Evaluating Crop Productivity using Solar Induced Chlorophyll Fluorescence into the weeds...
Outline

- Ground-based study in Iowa (Troy’s poster #26)
- SCOPE modeling (Dutta et al, BG 2019 and new paper in prep)
- TROPOMI, a new era in satellite SIF and its potential for agriculture (Liyin, poster #81)
- 2019 Midwest crop anomaly, an ideal natural experiment (in prep)?
Uplooking PhotoSpec (solar diffusor)

Disk Integrated Solar Irradiance Spectrum; modeled TOA and measured TOC

- Modeled solar TOA 0.35nm
- Modeled solar TOA 3.5nm
- Flame (3nm)
- QE Pro Far Red (0.3nm)
- QE Pro Red (0.3nm)
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Disk Integrated Solar Irradiance Spectrum; modeled TOA and measured TOC
Downlooking PhotoSpec (reflected radiance)

Reflected Radiance from canopy

- Flame (3nm)
- QE Pro Far Red (0.3nm)
- QE Pro Red (0.3nm)
- Measured $F_m$ spectrum at leaf (*30)
Reflected Radiance from canopy

- Flame (3nm)
- QE Pro Far Red (0.3nm)
- QE Pro Red (0.3nm)
- Measured $F_m$ spectrum at leaf (×30)

Radiance (W/m²/µm/sr) vs. wavelength (nm)

- 660
- 680
- 700
- 720
- 740
- 760
- 780
Downlooking PhotoSpec - ZOOM

Reflected Radiance from canopy

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- QE Pro Red (0.3nm)
- Measured Fm spectrum at leaf (*30)

Radiance (W/m²/µm/sr)

wavelength (nm)
Reflected Radiance from canopy

- Flame (3nm)
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Radiance (W/m²/µm/sr)

wavelength (nm)
Apparent Reflectance (normalized by Diffusor)
Time-Series of half-hourly GPP and SIF

**Soy (C3)**
slow rise, max<50µmol/m²/s

**Corn (C4)**
fast rise, max 70-80µmol/m²/s
SIF - GPP (more details on Troy’s poster 26)

slope steeper and more linear for C4
SCOPE modeling (Dutta et al BG 2019 + new paper in prep)

SIF is a better proxy for actual electron transport rate (which is part of the light reactions, i.e. doesn’t know about photosynthetic mechanisms C3 and C4)
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\[
\frac{J_a}{SIF} \propto \frac{\Phi_{PSII}}{\Phi_{SIF}}
\]

Be careful which model you use for the Yield relationships!
To the satellite scale, 95%ile of 8-Day SIF from TROPOMI
Ground-based comparison - USDA Coles fields
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Date

GPP (gC/m²/day)

Soy

Corn

daily SIF$_{740nm}$ (W/m²/sr/µm)

Ground-based comparison - USDA Coles fields

Date

0
5
10
15
20
25

GPP (gC/m²/day)

0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

740 nm (W/m²/sr/µm)

Soy
Corn
1.4* MPI GPP

daily SIF$_{740nm}$ (W/m²/sr/µm)
Ground-based comparison - USDA Coles fields

Context, how long does it take to empty a 1m² vertical column or CO₂ at 400ppm with a flux of 20gC/m²/day?
Ground-based comparison - USDA Coles fields

![Graph showing GPP (gC/m²/day) and daily SIF (W/m²/sr/µm) for Soy, Corn, 1.4* MPI GPP, 70% Corn, 30%Soy and TROPOMI Mean Iowa across dates from 2018-05 to 2018-10.]
USDA-NASS crop yield comparison for 2018
see Liyin He’s poster #81 for details
Crop yield vs SIF average
see Liyin He’s poster #81 for details
The 2019 anomaly, an ideal natural experiment?
Take home messages…

• More interested in SIF spectral shape (omitted here)?

• Good correlation between SIF and GPP for both C3 and C4 crops, though with different slopes (as expected)

• SIF a more linear proxy for $J_a$ (ETR), a lot more work needed to better model the PSII-SIF yield relationship

• Deviations from linear relationship mostly due to change in yield ratios as well as # of electrons needed to fix carbon (dark reactions), important for crops as a lot of C4

• TROPOMI is a game change in SIF research, find excellent agreement of summer SIF with USDA crop yield statistics

• 2019 anomaly study under way, an extreme event that can be exploited to better constrain agricultural carbon uptake
Thank you!

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ftp://fluo.gps.caltech.edu/data/tropomi/
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