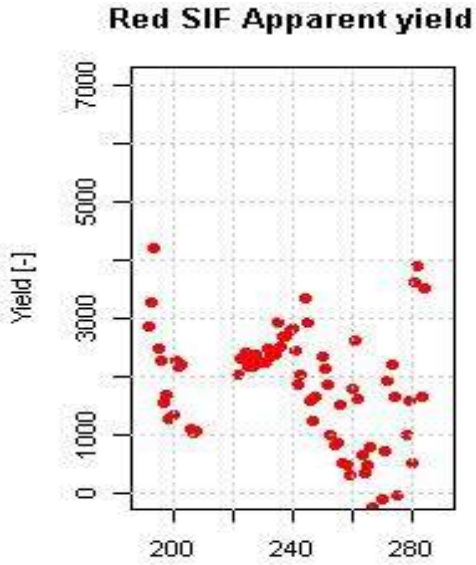
Gitelson et al 2017 (*Multiple drivers of seasonal change in PRI… at leaf and canopy levels*)

Mid-day Means in VIs and SIF (noon, 1 hour)

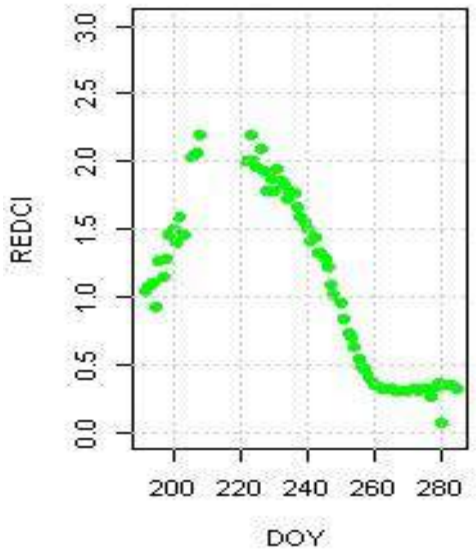
2017 Season, Corn, OPE3, USDA/ARC, Greenbelt, MD

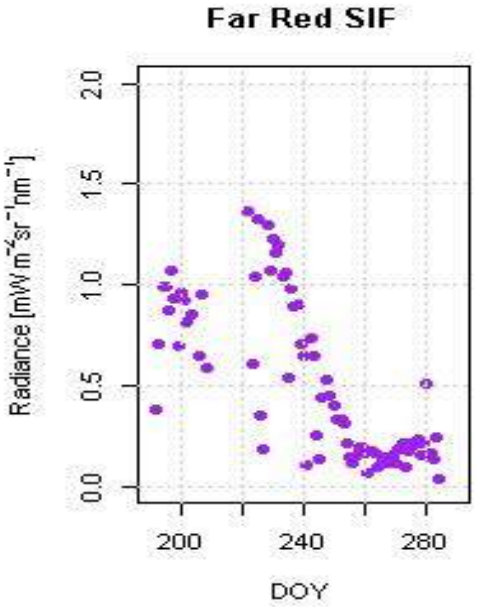


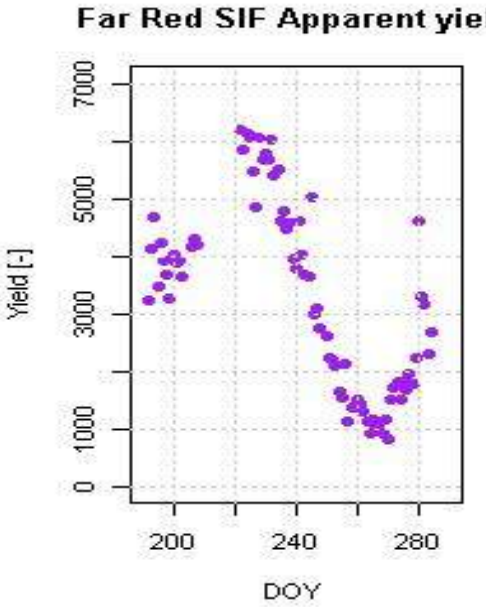




RED CI_{750}



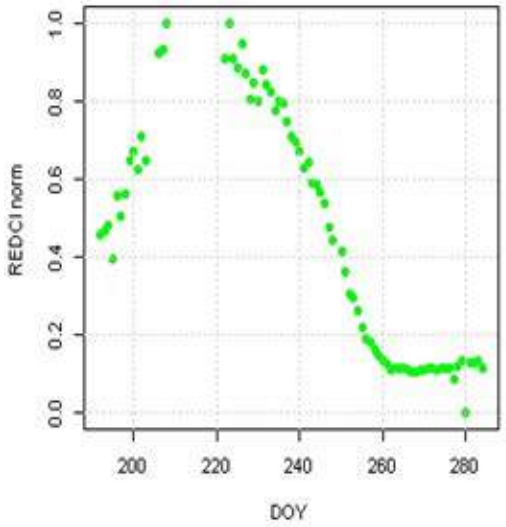




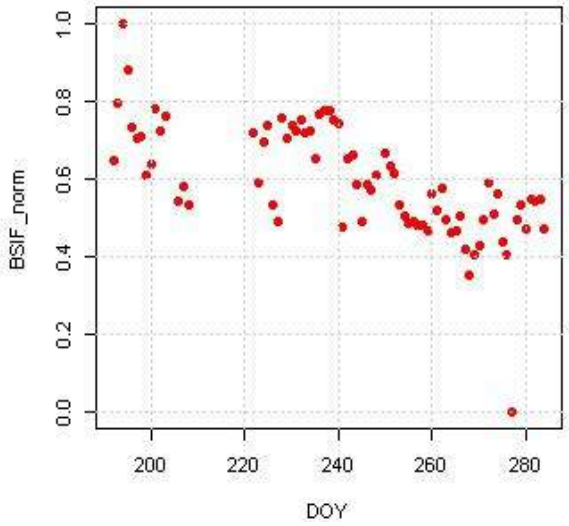
Mid-day Scaled/Normalized (0-1) in VIs and SIF

Corn 2017 Season, OPE3 USDA/ARC, Greenbelt, MD

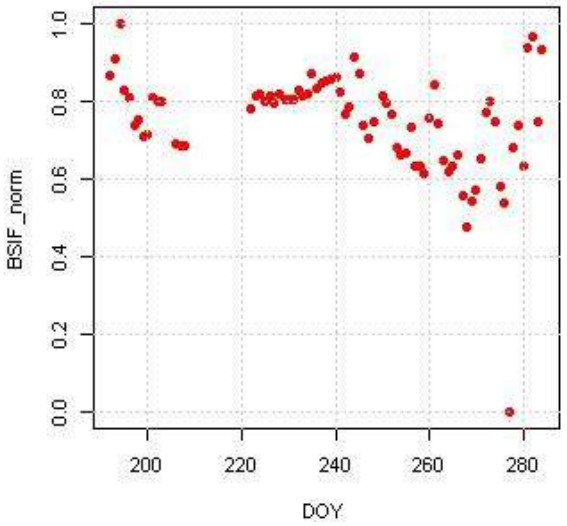
RED CI_{750}



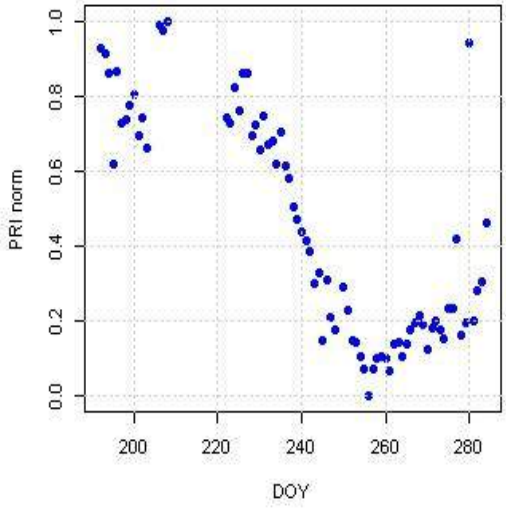
red SIF norm



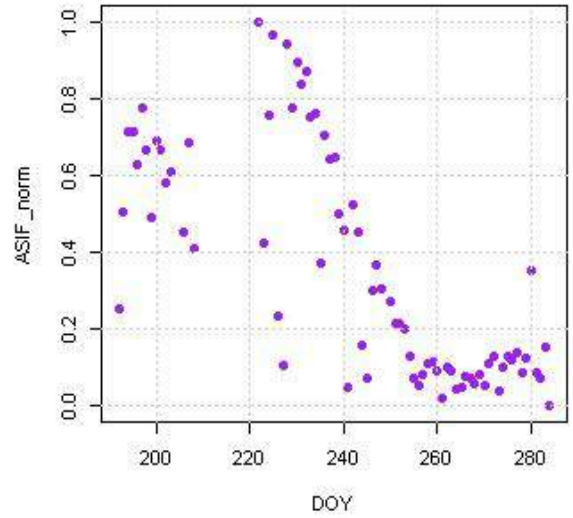
red SIF app yield norm



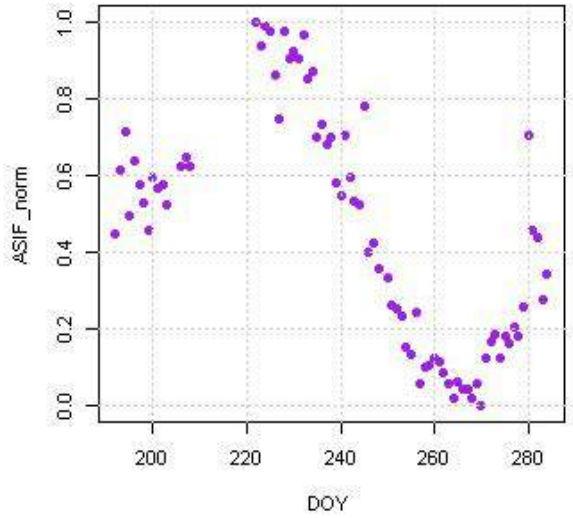
PRI normalized



Far red SIF norm



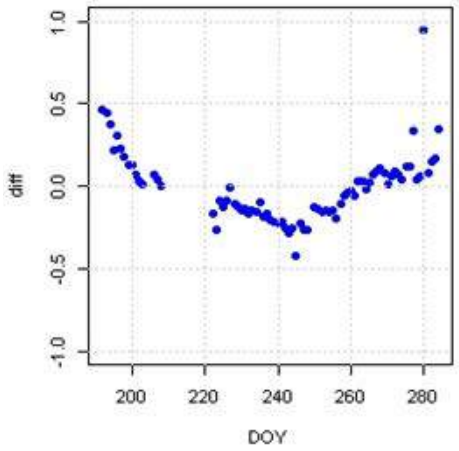
far red SIF app yield norm



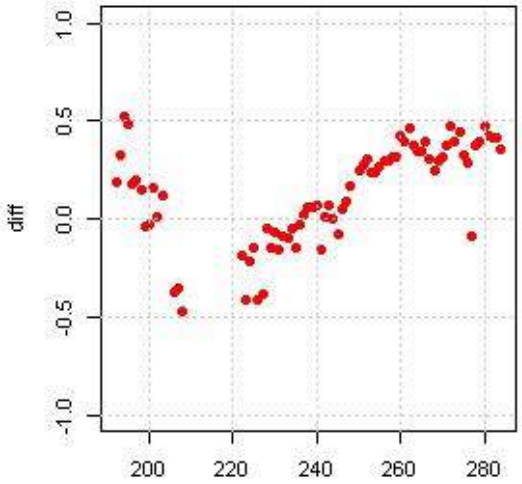
Mid-day Chl-removed PRI and SIF

Corn 2017 Season, OPE3 USDA/ARC, Greenbelt, MD

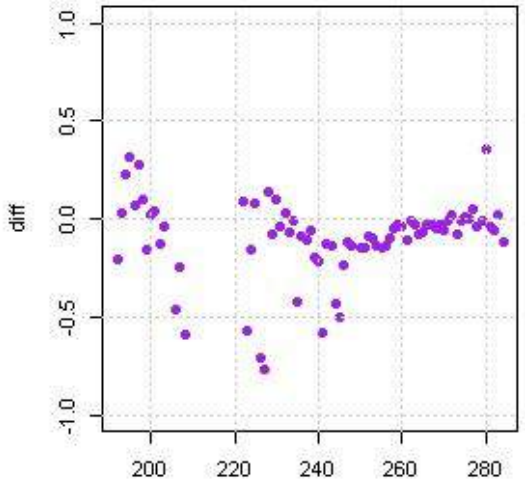
PRI - RED CI_{750}



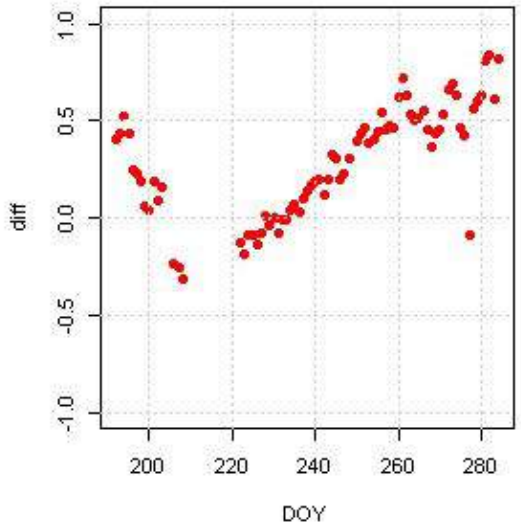
Red SIF - RED CI_{750}



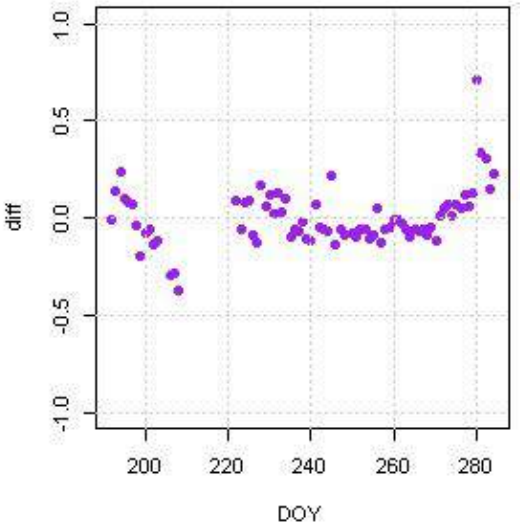
FAR-Red SIF - RED CI_{750}



Red SIF yield - RED CI_{750}



FAR-Red SIF yield - RED CI_{750}



Conclusion

Thank You!

OPTI ISE

- **In summary – preliminary findings from our first season using FLoX**
  - Mid-growing season diurnal dynamics in photochemical reflectance index (PRI) and SIF (SIF A and SIF B) for corn and tulip poplar display histeresis with diferent pathens and diferent magnitudes
  - For corn, the diurnal trends in PRI and emitted SIF changed with growth stage and phenology
  - Oltimately, we would like to trace the changes in photosynthetic function with phenology and not chlorophyll content, which efects can be domeneering and can obscure the relationships of PRI and SIF to GPP

- **Looking forward to**
  - evaluating PRI and SIF in relation to
    - ✓ photosynthetic function at canopy and leaf level - GPP and LUE (OPE3 and NEON, flux tower data)
    - ✓ independent leaf and canopy measurements of photosynthetic efficiency and SIF, so we can better understand the driving factors
  - incorporate into modeling framework (SCOPE) the leaf and canopy measurements to facilitate interpretation, comparisons and scaling

Collaboration, to compare diurnal and seasonal collections (FLoX and other systems) at different sites, conditions, species, to test approaches to account for the key differences.

Thank You!

БЛАГОДАРЯ ☺