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College of Agriculture
College of Engineering

UAS Applications in Agriculture and Hydrologic Research

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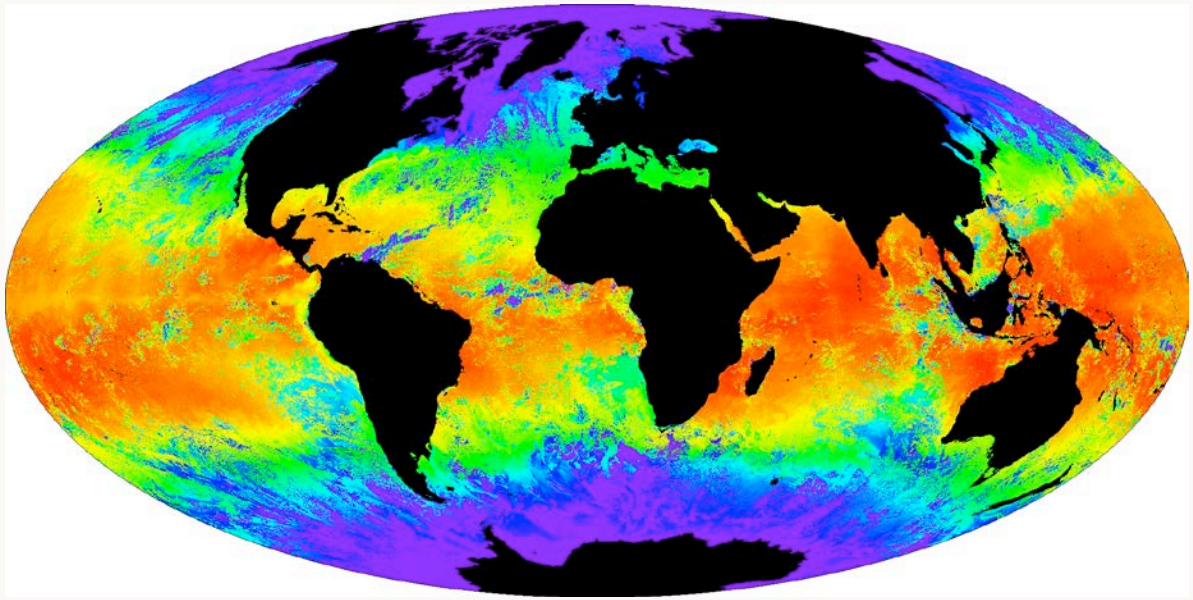
- Anthony Hearst, Graduate Research Assistant
- Jing Tan, Graduate Research Assistant

Applications of UAS to Land and Natural Resource Management

Argonne National Laboratory July 17, 2014

A Little Background

› Started with Sea Surface Temperature Measurements



- Large target
- Limited change within the repeat cycle of a satellite

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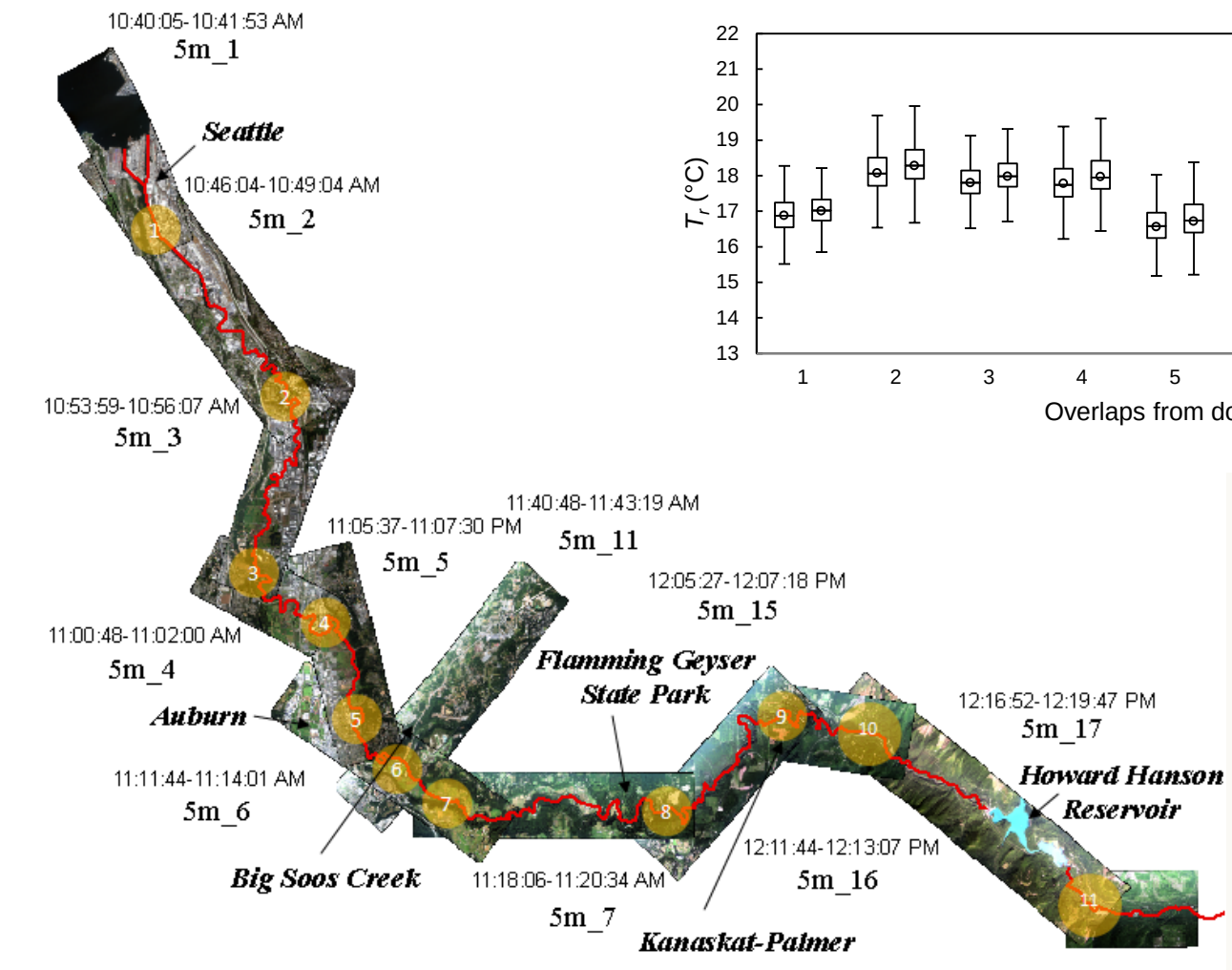
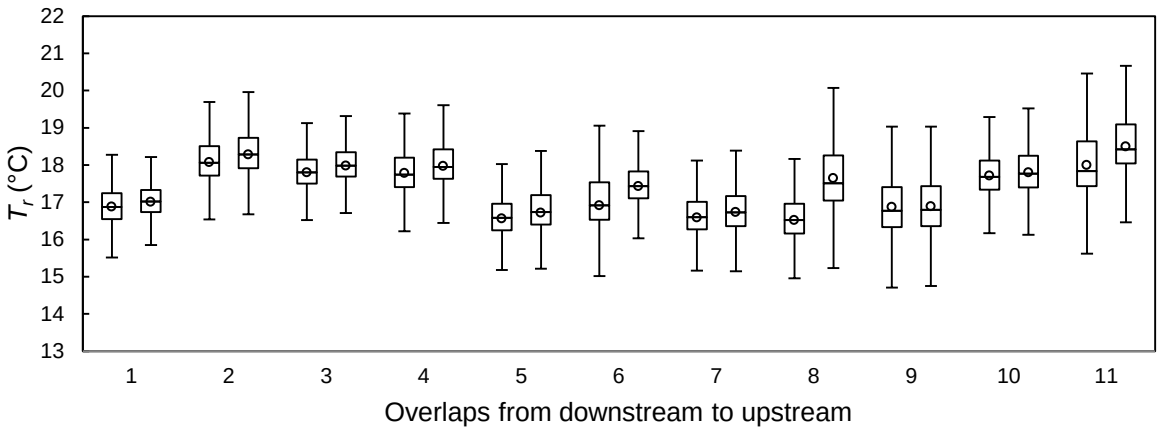
Riverine Systems

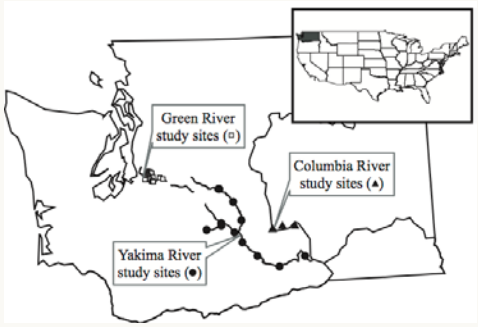
- Switched to monitoring water temperatures in river systems in the Pacific Northwest
  - Water temperature is a serious concern in the Pacific Northwest due to the salmon
  - Smaller target
  - Linear feature
  - Changing conditions
  - Evaluated suitability of different platforms

Source: http://www.canned-salmon.com

Stream Temperature Monitoring

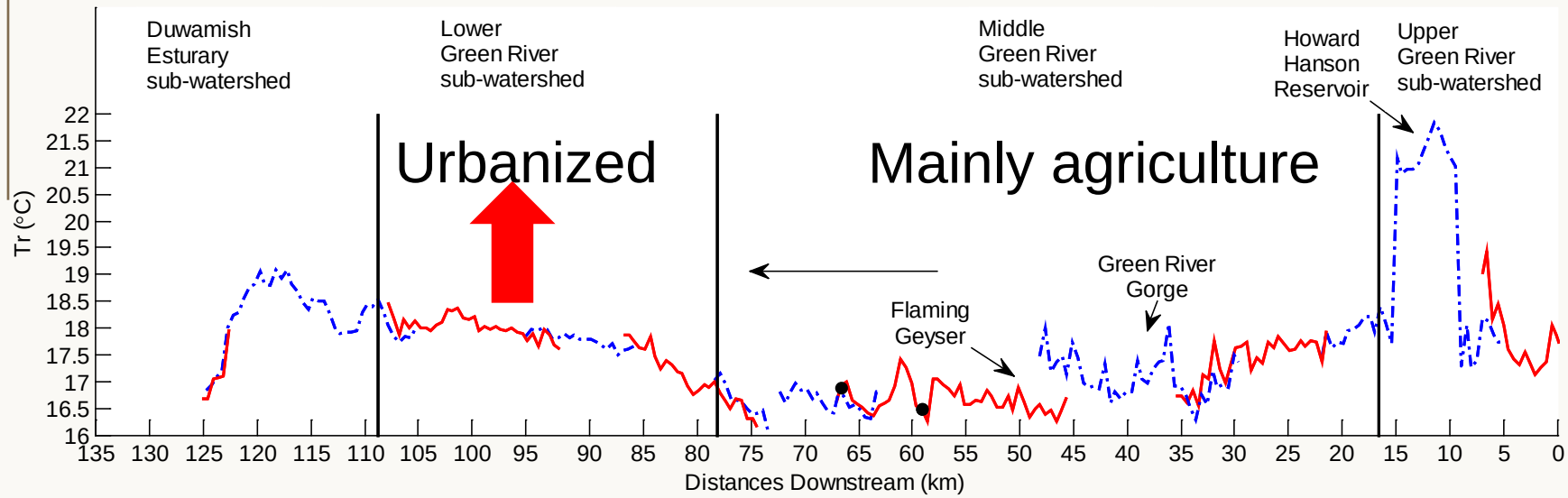






Tan and Cherkauer, 2013

Stream Temperature Monitoring



Tan and Cherkauer, 2013

Resolving the River

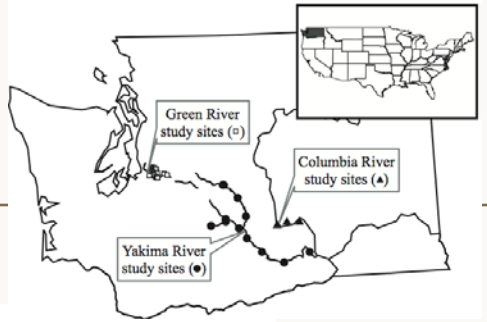
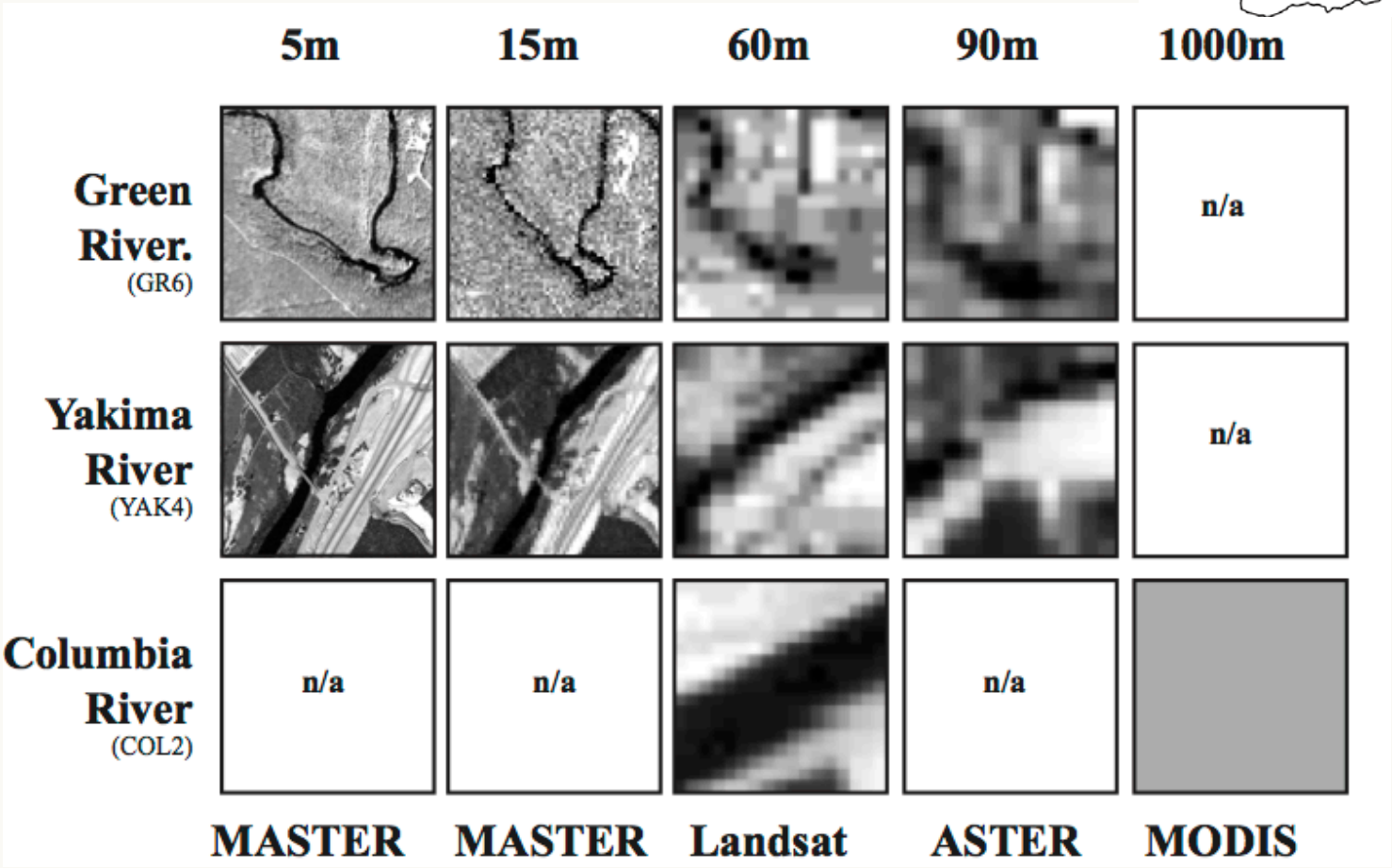


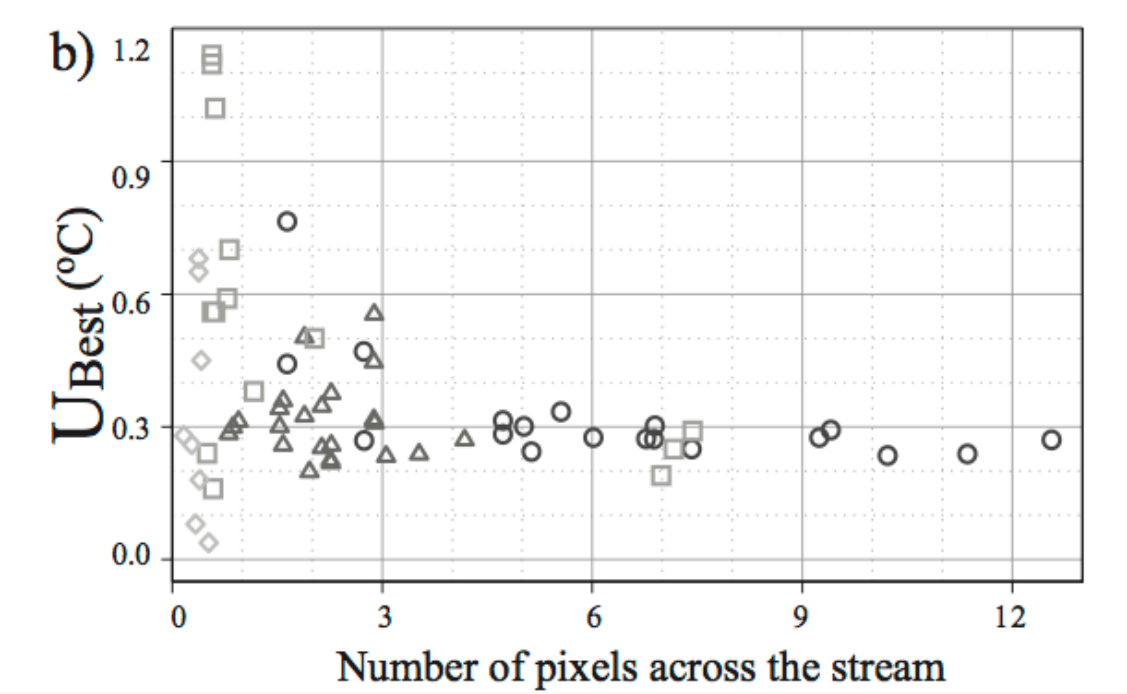
Image Resolution



Handcock et al., 2006

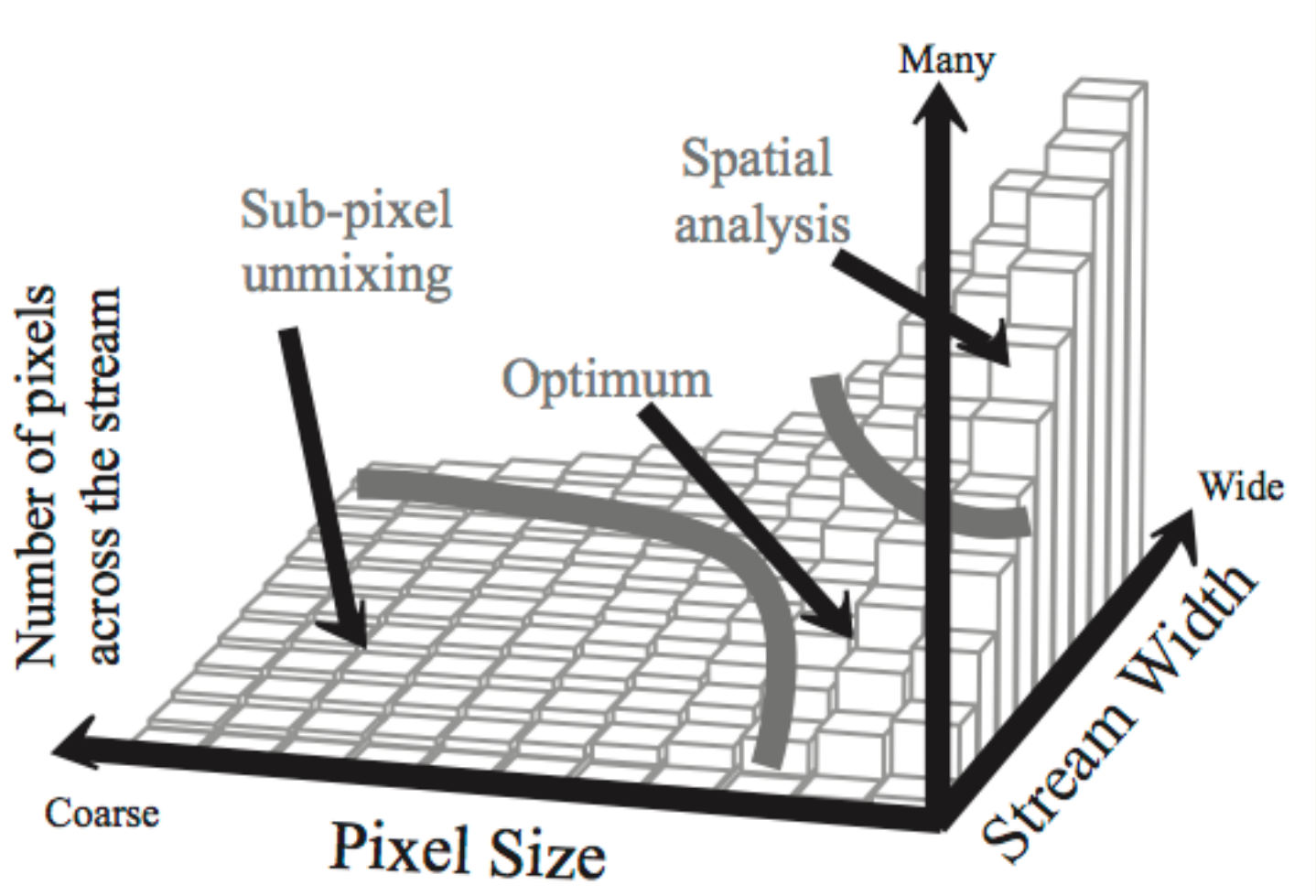
Resolving the River

Uncertainty in the temperature measurement is reduced when the width of the channel is captured by three or more pixels



Handcock et al., 2006

Resolving the River



Handcock et al., 2006

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Midwestern Riverine Systems

- In the Midwest thermal condition is not typically the limiting condition
  - Fewer cold water fish species
  - Sediment and nutrients more significant problems
    - *They are more difficult to measure than temperature*
    - *Collection of water samples for lab analysis is labor intensive*
    - *Real-time sensors are expensive and temperamental*
  - Tributaries are important sources of water quality problems

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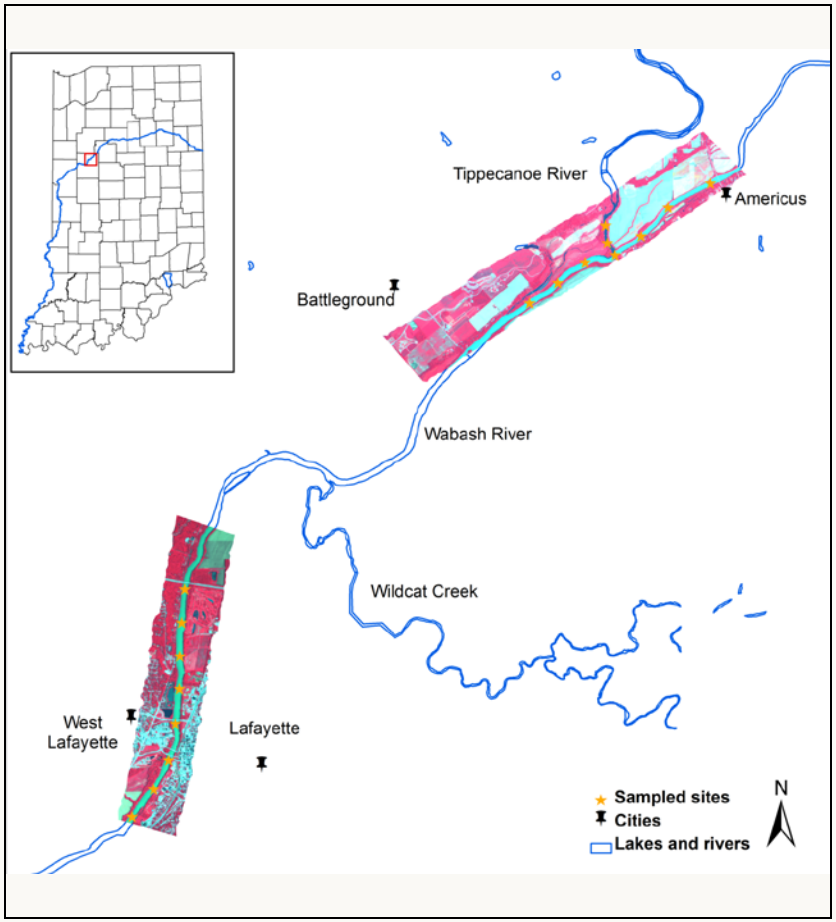
Applications in the Wabash River



- Optically active constituents (OACs)
  - Chlorophyll a (Chl-a)
  - Total Suspended Solids (TSS)
  - Colored Dissolved Organic Matter (CDOM)

› Hyperspectral imagery is important

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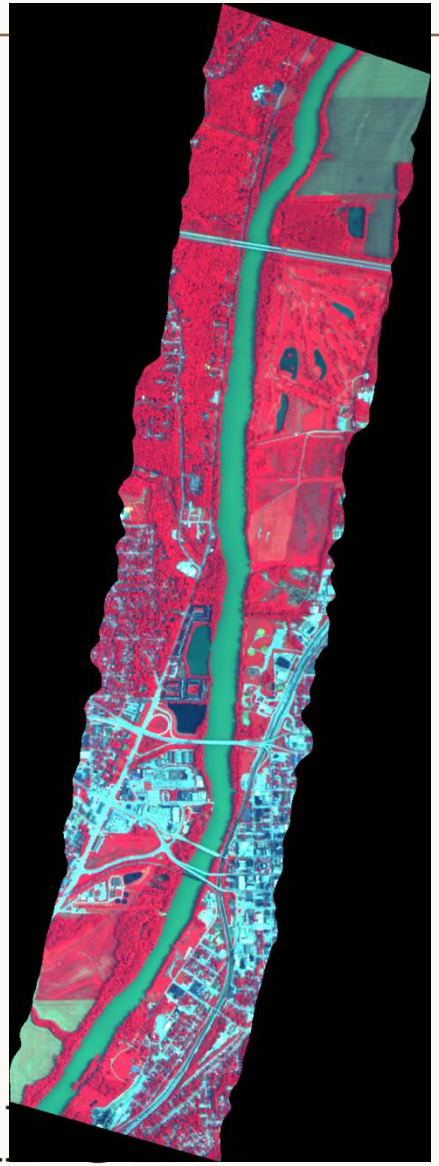
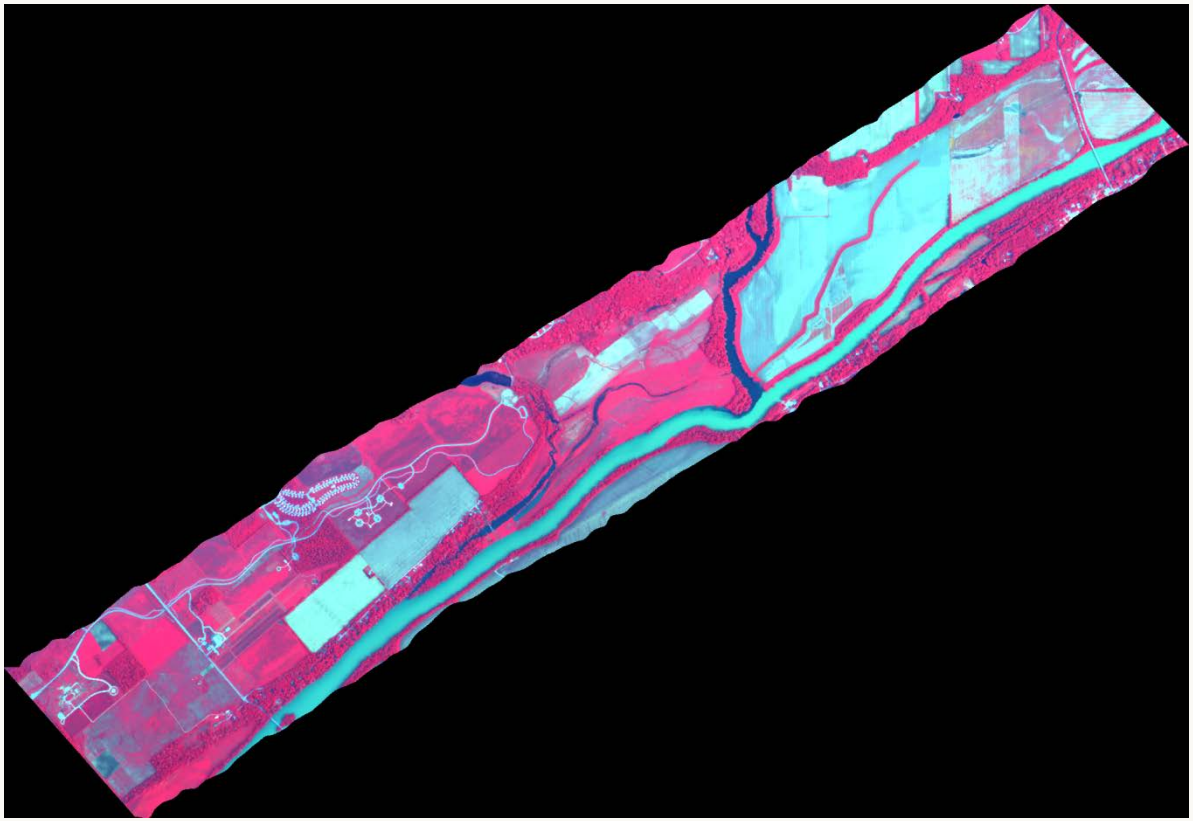
Wabash River through Lafayette, IN



Confluence of the Tippecanoe River with the Wabash River



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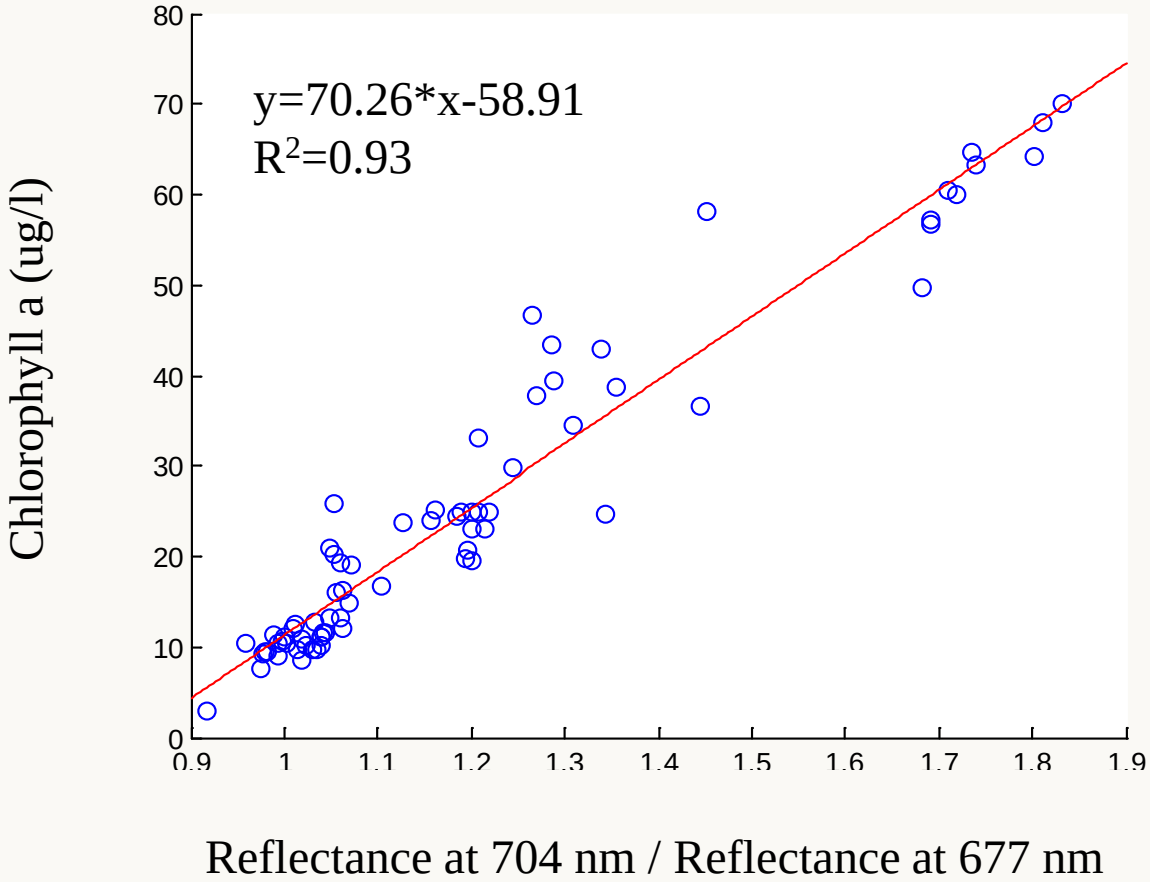
Chlorophyll-a vs Reflectance



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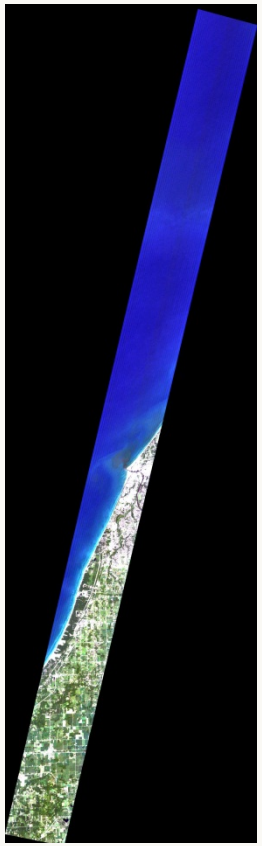
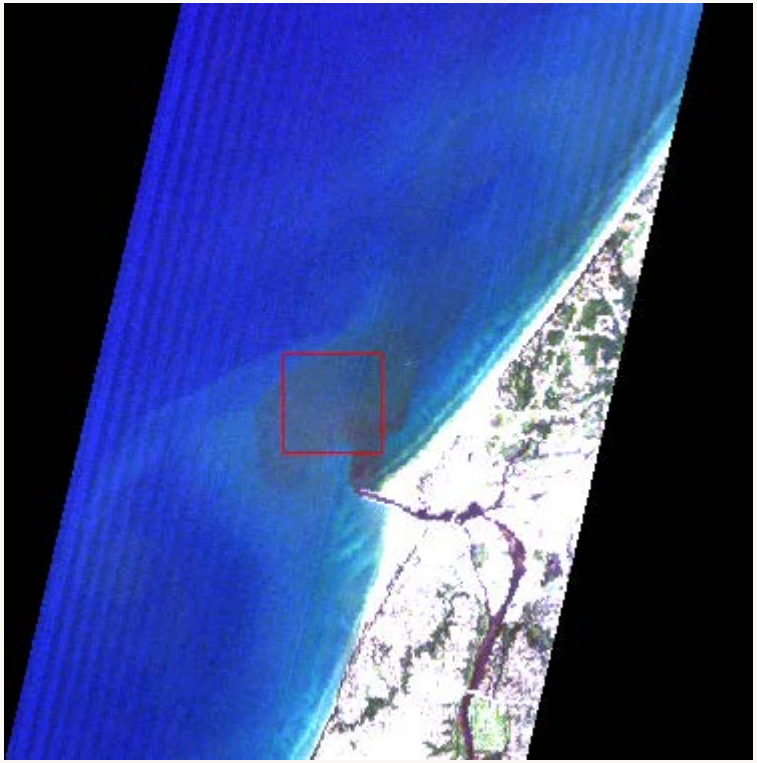
Lake Michigan Plume Monitoring





August 7, 2012 at St Joseph River

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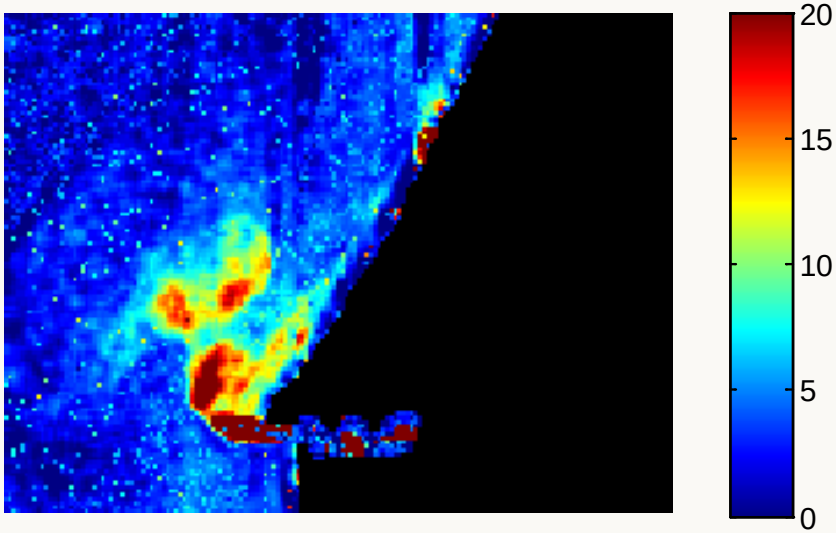
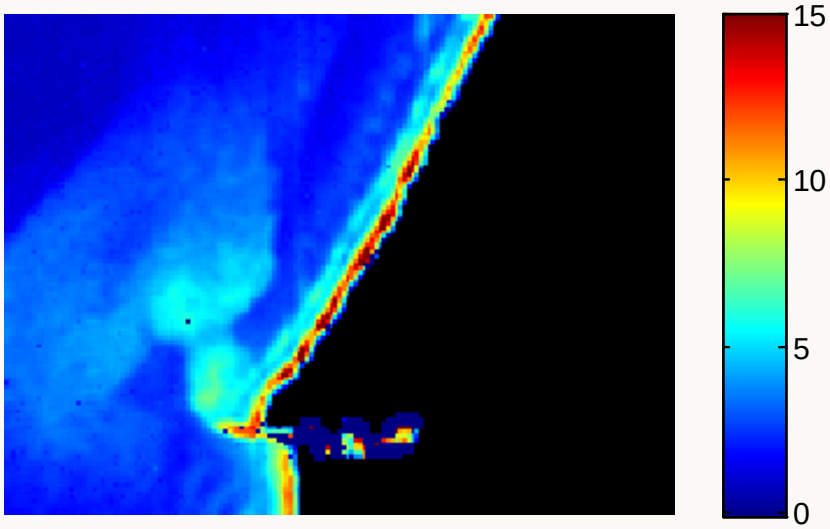
Water Quality of Episodic Plumes

Chlorophyll-a



Total Suspended Solids



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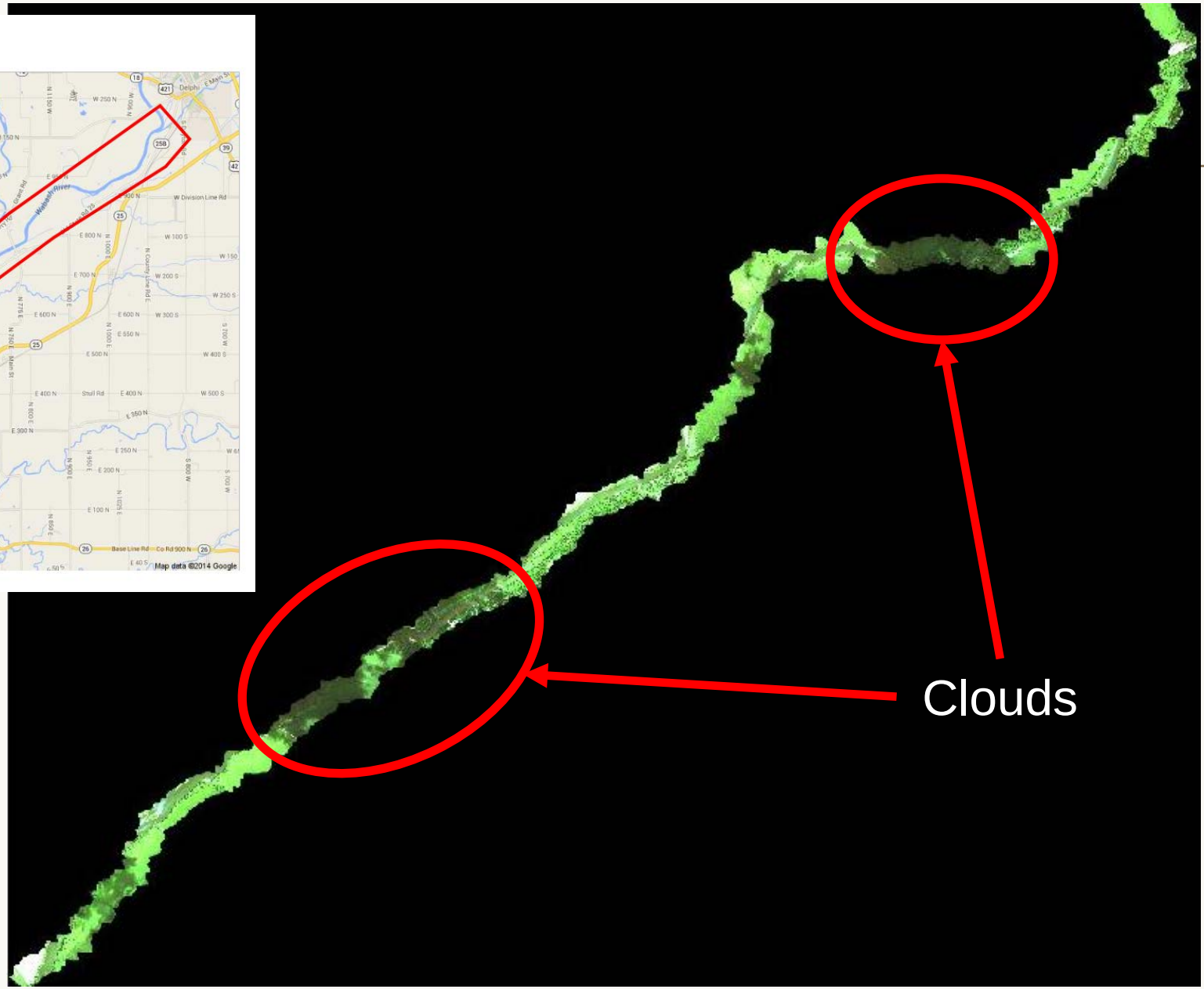

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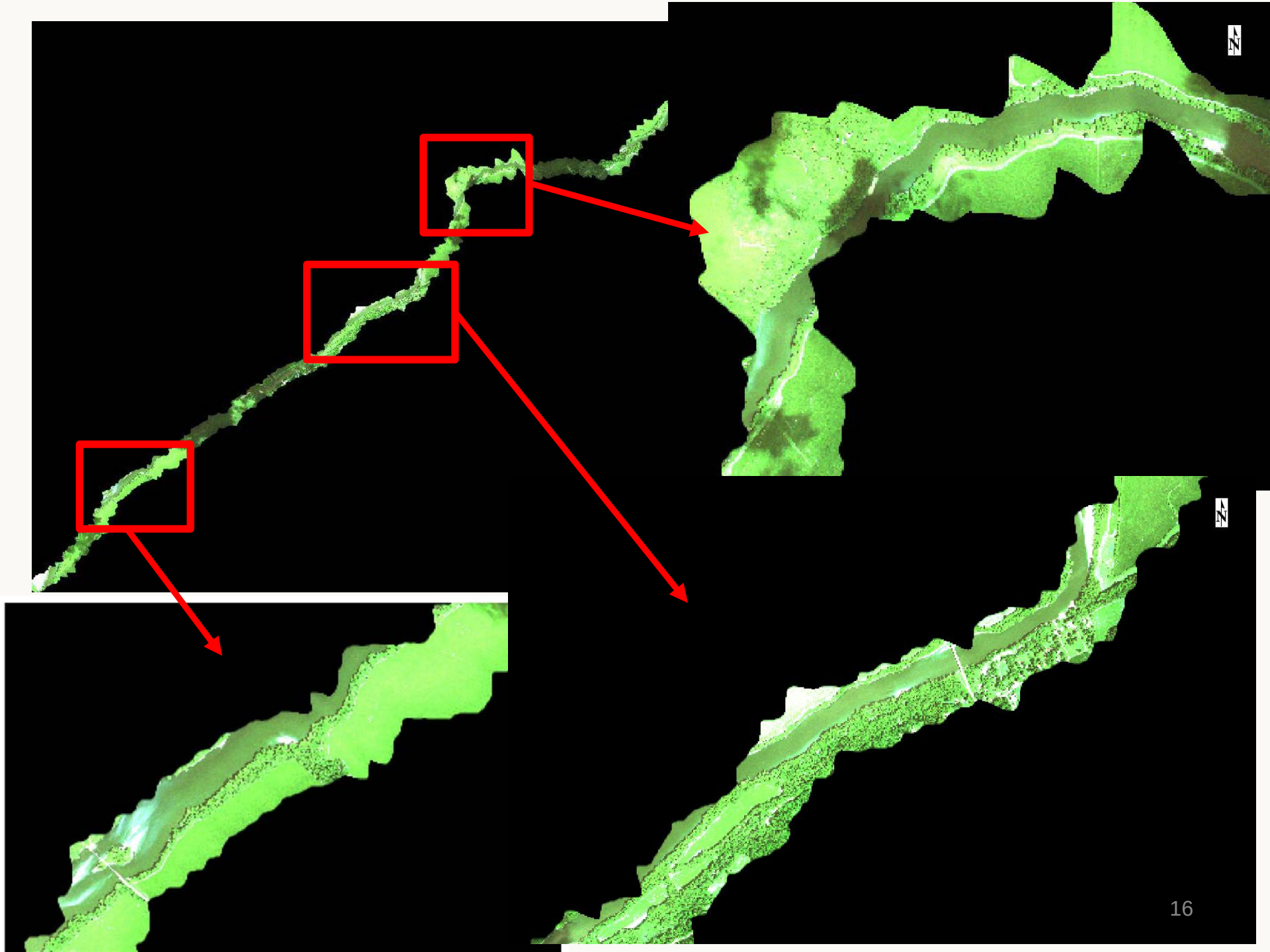
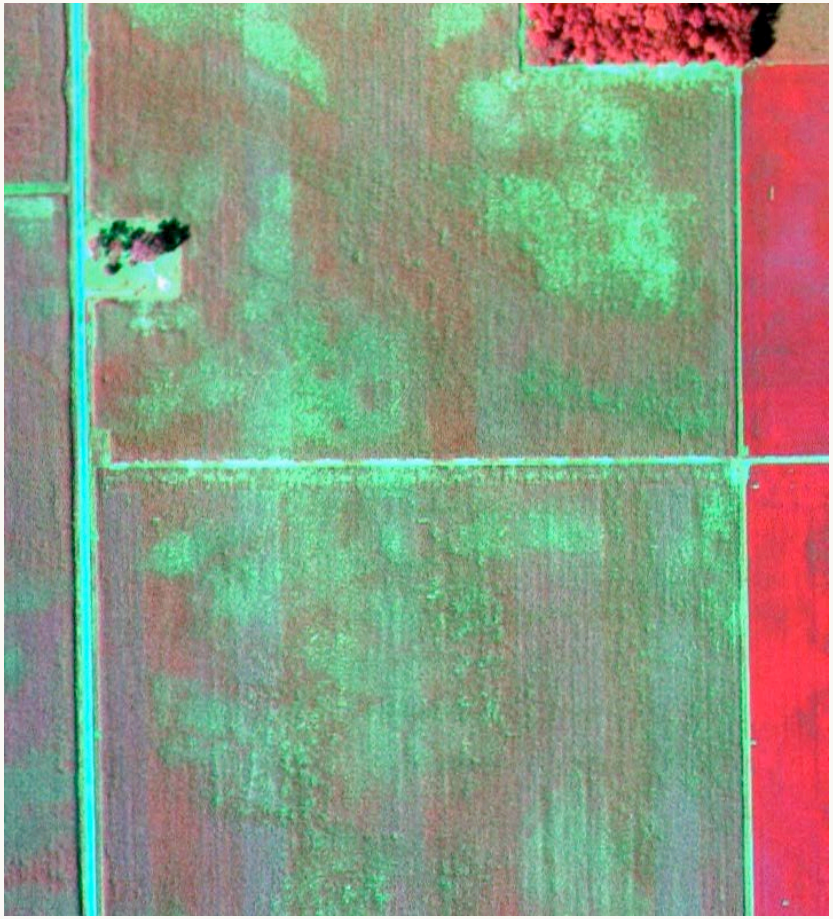


Hyperspectral Platform

AGX Tecnologia, Brazil
http://www.agx.com.br

Agricultural Applications

- Long history of agricultural applications for remote sensing
- Laboratory for Applications of Remote Sensing (LARS) established at Purdue in 1966



AgriVision multispectral image (channels 3, 2 and 1). August 31, 2002.

Remote Sensing for Agriculture

LARS Field Measurement Facility
circa 1975

- Larger target areas more suitable for satellite
- Aircraft commonly used for higher resolution
- Conditions change quickly, so repeat times must be short and demand exists for immediate turn around

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Farmer Interest in UAS Technology

Table 1. Characteristics related to farm size

		Size of Farms (acres)				
		All	0-500	501-1500	1501-3000	Over 3000
Source of UAV images	Hire	51%	44%	63%	45%	60%
	Both	27%	22%	19%	32%	40%
	Own	22%	33%	19%	23%	0%
Number of responses		66	20	16	23	7

Ringel and Sills, 2014

Farmer Interest in UAS Technology

Table 2. UAV topic evaluation for corresponding participant characteristics

		Number of responses	Received aerial imagery before	Familiar with the term UAV	Want UAV data to be private*	Want notice before surrounding UAVs fly*
All participants		66	82%	86%	73%	39%
Farm Size						
	0-500 ac	20	85%	95%	72%	35%
	501-1500 ac	16	81%	75%	69%	25%
	1501-3000 ac	23	78%	82%	73%	57%
	Over 3000 ac	7	86%	100%	86%	29%
Age						
	20-35 yrs	15	100%	93%	69%	67%
	35-50 yrs	18	78%	77%	69%	44%
	50-65 yrs	23	78%	91%	65%	22%
	over 65 yrs	10	70%	80%	100%	30%

* Does not include undecided answers

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Ringel and Sills, 2014

Farmer Interest in UAV Technology

Table 3. UAV topic significance corresponding to participant characteristics

		Number of responses	Adopt within the next four years	Willing to pay up $10,000 for a UAV	Want a payback period of <= 3 yrs
All participants		66	82%	86%	86%
Farm Size					
	0-1500 ac	36	81%	94%**	83%*
	Over 1500 ac	30	83%	77%**	90%*
Age					
	20-50 yrs	33	85%	82%*	91%**
	Over 50 yrs	33	79%	88%*	85%**

* Significant to 65% confidence interval

** Significant to 85% confidence interval

Note: no significance was found between participant characteristics and adoption

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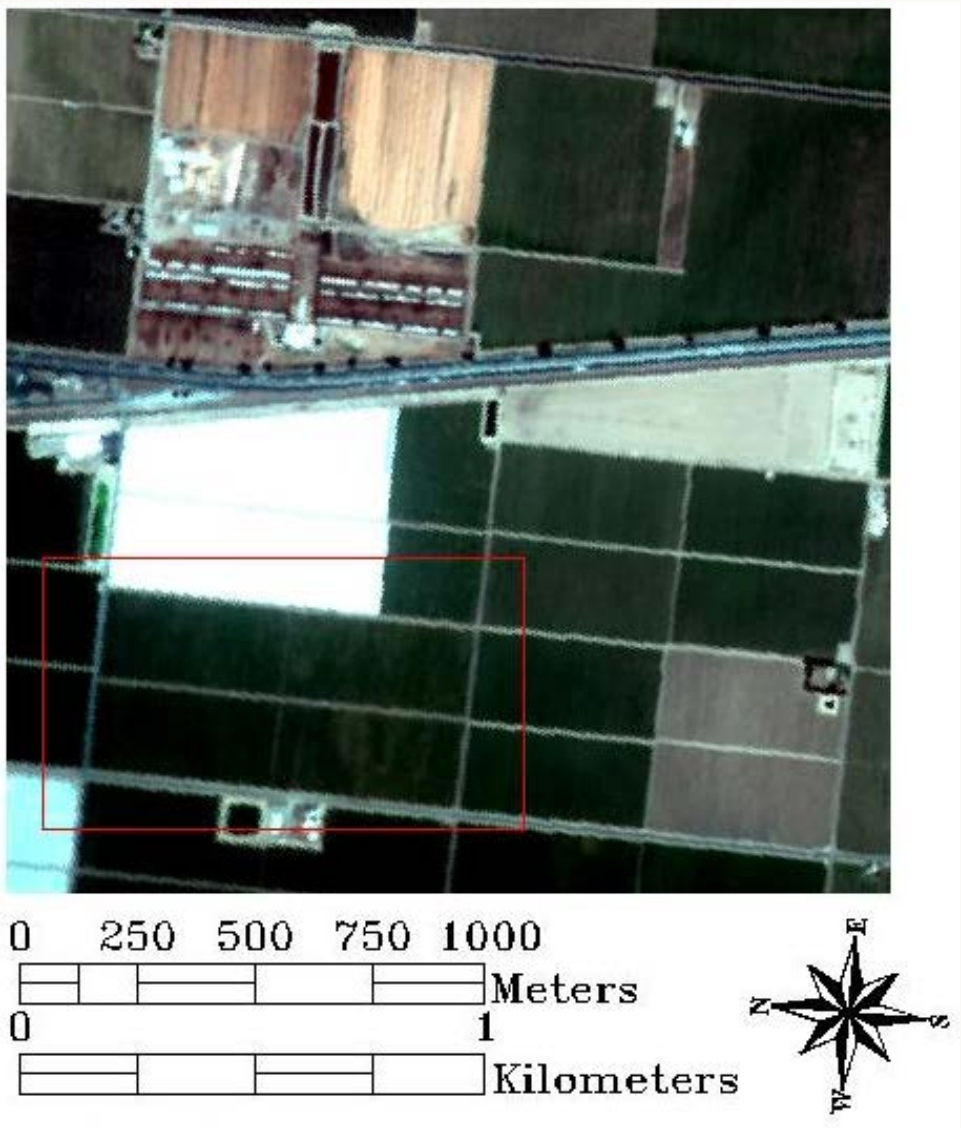
Ringel and Sills, 2014

Delano Vineyards, C.A.

MASTER image
June 26, 2012



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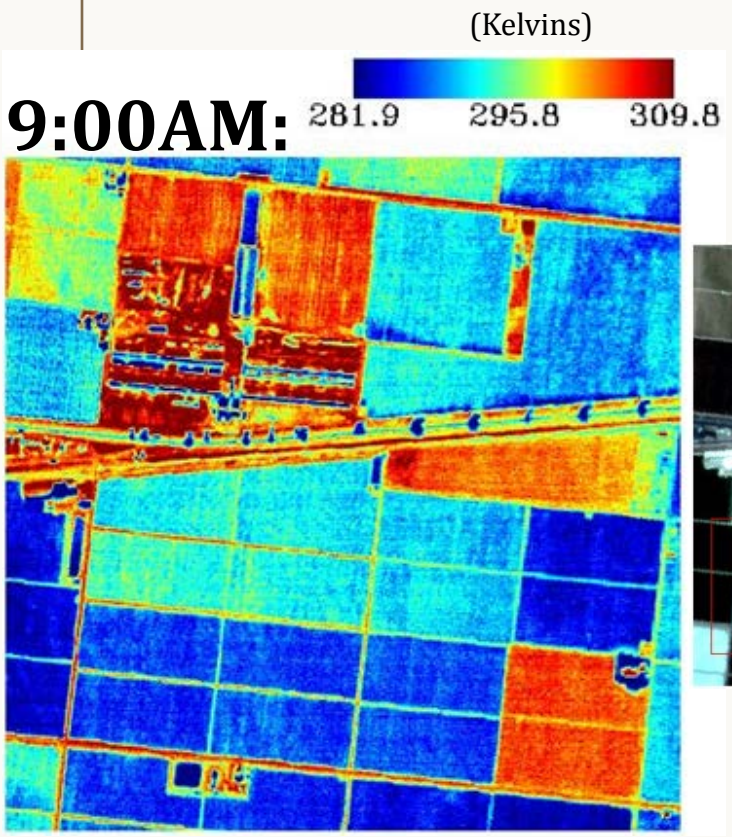
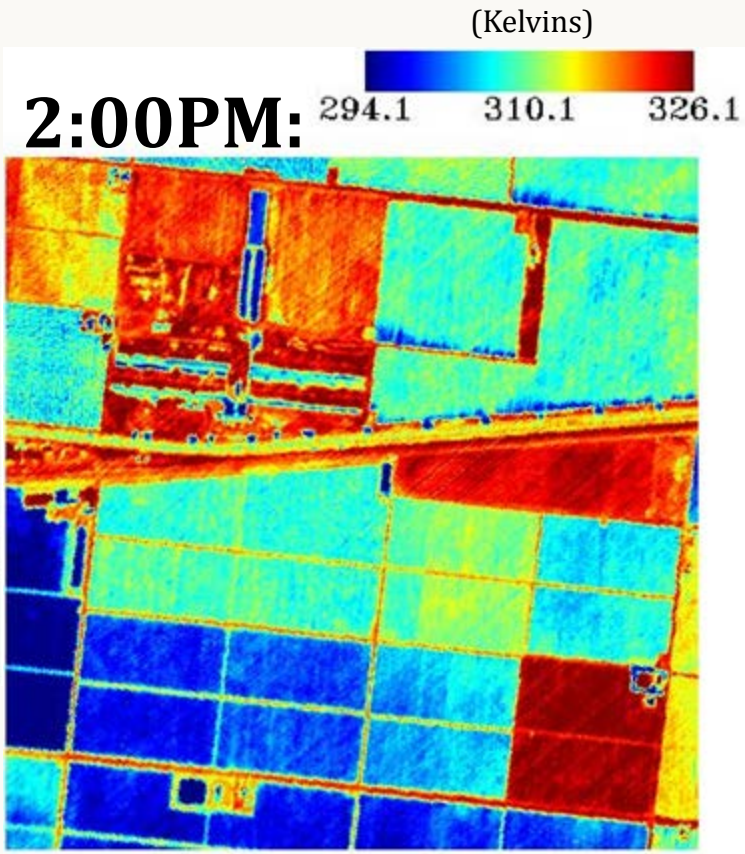
Radiometric Surface Temperature (K)





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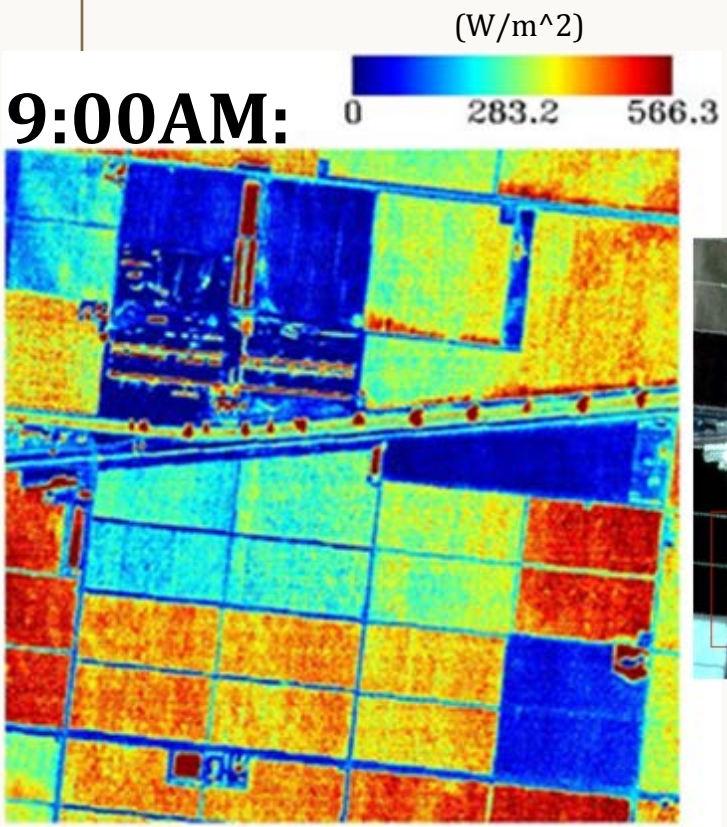
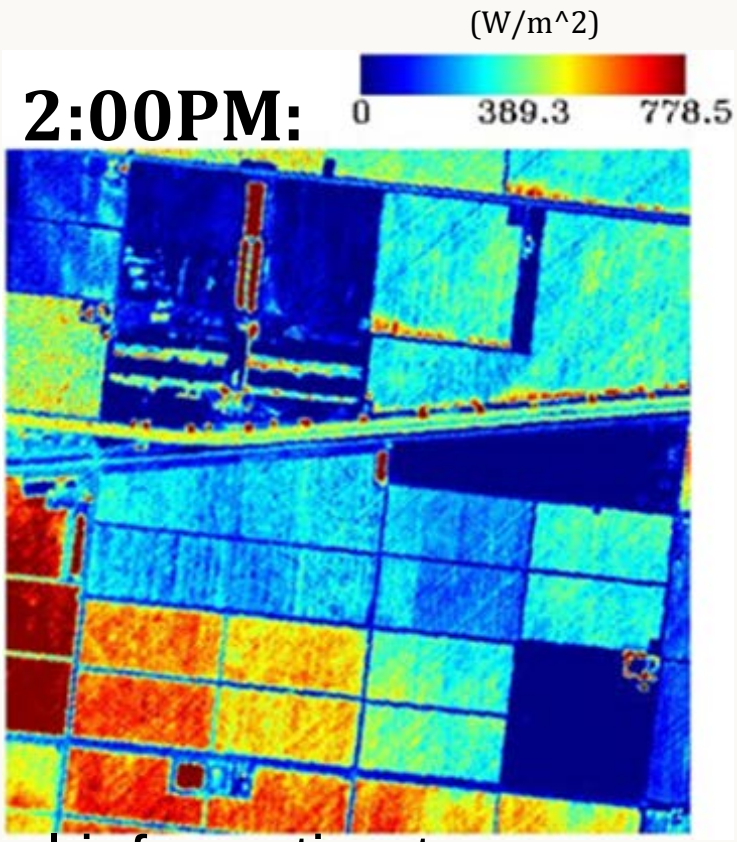
Evapotranspiration

Latent Heat Flux (W/m^2)

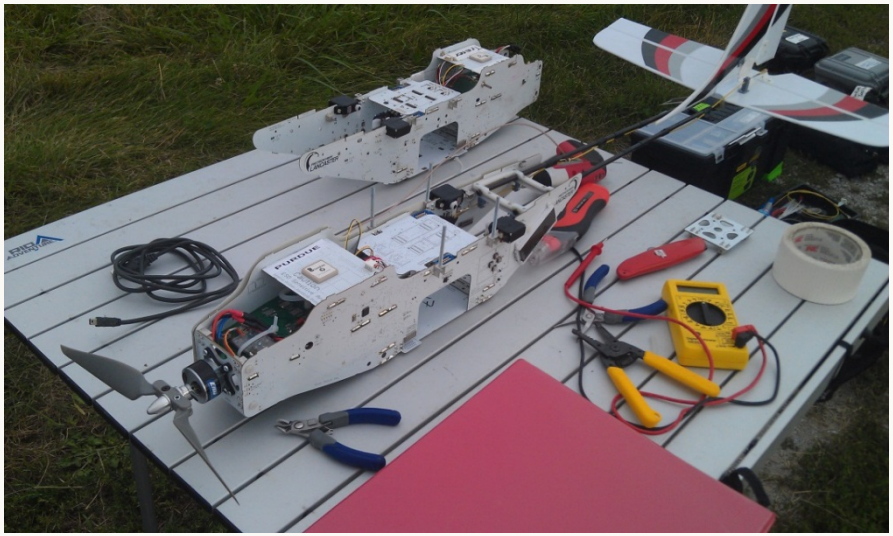
$LE = R - G - H$

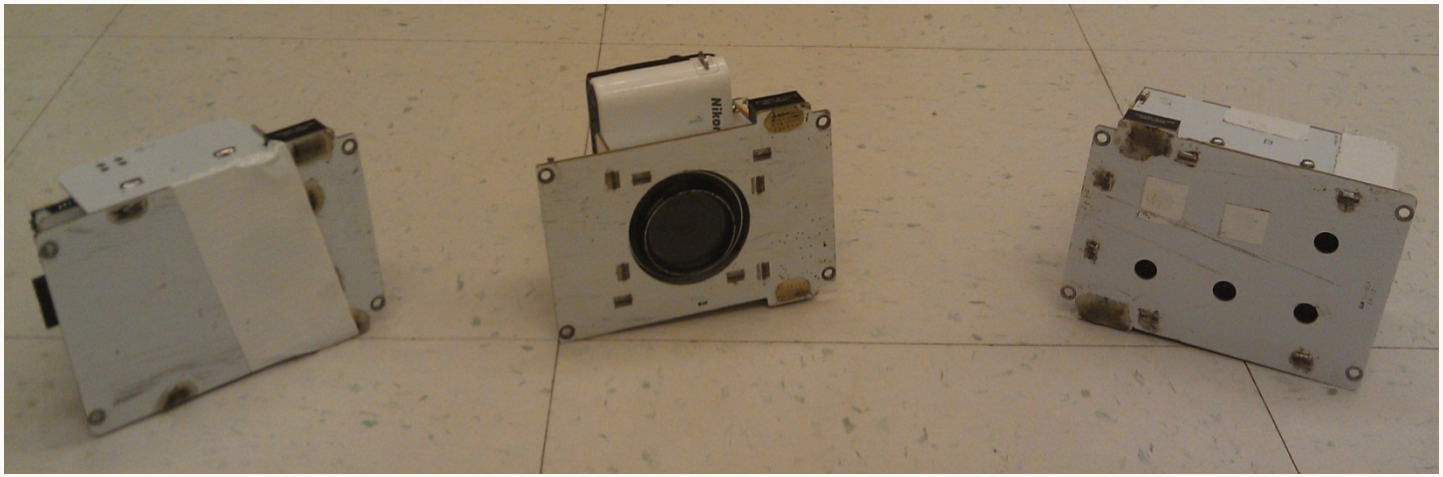




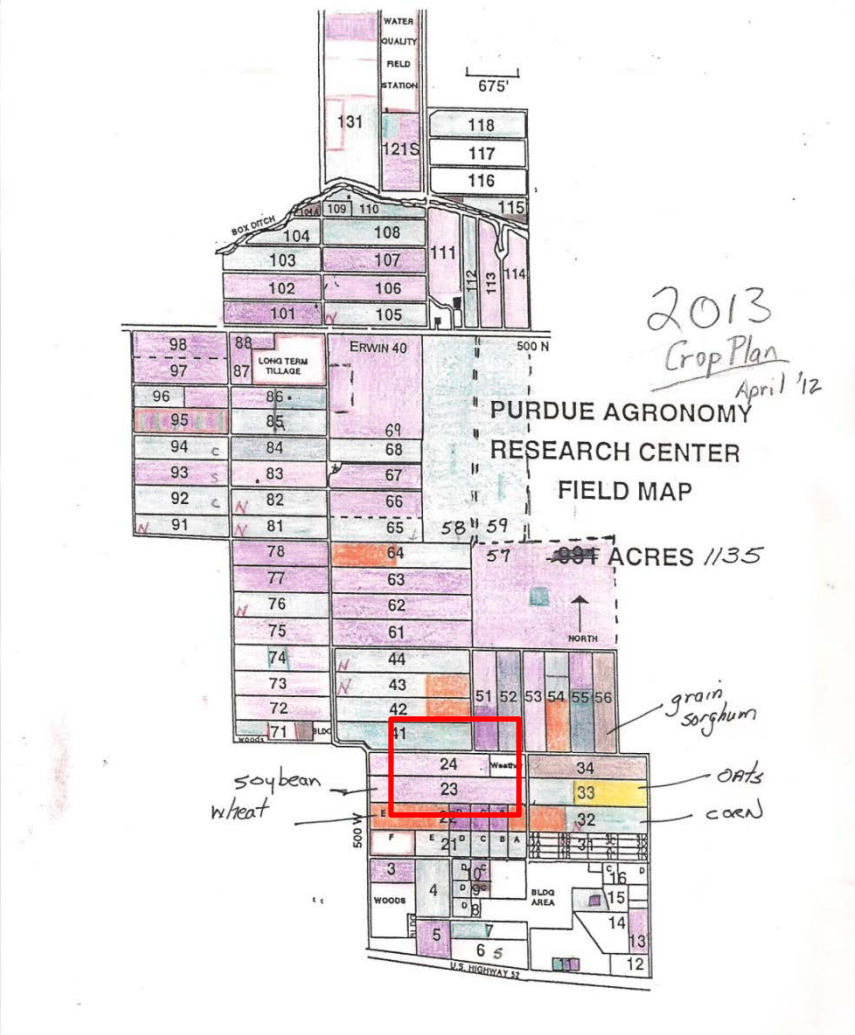
Couple with multi-spectral information to quantify stress

Image Acquisition System

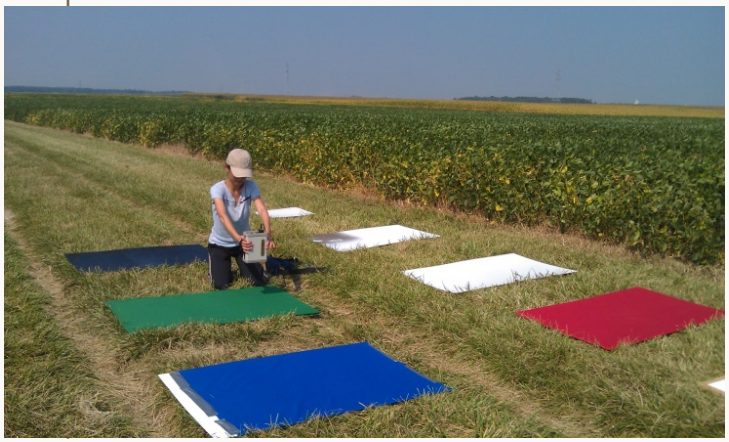


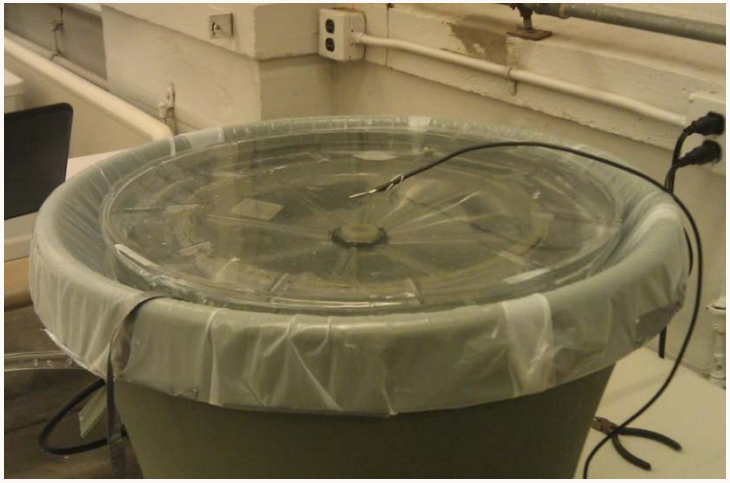


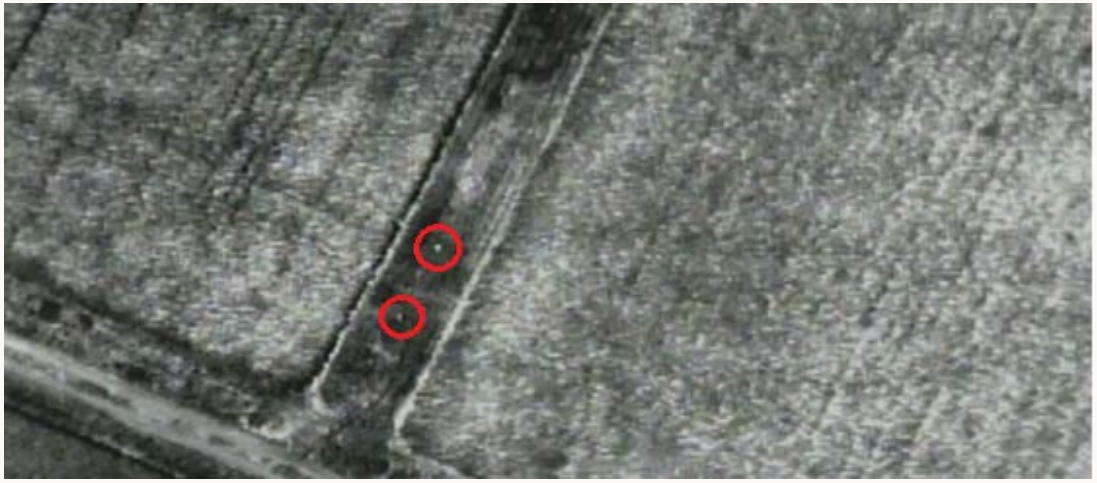
Field Site Information



Ground Reference Data

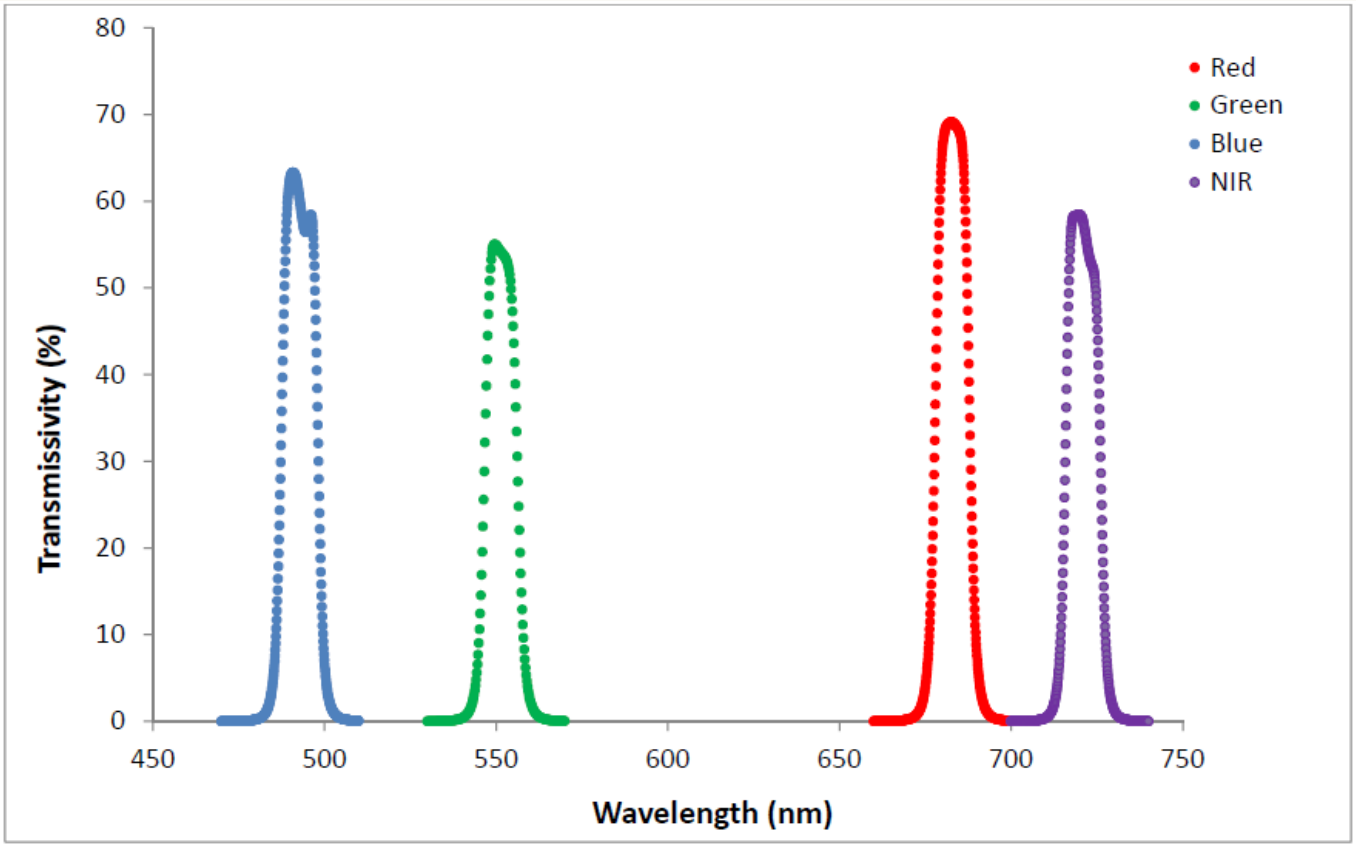






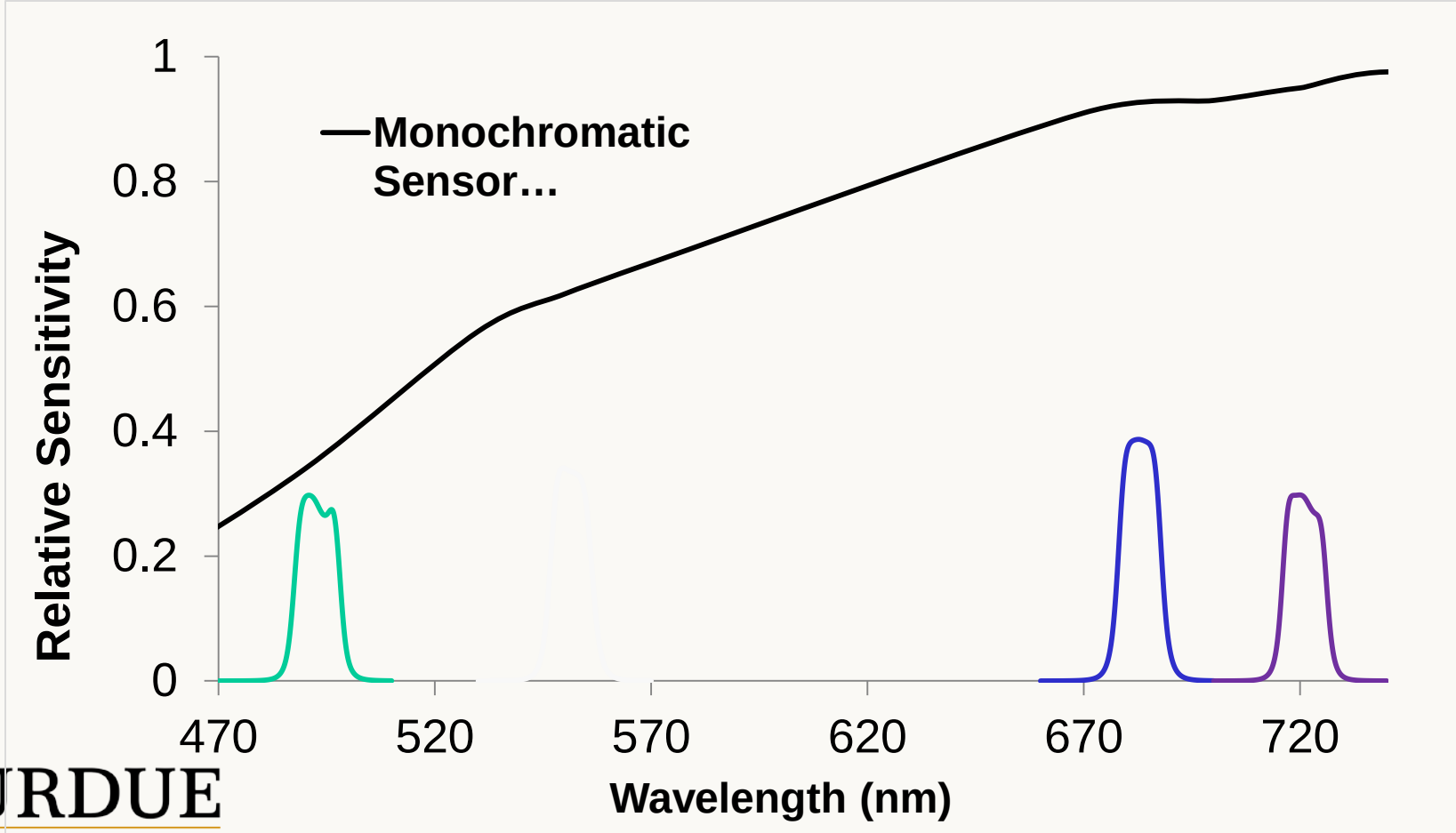
Radiometric Calibration

- Tetracam MCA-6 sensor characteristics
- Band filter transmission



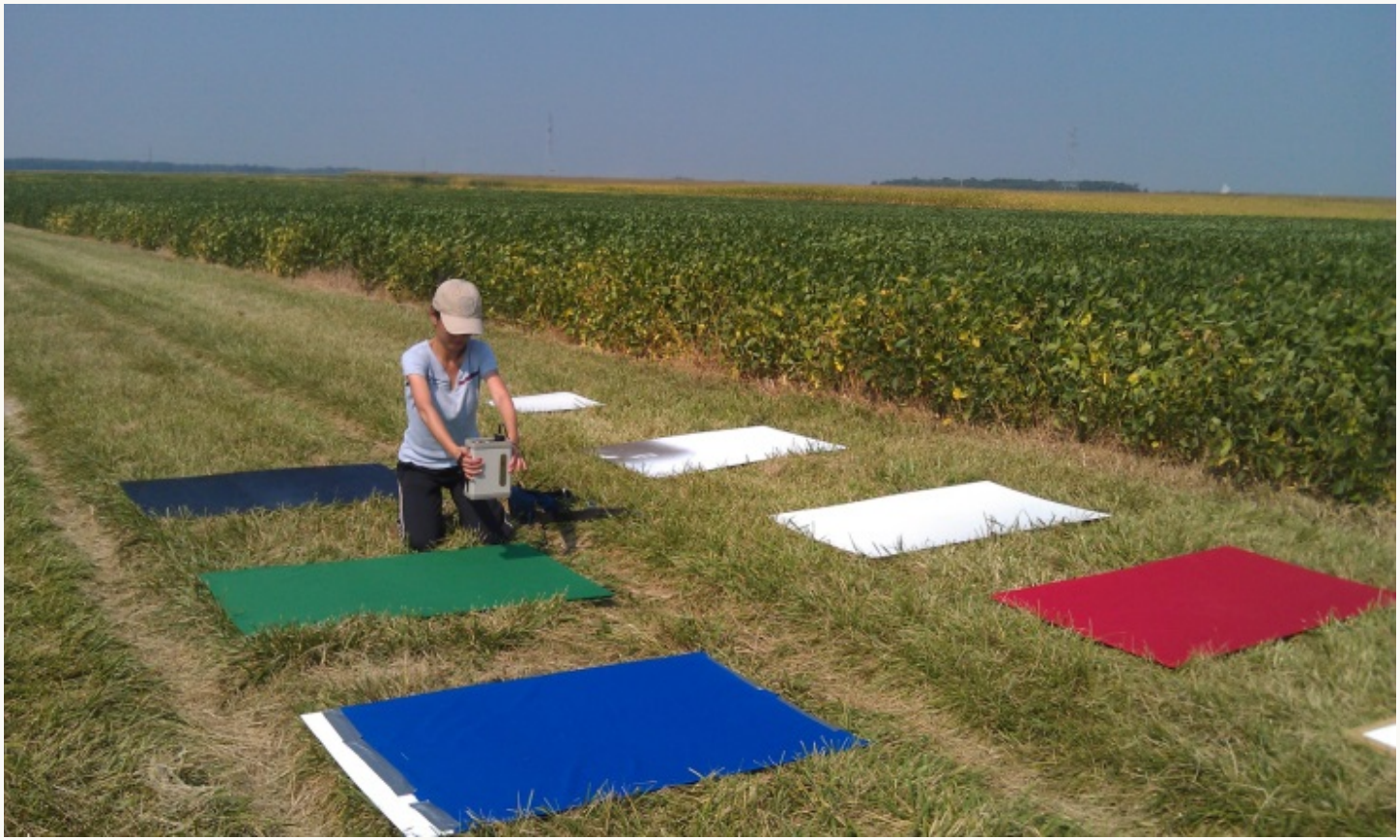
Radiometric Calibration

› Weighted response functions



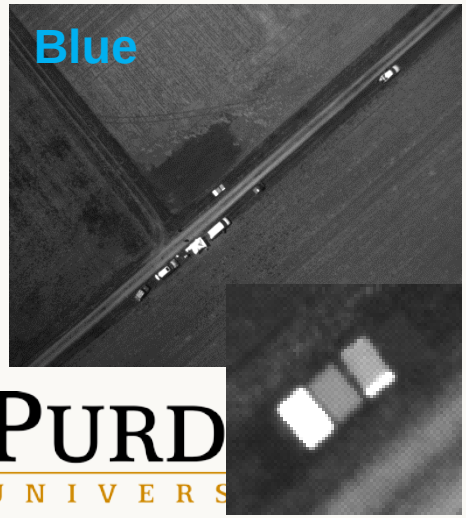
Radiometric Calibration

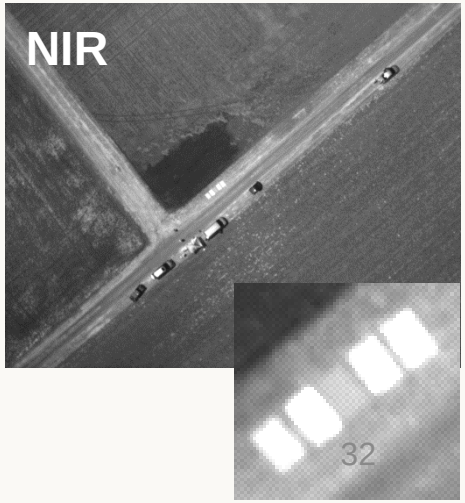
› Measure reflectance of lambertian targets



Radiometric Calibration

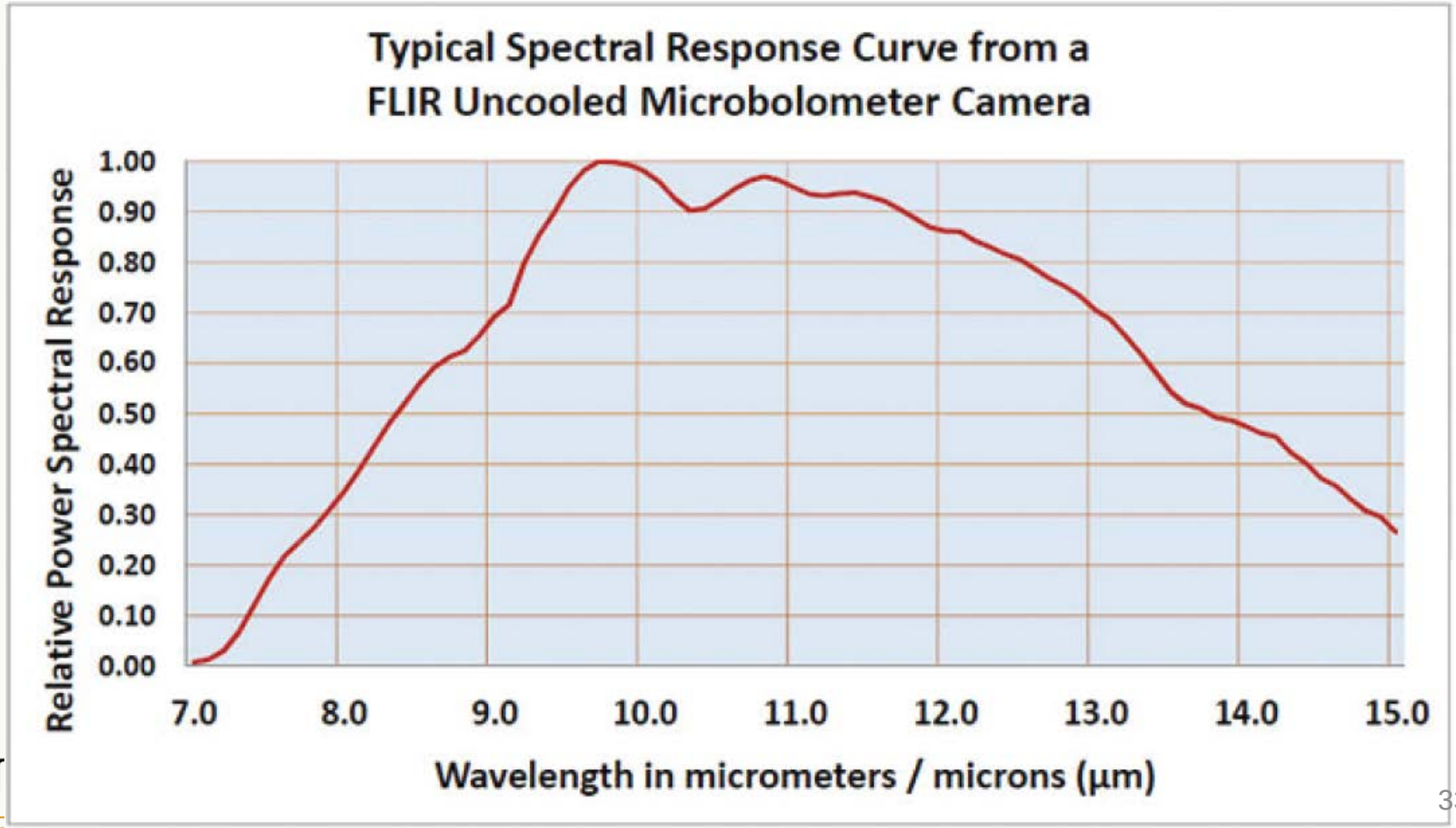
- Regression between weighted field data and panel DNs





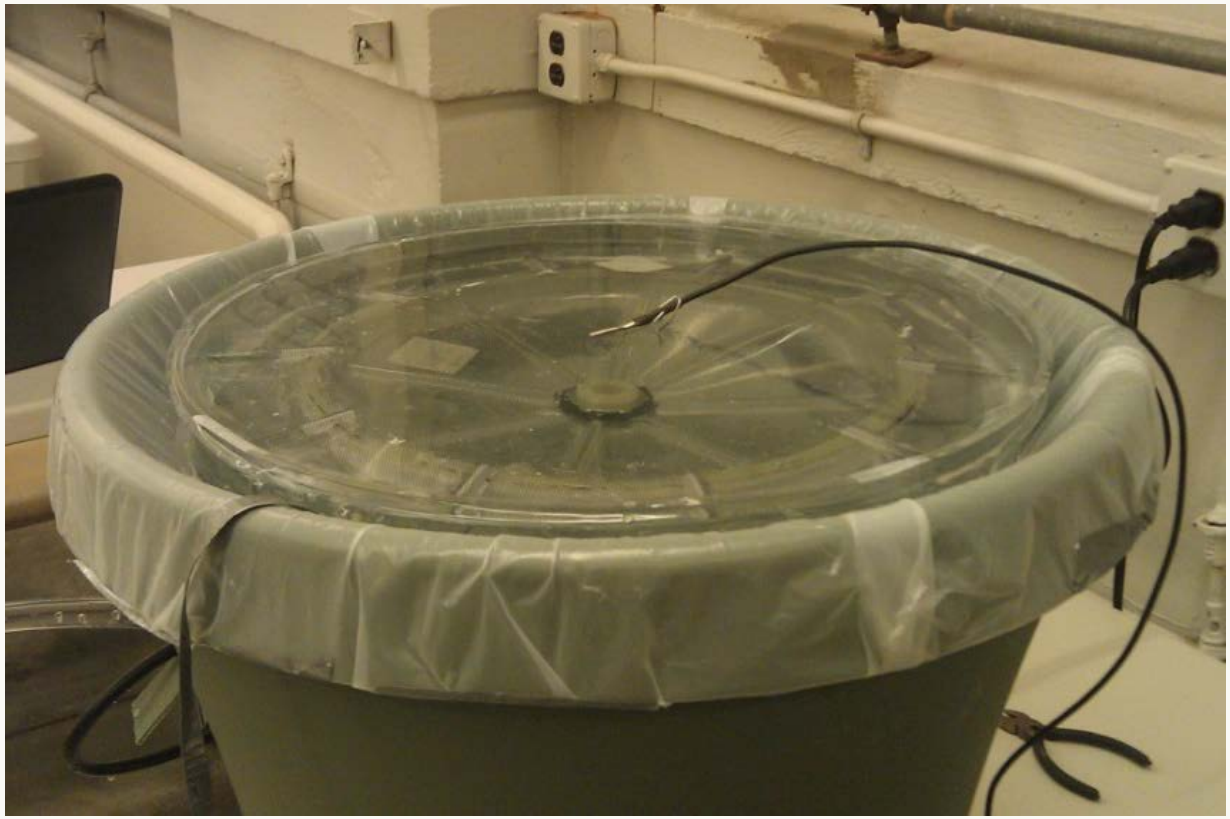
Thermal Calibration

› FLIR-Tau 1 sensor characteristics



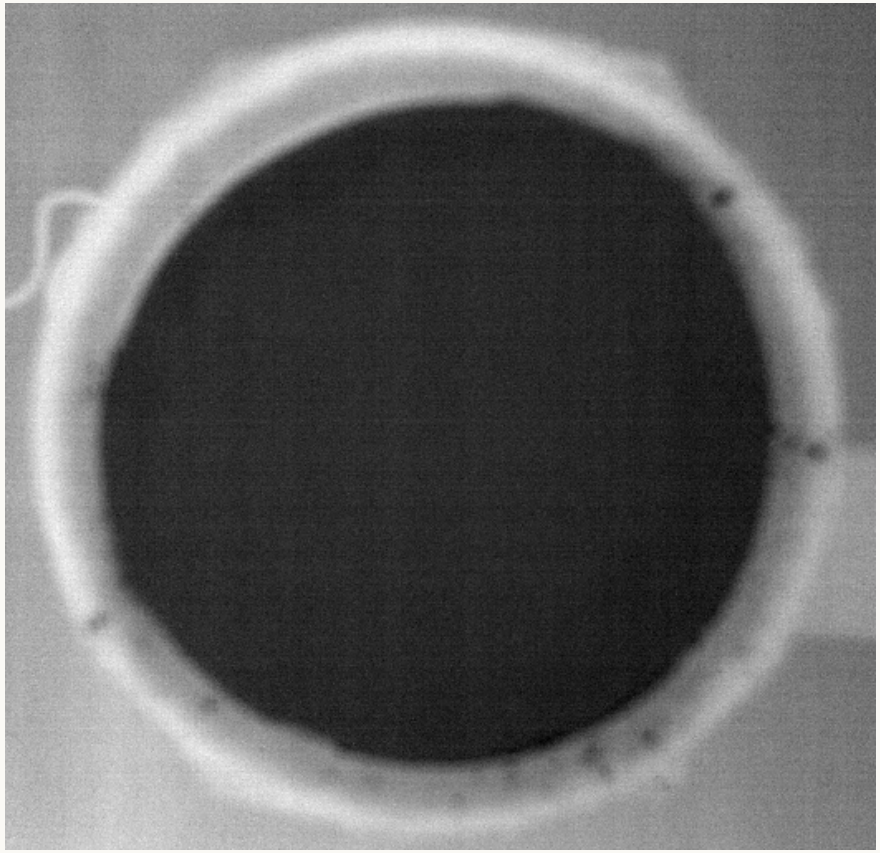
Thermal Calibration

› Monitor temperature of blackbody targets



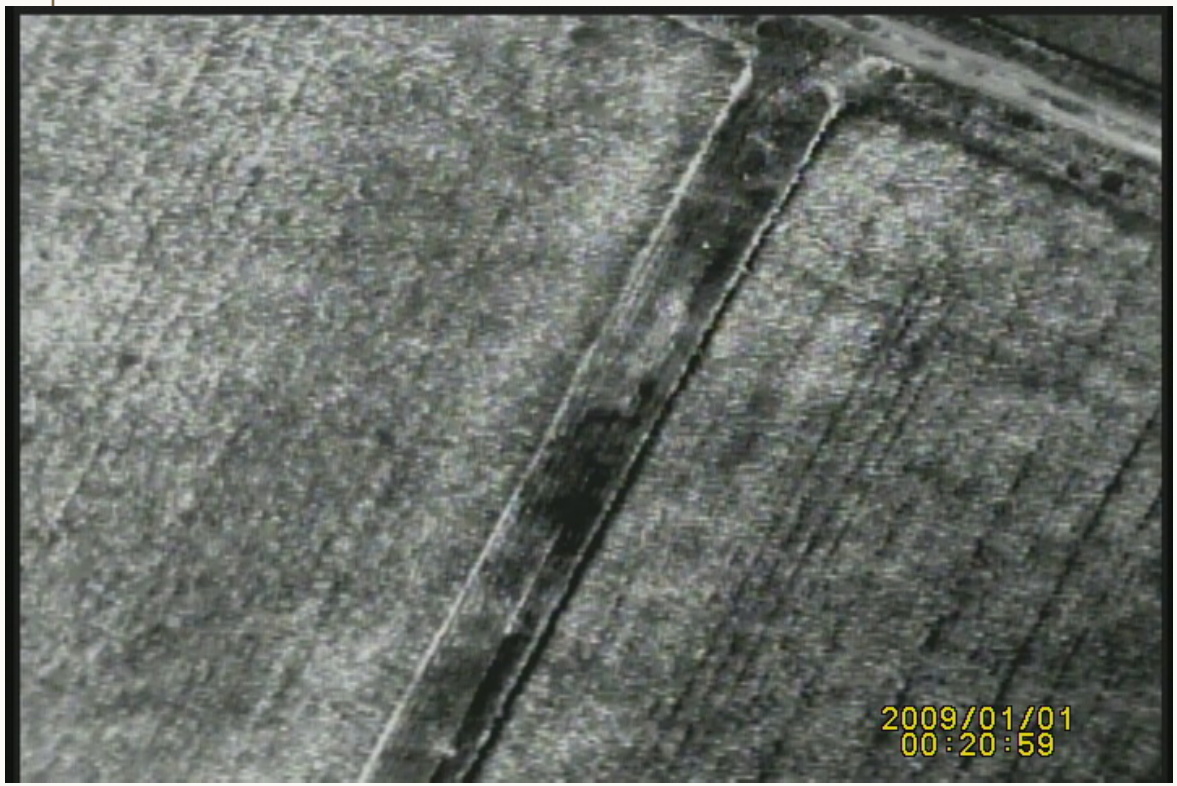
Thermal Calibration

› Avoid cooling film formation through mixing



Thermal Calibration

- Calibrate imagery based on in scene targets of known temperature



Thermal Calibration

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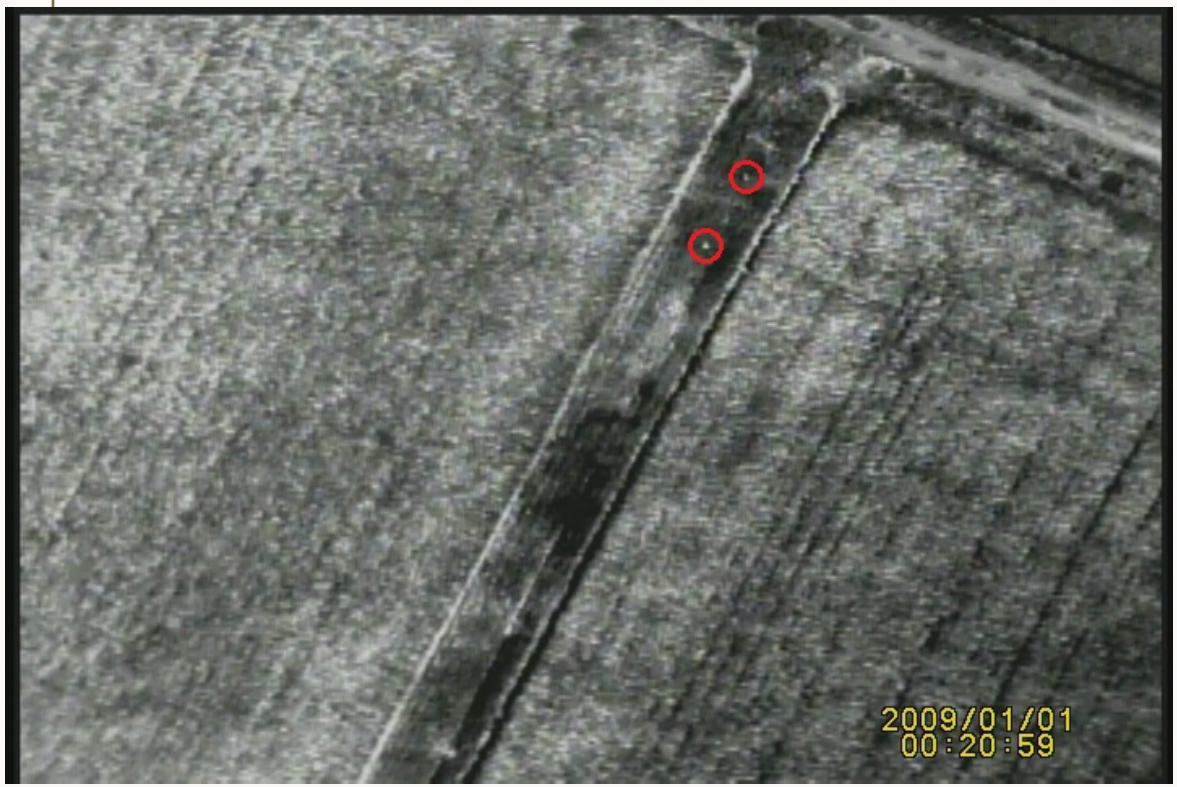
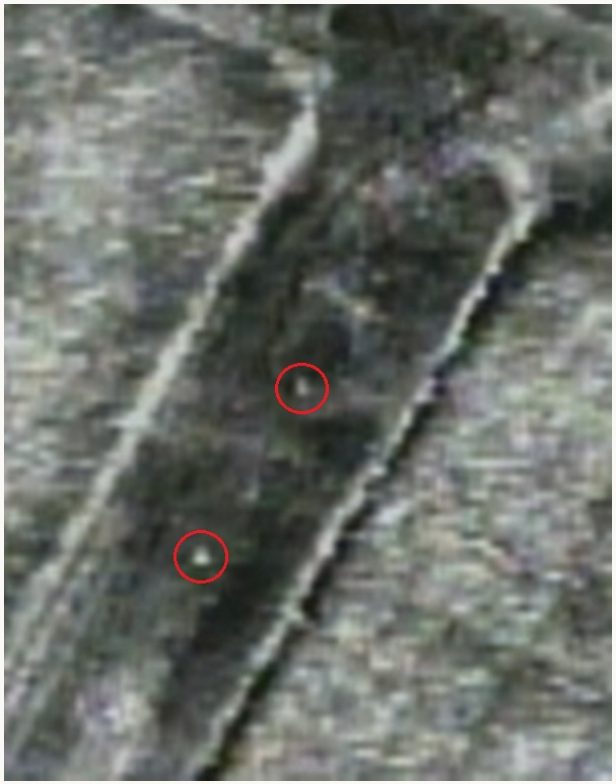
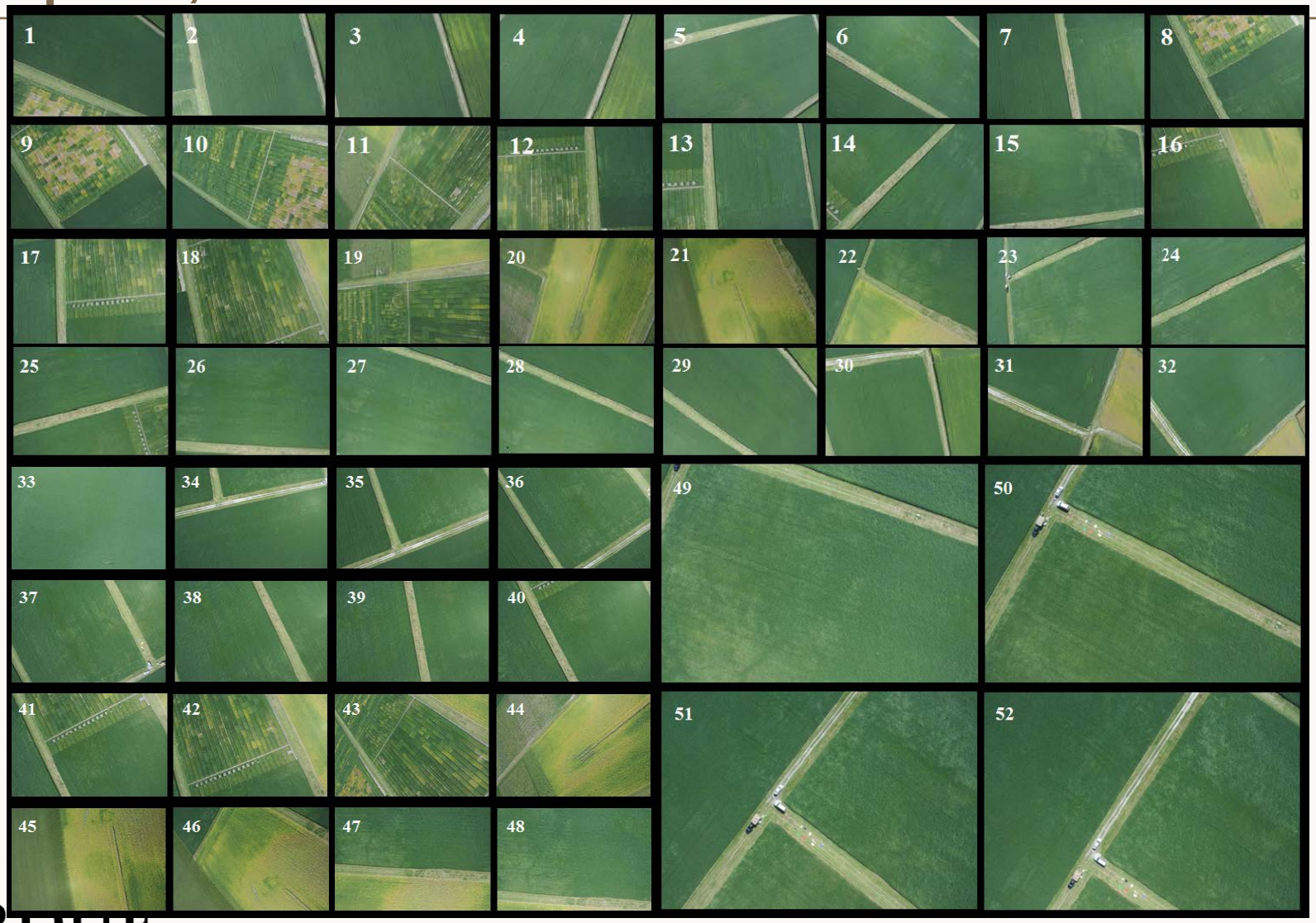




Raw Digital Camera Images

Sept 4th, 2013



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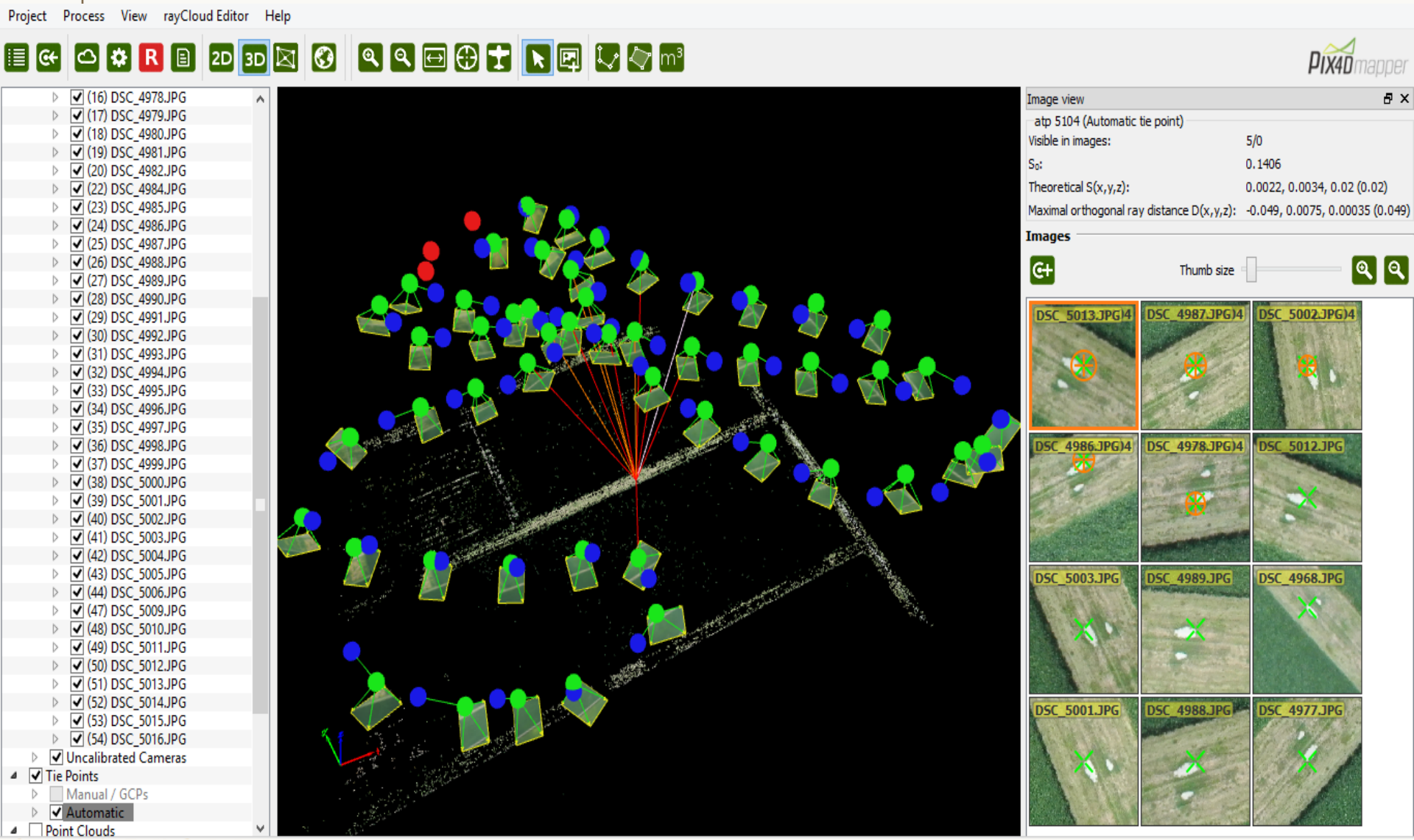
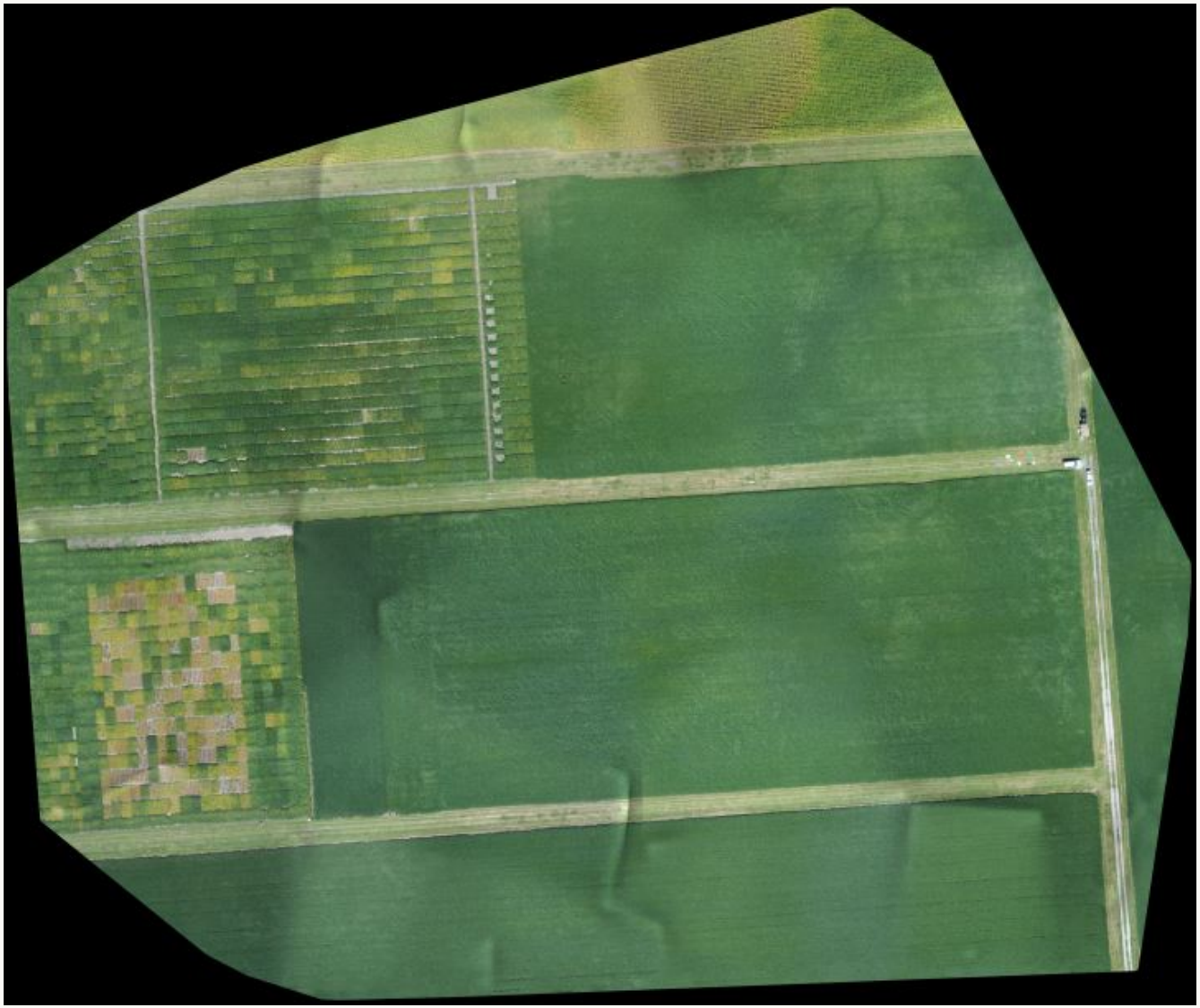
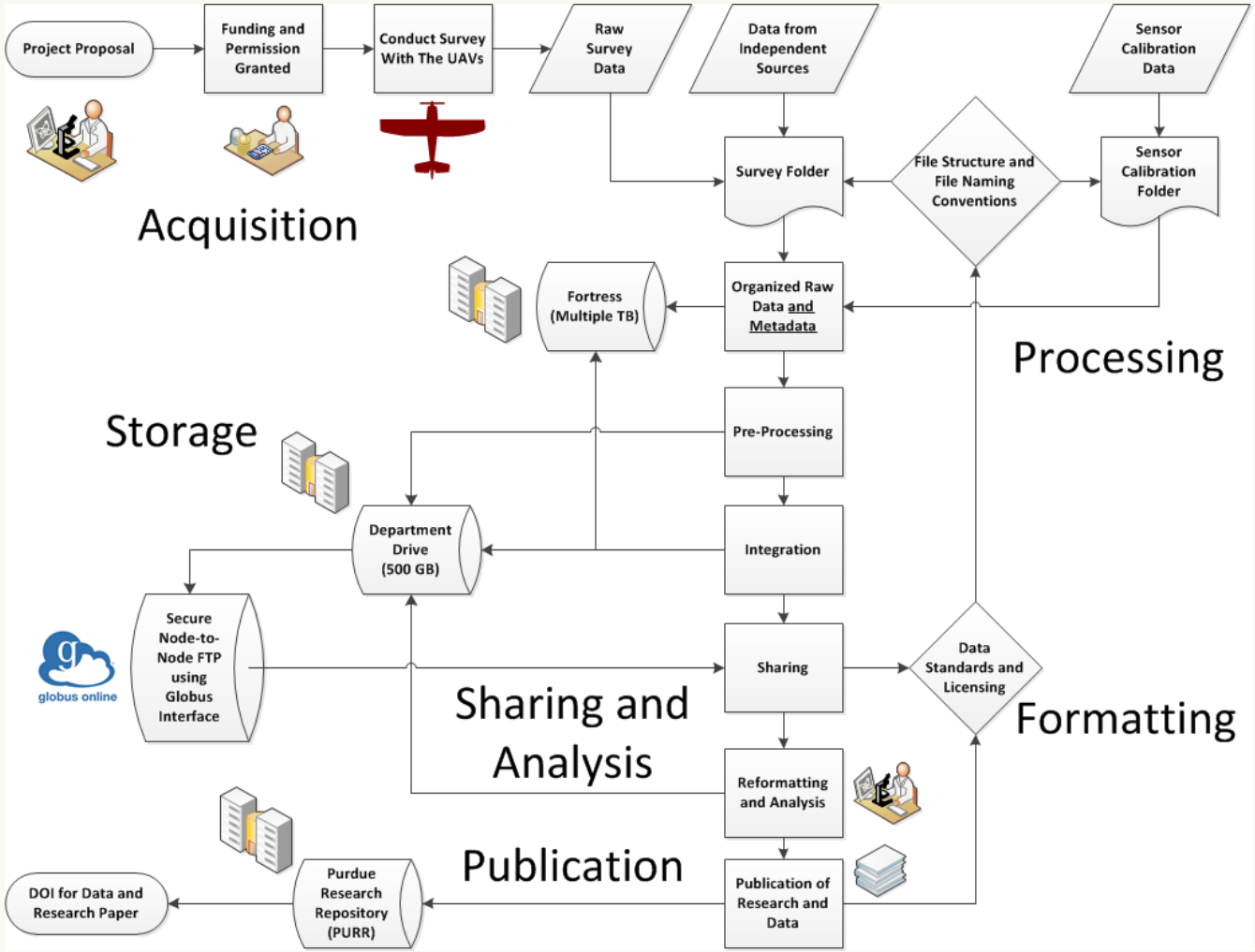
Pix4Dmapper Image Stitching



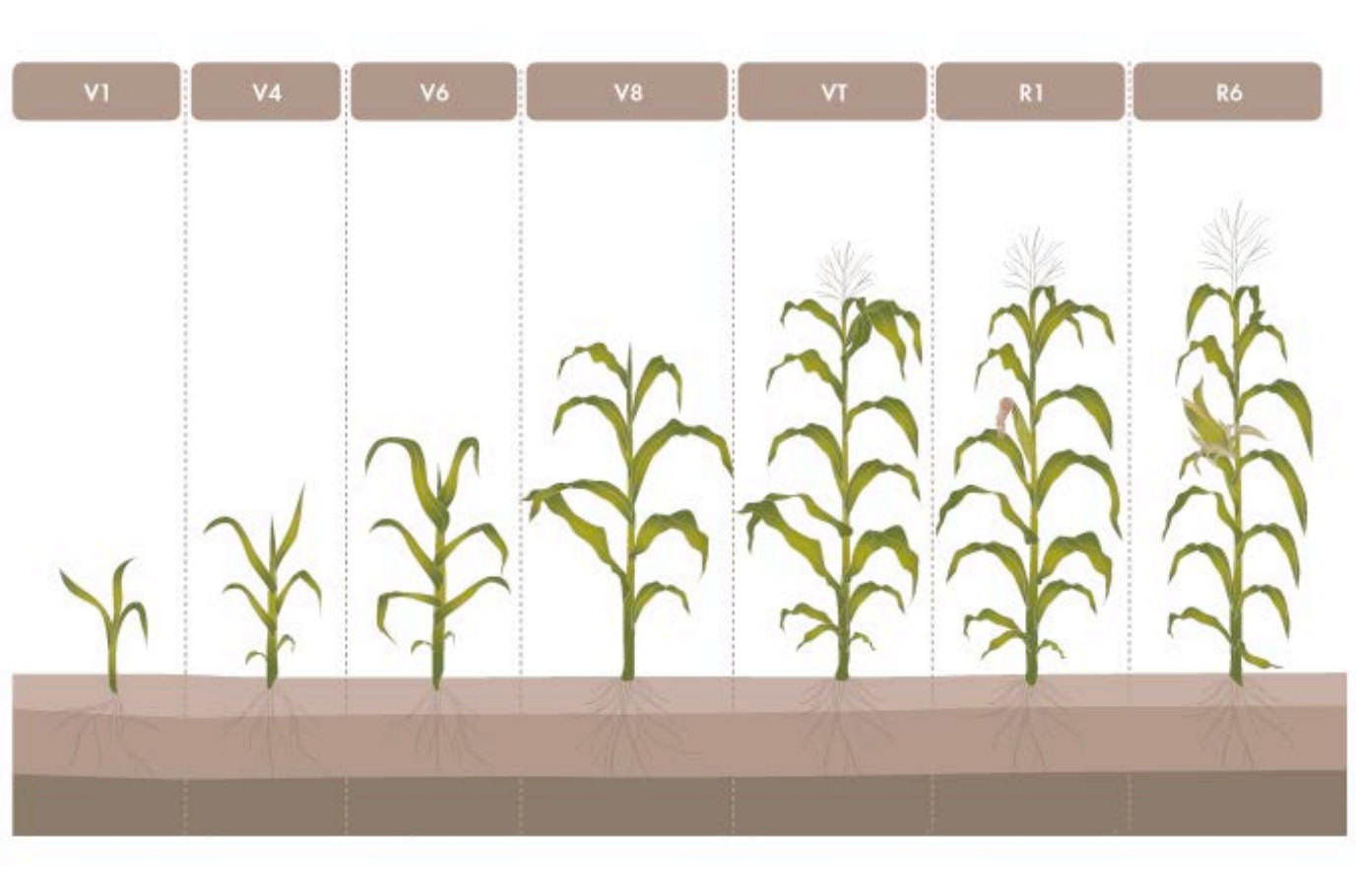
Ortho-Mosaic (52 Images)



Overall Data Management Structure



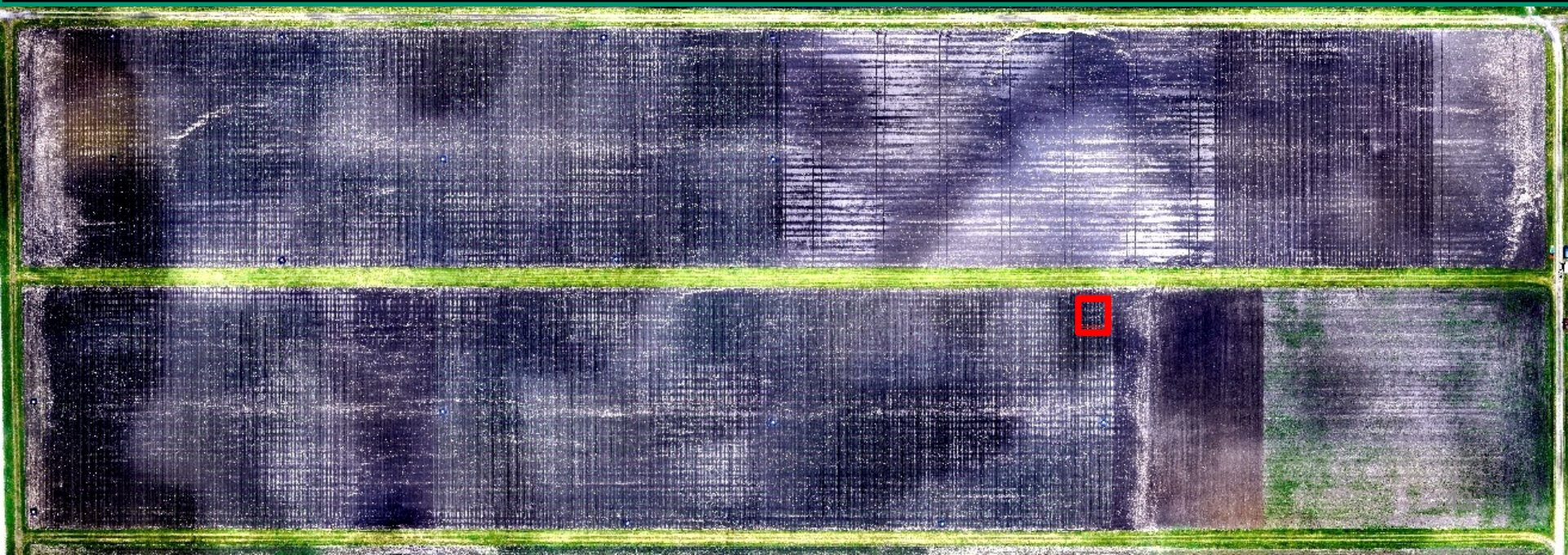
Phenology of Corn



Source: http://www.sqm.com/

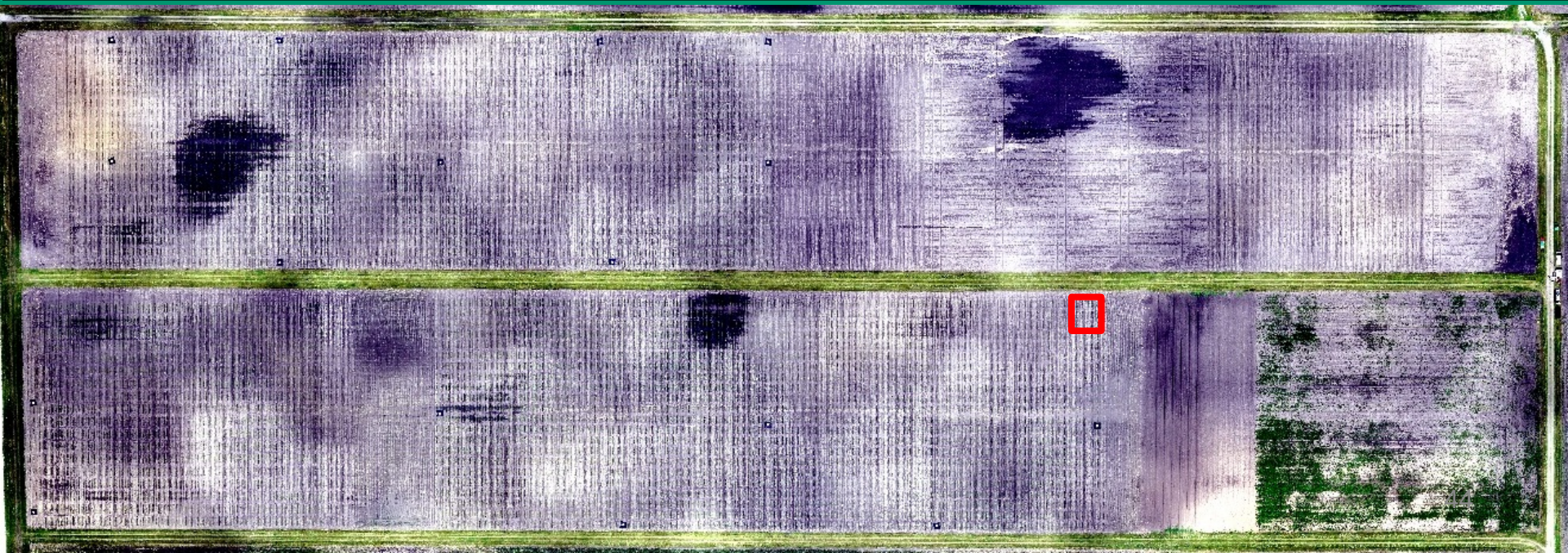
Soybean Phenology

- June 5th, 2014
- 0 days
  - ~1 week after planting



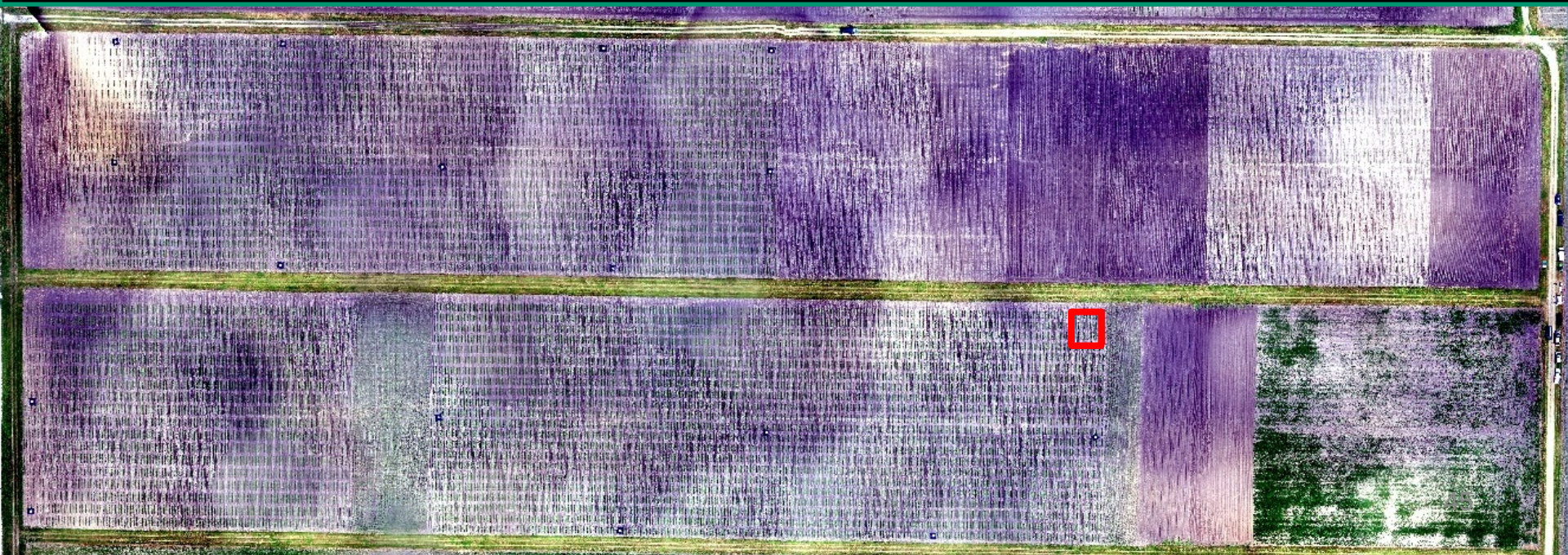
Soybean Phenology

- June 13th, 2014
- 8 days



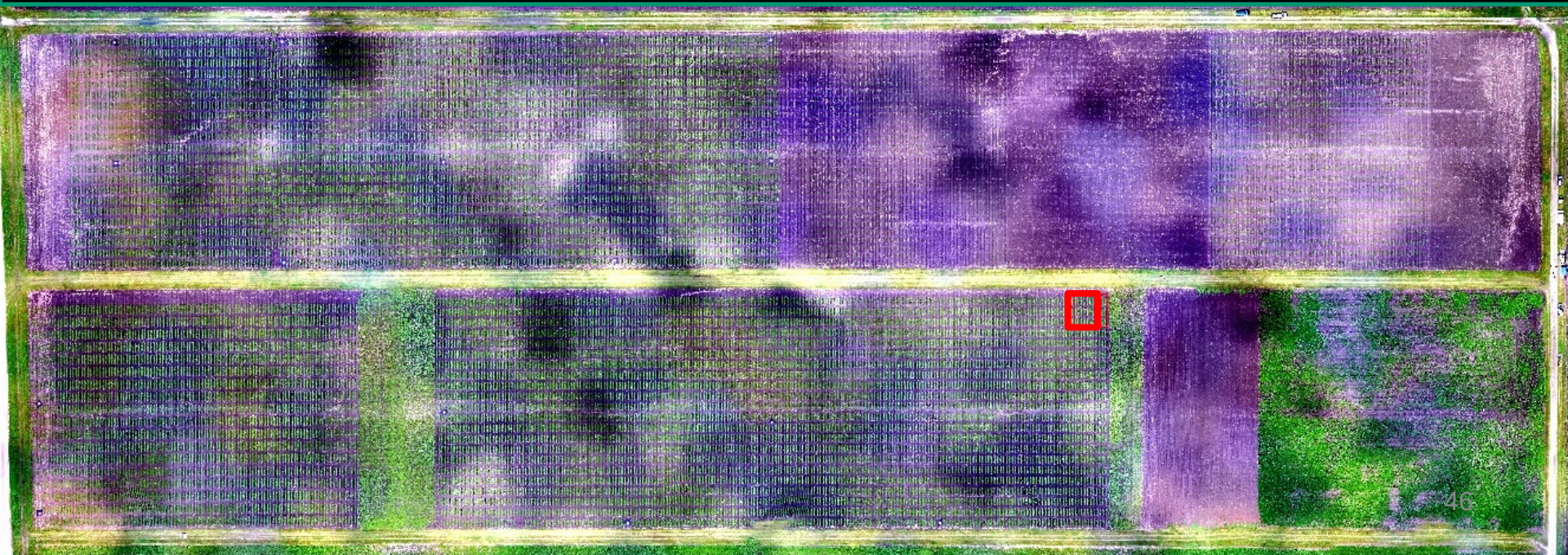
Soybean Phenology

- June 18th, 2014
- 13 days



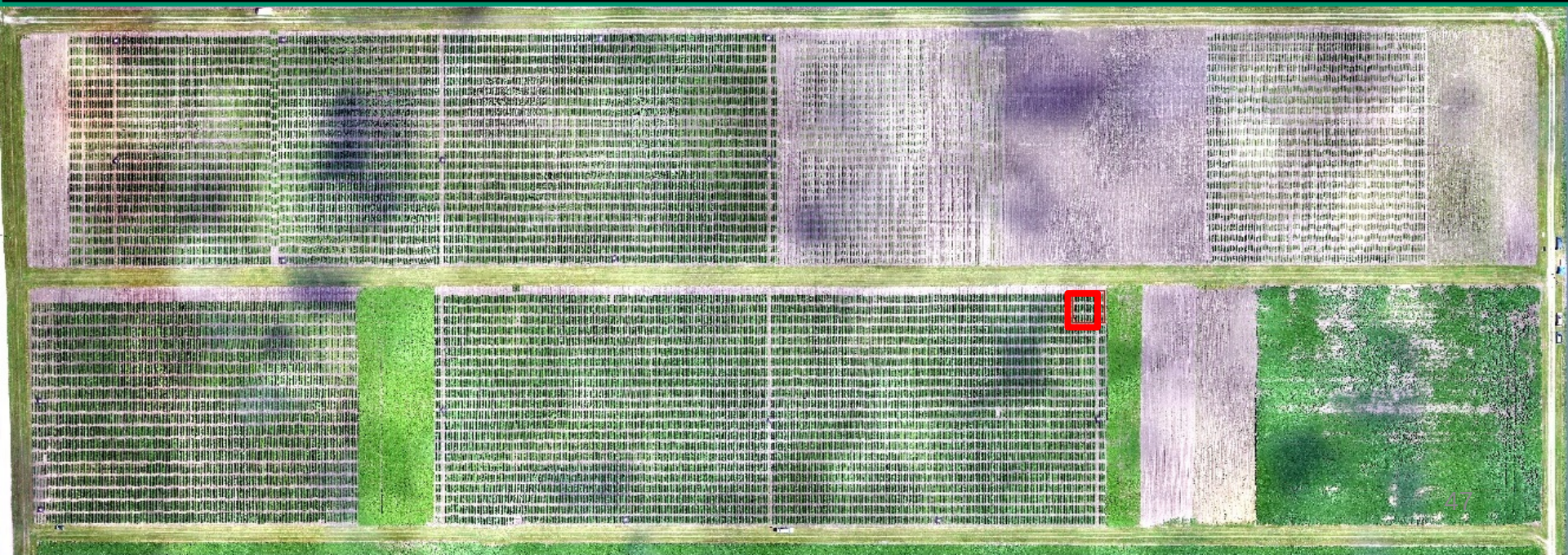
Soybean Phenology

- June 25th, 2014
- 20 days



Soybean Phenology

- July 3rd, 2014
- 28 days



Thank You!

For more information on our program go to http://www.agry.purdue.edu/hydrology