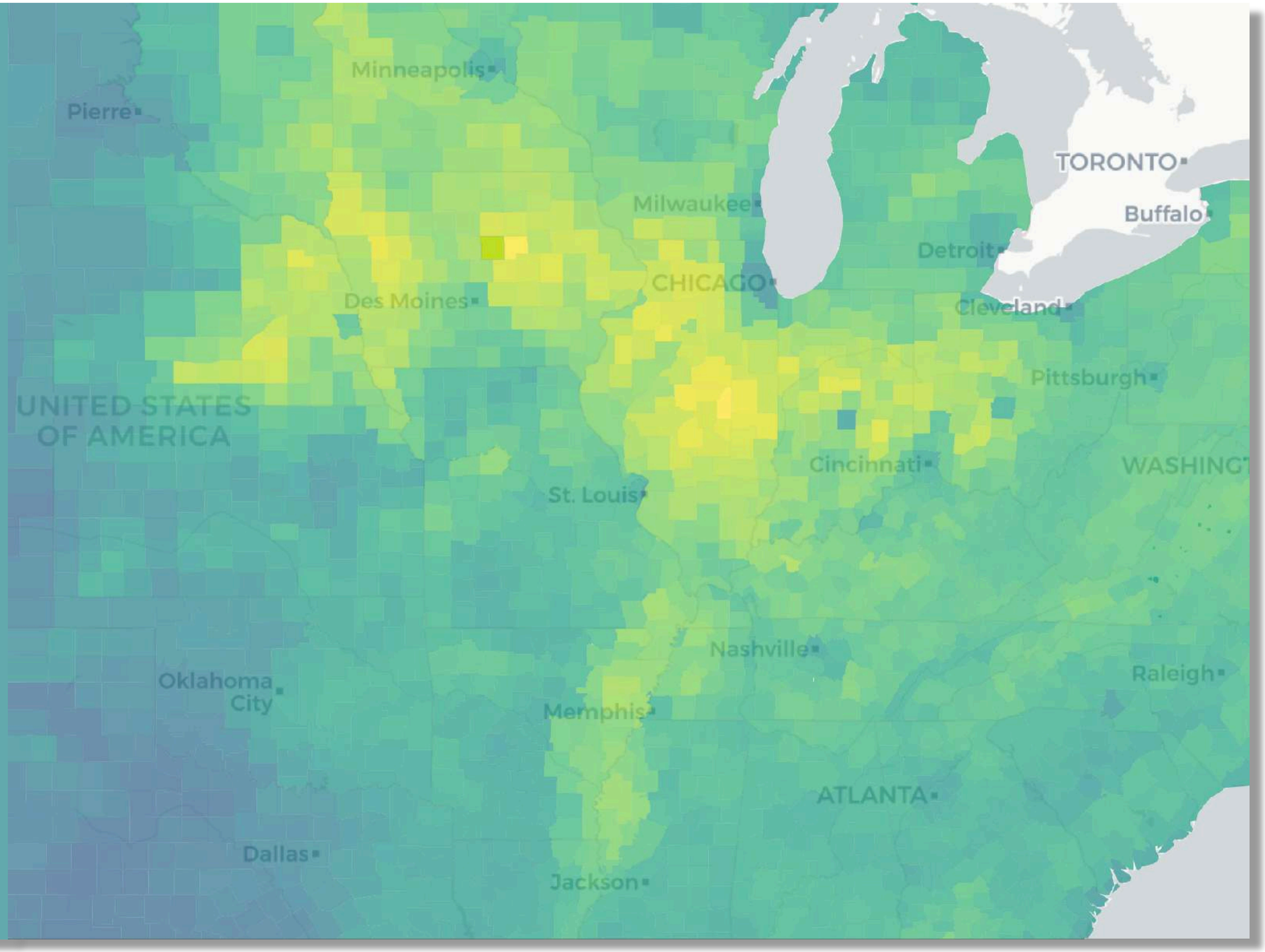
Evaluating Crop Productivity using Solar Induced Chlorophyll Fluorescence

into the weeds…

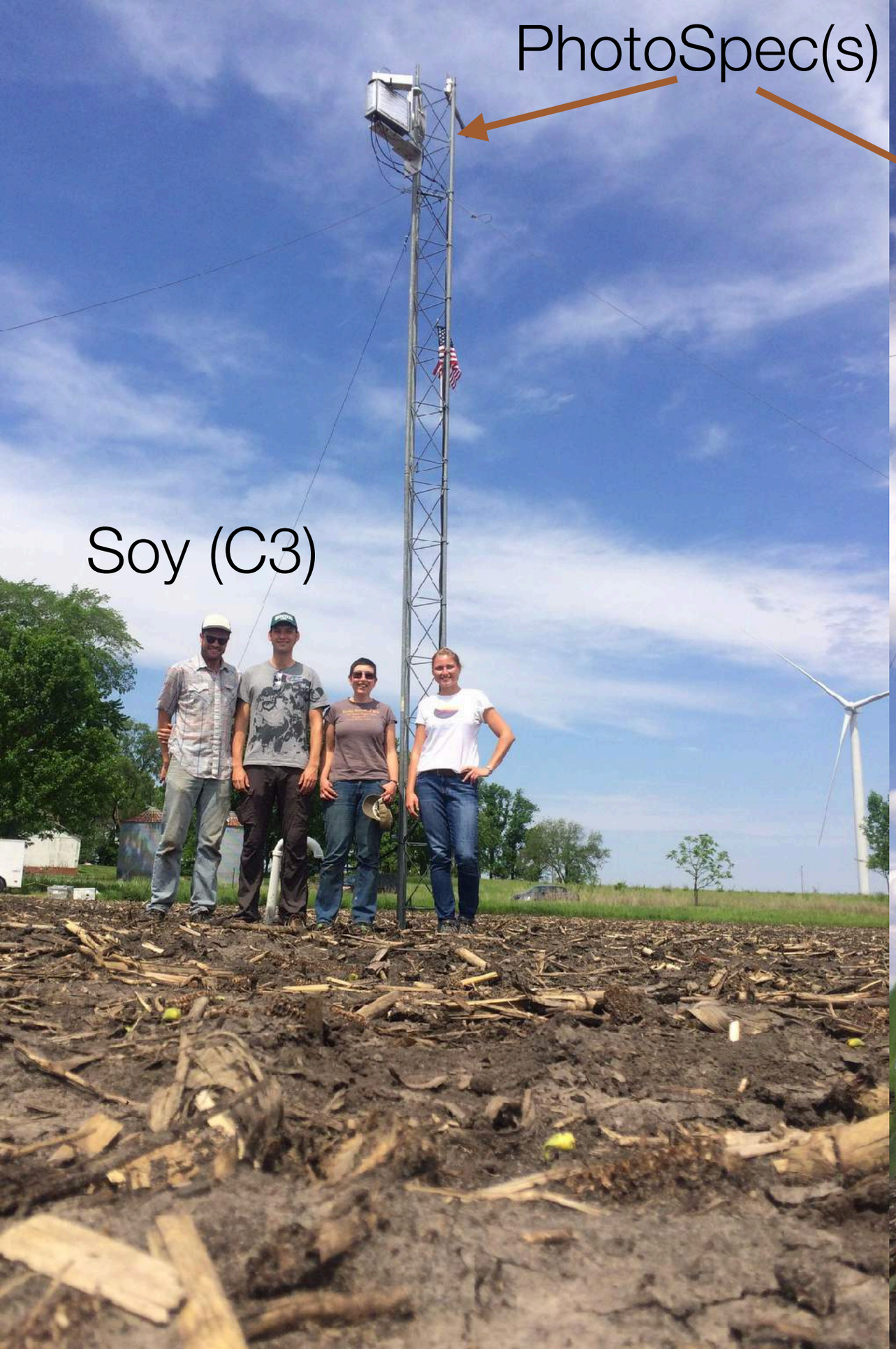


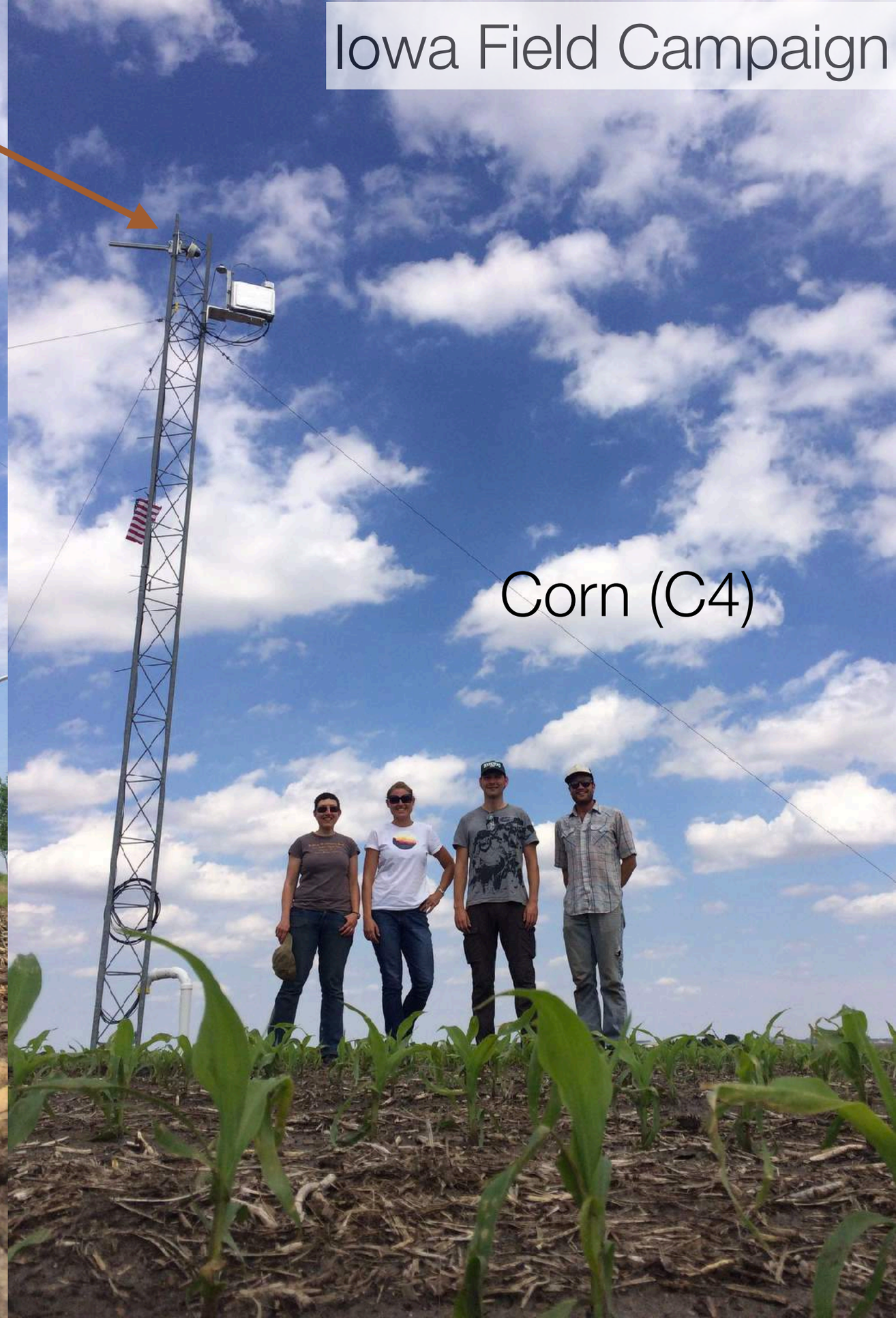
Christian Frankenberg
California Institute of Technology, Jet Propulsion Laboratory
Jochen Stutz, Katja Grossmann, Christian Dold, Jerry Hatfield, Troy Magney, Debsunder Dutta, Yi Yin, Zoe Pierrat, Kaiyu Guan, Gretchen Keppel-Aleks, Liyin He, Philipp Koehler

Outline

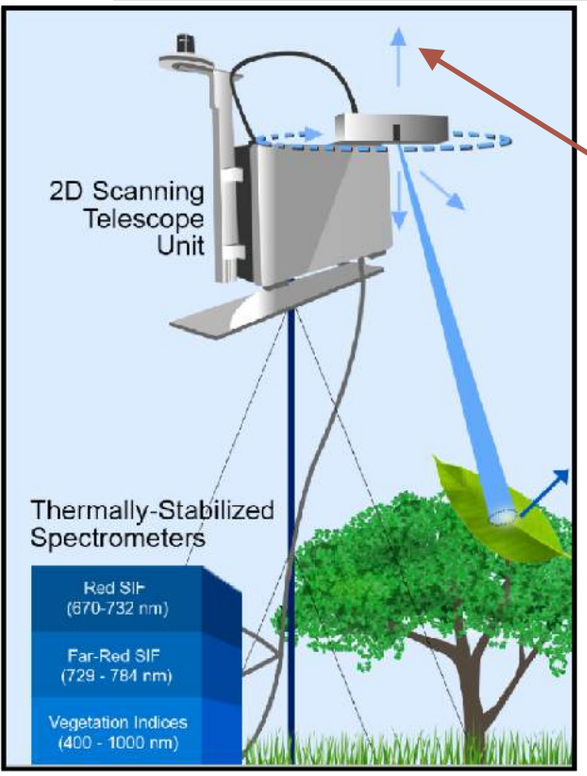
- Ground-based study in Iowa (Troy's poster #26)
- SCOPE modeling (Dutta et al, BG 2019 and new paper in prep)
- TROPOMI, a new era in satellite SIF and its potential for agriculture (Liyin, poster #81)
- 2019 Midwest crop anomaly, an ideal natural experiment (in prep)?

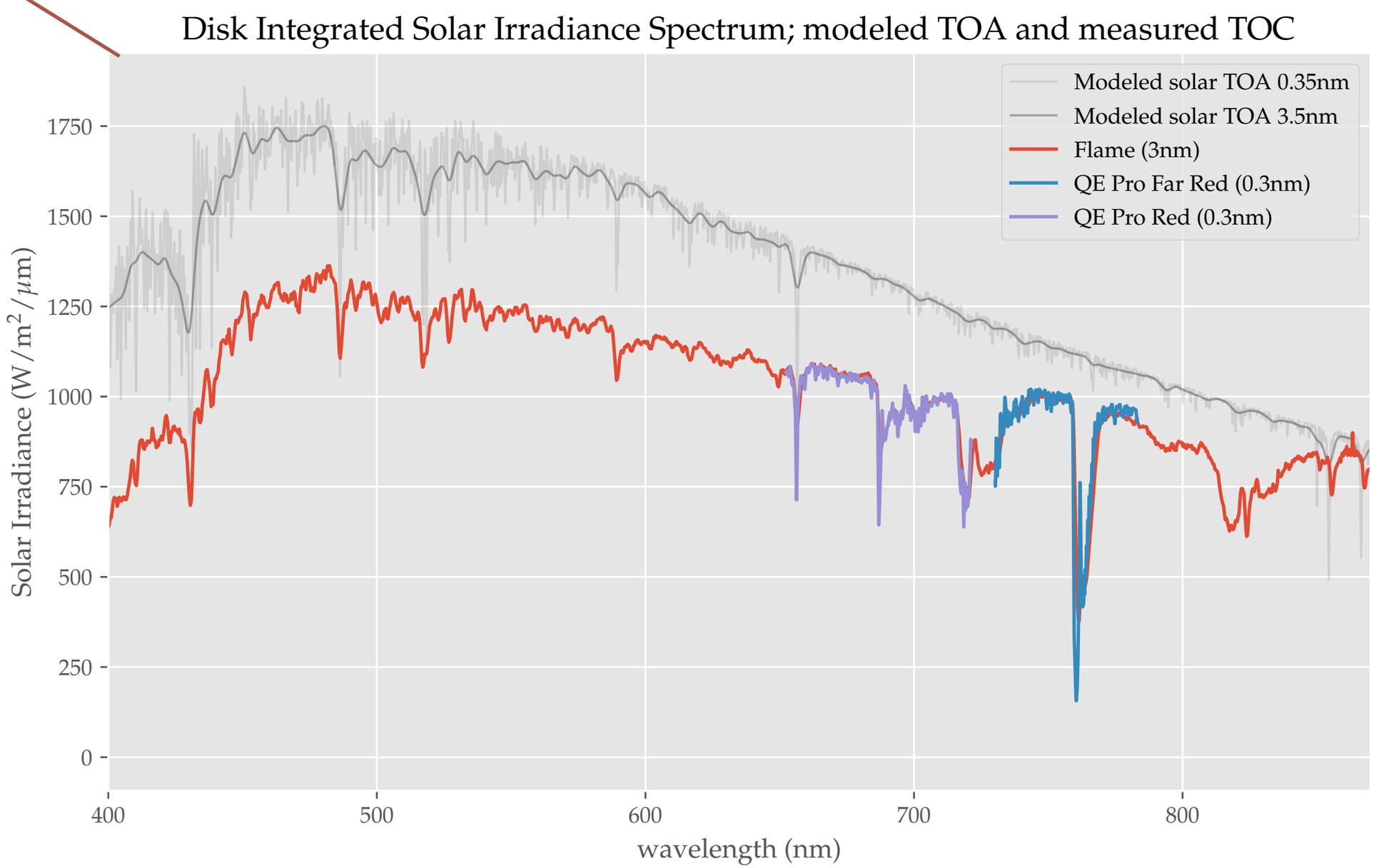
Iowa Field Campaign





Uplooking PhotoSpec (solar diffusor)





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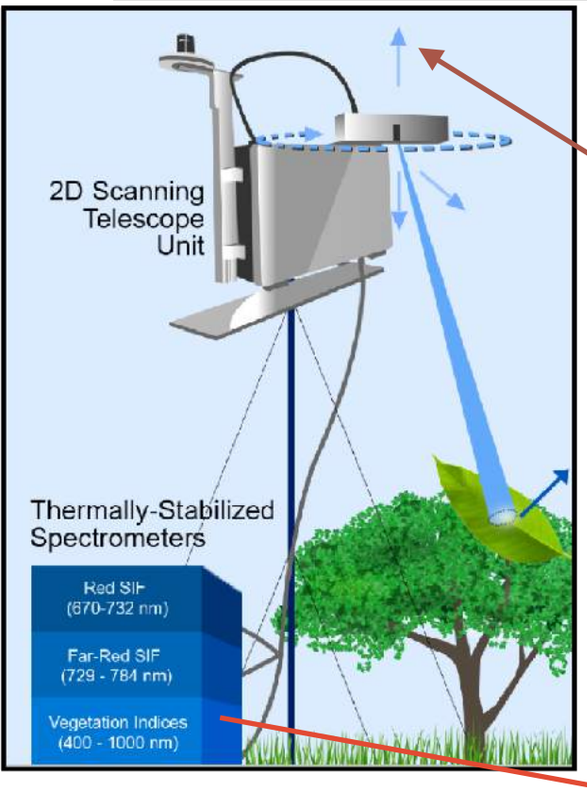

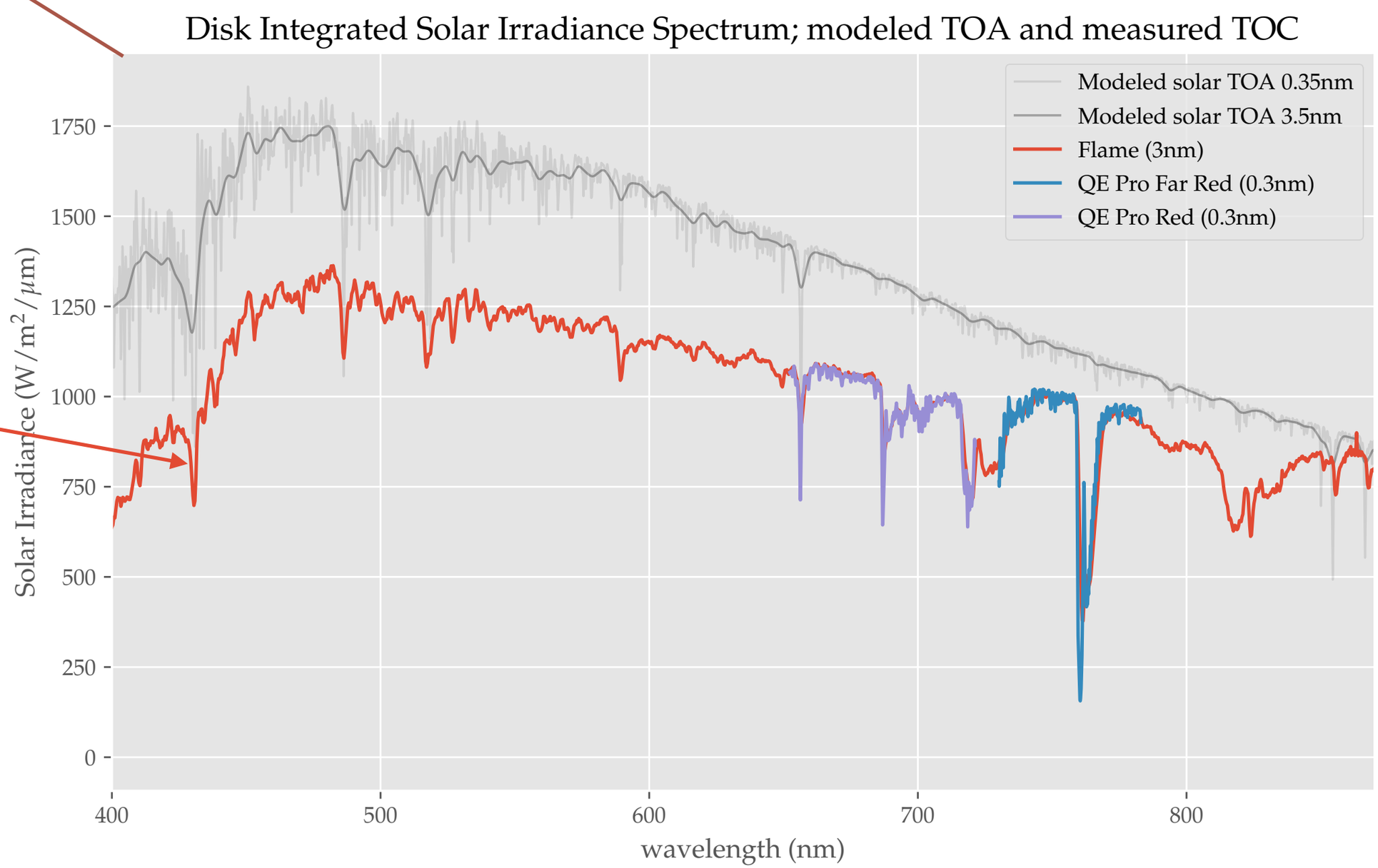

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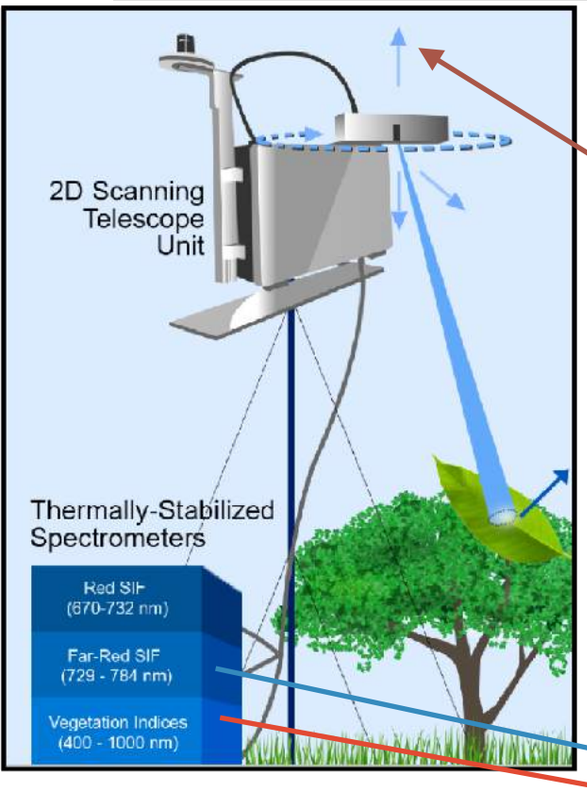

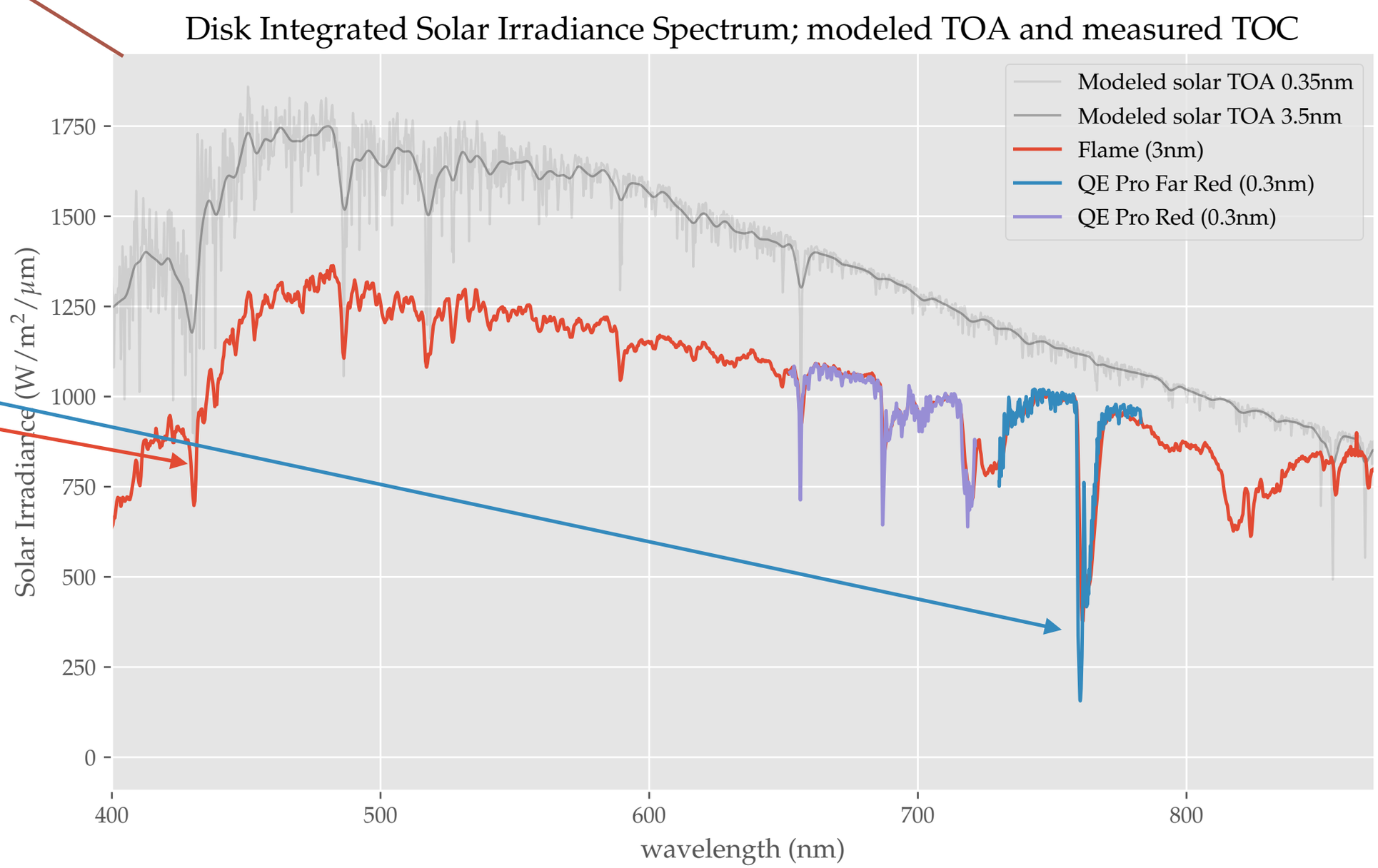

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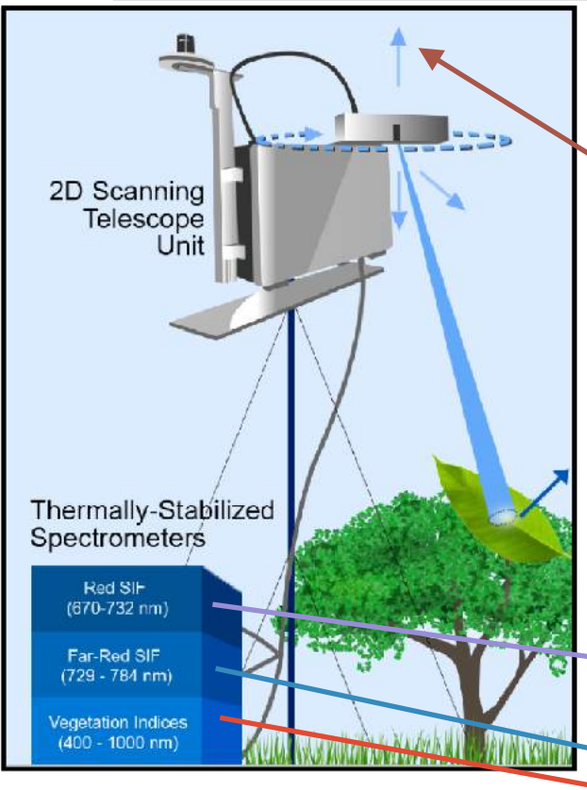

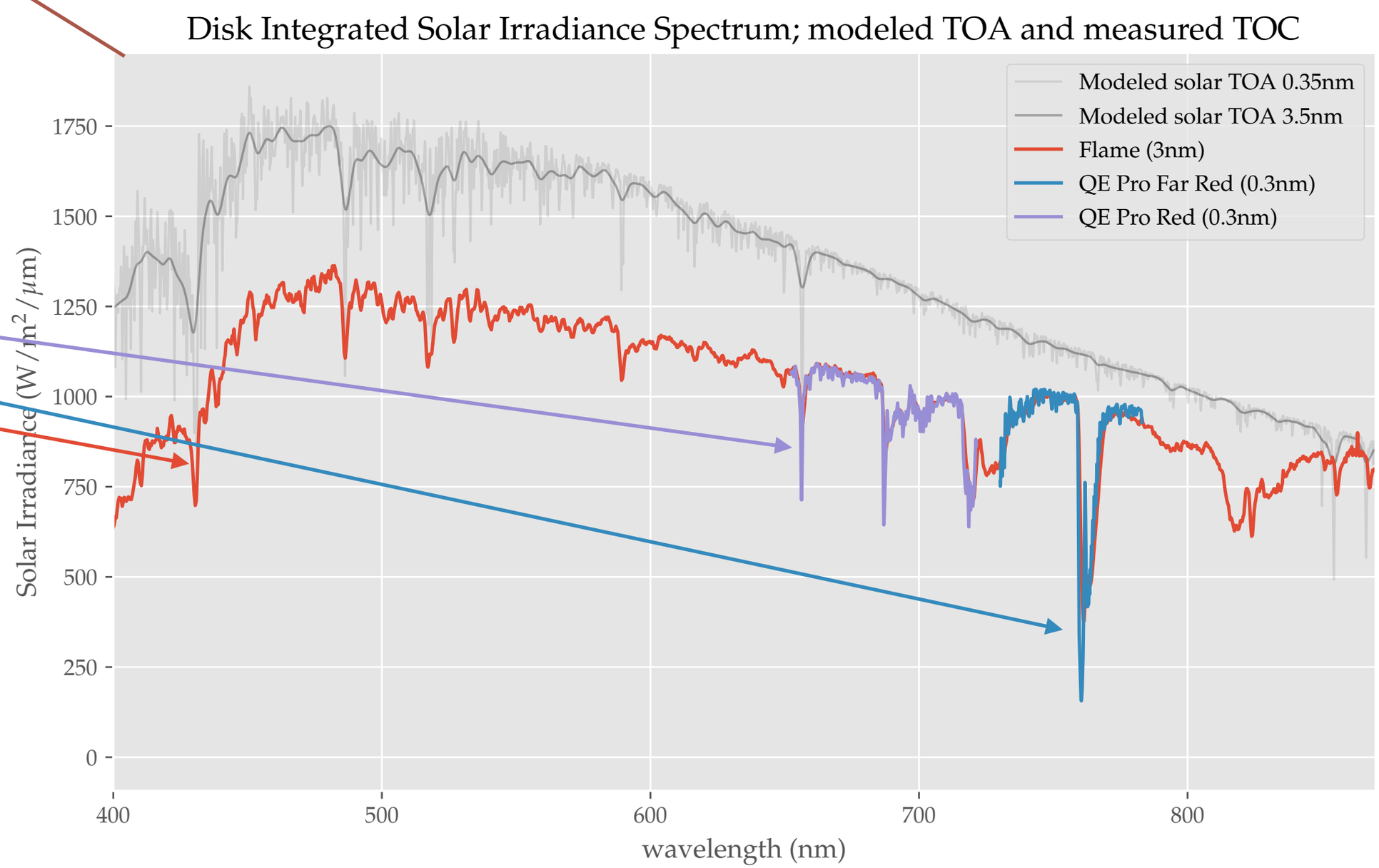

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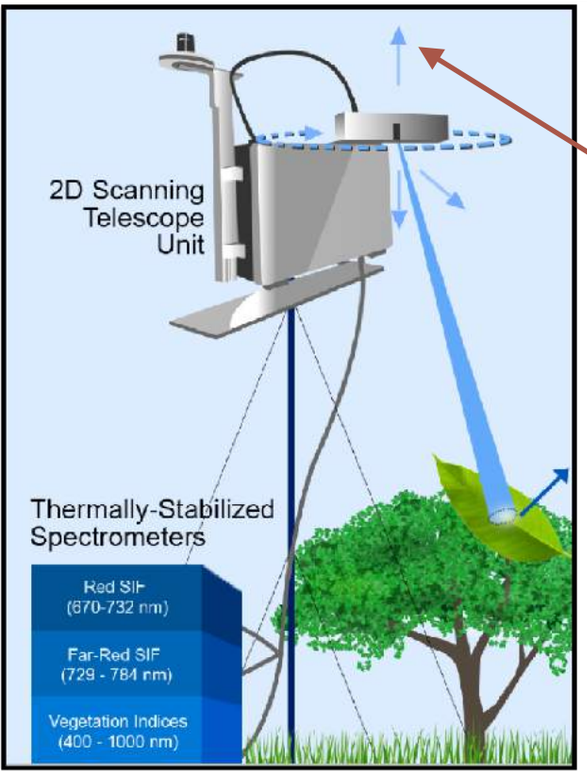
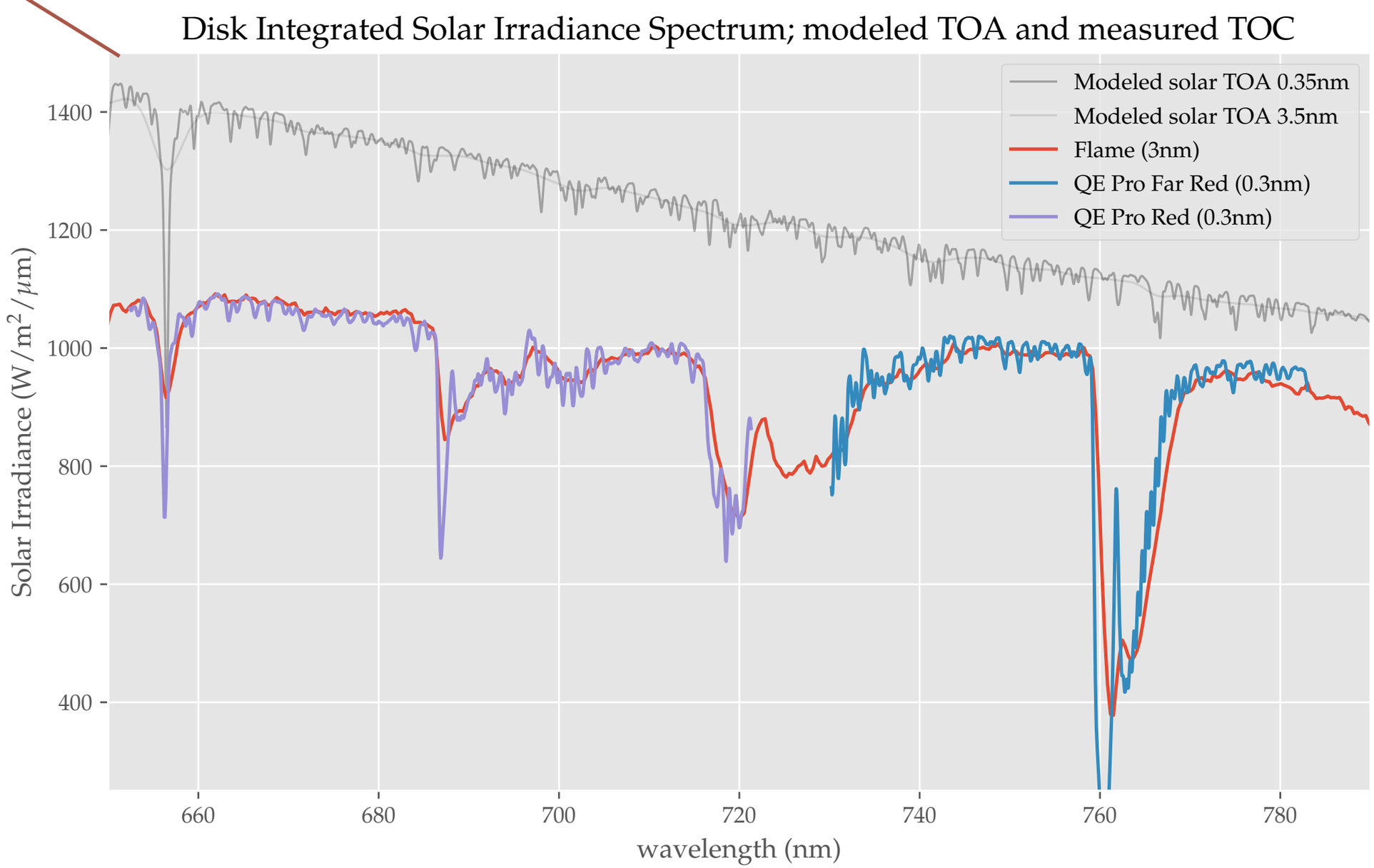
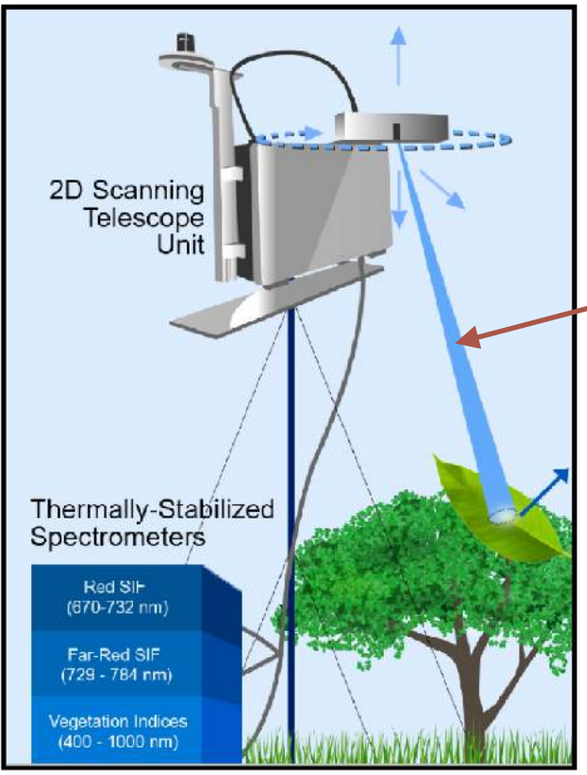
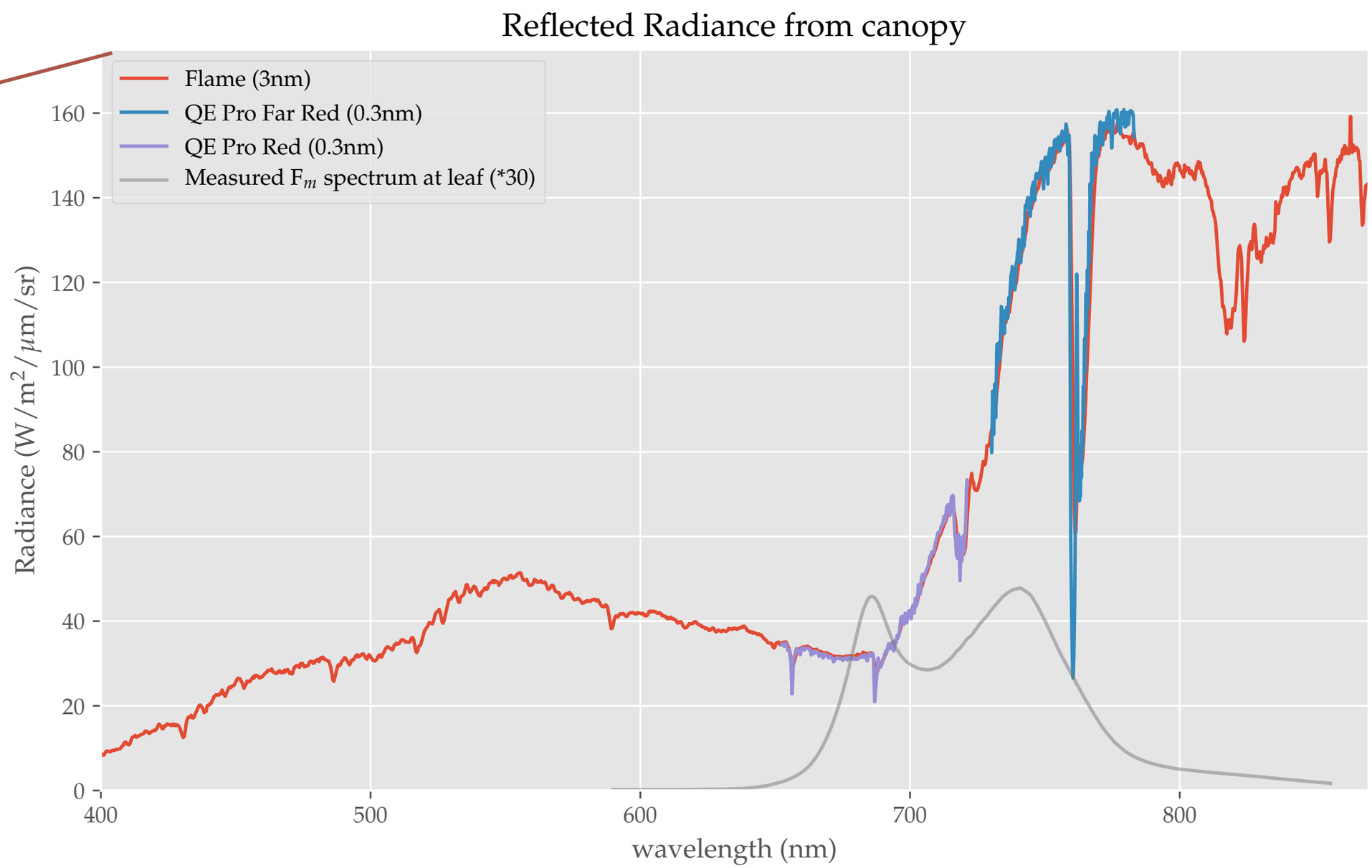


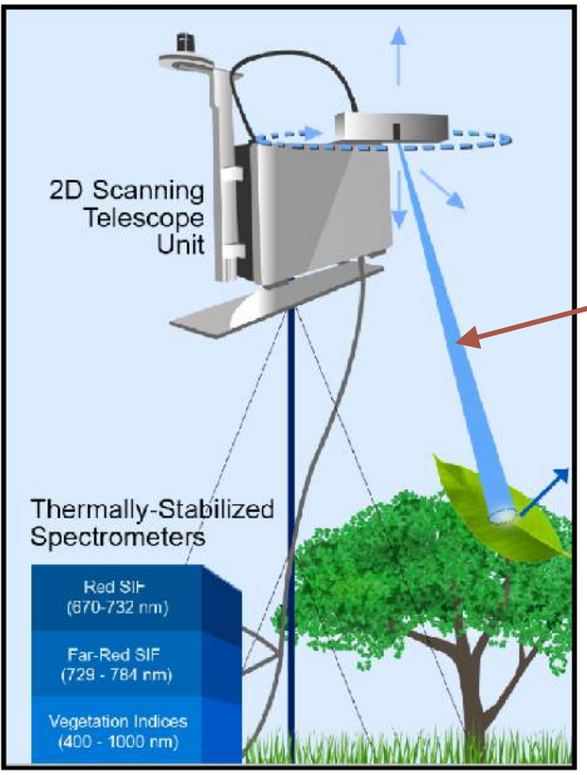


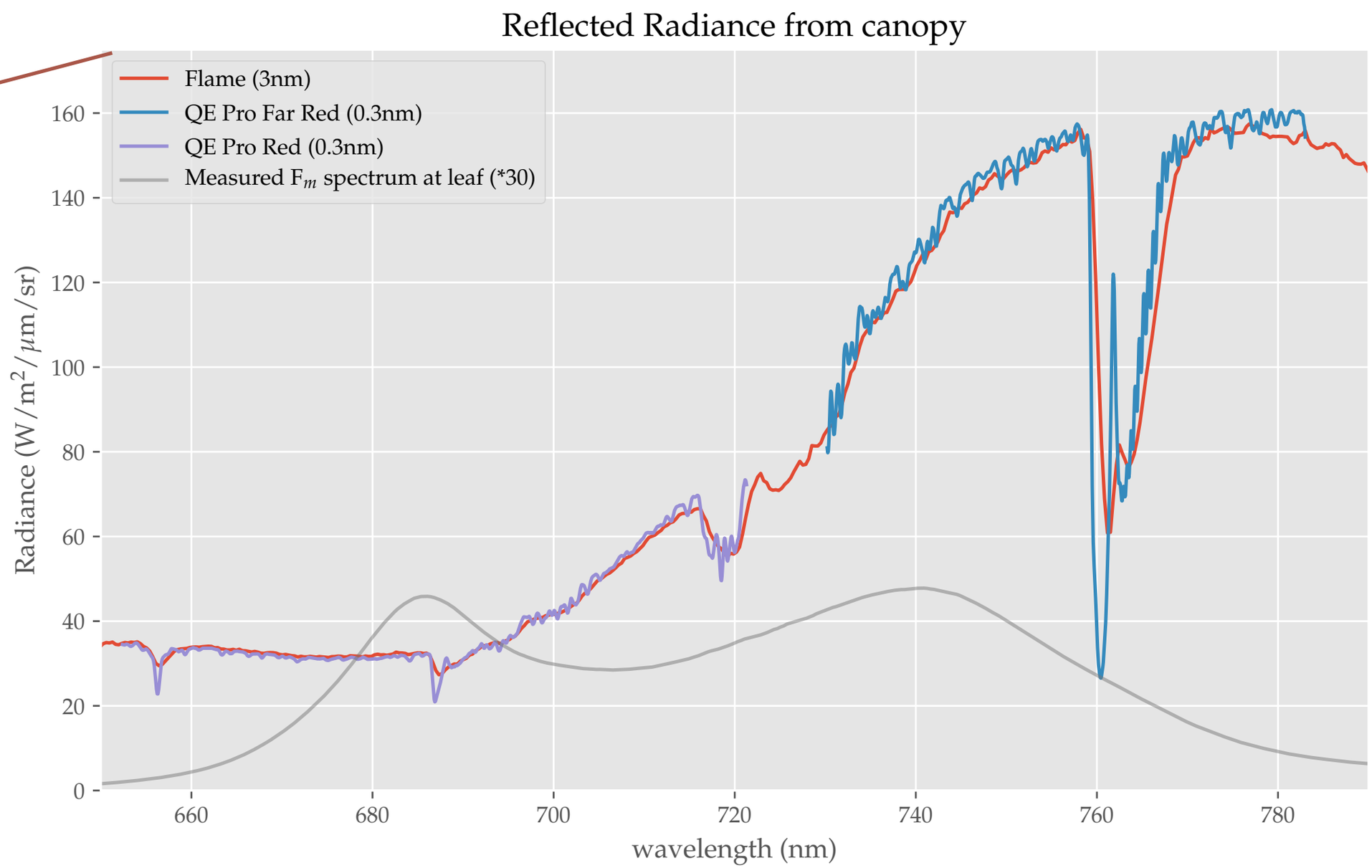
Downlooking PhotoSpec (reflected radiance)





Downlooking PhotoSpec - ZOOM





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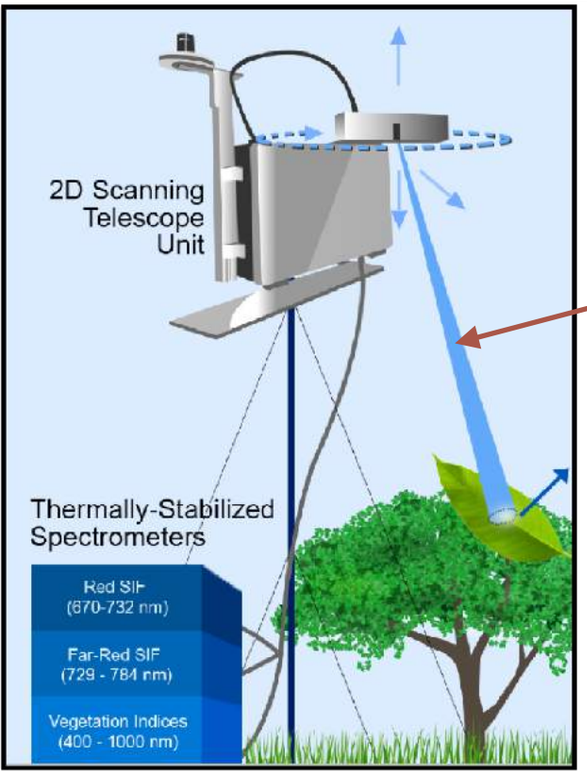

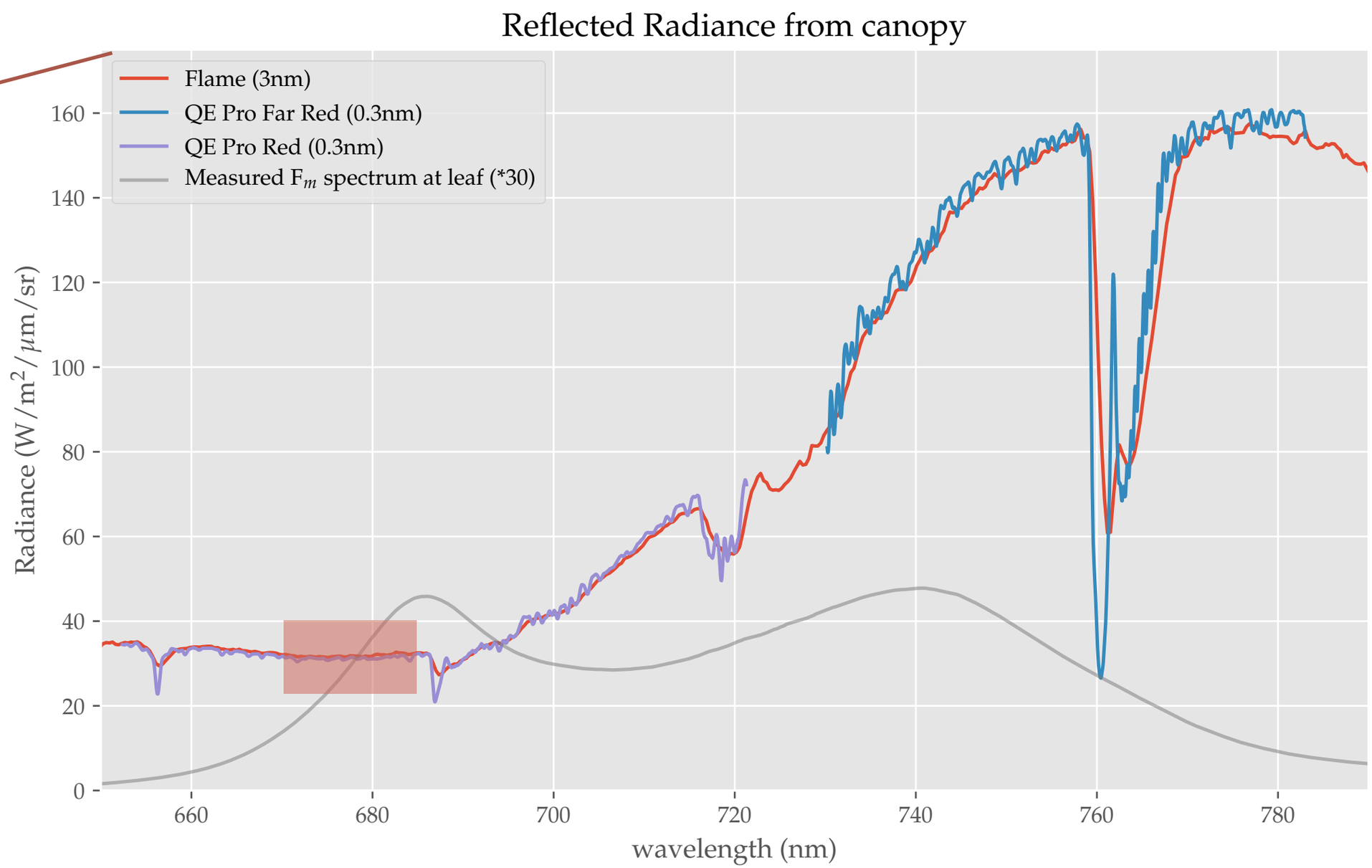

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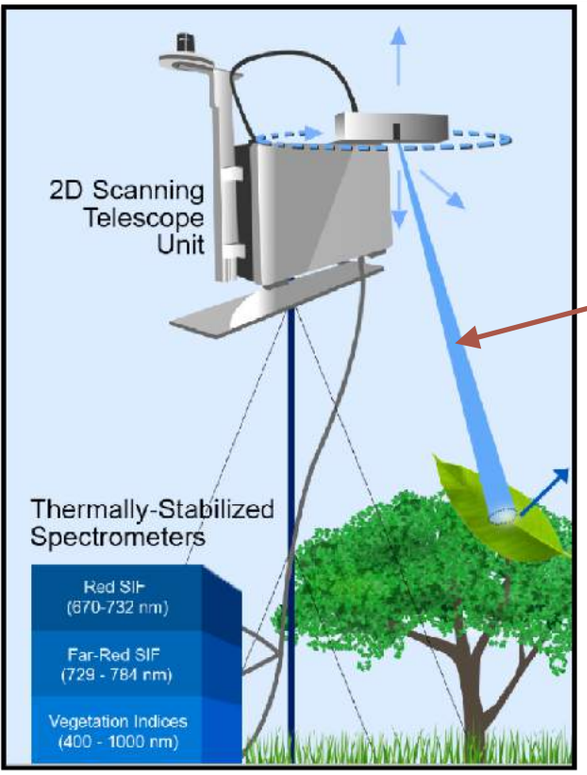
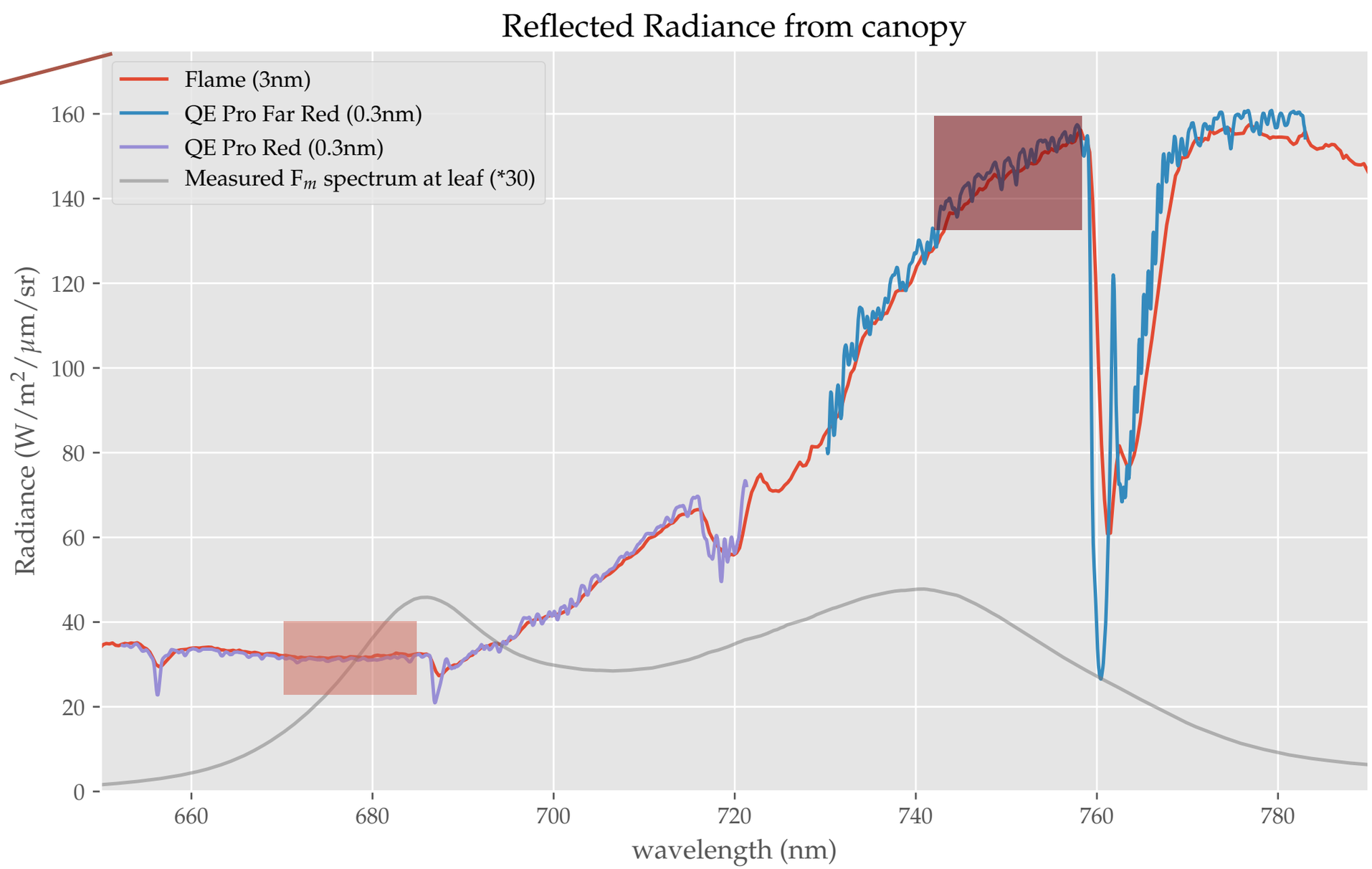
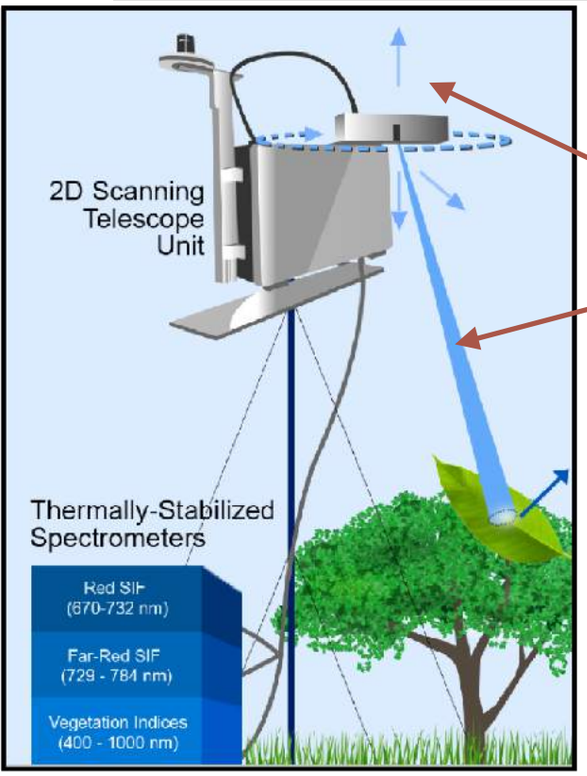
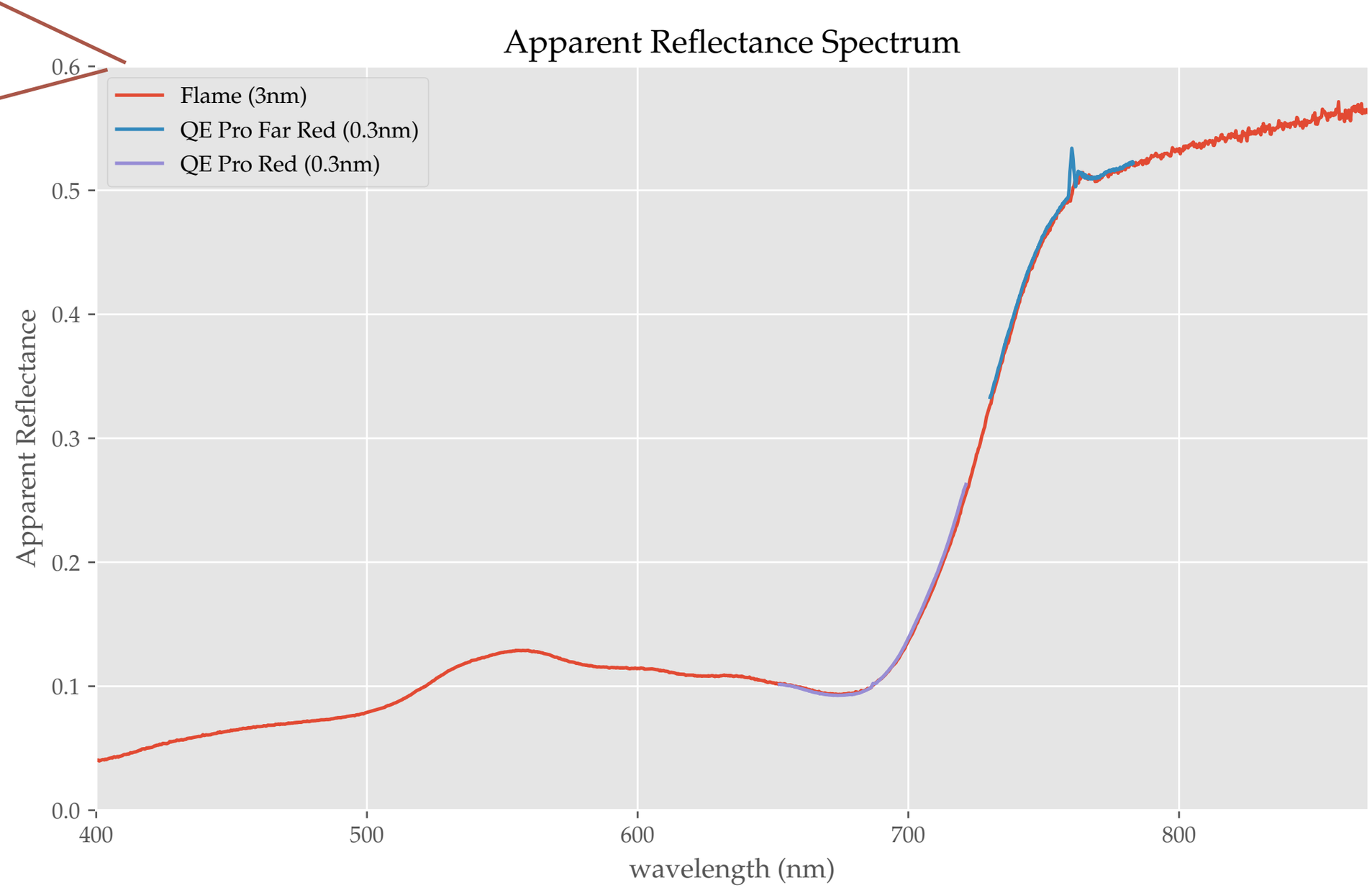




Apparent Reflectance (normalized by Diffusor)





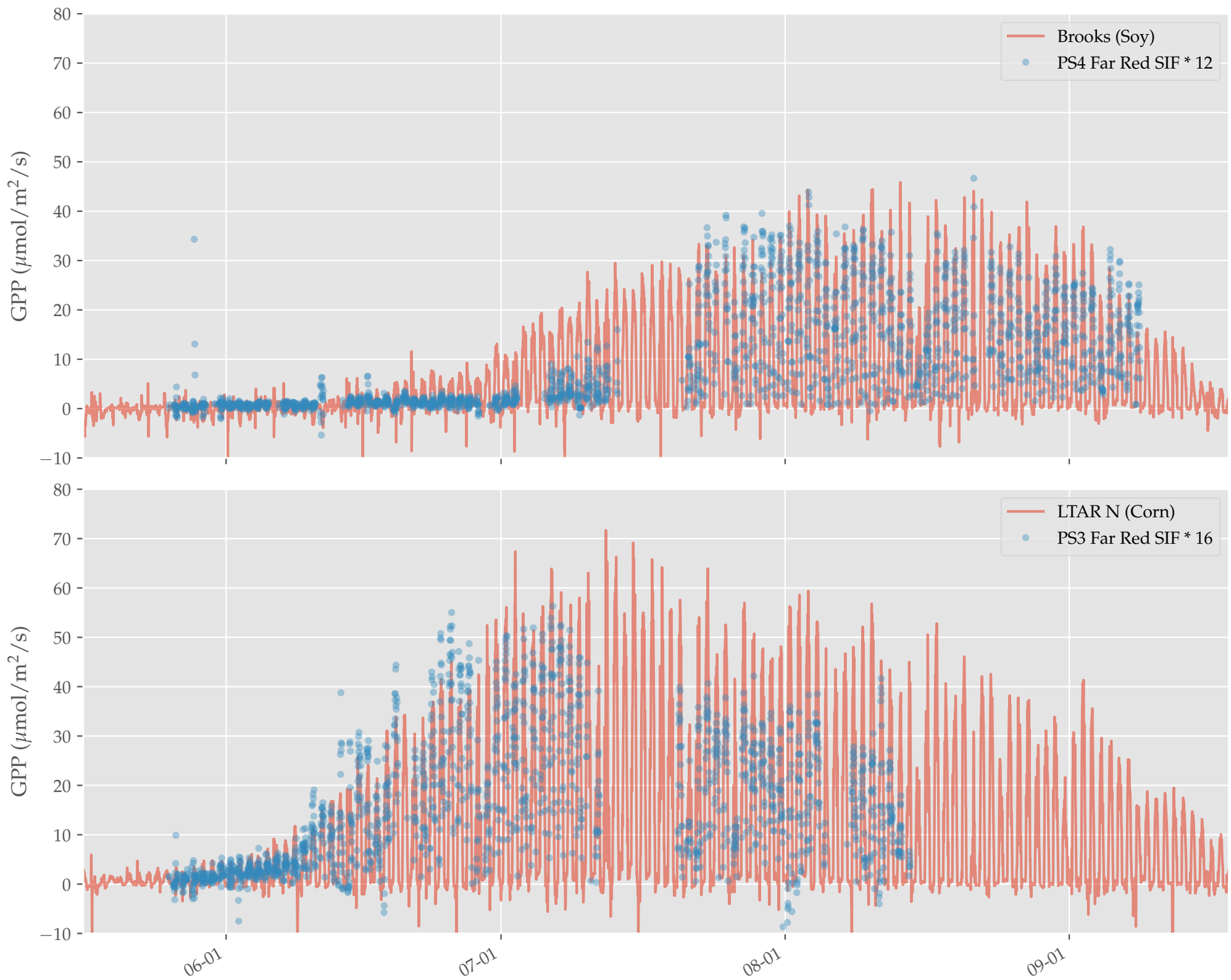
Time-Series of half-hourly GPP and SIF

Soy (C3)

slow rise, max<50μmol/m²/s

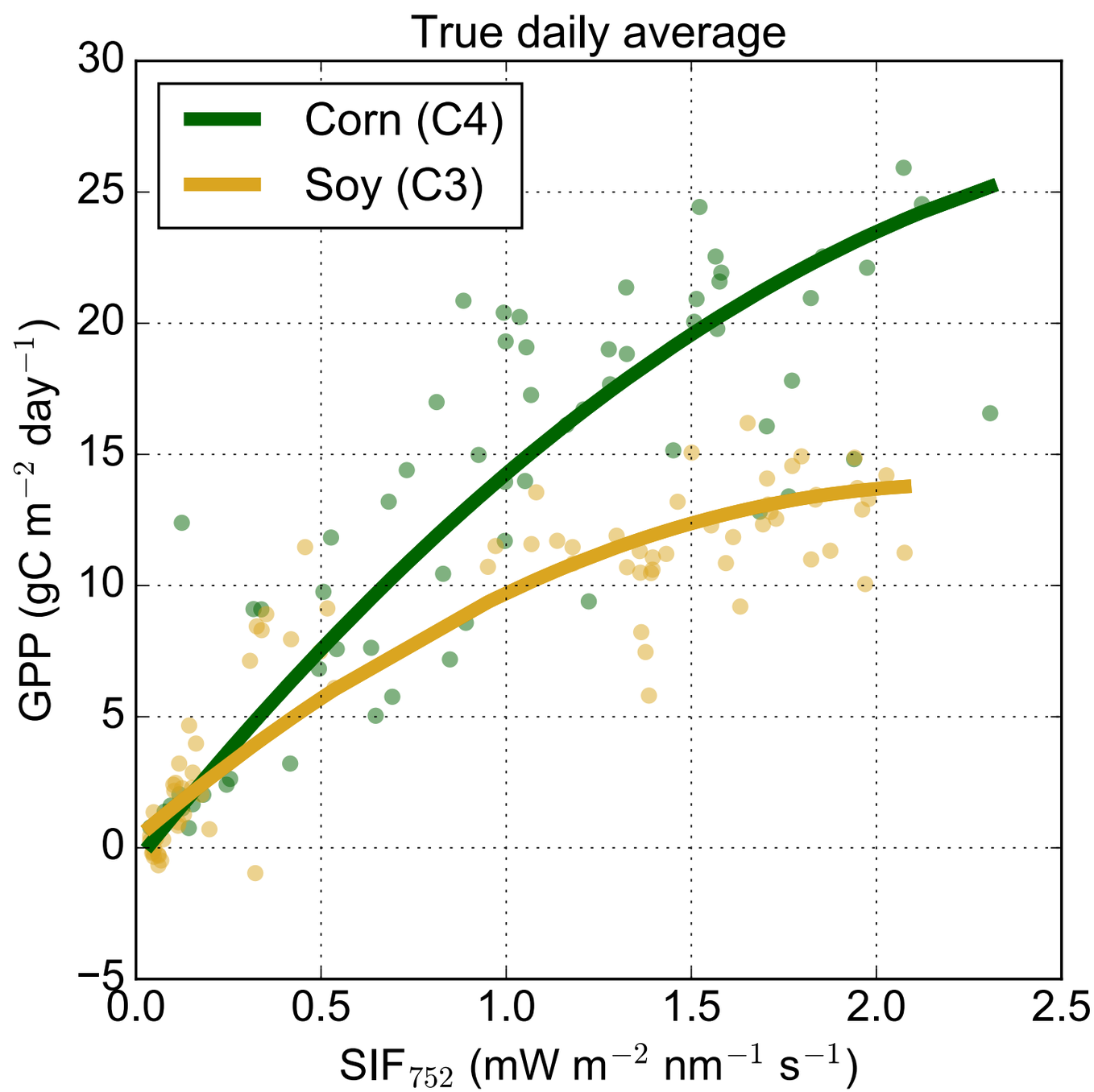
Corn (C4)

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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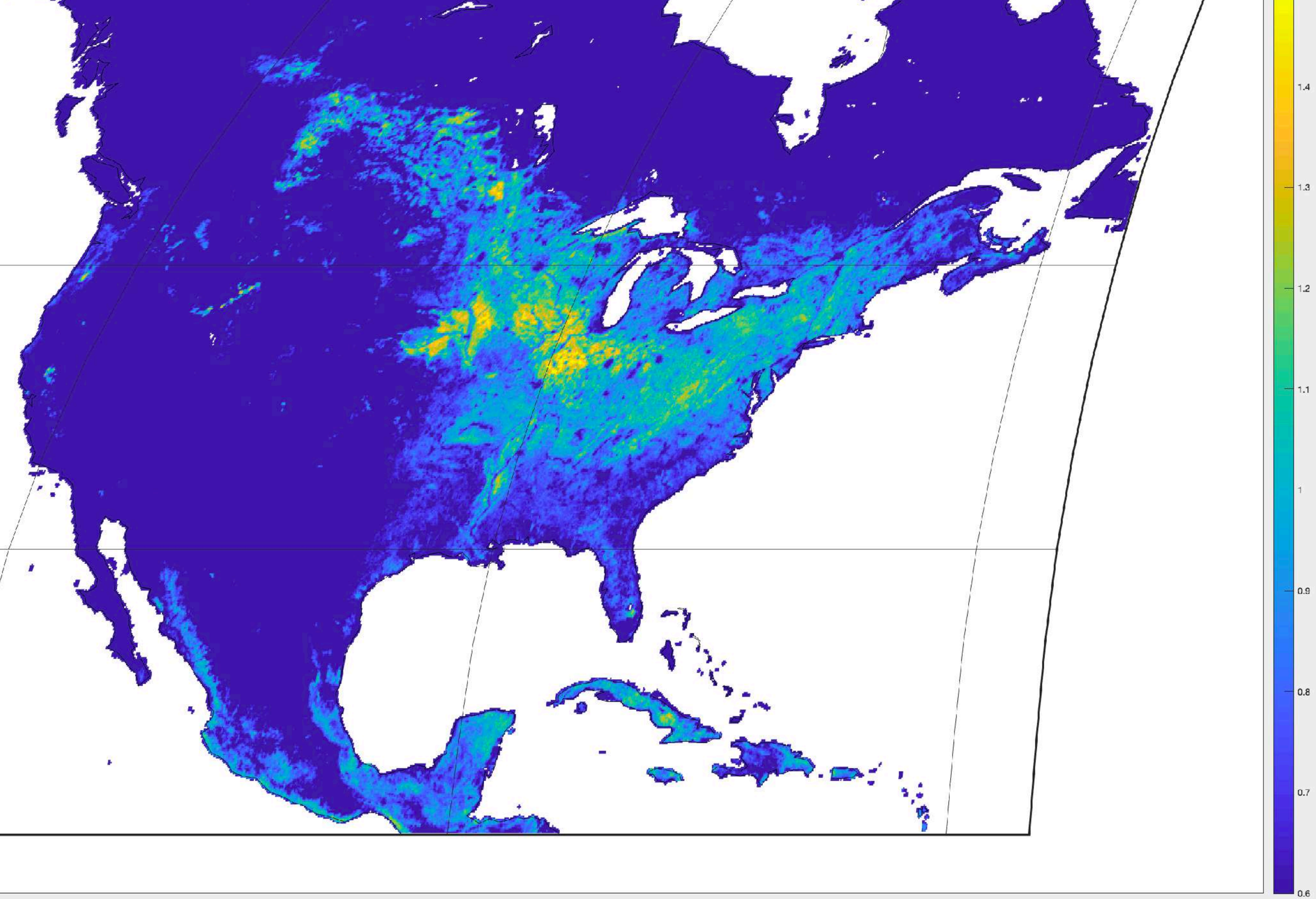
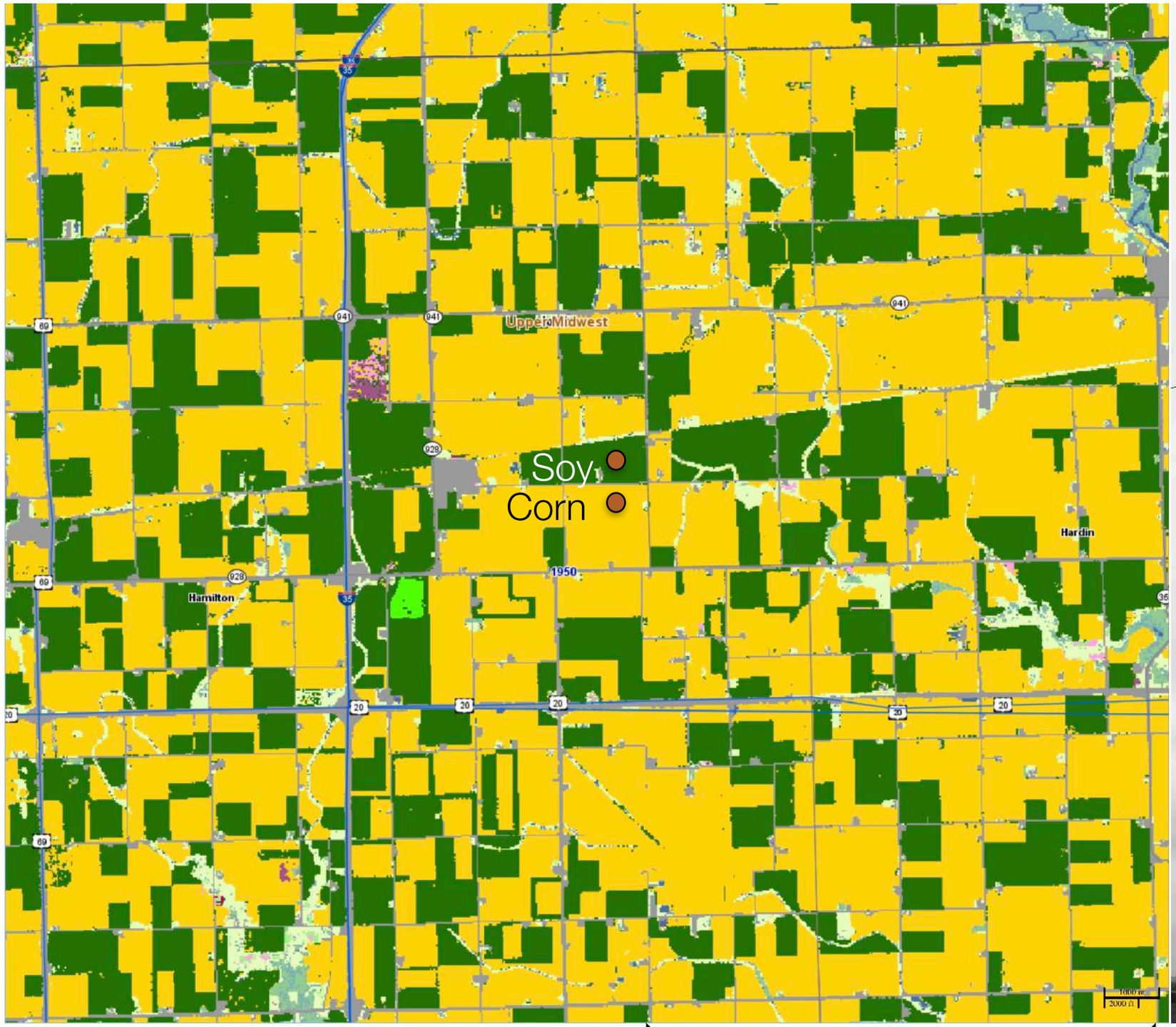
Be careful which model you use for the Yield relationships!



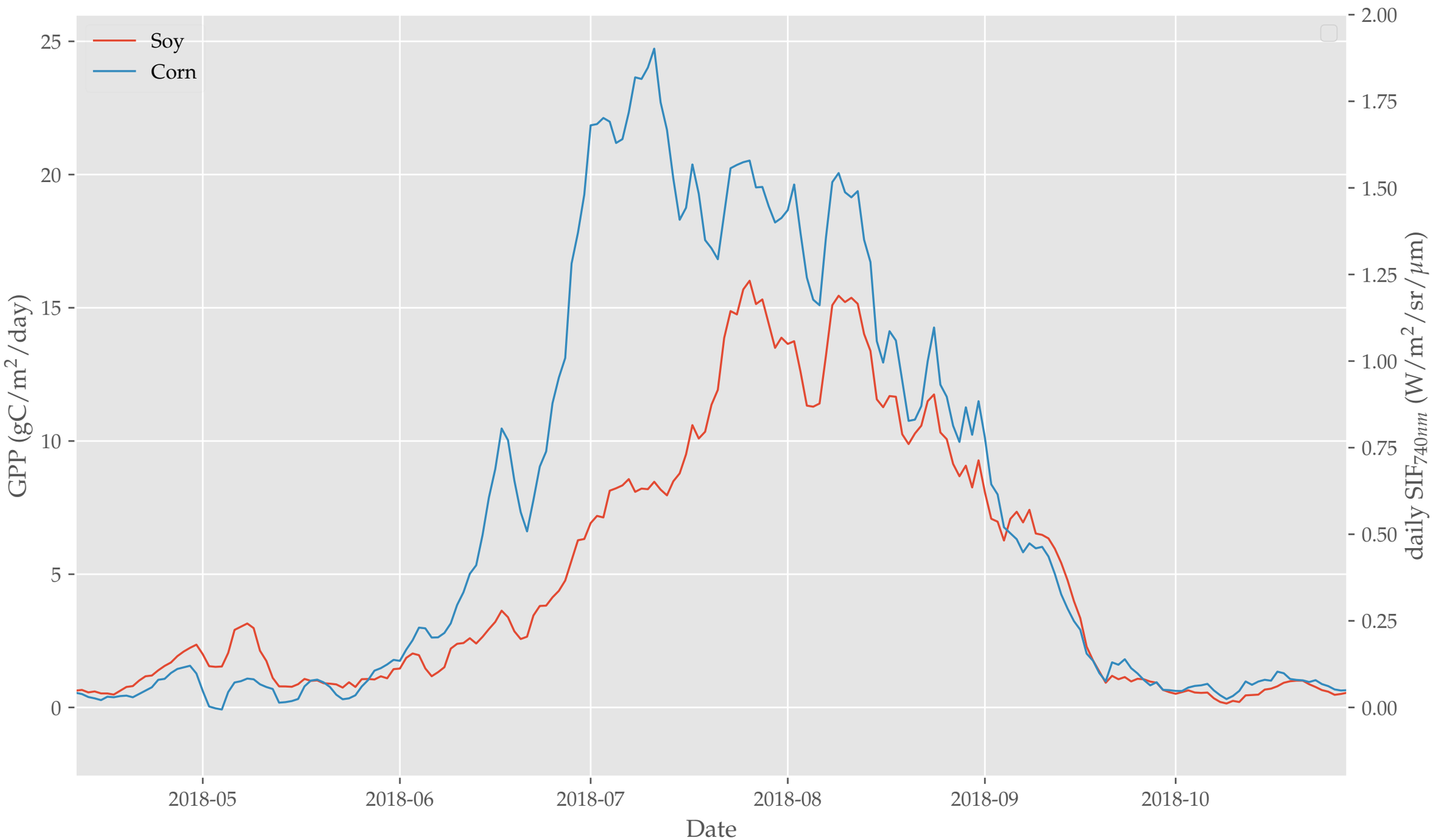
To the satellite scale, 95%ile of 8-Day SIF from TROPOMI

Ground-based comparison - USDA Coles fields



10km

Ground-based comparison - USDA Coles fields



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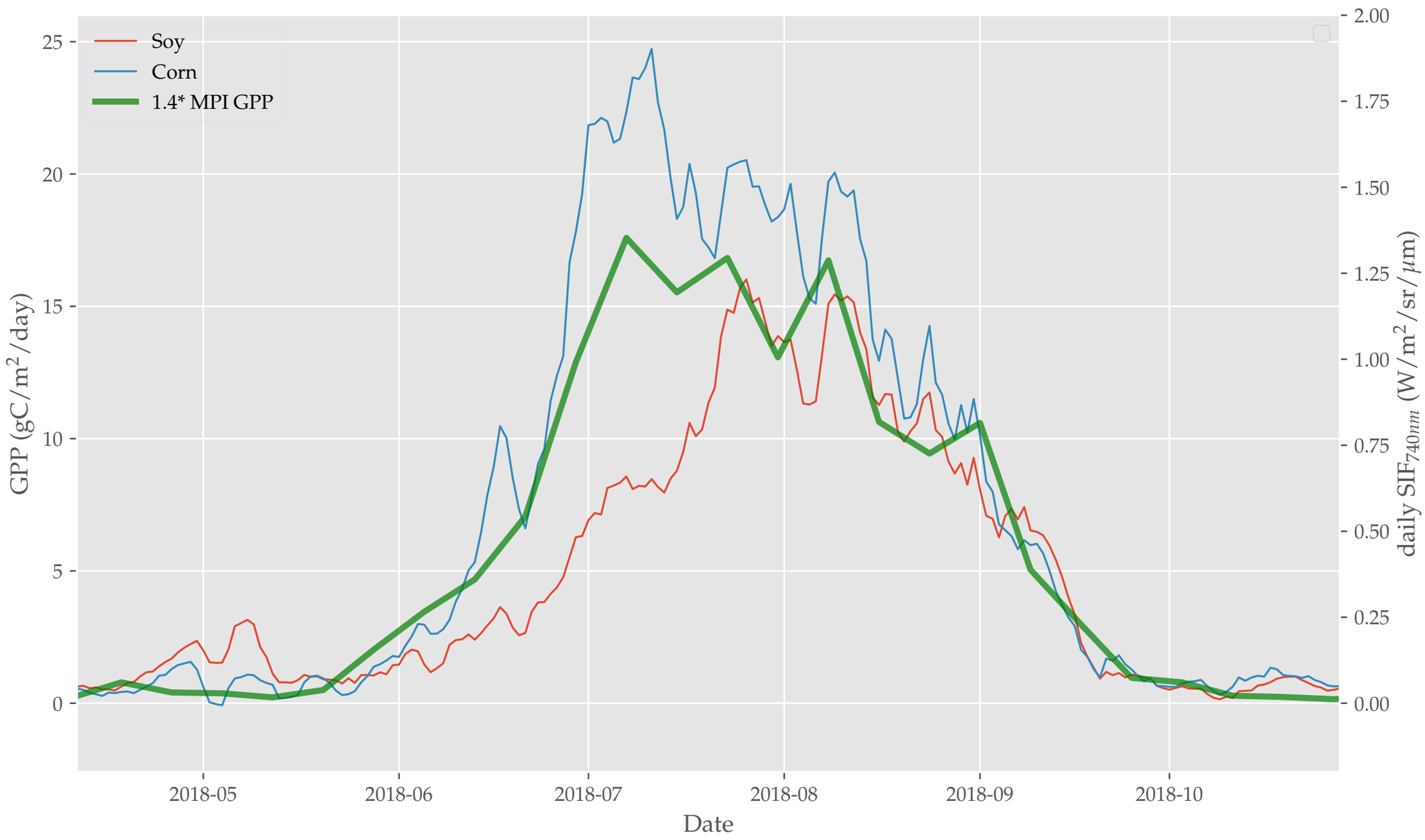

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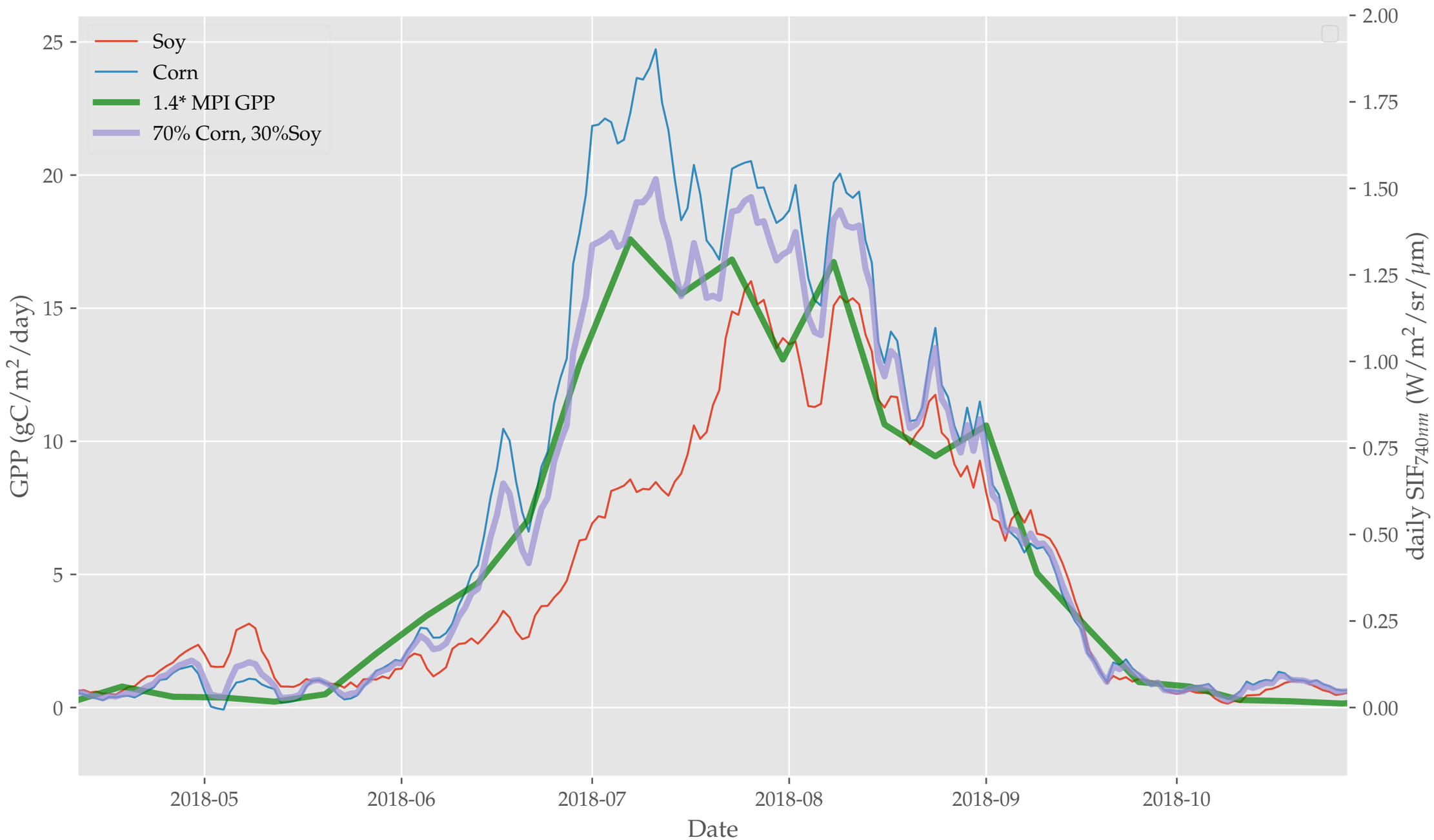
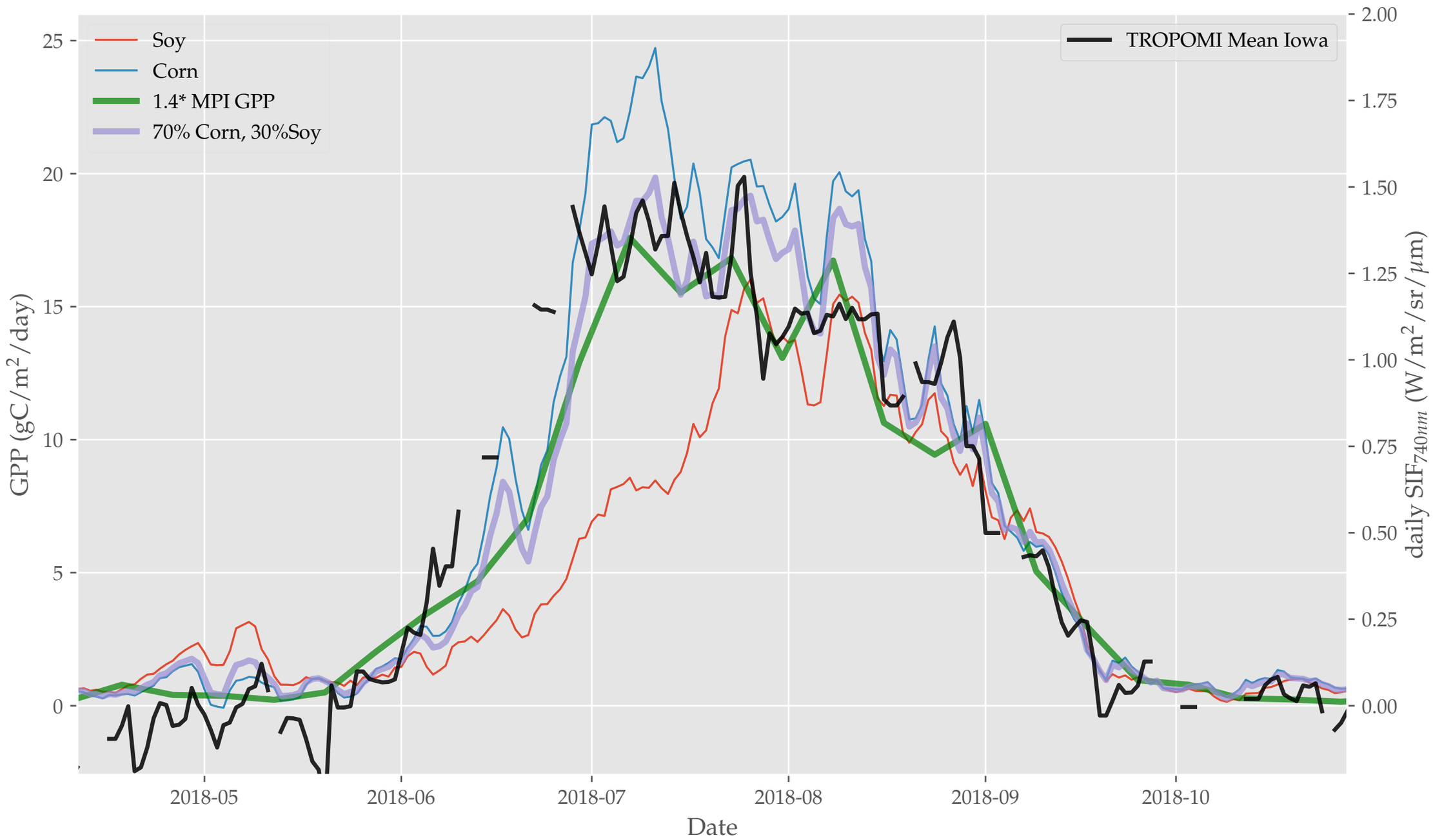


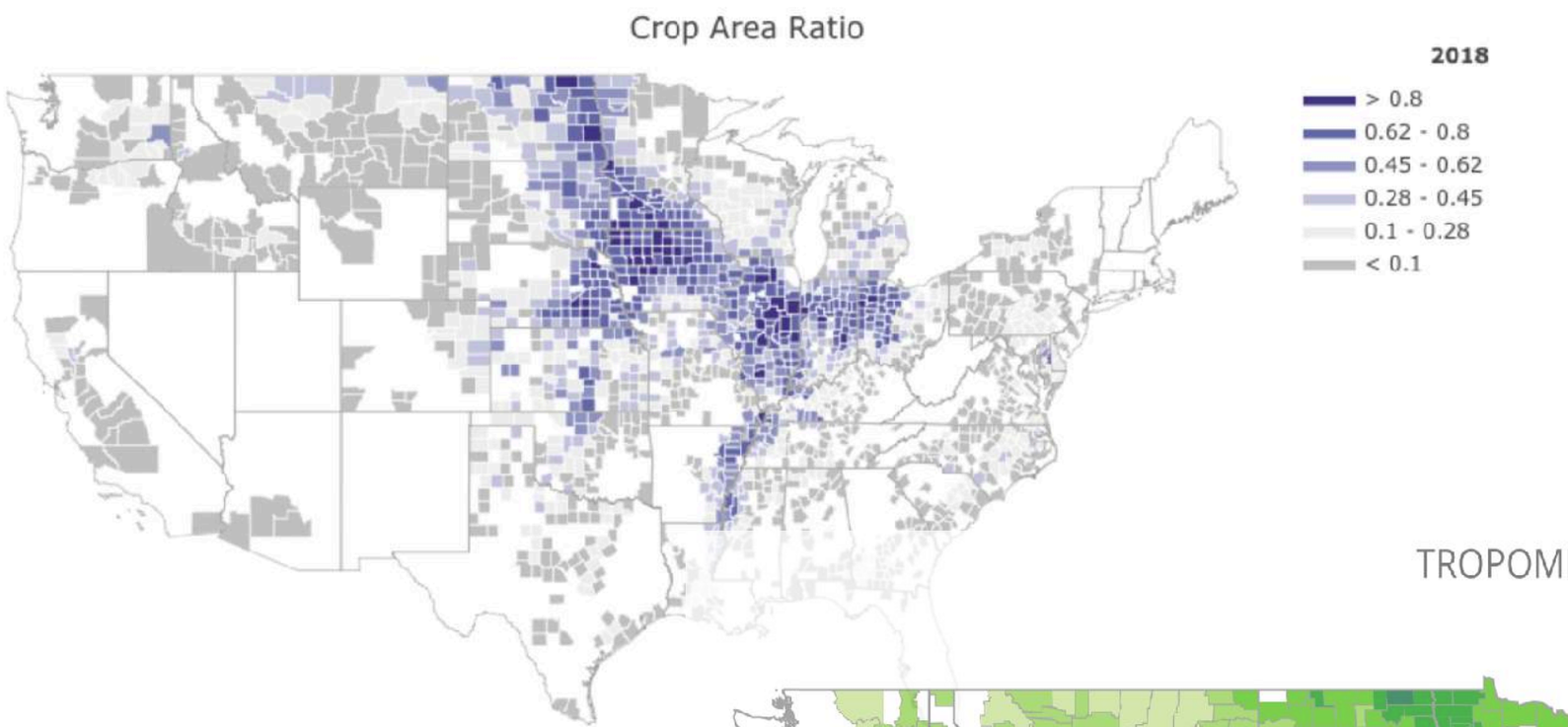
Context, how long does it take to empty a 1m^2 vertical column or CO_2 at 400ppm with a flux of 20gC/m^2/day?

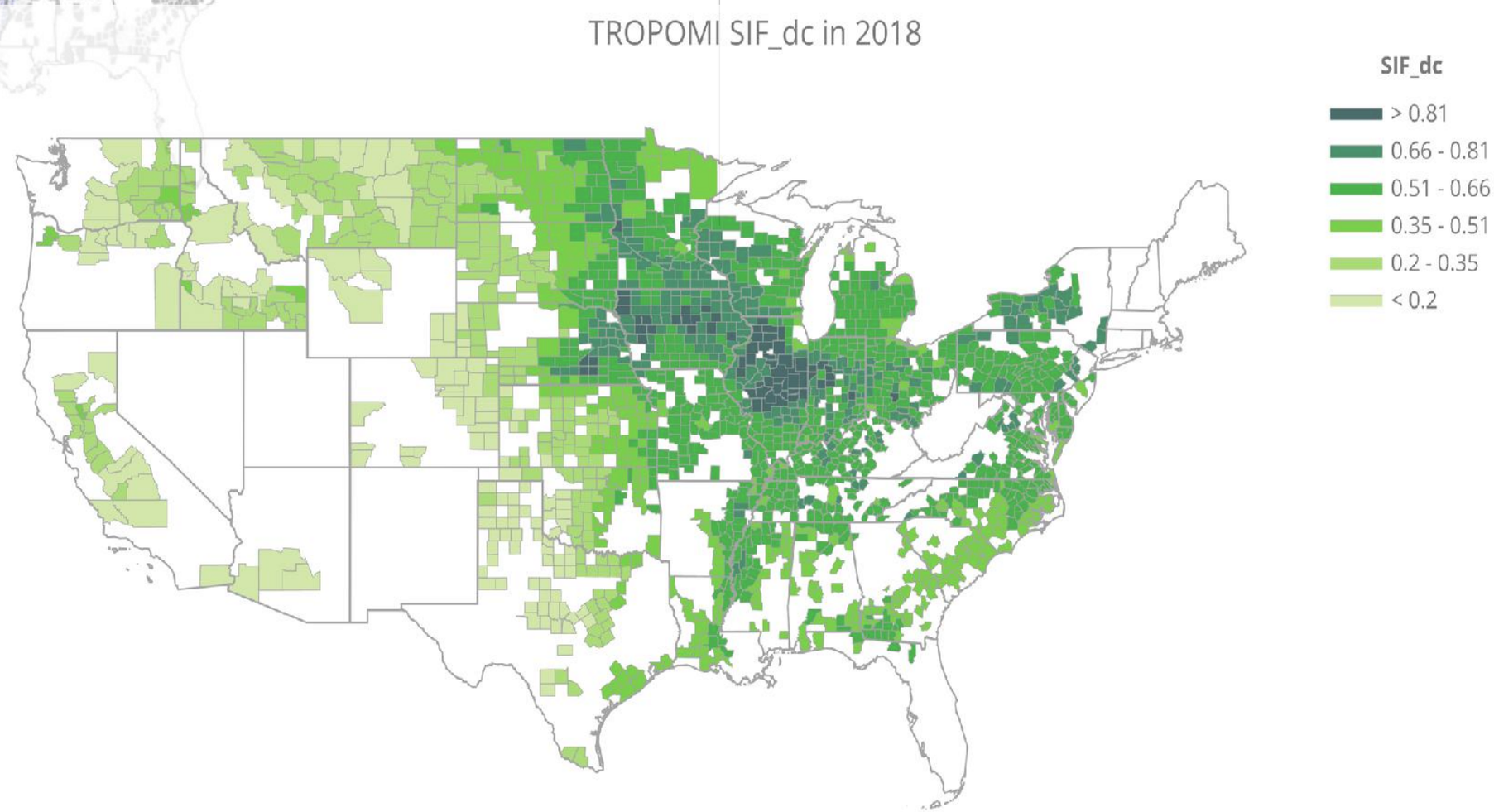
Ground-based comparison - USDA Coles fields



USDA-NASS crop yield comparison for 2018

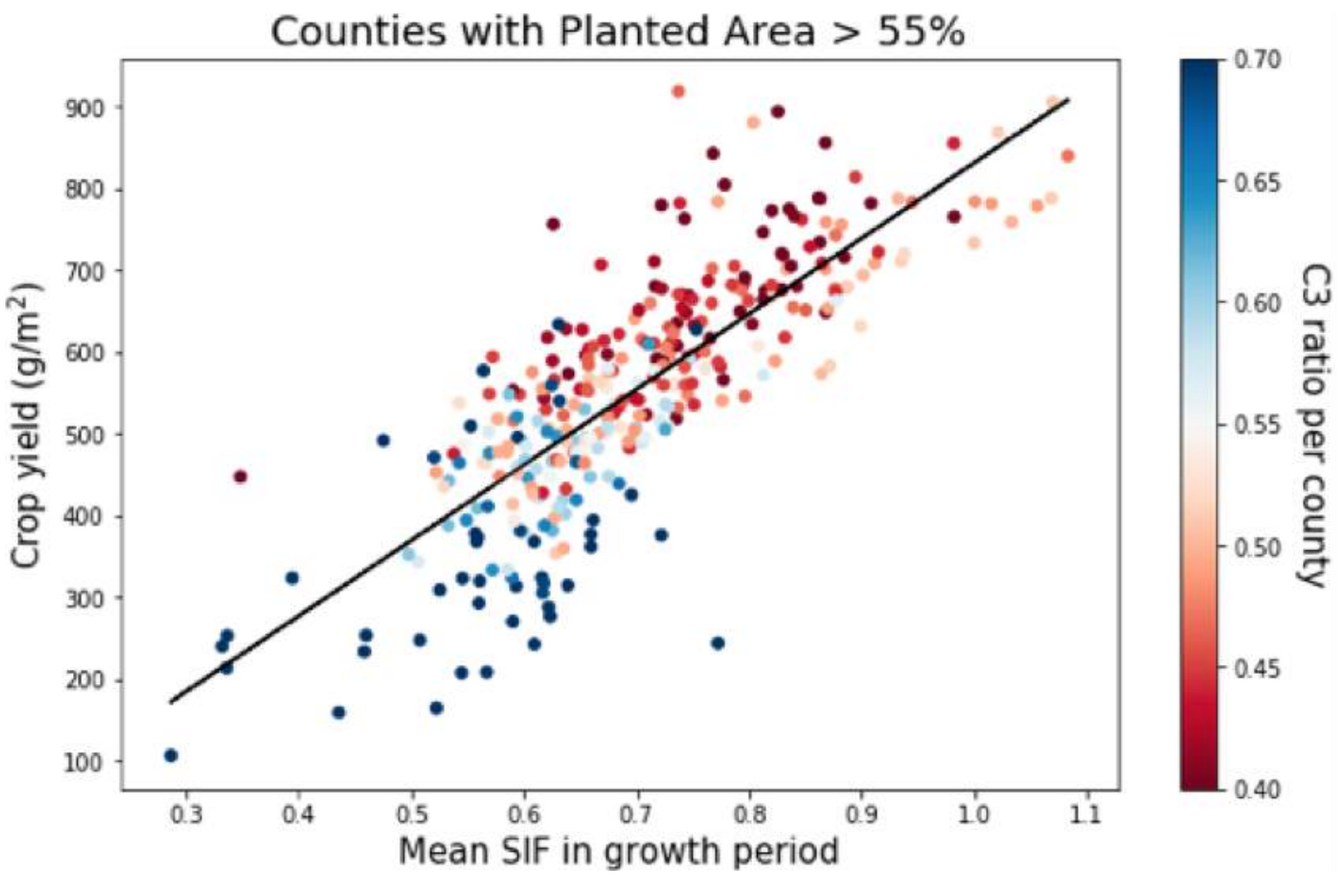
see Liyin He's poster #81 for details

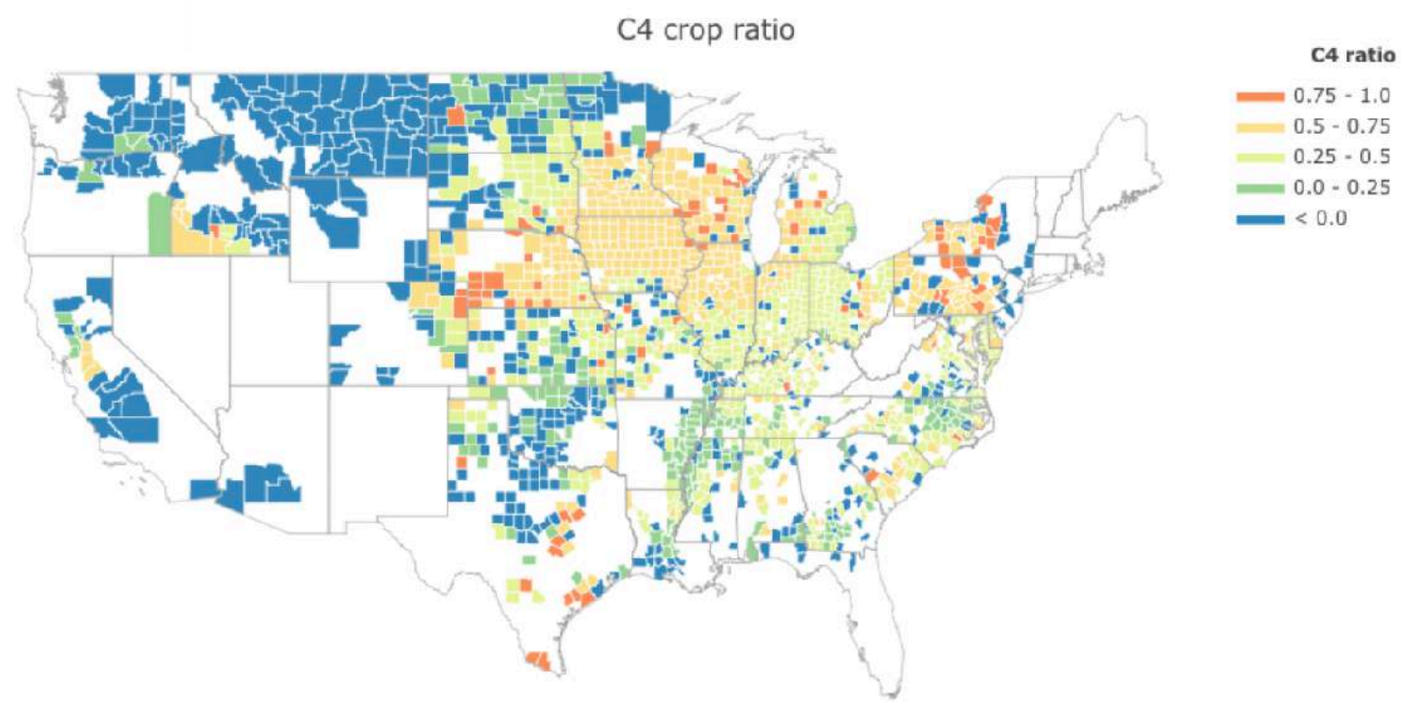




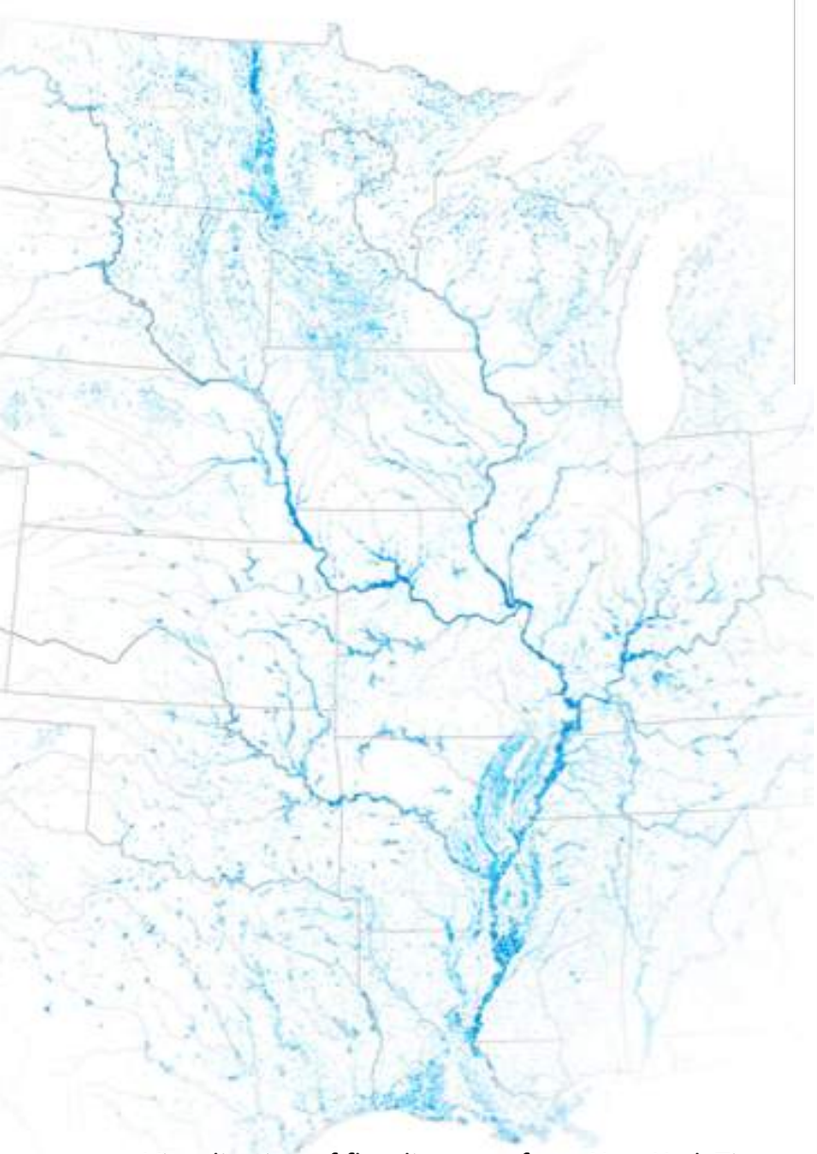
Crop yield vs SIF average

see Liyin He's poster #81 for details

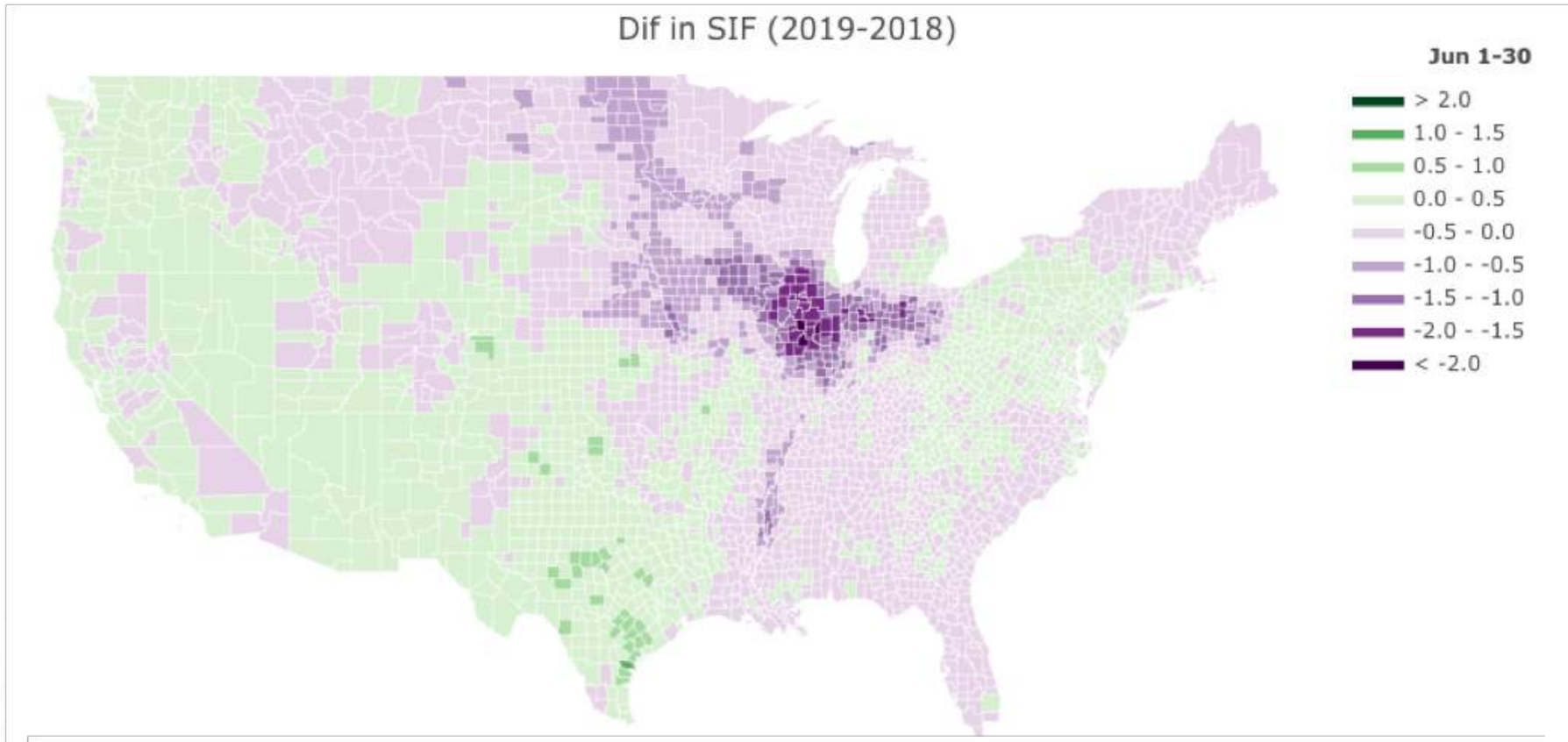


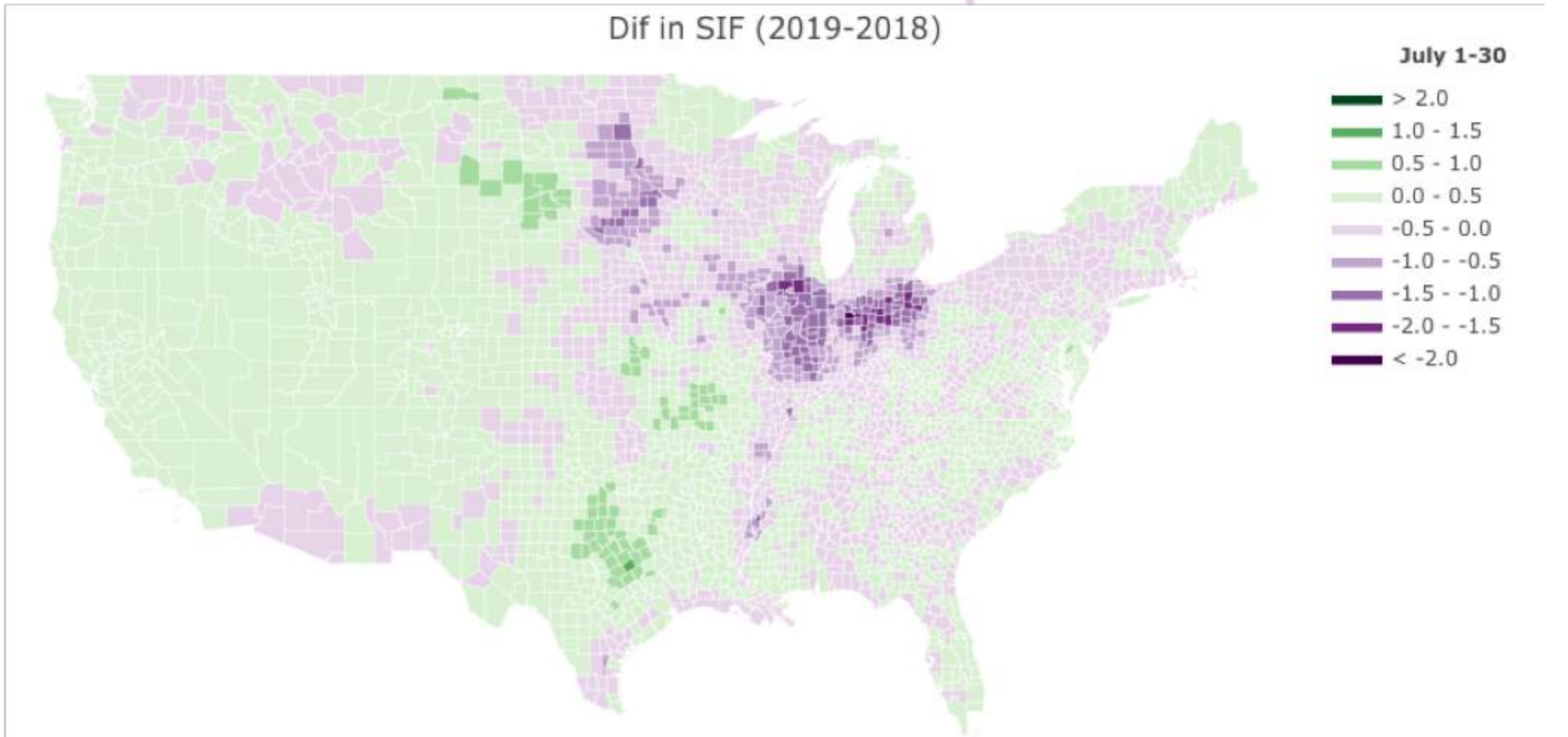


The 2019 anomaly, an ideal natural experiment?



Visualization of flooding area from New York Times





Take home messages…

- More interested in SIF spectral shape (omitted here)?
  Magney, Troy S., et al. "Disentangling changes in the spectral shape of chlorophyll fluorescence: Implications for remote sensing of photosynthesis." Journal of Geophysical Research: Biogeosciences (2019).

- 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!

Funding:
Ground-based work + science analysis: NASA Carbon Cycle Science
TROPOMI data via NASA ESUSPI grant, data at
ftp://fluo.gps.caltech.edu/data/tropomi/
Graduate Student Fellowship from Resnick Institute