Geophysical Research Letters

Supporting Information for

From the ground to space: Using solar-induced fluorescence to estimate crop productivity

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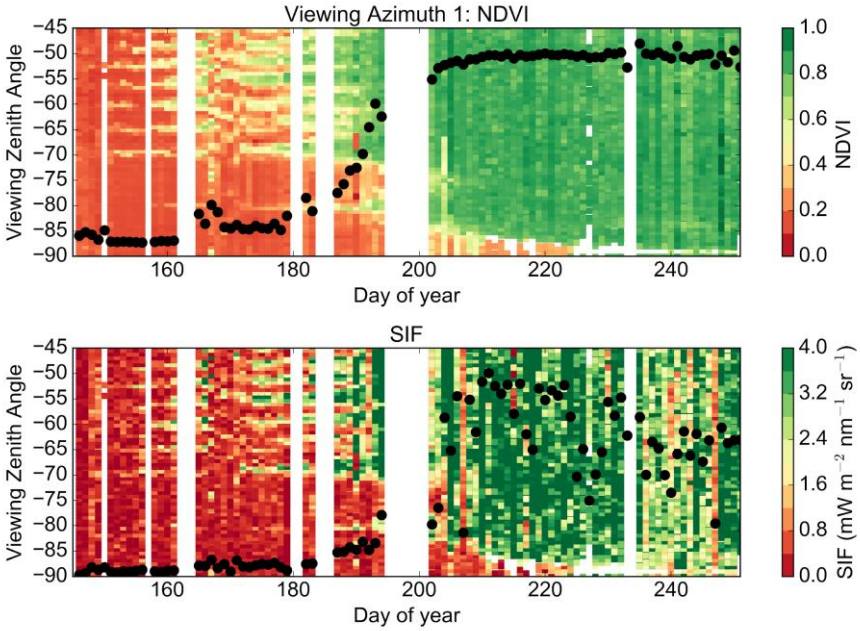
Table S1. The conversion factors used for NPP (g C/m^2) for individual crop type (modified based on Guan el al., (2016)). Light grey represents the ones involved in our analysis after the filtering of total crop planted area > 45% per county.

Crop	Published production unit	kg per production unit	Moisture content (%)	Harvest Index	Fraction of production allocated to aboveground (fAG)
Corn for Grain	Bushel	25.401	11	0.45	0.85
Soybean	Bushel	27.216	10	0.4	0.87
Hay (other)	Ton	907	15	1	0.53
Wheat	Bushel	27.216	11	0.4	0.83
Hay (alfalfa)	Ton	907	15	1	0.53
Cotton	Lb	0.453	8	0.4	0.8
Sorghum for grain	Bushel	25.401	10	0.4	0.8
Corn for silage	Ton	907	65	1	0.85
Barley	Bushel	21.772	12	0.4	0.67
Durum Wheat	Bushel	27.216	12	0.4	0.83
Sunflowers	Lb	0.453	10	0.35	0.94
Oats	Bushel	14.515	11	0.4	0.71
Peanuts	Lb	0.453	9	0.4	0.8
Sugarbeets	Ton	907	85	0.4	0.8
Canola	Lb	0.453	10	0.35	0.94
Rice	Lb	0.453	9	0.4	0.8
Potatoes	Hundred Weight	50.8	80	0.5	0.8

(a) Soybean



(b) Corn

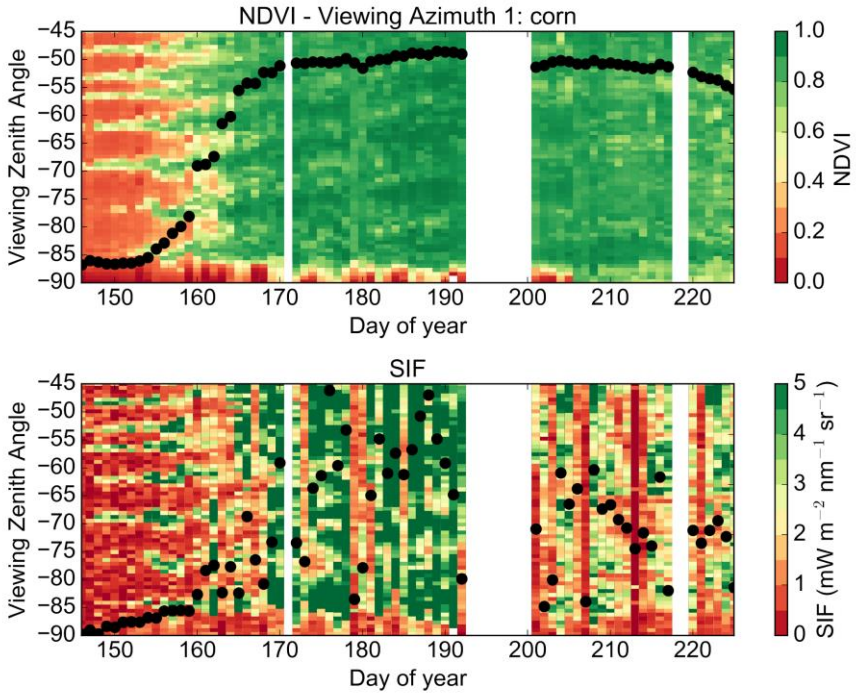


Figure S1.

The impact of viewing geometry on both (a) soybean and (b) corn sites. Note that NDVI is invariant when NDVI > 0.6, which can be used as the indicator of the peak growth season, whereas far-red SIF at 740nm shows dynamic response during the same period.

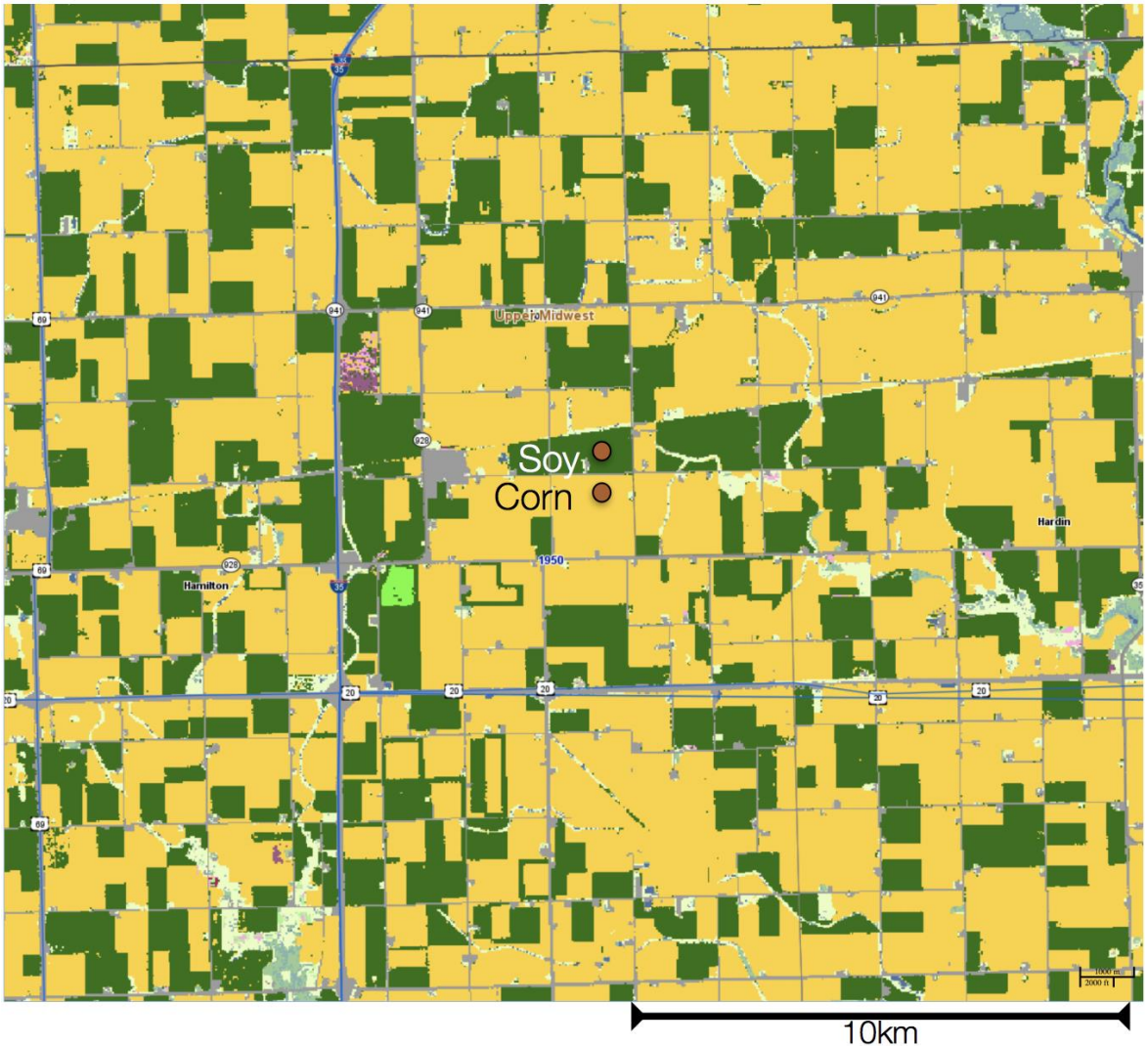


Figure S2.

The location of USDA flux towers of C3 (42.488414°N, -93.522582°W; soybeans, *Glycine max* L. Merr.) and C4 (42.481677°N, -93.523521°W; corn, *Zea mays* L.), surrounded by homogeneous soybean and corn fields used in the 2018 satellite/flux tower comparison. Green represents soybean and yellow represents corn. Within +/-10 km from the flux towers, there are ~58% corn and ~30% soybeans derived from the 30-meter crop-specific land cover data layer (CDL; https://nassgeodata.gmu.edu/CropScape/).

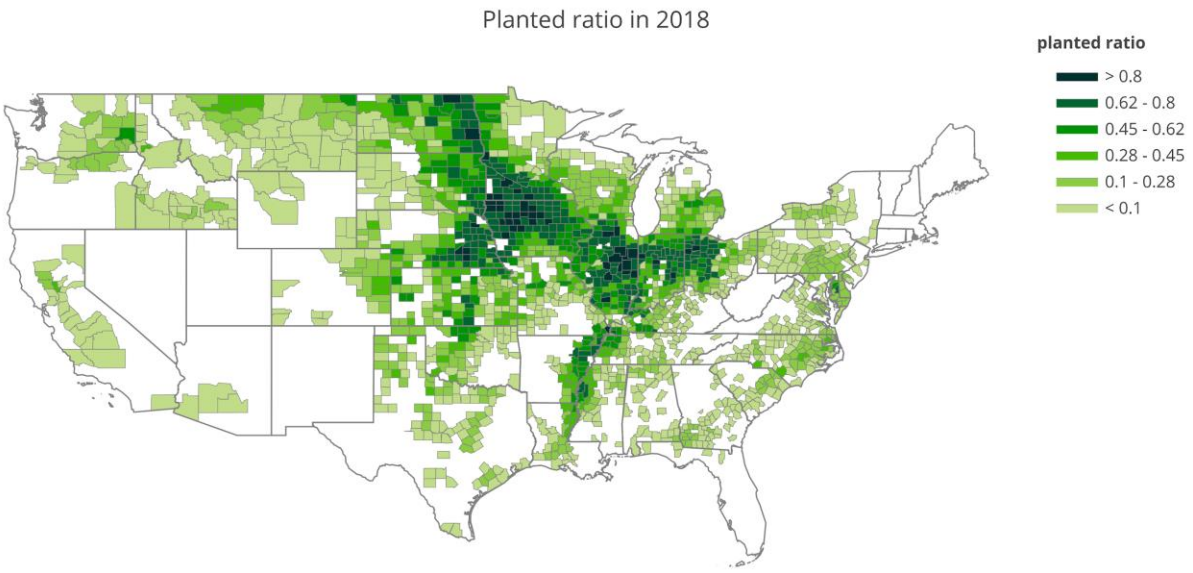


Figure S3.
The fraction of total planted area of each county in 2018. The planted area for individual crop type in each county is obtained from USDA NASS Quick Stats Database (quickstats.nass.usda.gov), and the total area of each county is obtained from the United States Census Bureau (https://factfinder.census.gov/).

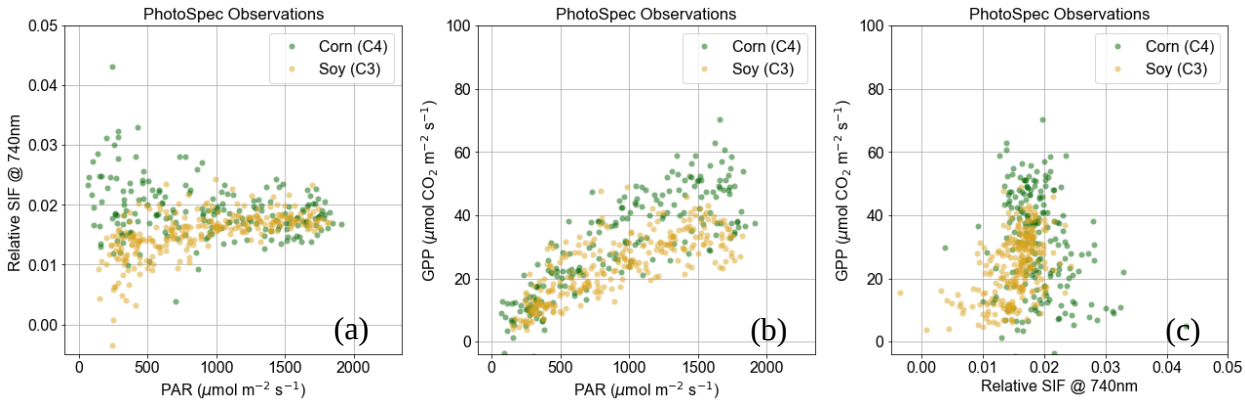


Figure S4.

Canopy-scale relationships in the peak growing season based on hourly averaged data from PhotoSpec for soybean (gold) and corn (green): (a) relative SIF:PAR, (b) GPP:PAR, (c) GPP:relative SIF for both soybeans and corn. Relative SIF cancels out radiation, and can be considered as a proxy of SIF yield. Thus, there is no obvious correlation with PAR or GPP. Since relative SIF is quite stable, this implies that the canopy structure is quite stable and PAR we used in the peak growing season is almost chlorophyll-absorbed APAR.

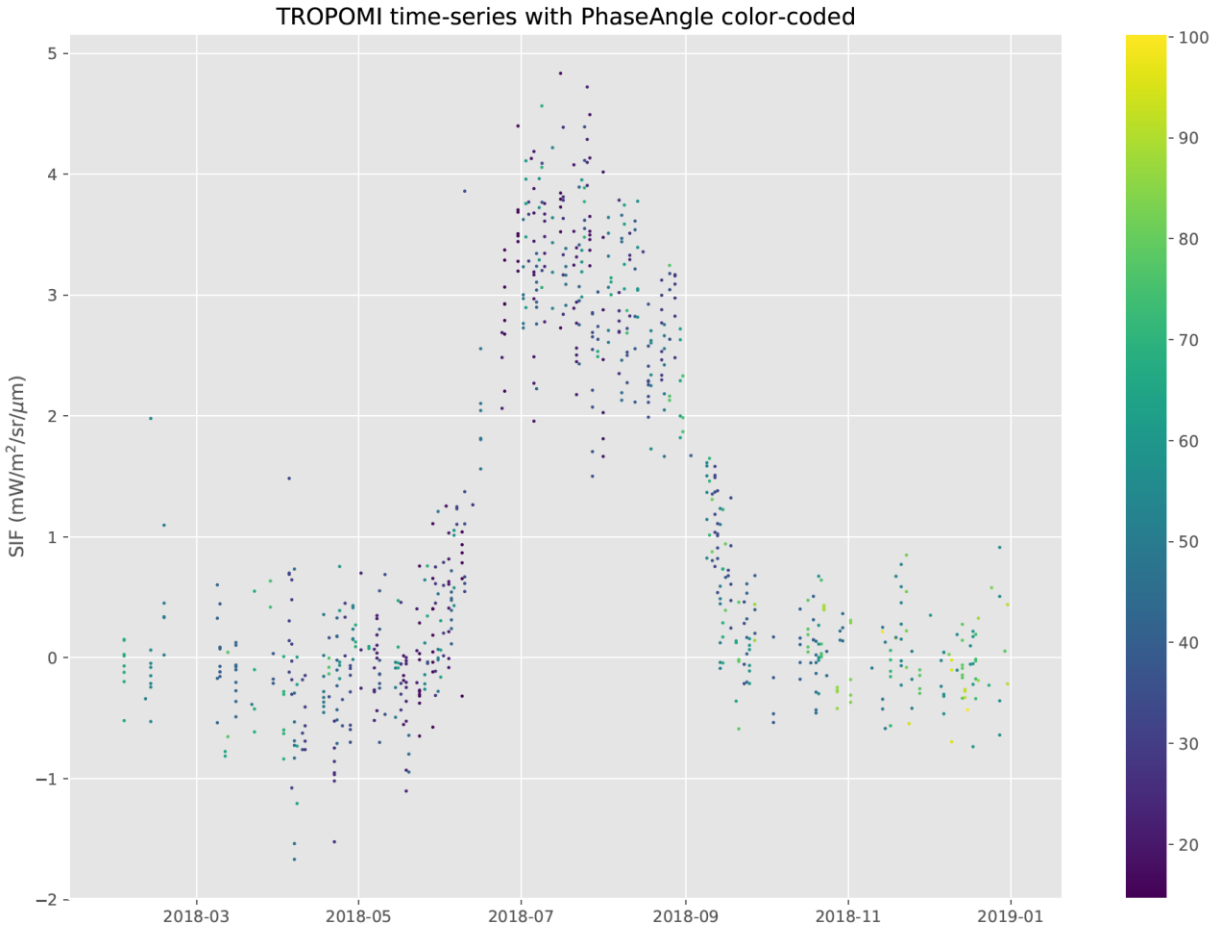
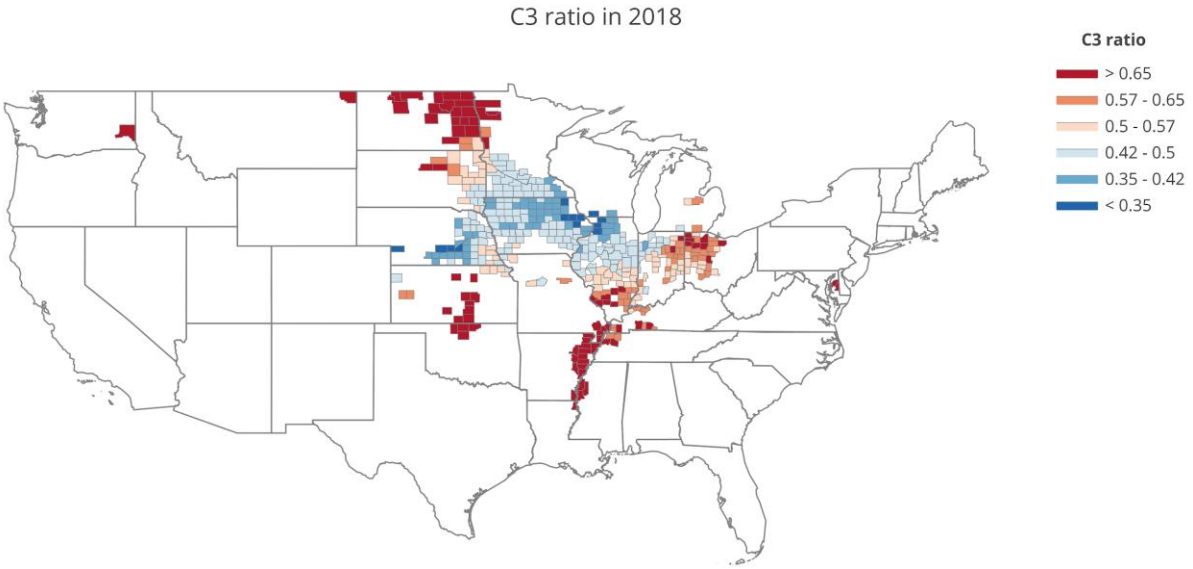


Figure S5.

Footprint-level TROPOMI time series colored by the phase angle within +/-10 km from the flux towers used in **Figure 2**. Fewer TROPOMI observations are due to increased cloud cover at the beginning of the growing season. In addition, there is no apparent viewing angle dependent behavior in the TROPOMI datasets over the growing season.



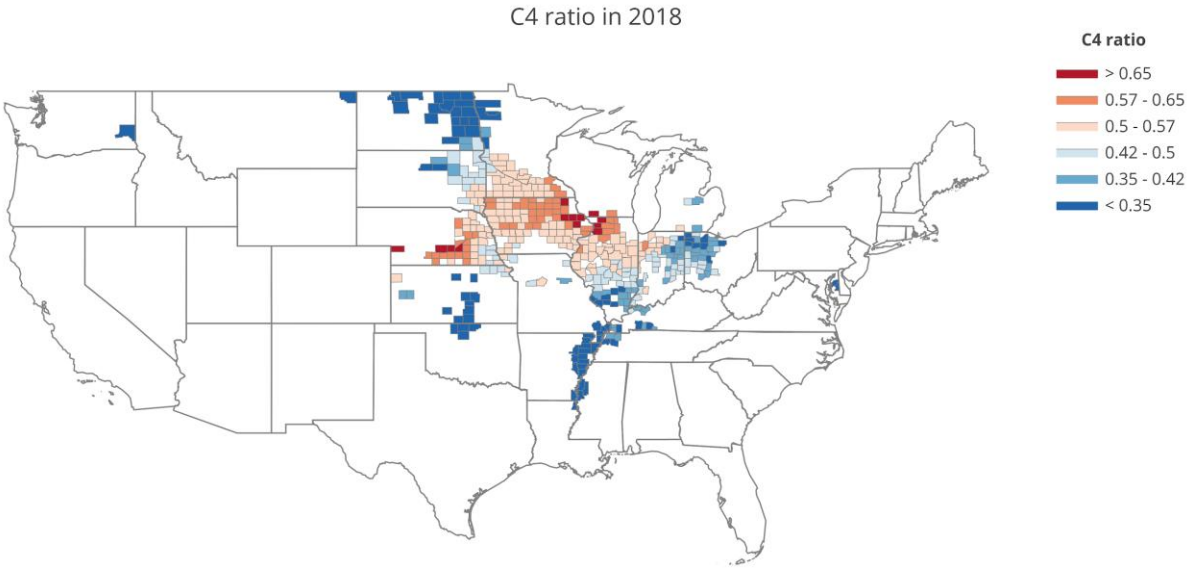
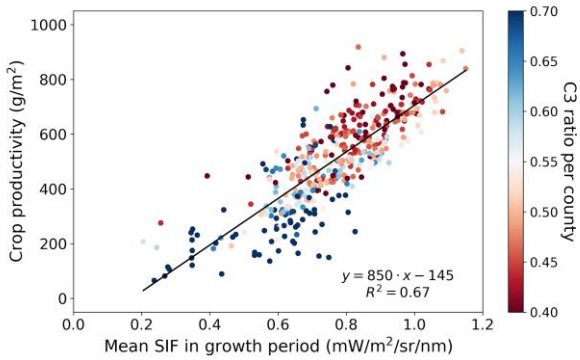
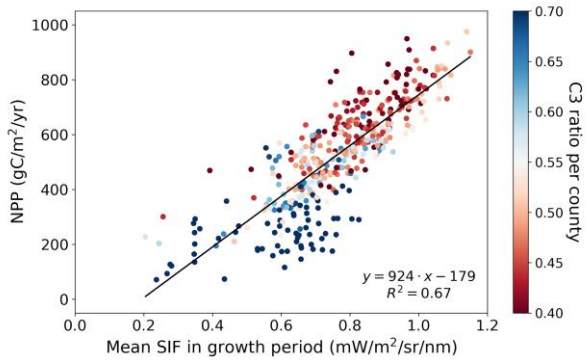


Figure S6.
The fraction of C3 (and C4) crops over the total planted areas for agricultural dominated counties, which have > 45% planted areas.

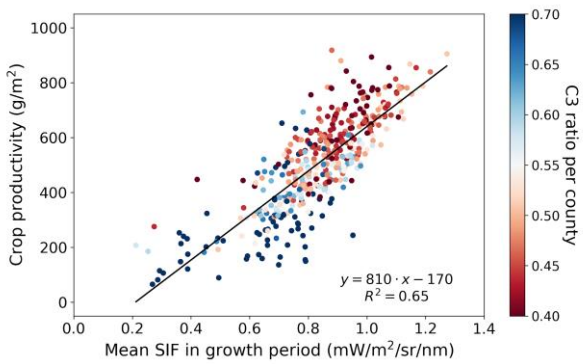
(a) threshold = 0.2



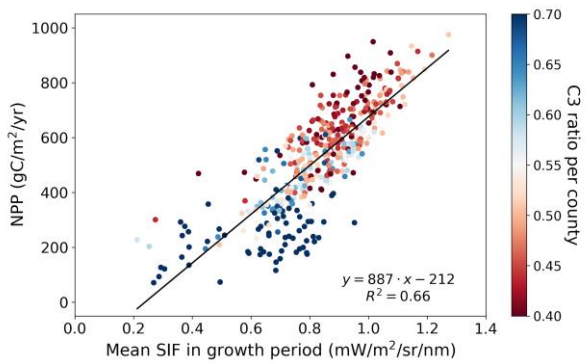
(b) threshold = 0.2



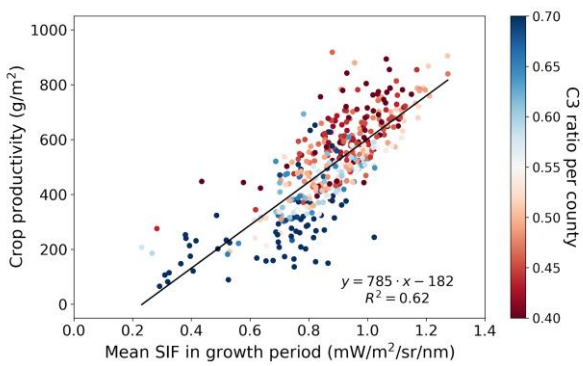
(c) threshold = 0.3



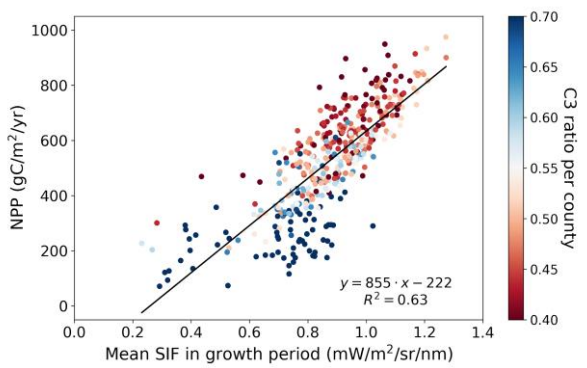
(d) threshold = 0.3



(e) threshold = 0.4



(f) threshold = 0.4



(g) threshold = 0.5

(h) threshold = 0.5

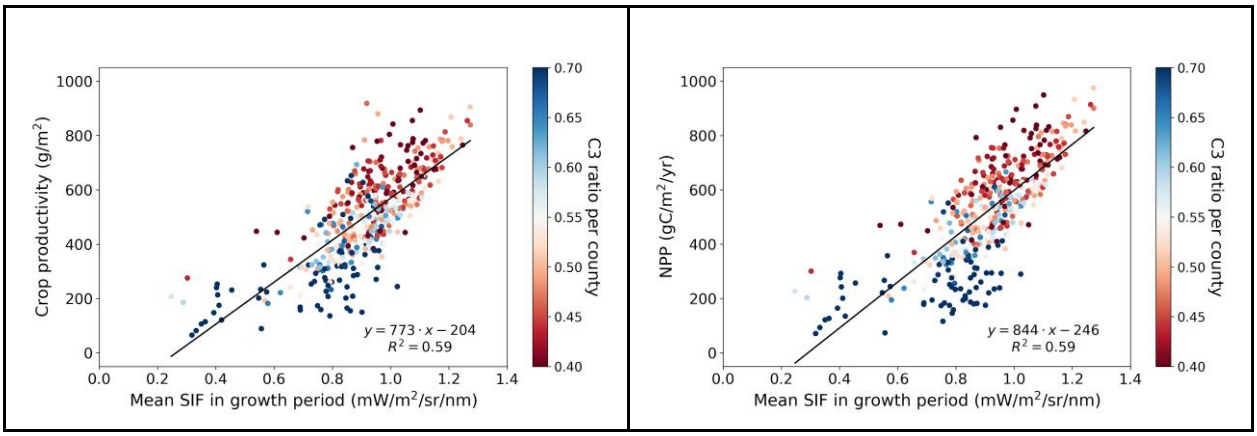
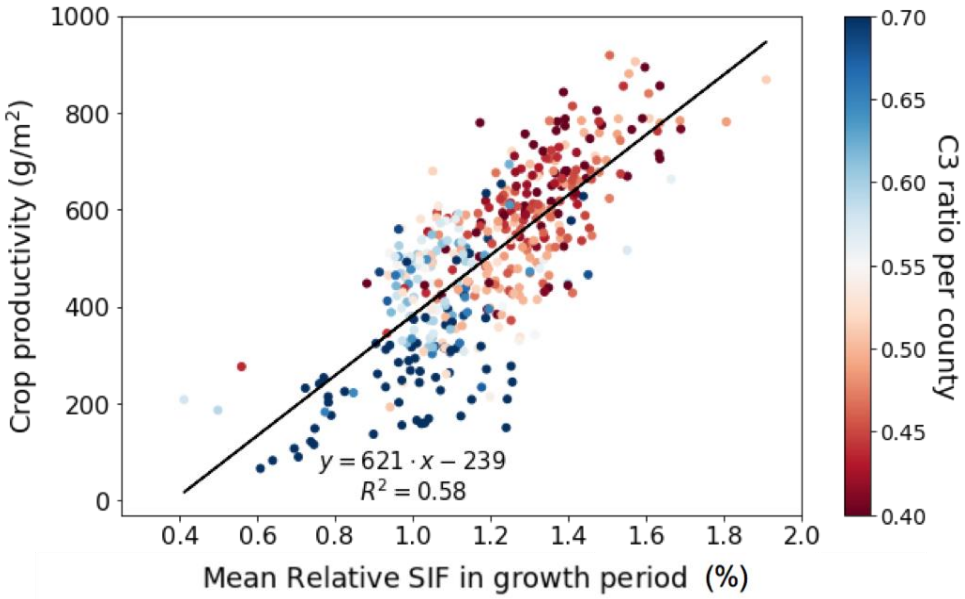


Figure S7.

In counties with planted area > 45%, the relationship of crop productivity and NPP against average TROPOMI SIF during the growth period of 2018. The growth period for each county is defined when SIF is larger than some proportion of its maximum SIF. In the main text, we choose the threshold as 0.1, and here we represent the results with the varying threshold from 0.2 to 0.5. The color scheme represents the relative fraction of C3 crops, with blue means more C3 and red means more C4.

(a)



(b)

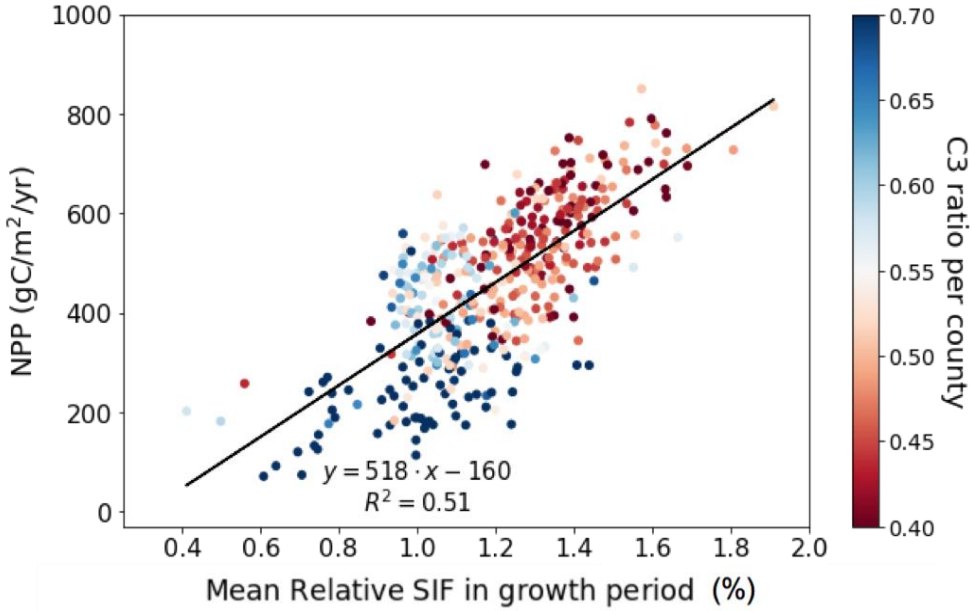
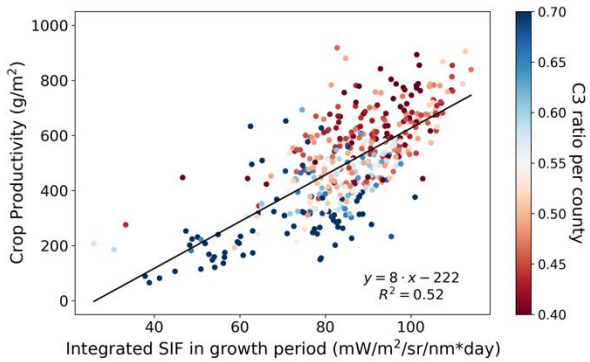


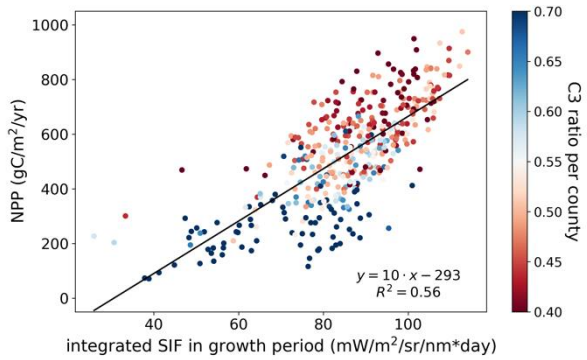
Figure S8.

Spatial pattern of county-scale (a) crop productivity derived from USDA NASS and (c) average TROPOMI SIF during the growth period of 2018. In counties with planted area >45%, the relationship of (b) crop productivity:relative SIF and (d) NPP:relative SIF. The color scheme represents the relative fraction of C3 crops, with blue meaning more C3 and red means more C4.

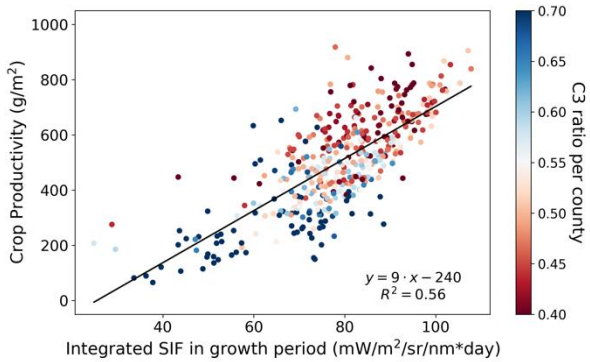
(a) Percentile = 65%



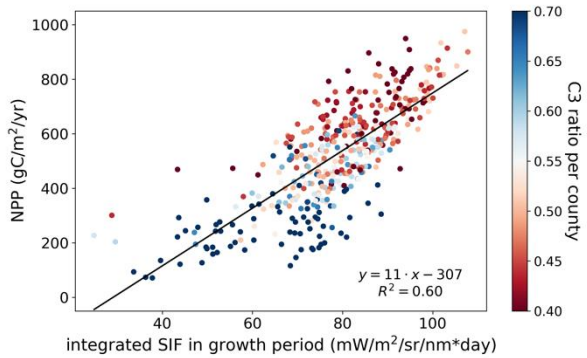
(b) Percentile = 65%



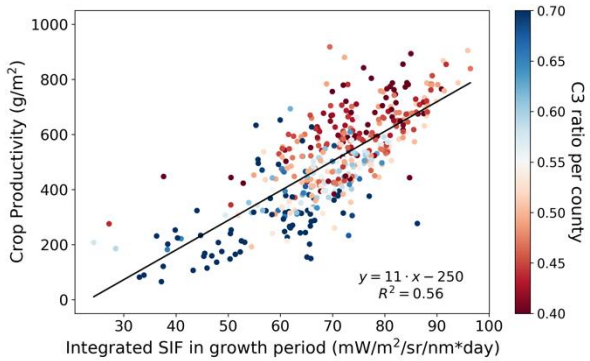
(c) Percentile = 70%



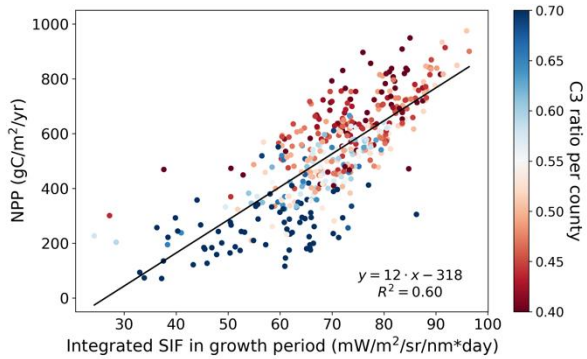
(d) Percentile = 70%



(e) Percentile = 75%



(f) Percentile = 75%



(g) Percentile = 80%

(h) Percentile = 80%

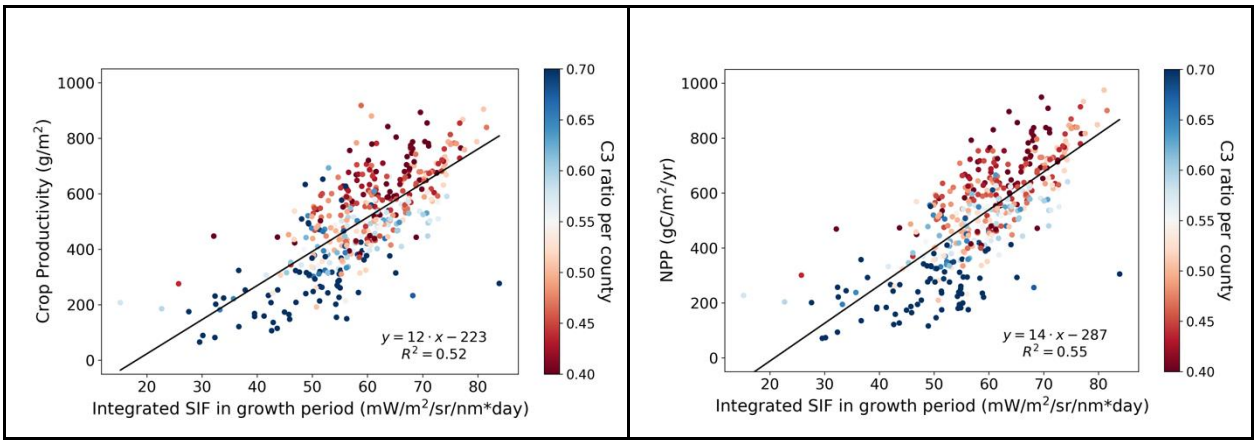


Figure S9.

In counties with planted area > 45%, the relationship of crop productivity and NPP against integrated TROPOMI SIF during the growth period of 2018. The growth period for each county is defined as the time when SIF is larger than some percentile (from 60% to 80%) of the total observations. The color scheme represents the relative fraction of C3 crops, with blue means more C3 and red means more C4.