UAV use in Agriculture:
Practical, Legal, and Technological Considerations

Austin Bontrager

Servi-Tech Expanded Premium Services

Why collect field imagery?

Long-term field trends

- Soil properties
- Compaction problems
- Land use history

Short-term conditions or events

- Irrigation problems or inconsistencies
- Nutrient deficiencies
- Application errors
- Weather damage
- Insects*
- Disease*

*May be visible only *after* the damage is done.

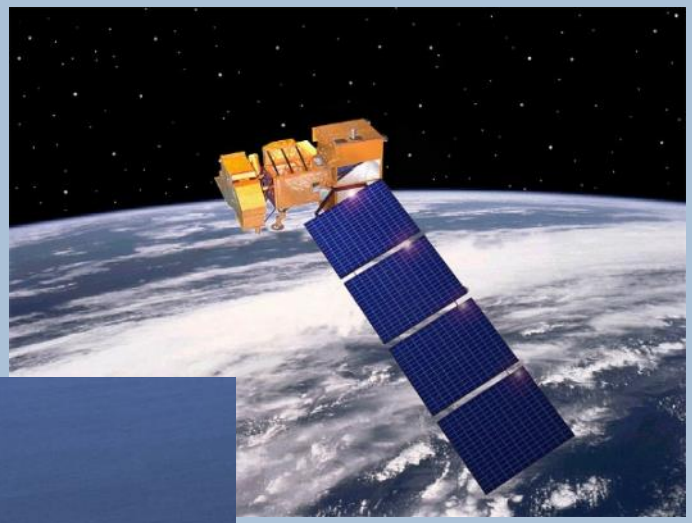
Still better than not knowing!

Why collect field imagery?

- Imagery is collected so a grower can make a *change* to their operation, or so the scouting method can change.
- Are they *willing* and *able* to change how they plant, fertilize, irrigate, spray, or harvest?
- Will the consultant change how they scout the field?

Sources of Imagery

- Satellite

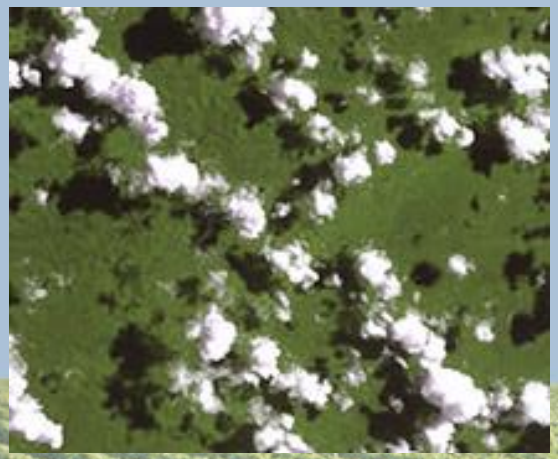


- Manned-Aircraft

- UAV (drone)

Satellite

- Lowest cost source of imagery
- Relatively low resolution
  - 15 foot pixels *at best*
- Unreliable availability
  - Clouds, smoke, and haze



Manned Aircraft

- Higher cost than satellite, but cheaper than UAV imagery.
- Far better resolution than satellite.
  - 1 foot pixels vs 15 foot pixels.
- Much more reliable image capturing than satellite.
- Very scalable for adding more fields.

UAV

- Ultra-high resolution imagery allows for unique products.
  - Weed maps
  - Plant population/stand count maps
  - Canopy closure percentage across the field.
  - Feature training and identification.
- Very expensive (or time consuming) to collect and process at this point.

Terminology

What is a “drone?”

Terminology

What is a “drone?”

Terminology

What is a “drone?”

Terminology

UAV – Unmanned Aerial Vehicle

UAS – Unmanned Aerial System

> "A UAS is the unmanned aircraft (UA) and all of the associated support equipment, control station, data links, telemetry, communications and navigation equipment, etc., necessary to operate the unmanned aircraft." – FAA

sUAS – A UAS where the aircraft weighs less than 55 lbs.

Is this thing technically a UAV?

Is this thing technically a UAV?

Start

Can you control it from the ground *and/or* does it have an autopilot?

Yes

Does it weigh more than 0.55 lbs?

Yes

Is there a human on board?

No

It is probably a UAS

No

It might just be a paper airplane.

No

It is too small for the FAA to care about

Yes

That's just a normal aircraft

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Is this thing technically a UAV?

Legal Implications

- What is a commercial use?
  - Selling maps/imagery to growers?
  - Using a UAV to help scout a field?
  - Farmer checking their own pivots?
  - An ag retailer posting video on their Facebook page?

Commercial Restrictions

- Must maintain visual line-of-sight and be ready for manual override.
- Stay below 400 feet above ground level.
- One UAV per operator.
- Operator must take paper test and apply for certification.
- UAV must be registered online.
- Can’t fly at night.
- … and more! Check online for full details.

Part 107 Rule Changes

- No more pilots license (easier to take test)
- No more secondary “spotter” person
- No more NOTAMs
- No distance buffer around class G (no ATC tower) airports.
- No more 333 exemption, Certificate of Waiver or Authorization (COA,) or paper registration of aircraft required.

So which one should I buy?

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Multi-Rotor vs. Fixed-Wing

Multi-Rotor
- *Much* easier to take-off and land
- Capable of lower/slower flight

Fixed-Wing
- Can handle faster wind
- Higher top speed
- Much longer battery life

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How are you going to use your UAV?

- The UAS is used as a tool by the person who is already checking the field.

- The imagery sold as a separate service that compliments other agronomic services.

Live Video

Pros

- Faster than flying a whole-field image.
- Useful for identifying equipment problems.
- Is a lot of fun to fly.
- No image processing required.

Cons

- Not as useful for locating or quantifying crop stress areas.
- Can’t easily archive or compare the data for future use.
- Can’t use to create variable-rate prescriptions.

Image source: http://www.miniquadclub.com/5-tips-to-flying-fpv-for-the-newbie/

Which camera/sensor?

- RGB
- Multi-Spec
- Filter-swapped “NIR” cameras
- Thermal (?)

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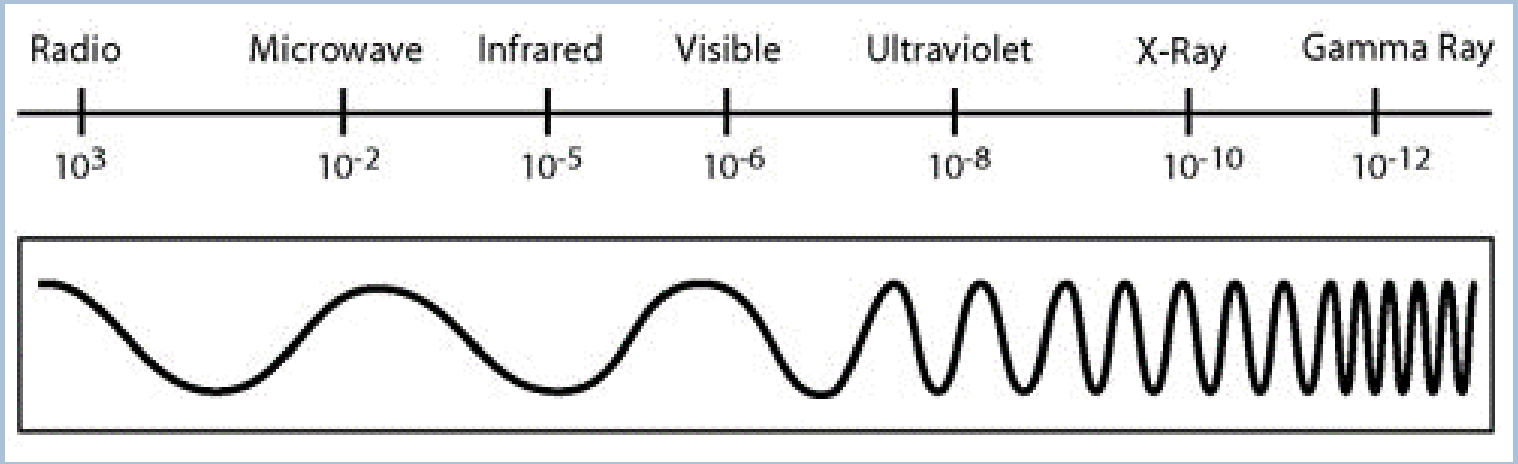
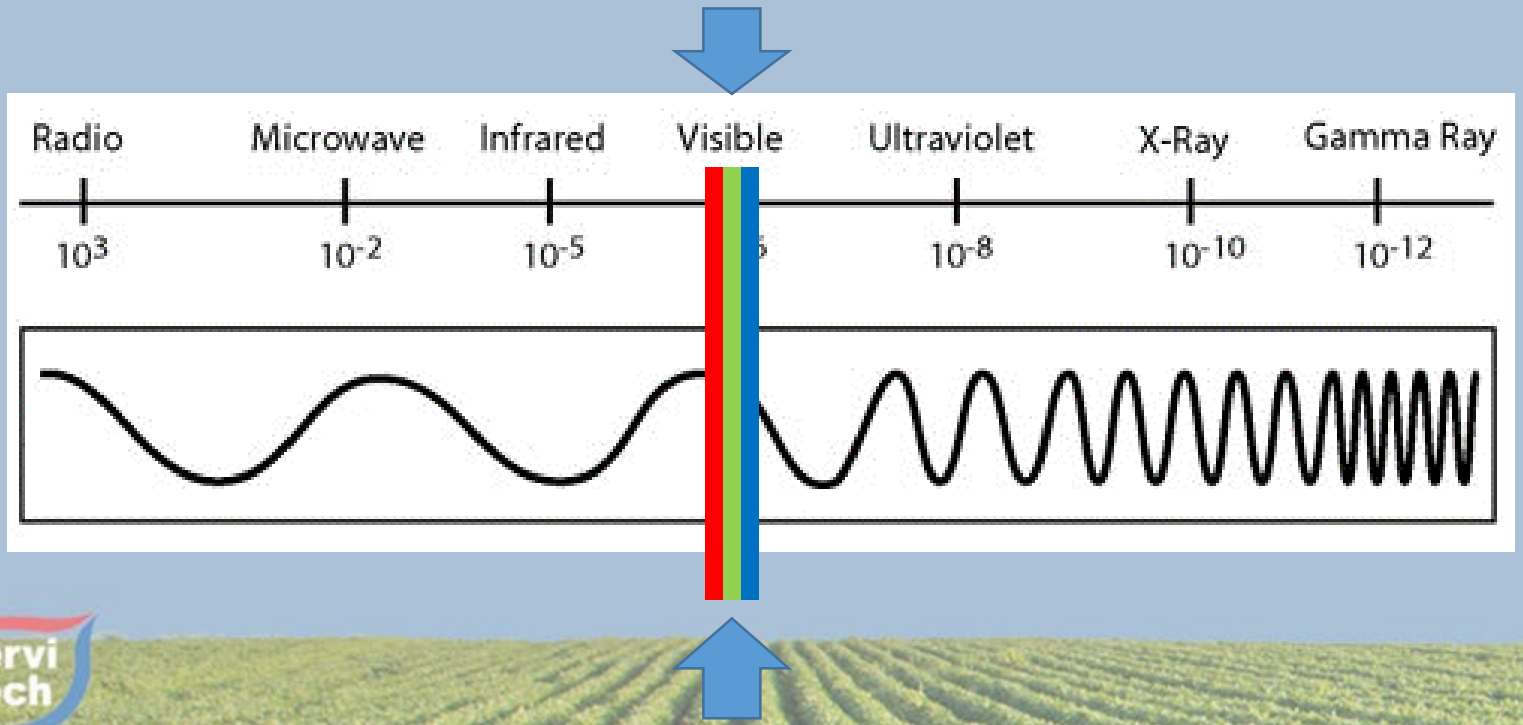
Science lesson about light

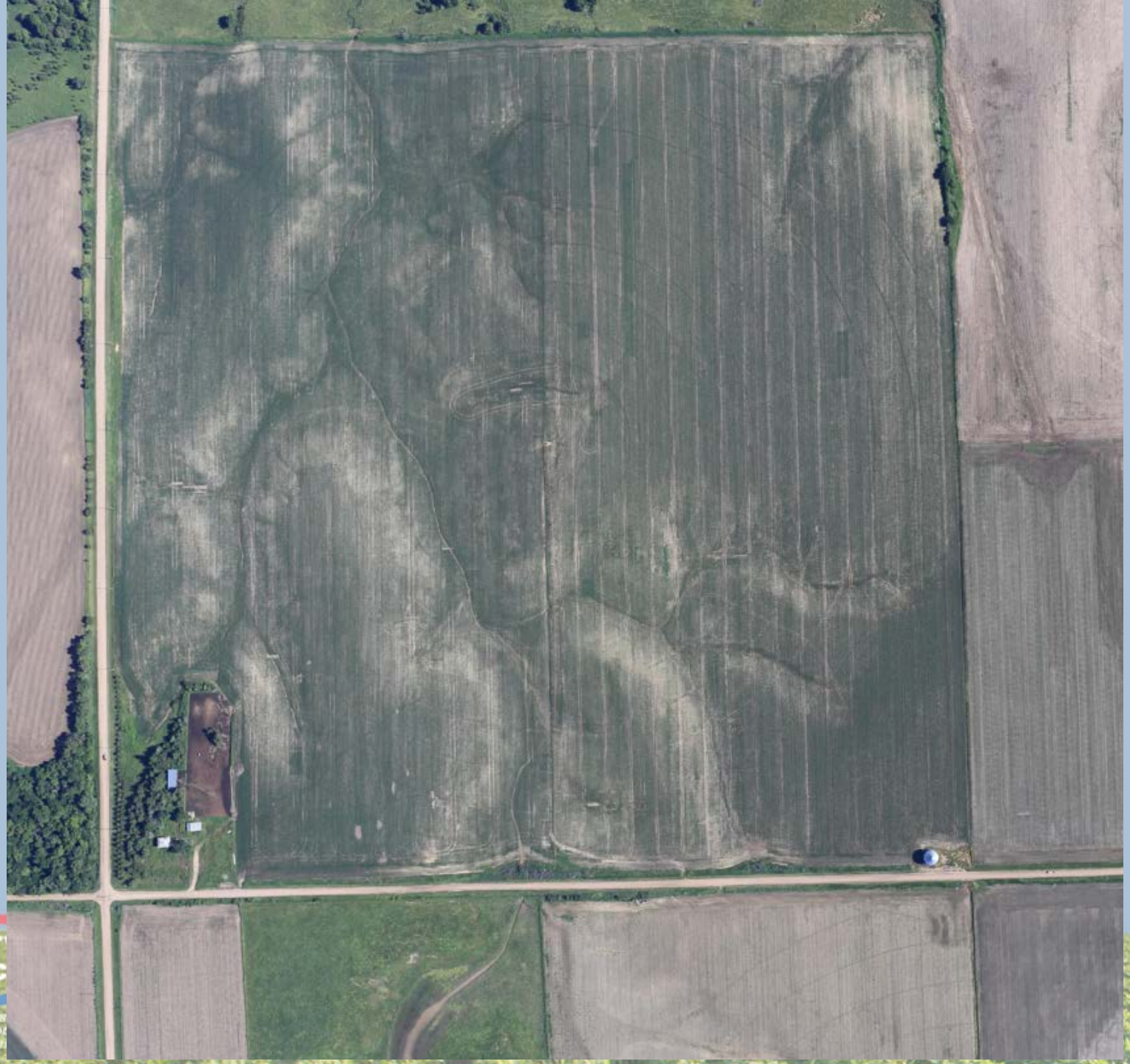
- Visible light
- Near Infrared
- Long-wavelength Infrared



Visible Light

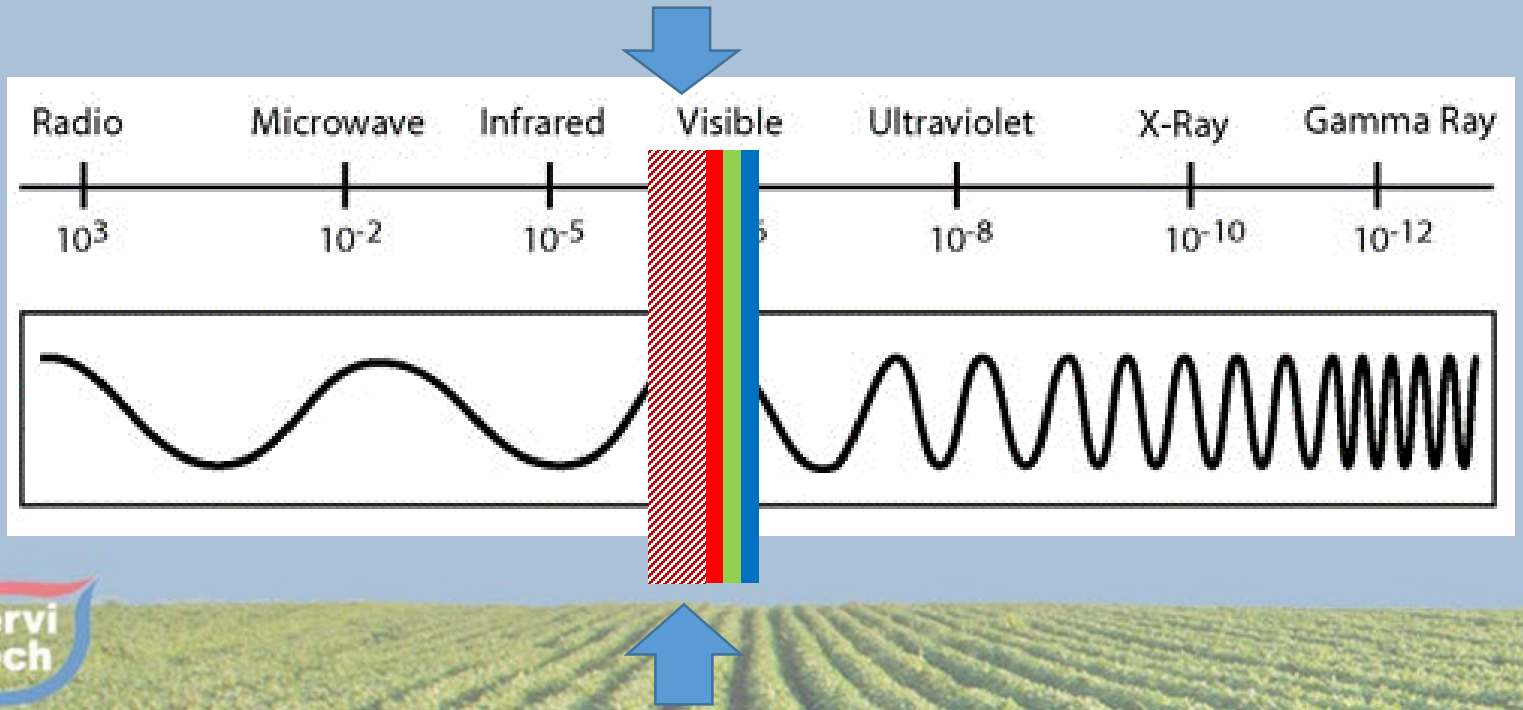
- “Native” image
- RBG (Red Green Blue) image
- “What you see is what you get.”





Near Infrared (NIR)

- Invisible, reflected light.
- Healthy vegetation reflects it very well.
- Used to calculate vegetative indices like Normalized Difference Vegetative Index (NDVI)

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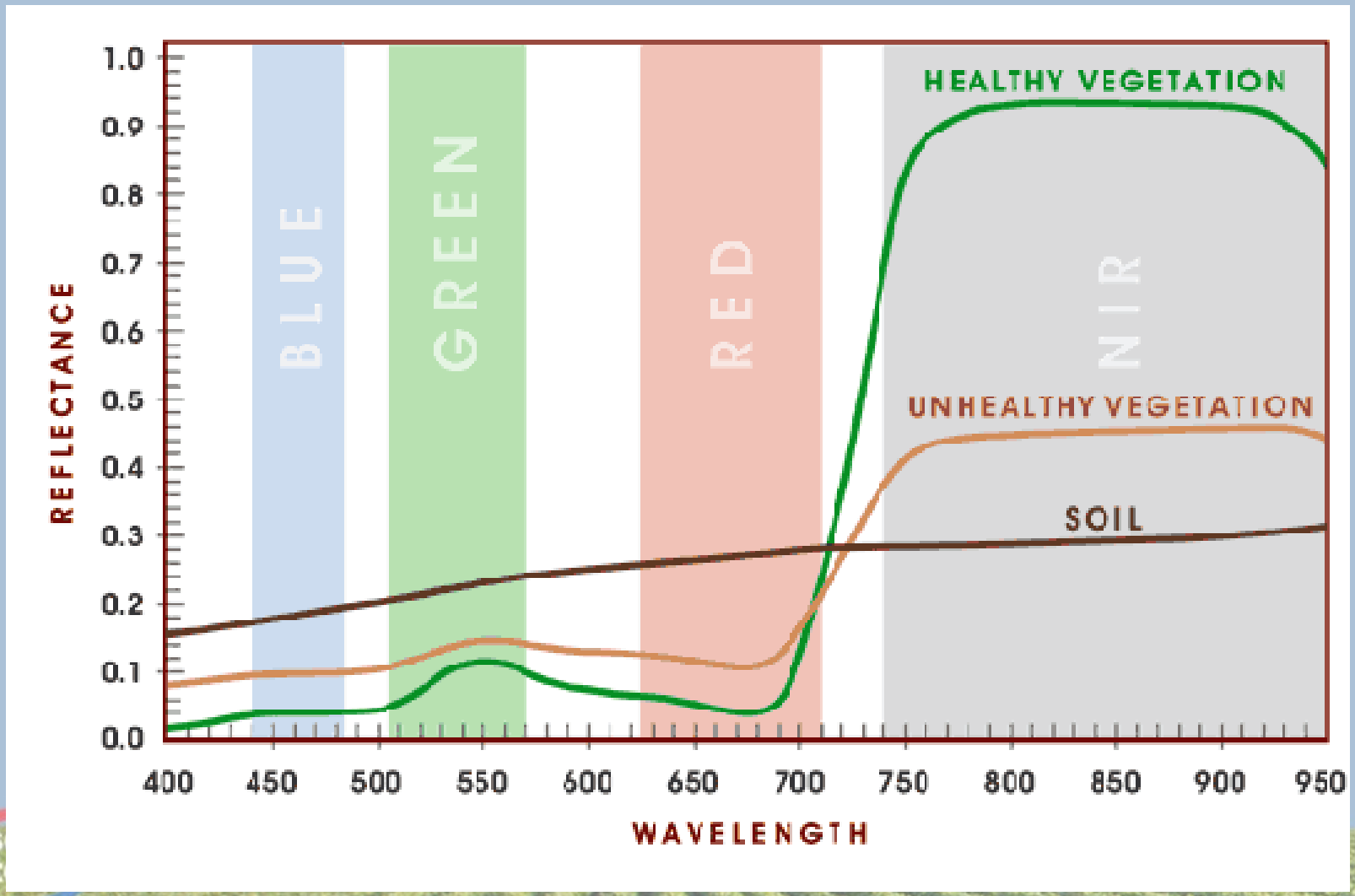
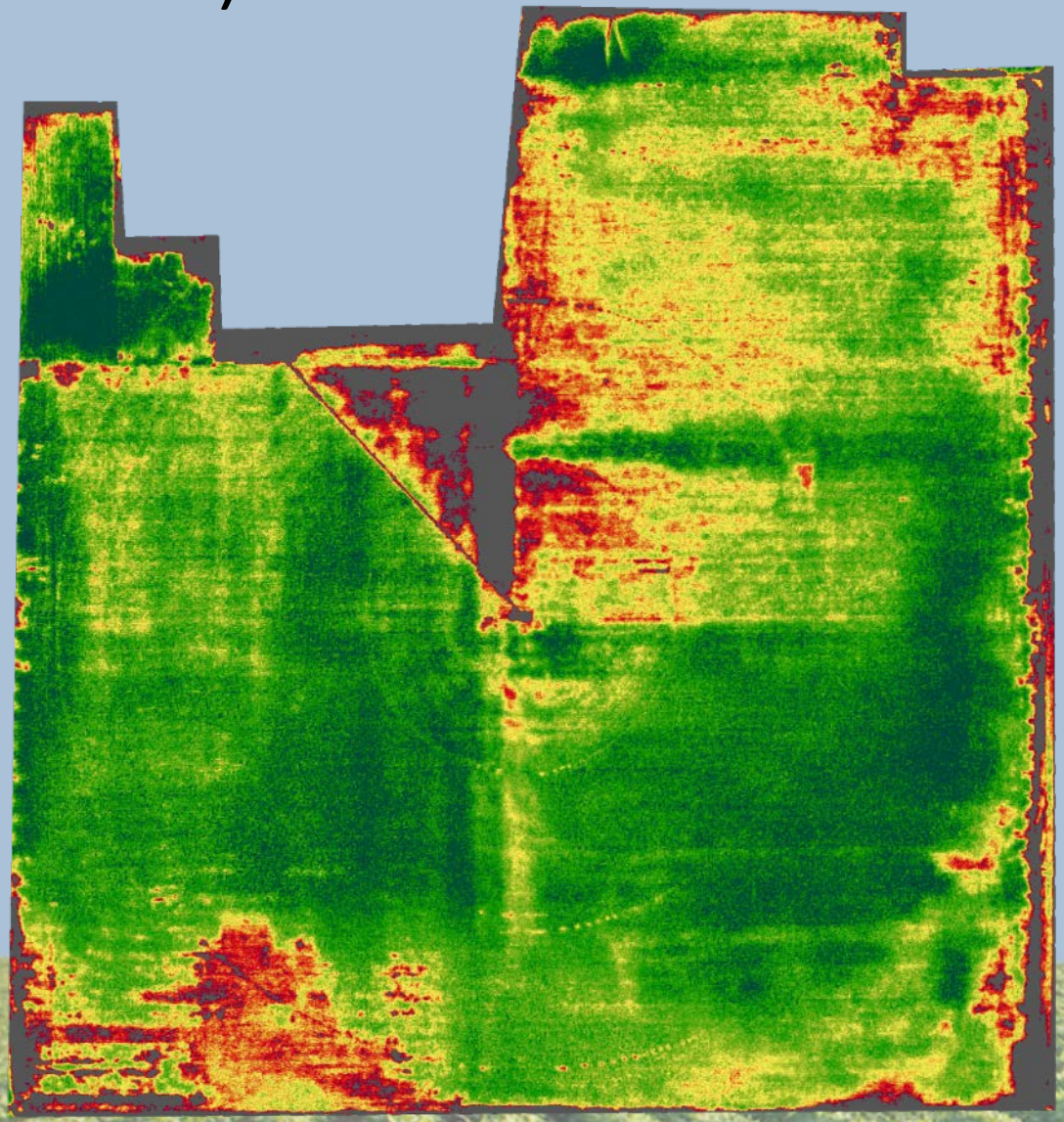
What is a “vegetation index?”



Normalized Difference Vegetation Index (**NDVI**)



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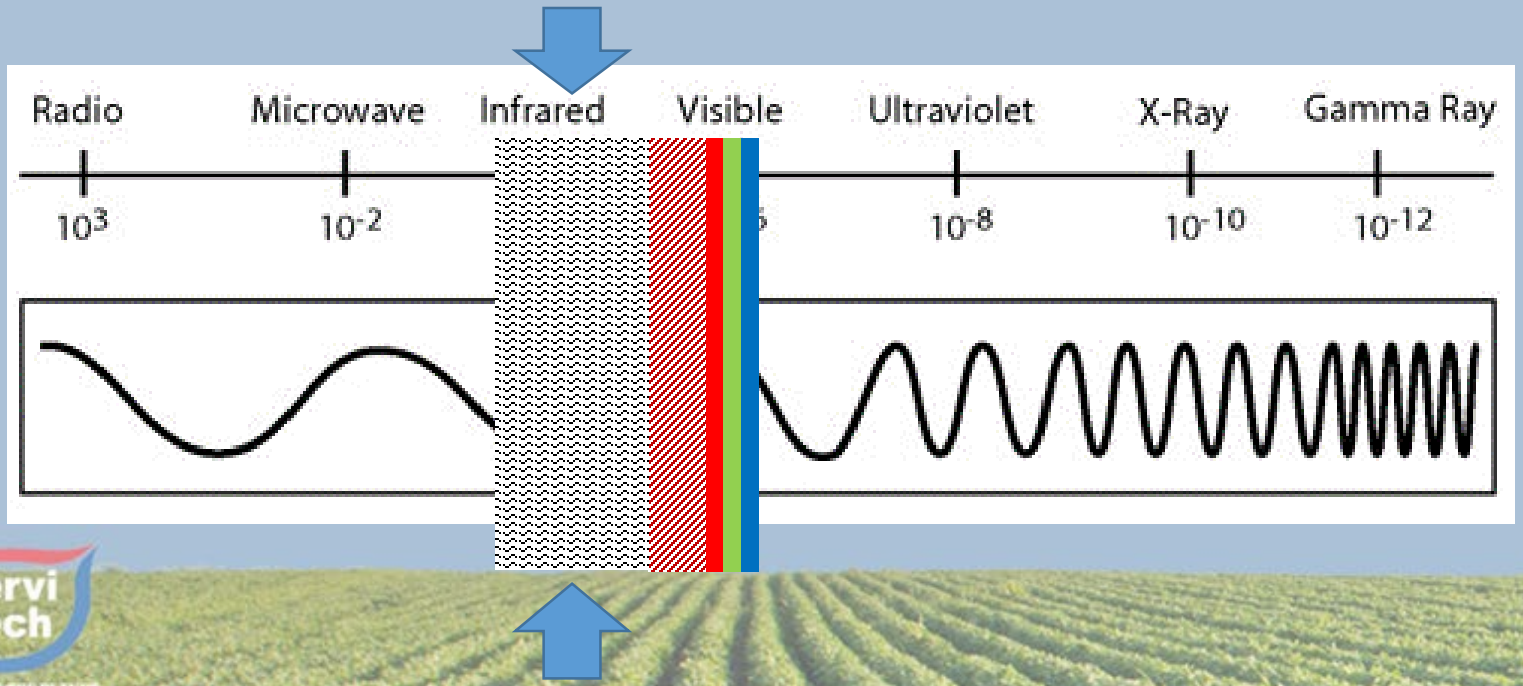
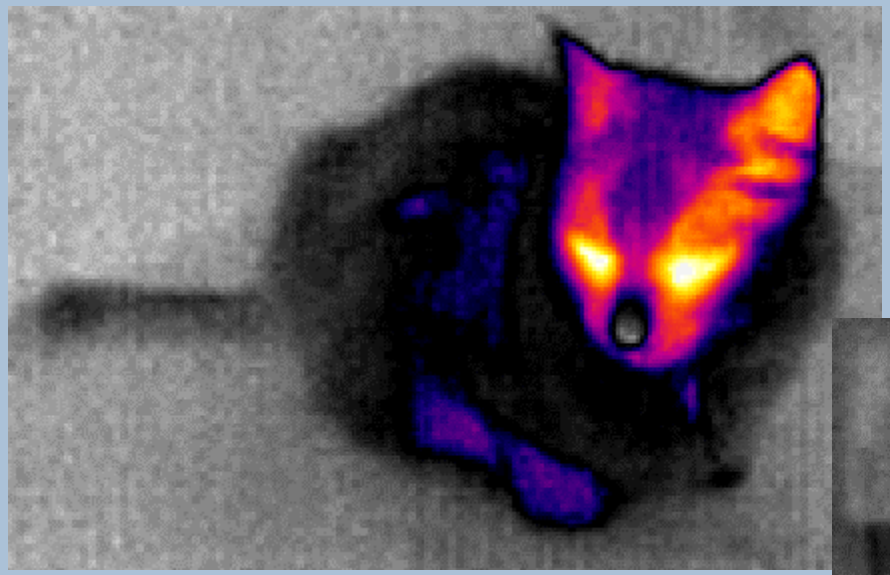
Long-wavelength Infrared

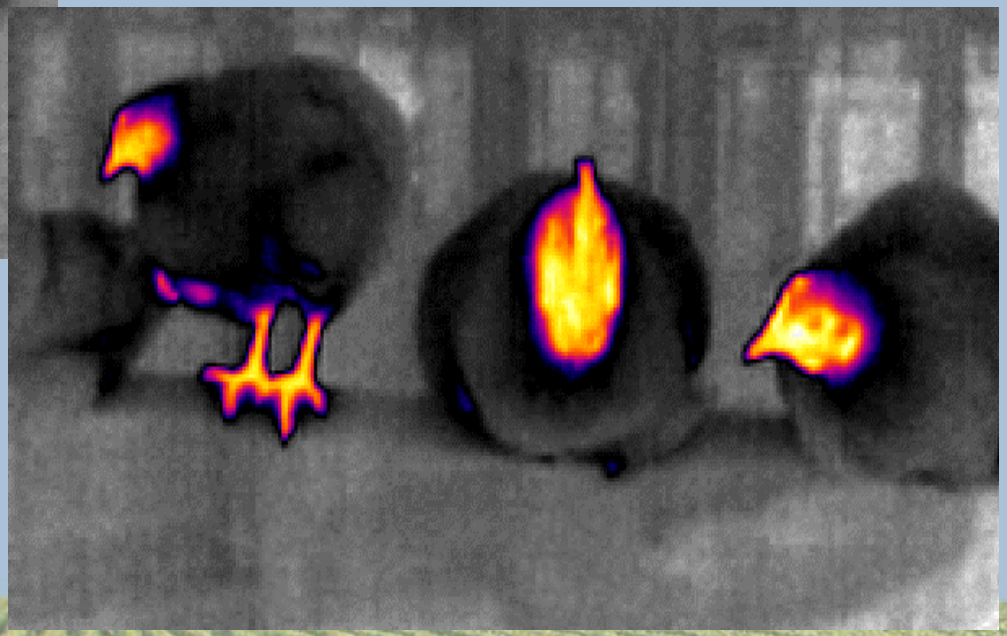
- “Thermal” or “heat” imaging.
- Emitted (glowing), rather than reflected.
- Healthy vegetation is cooler than stressed vegetation.
- Wet soil is cooler than dry soil.



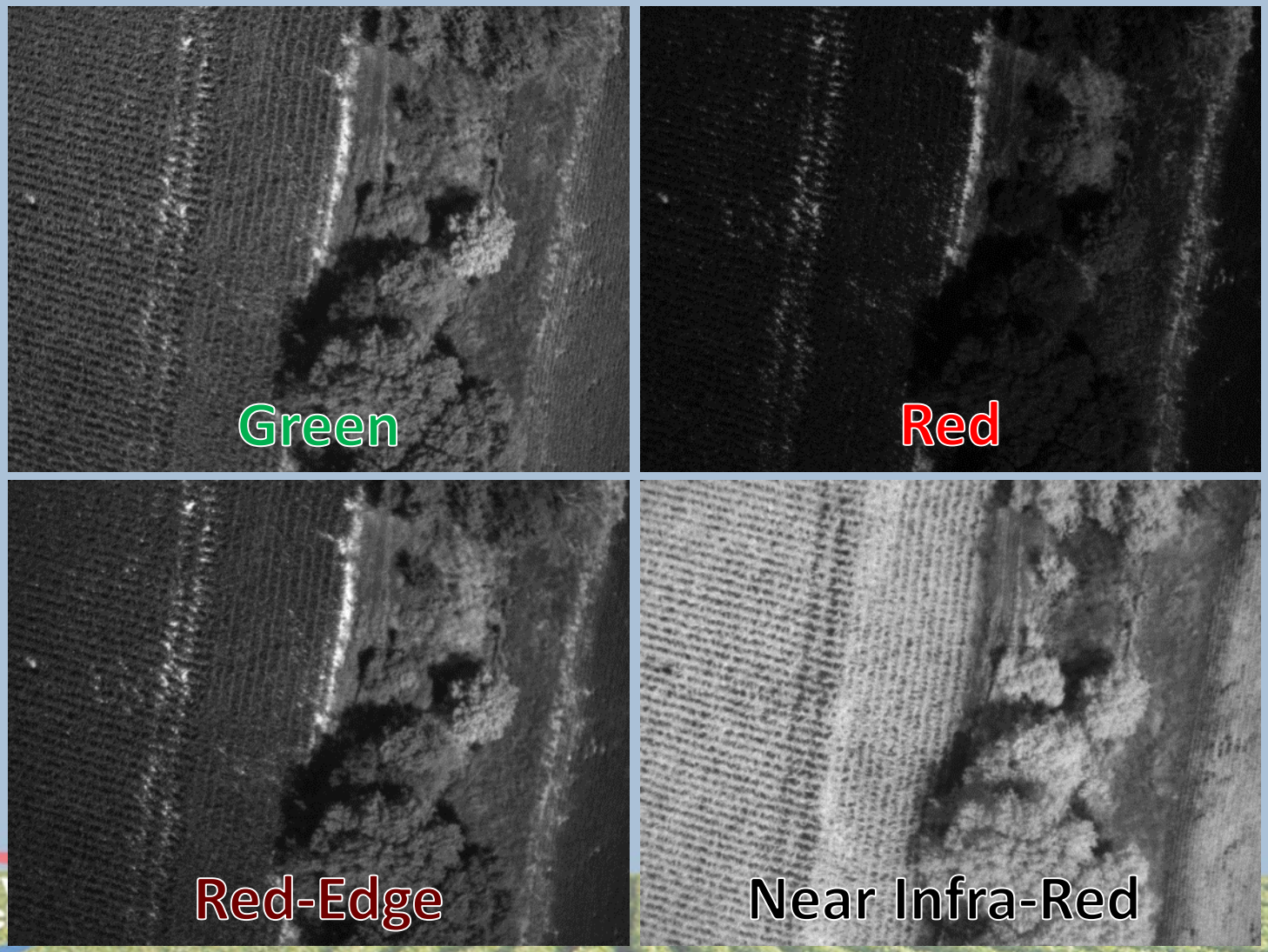
Long-wavelength Infrared

Long-wavelength Infrared

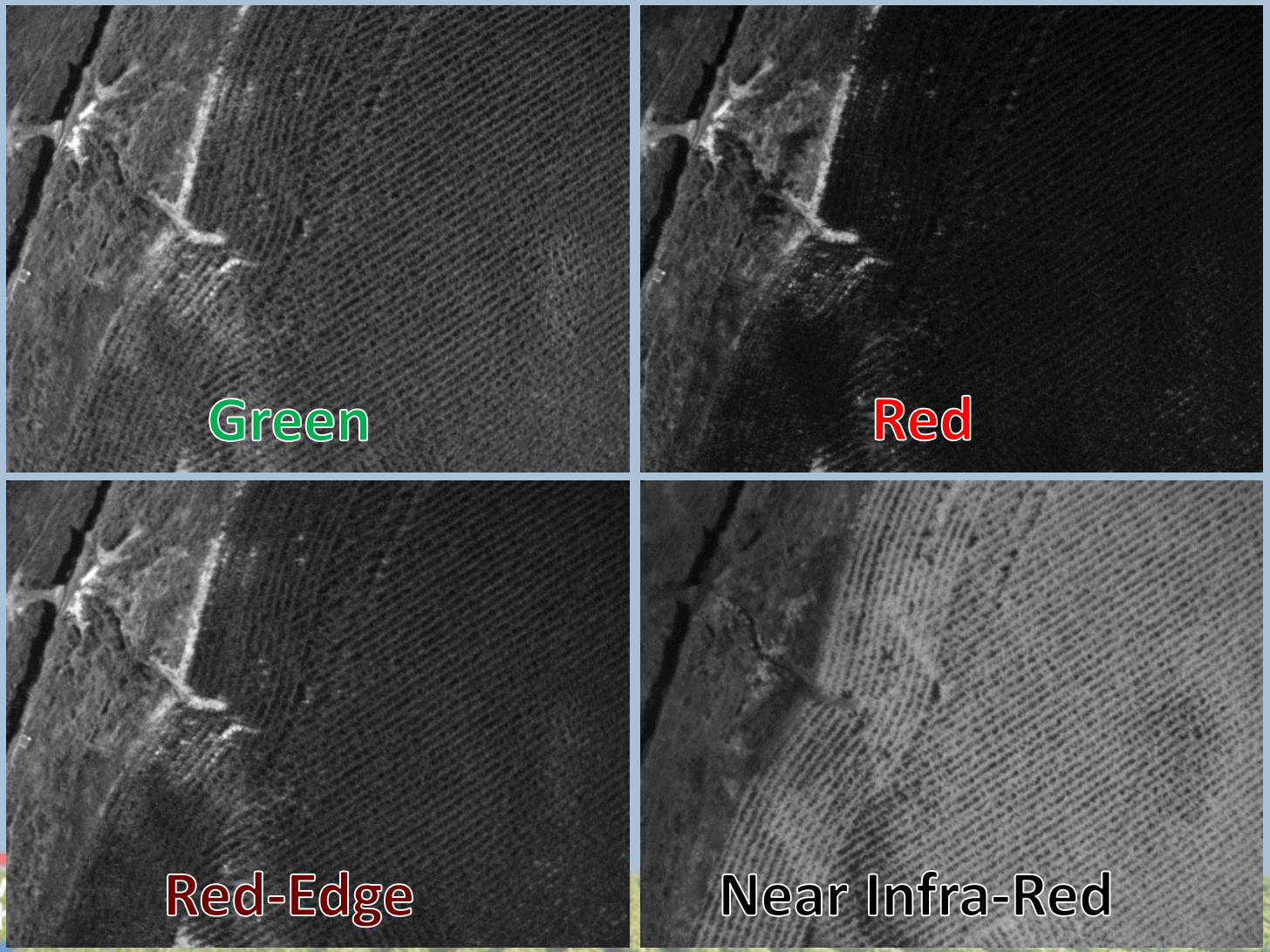




4-channel multi-spectral sensor



4-channel multi-spectral sensor



Modified RGB to “NIR” camera

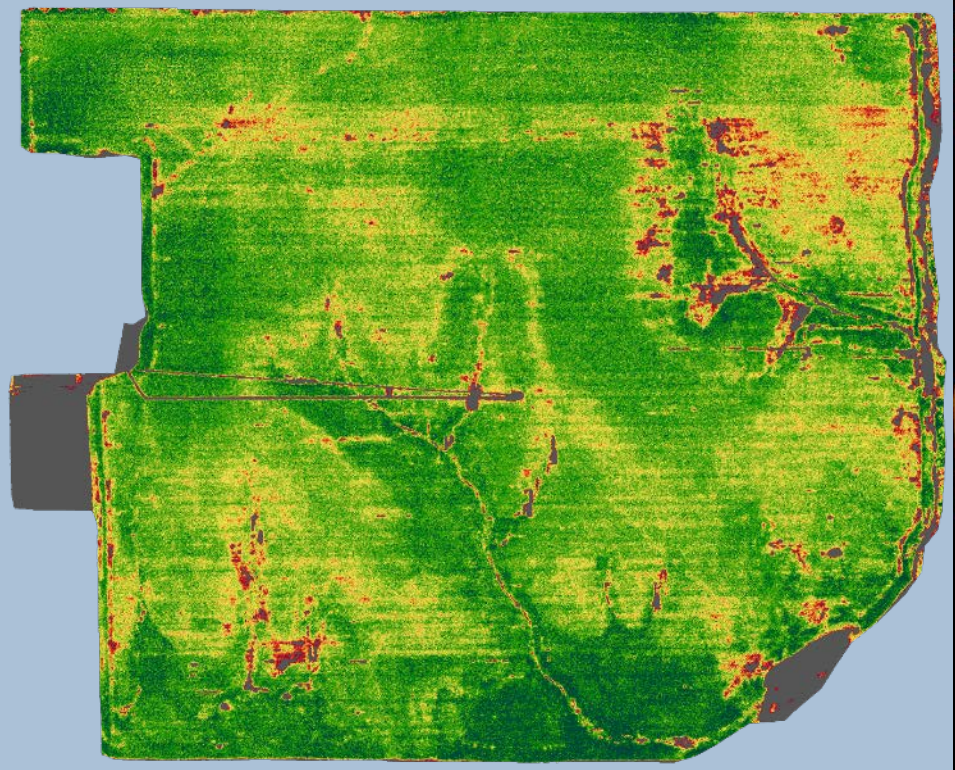
Modified RGB to “NIR” camera

Which type of camera/sensor is better?

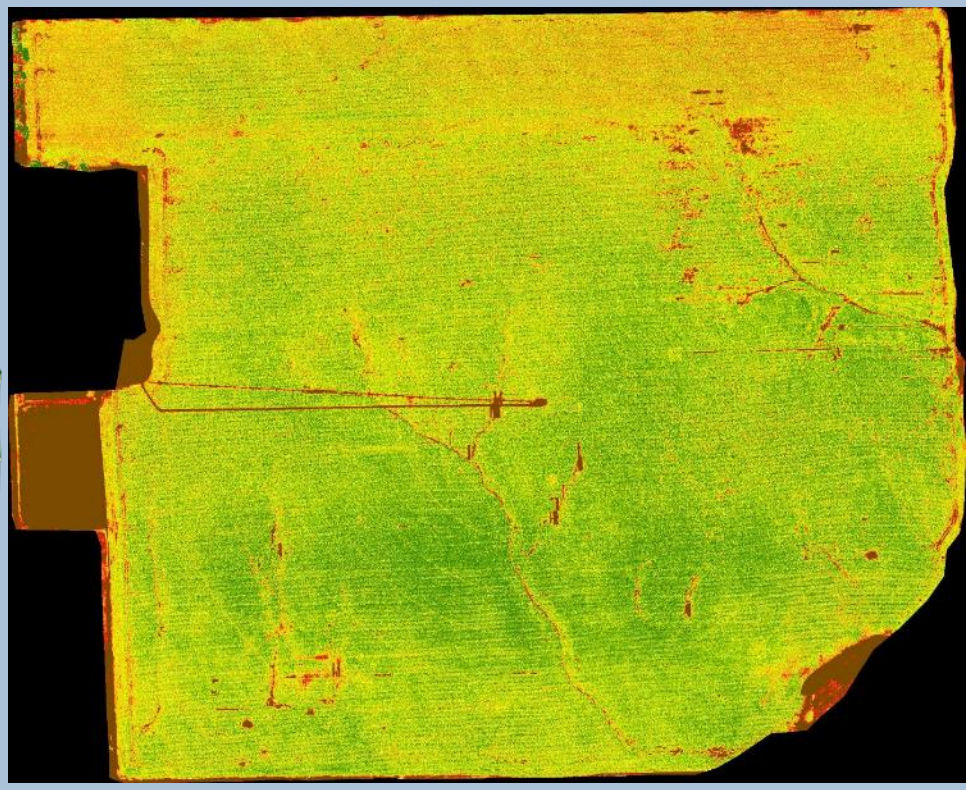
- A true Multi-Spec camera has *much better* final map quality than a filter swap-job. (Less “noise” and better contrast.)

- Swap-jobs are cheaper and can often cover a larger area (due to a wider field of view.)

Which type of camera/sensor is better?



True Multi-Spec sensor



Filter-swapped “NIR” camera

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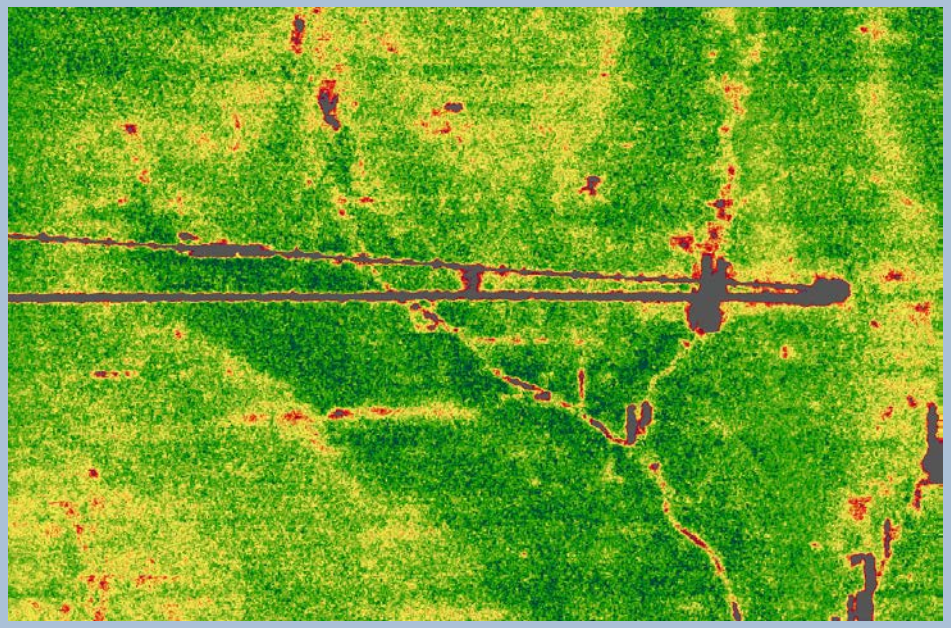
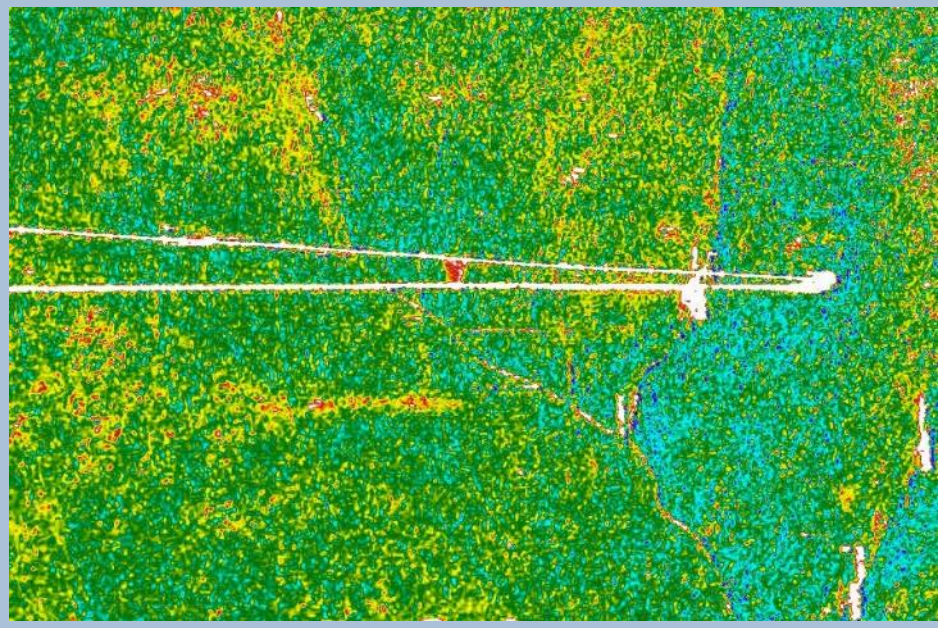
Why not use a RGB camera for crop health?

- Would you hire a color-blind interior decorator?
- If your camera can't see NIR, then it's color-blind!



True Multi-Spec sensor

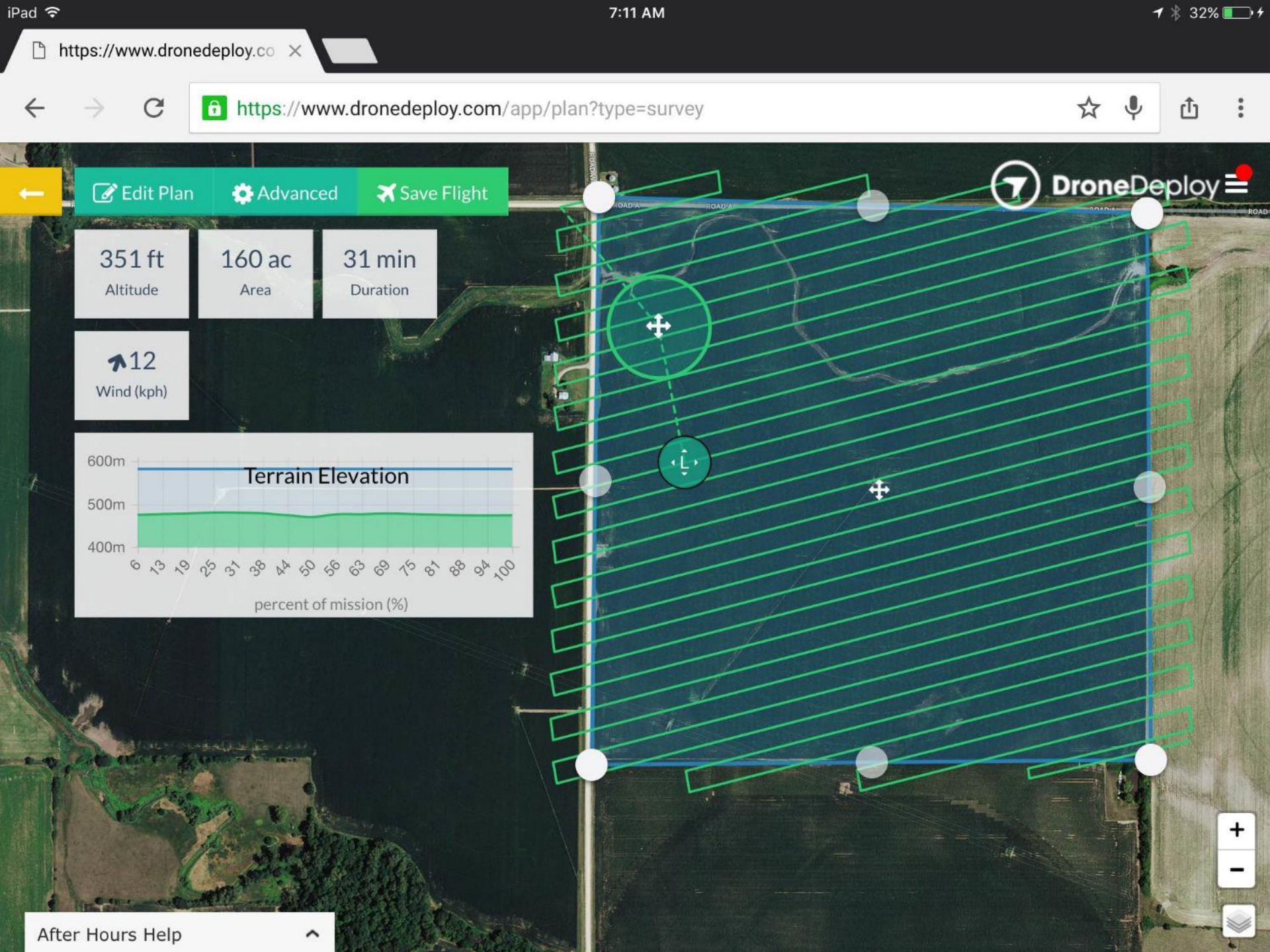


Processed RGB image

Flying the UAV

1. Mission planning
2. Launch
3. Observation
4. Landing and recovery
5. Processing the imagery


Mission Planner 1.3.28 build 1.1.5624.13992
FLIGHT DATA
FLIGHT PLAN
INITIAL SETUP
CONFIG/TUNING
SIMULATION
TERMINAL
HELP
DONATE
COM12
57600
CONNECT
Distance: 28.8869 km
Prev: 651.20 m AZ: 240
Home: 412.08 m
Zoom
Action
GEO
40.862446
-97.200508
471.83m
Grid
View KML
GoogleHybridMap
Status: loaded tiles
Load WP File
Save WP File
Loaded 2015-07-14 Luet
Read WPs
Write WPs
Home Location
Lat 40.86583
Long -97.198523
Alt (abs) 460
©2015 Google - Map data ©2015 Tele Atlas, Imagery ©2015 TerraMetrics
Waypoints
sorted res...
RAW fligh...
Ceder Bell...
KEYCHAI...
camSim.exe
SlantView ...
SlantRang...
Mission Pl...
New Bitm...
8:32 PM


iPad
7:11 AM
32%
https://www.dronedeploy.co
https://www.dronedeploy.com/app/plan?type=survey
Edit Plan
Advanced
Save Flight
DroneDeploy
351 ft
Altitude
160 ac
Area
31 min
Duration
12
Wind (kph)
Terrain Elevation
600m
500m
400m
6 13 19 25 31 38 44 50 56 63 69 75 81 88 94 100
percent of mission (%)
After Hours Help

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Launching by hand

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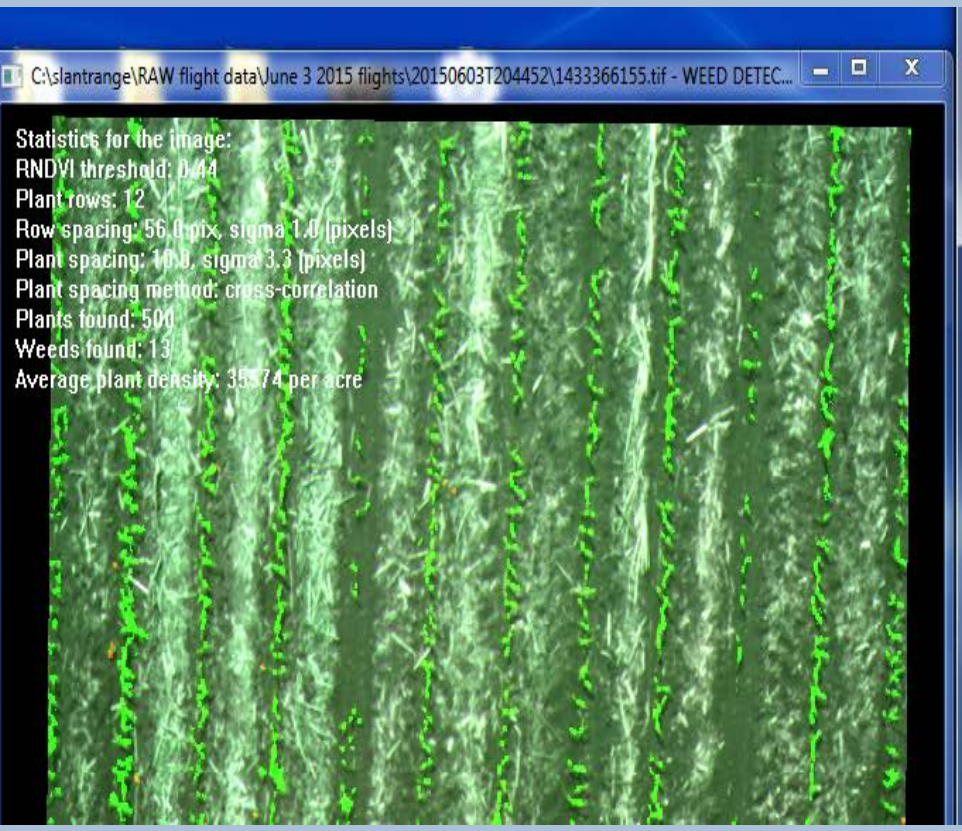
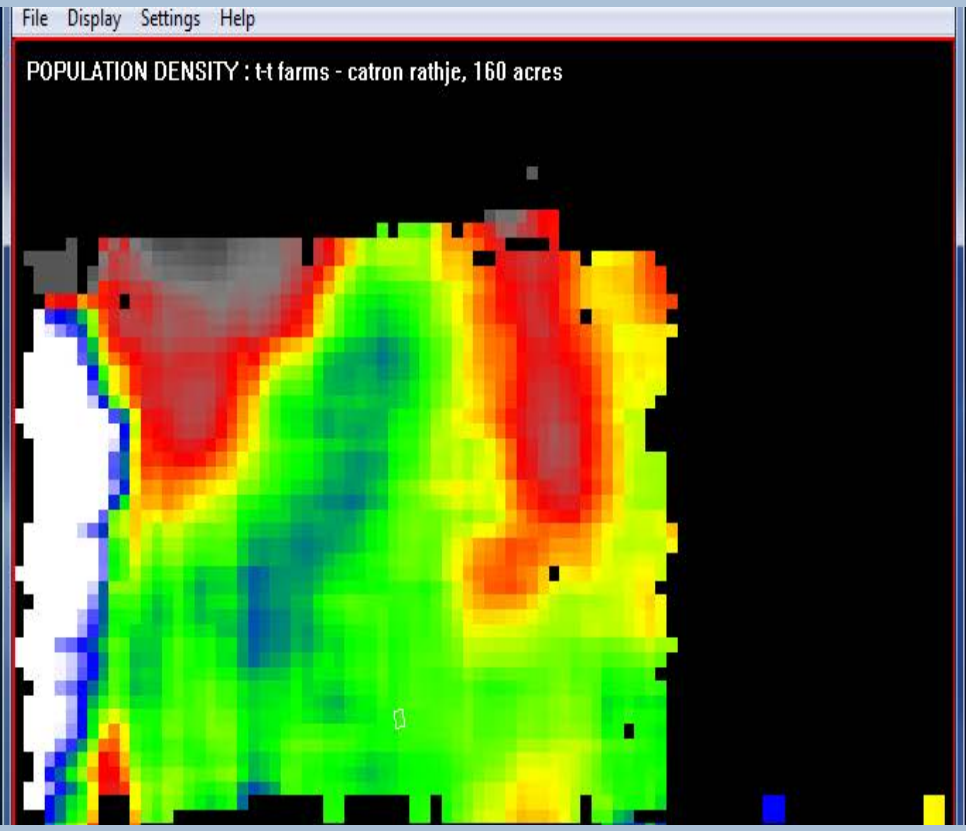
1975 2015

UAV imagery





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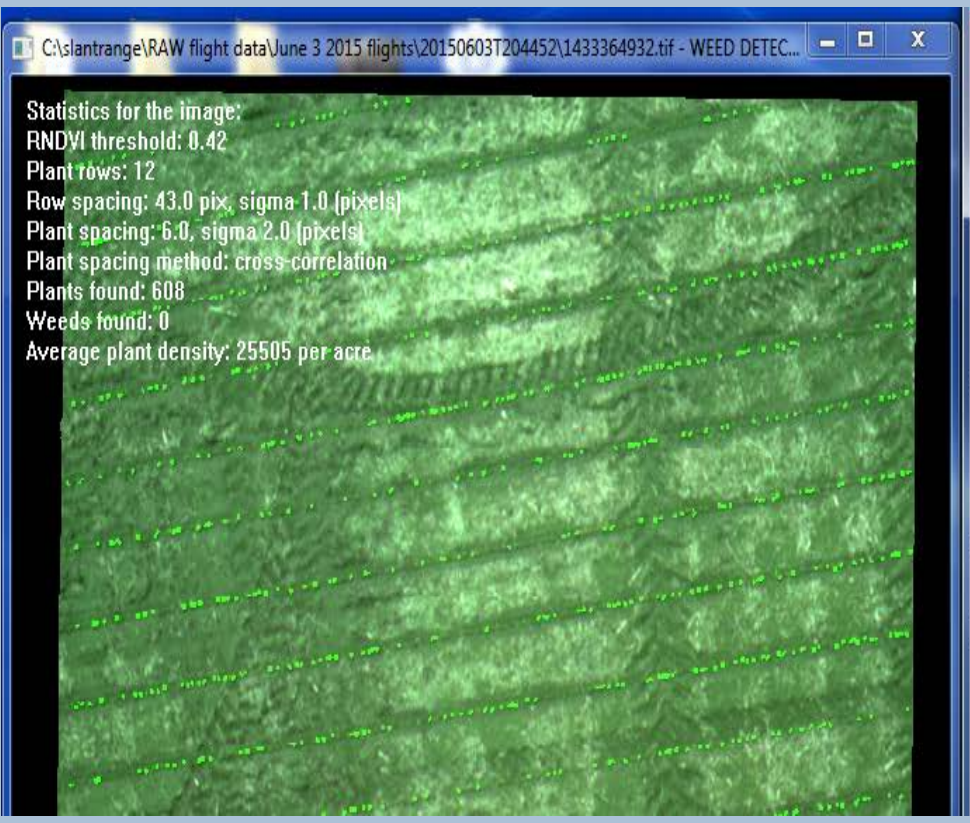
UAV imagery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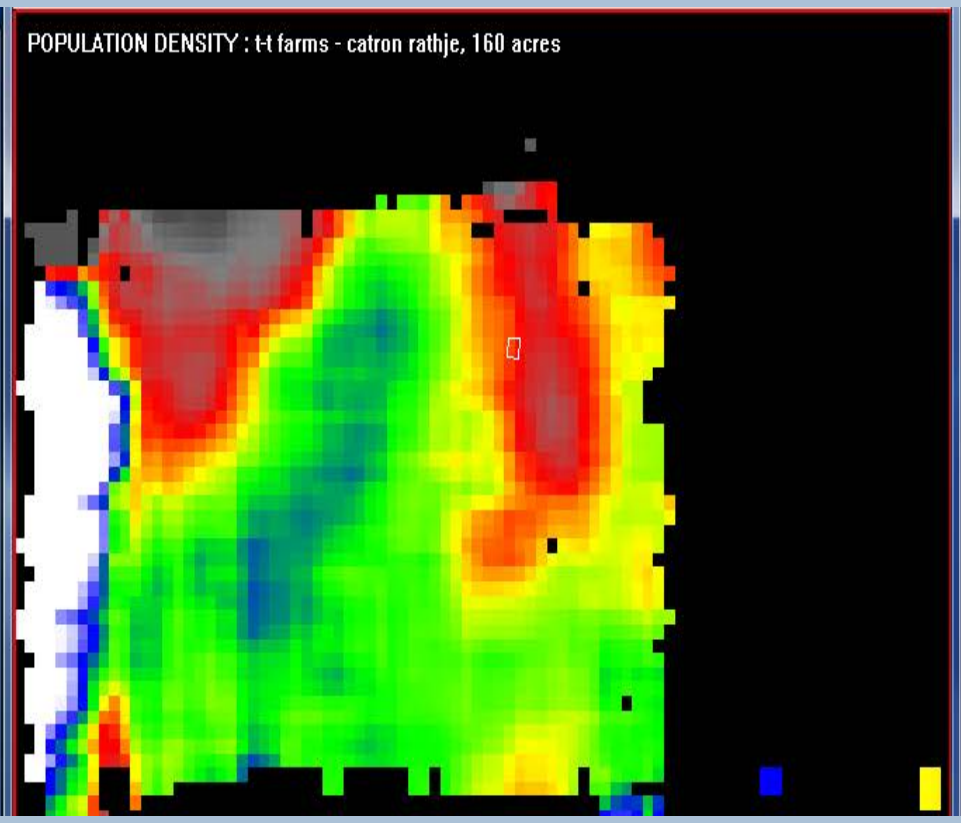
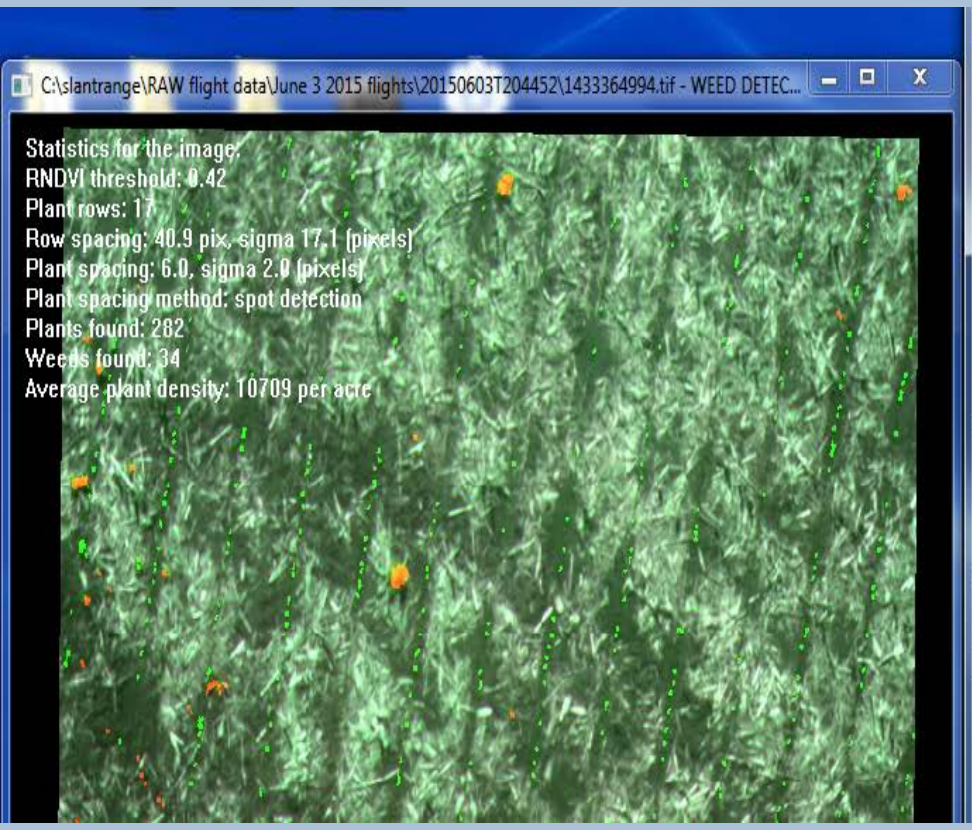
Statistics for the image:
RNDVI threshold: 0.42
Plant rows: 12
Row spacing: 43.0 pix, sigma 1.0 (pixels)
Plant spacing: 6.0, sigma 2.0 (pixels)
Plant spacing method: cross-correlation
Plants found: 608
Weeds found: 0
Average plant density: 25505 per acre


POPULATION DENSITY : t-t farms - catron rathje, 160 acres

UAV imagery


C:\slantrange\RAW flight data\June 3 2015 flights\20150603T204452\1433364994.tif - WEED DETEC...
Statistics for the image:
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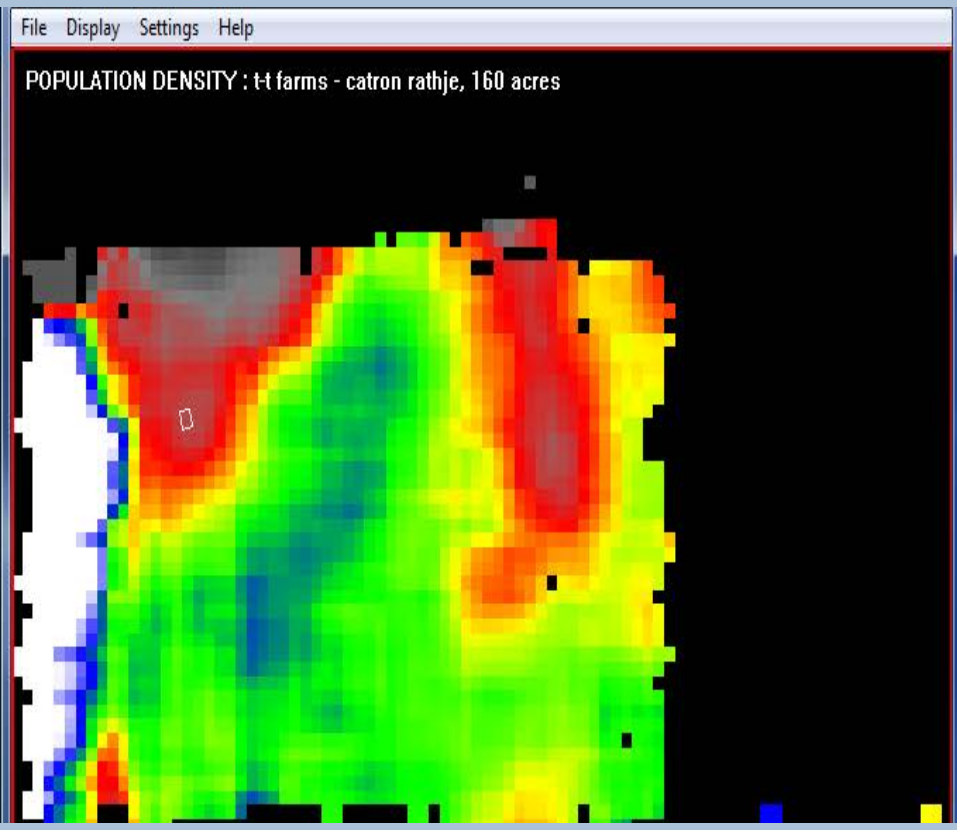
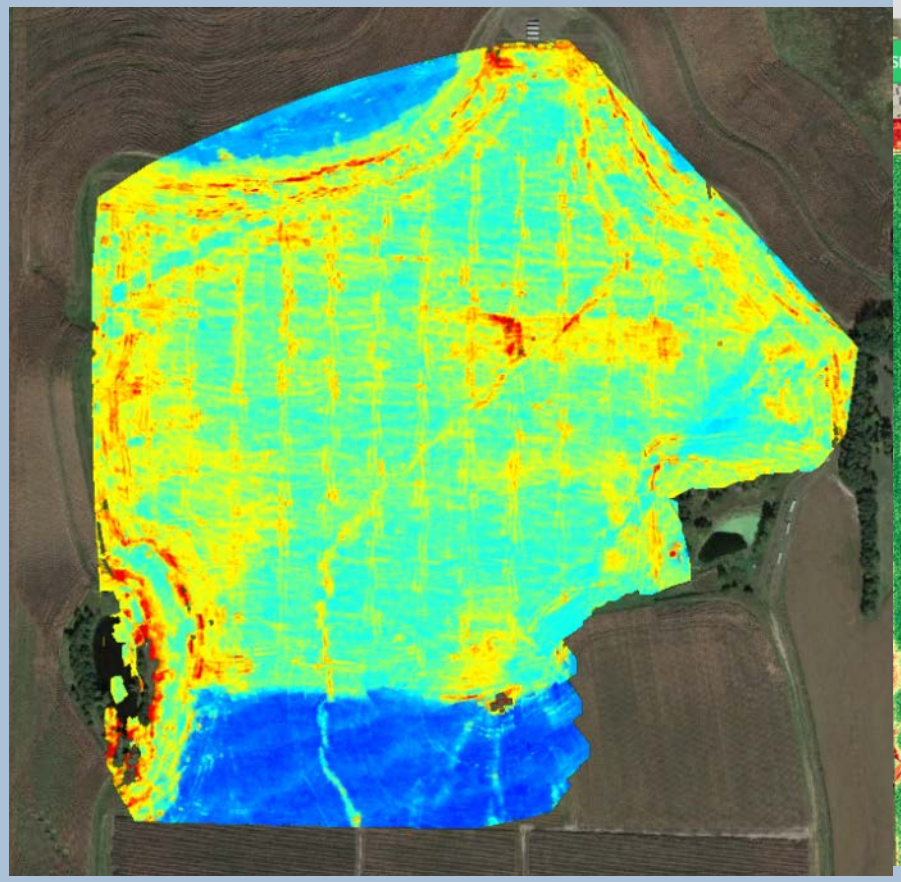
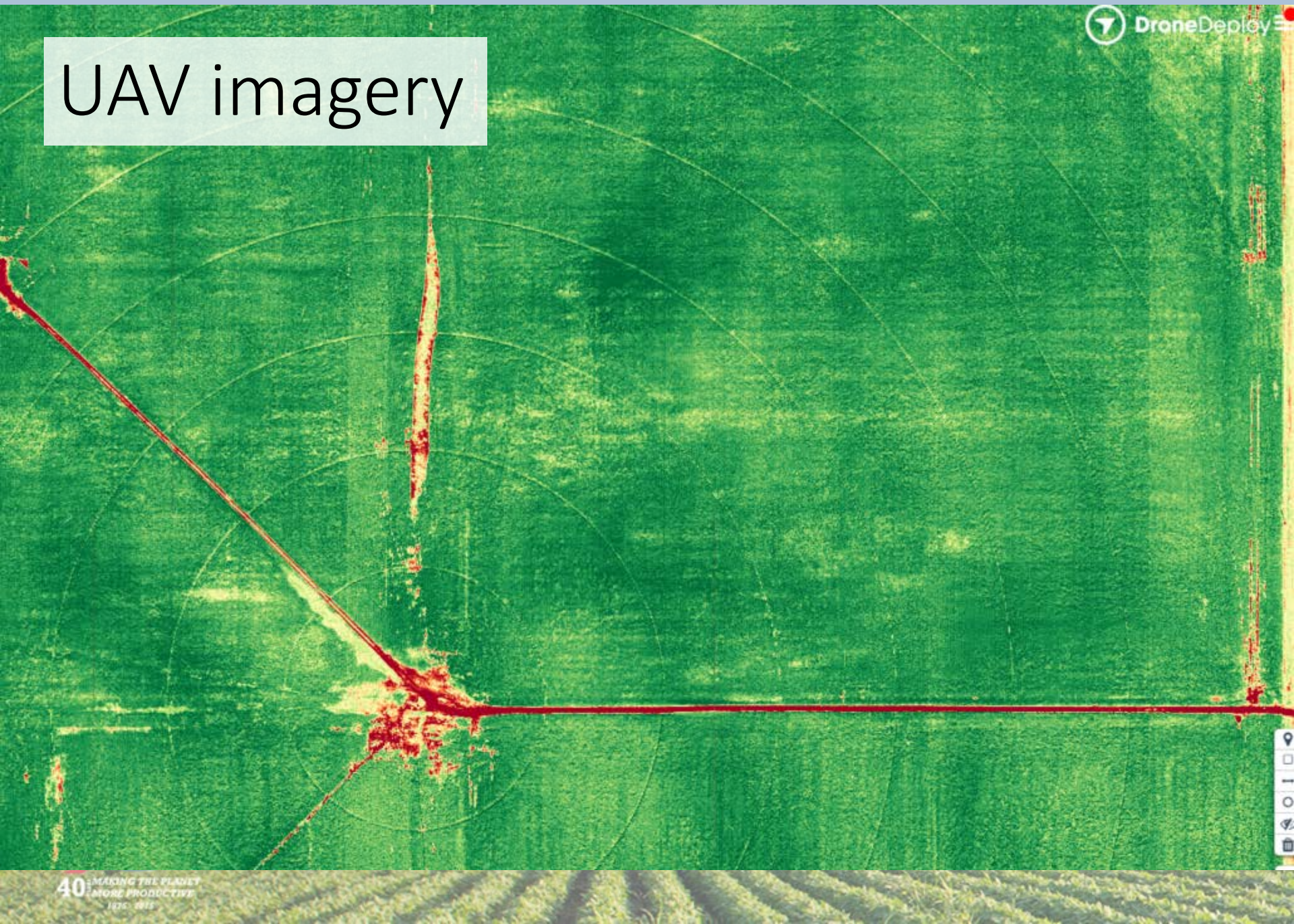
Plant rows: 17
Row spacing: 40.9 pix, sigma 17.1 (pixels)
Plant spacing: 6.0, sigma 2.9 (pixels)
Plant spacing method: spot detection
Plants found: 282
Weeds found: 34
Average plant density: 10709 per acre


File Display Settings Help
POPULATION DENSITY : t-t farms - catron rathje, 160 acres

UAV imagery



UAV imagery

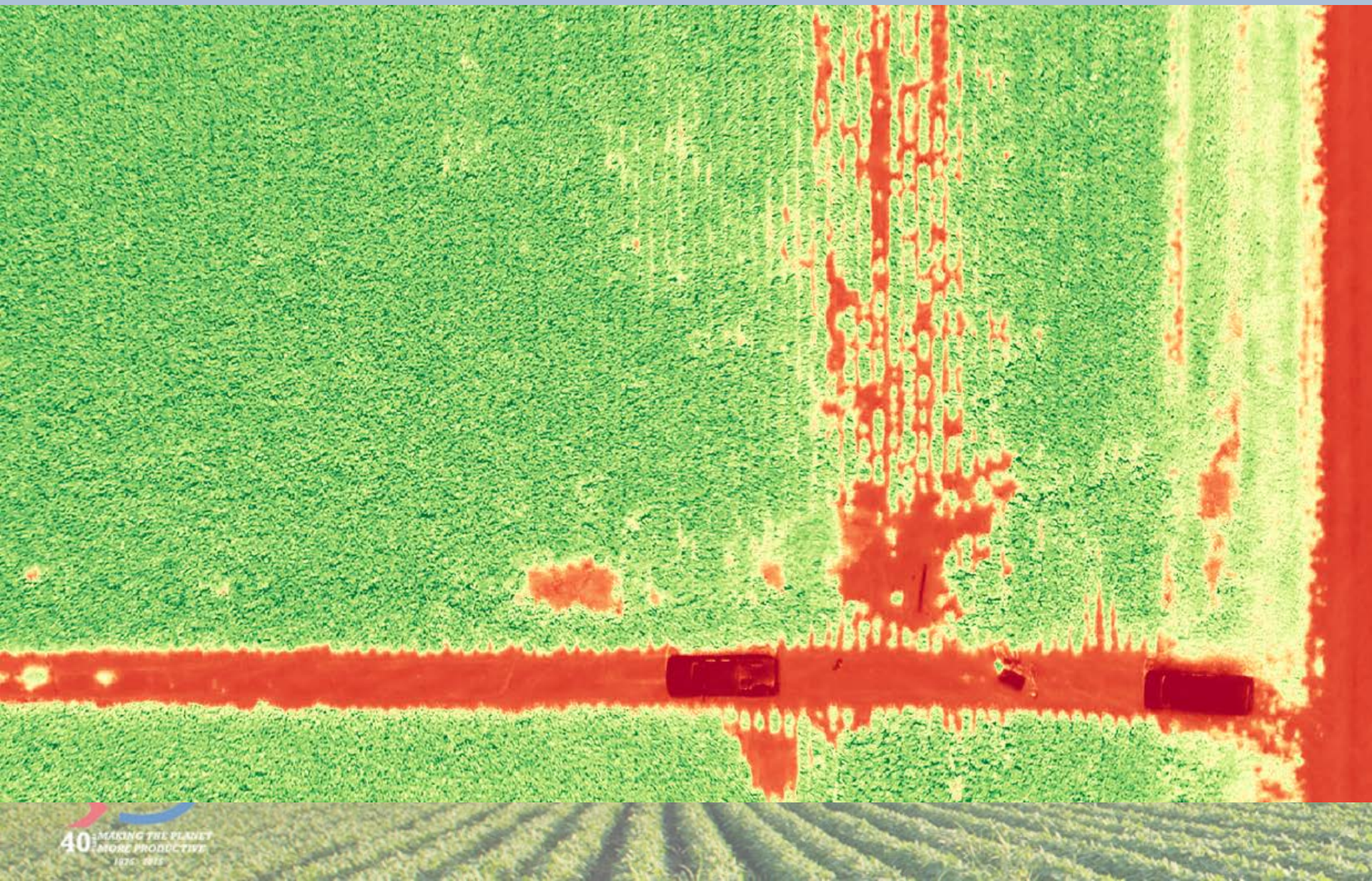


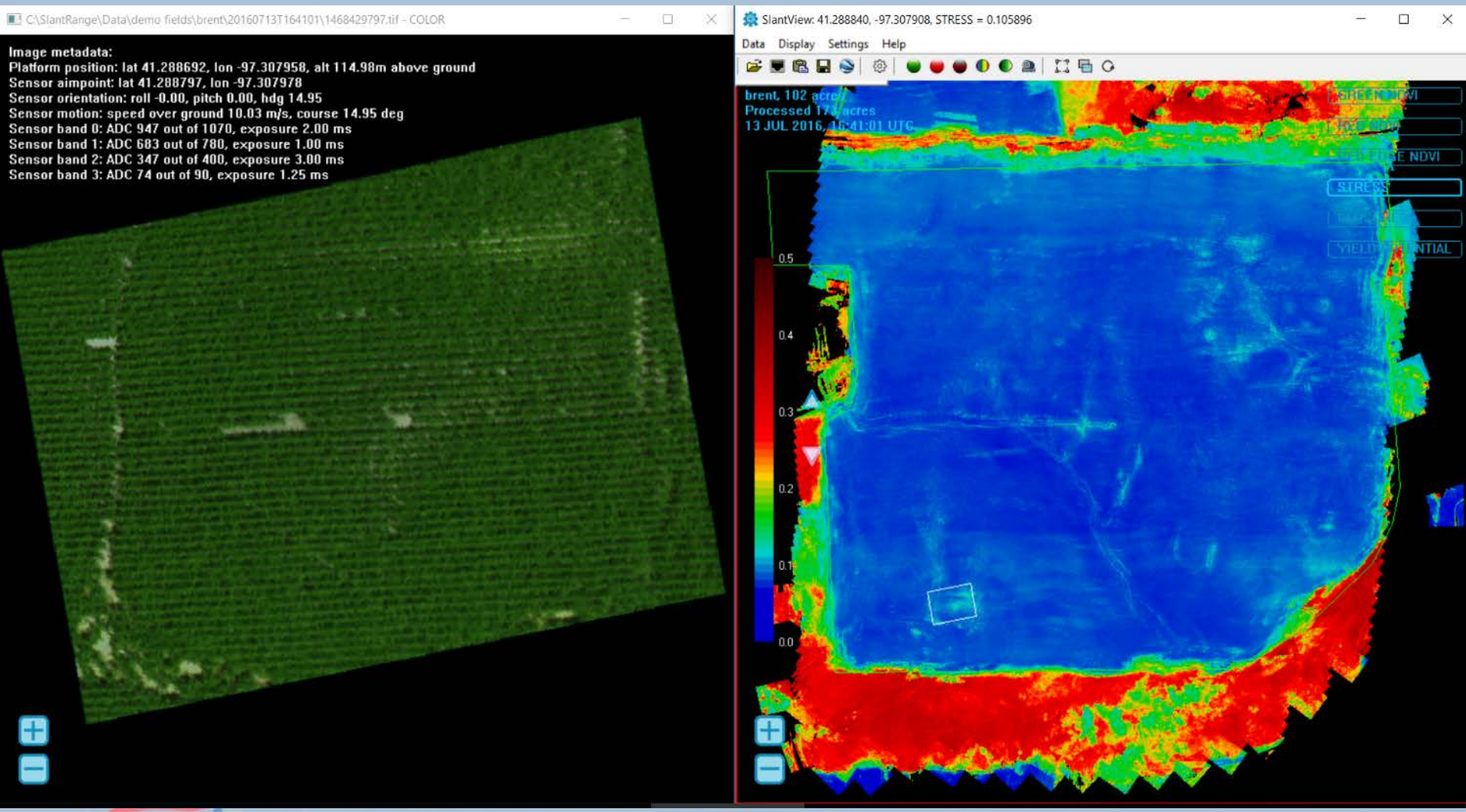
UAV imagery

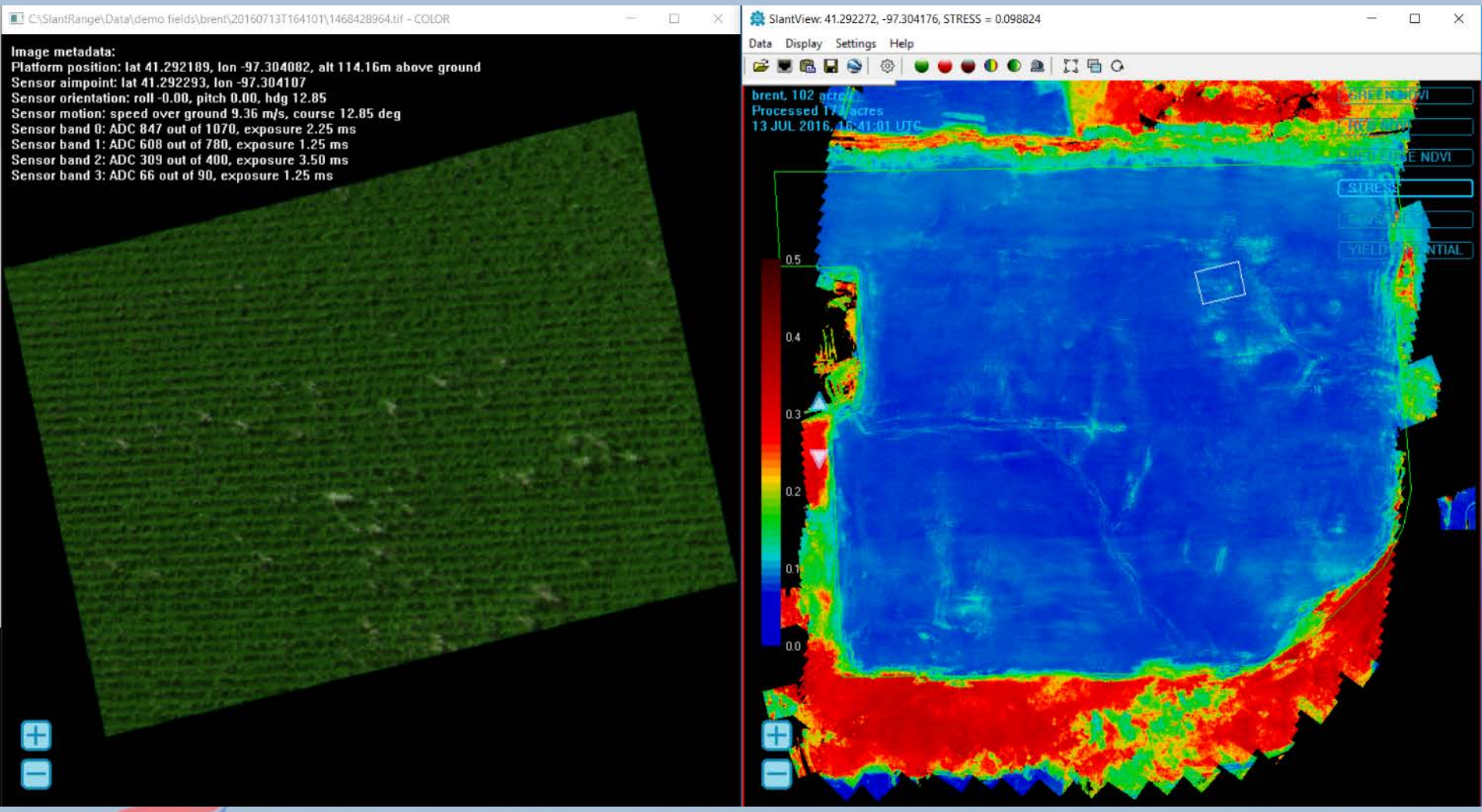
UAV imagery

UAV imagery

UAV imagery







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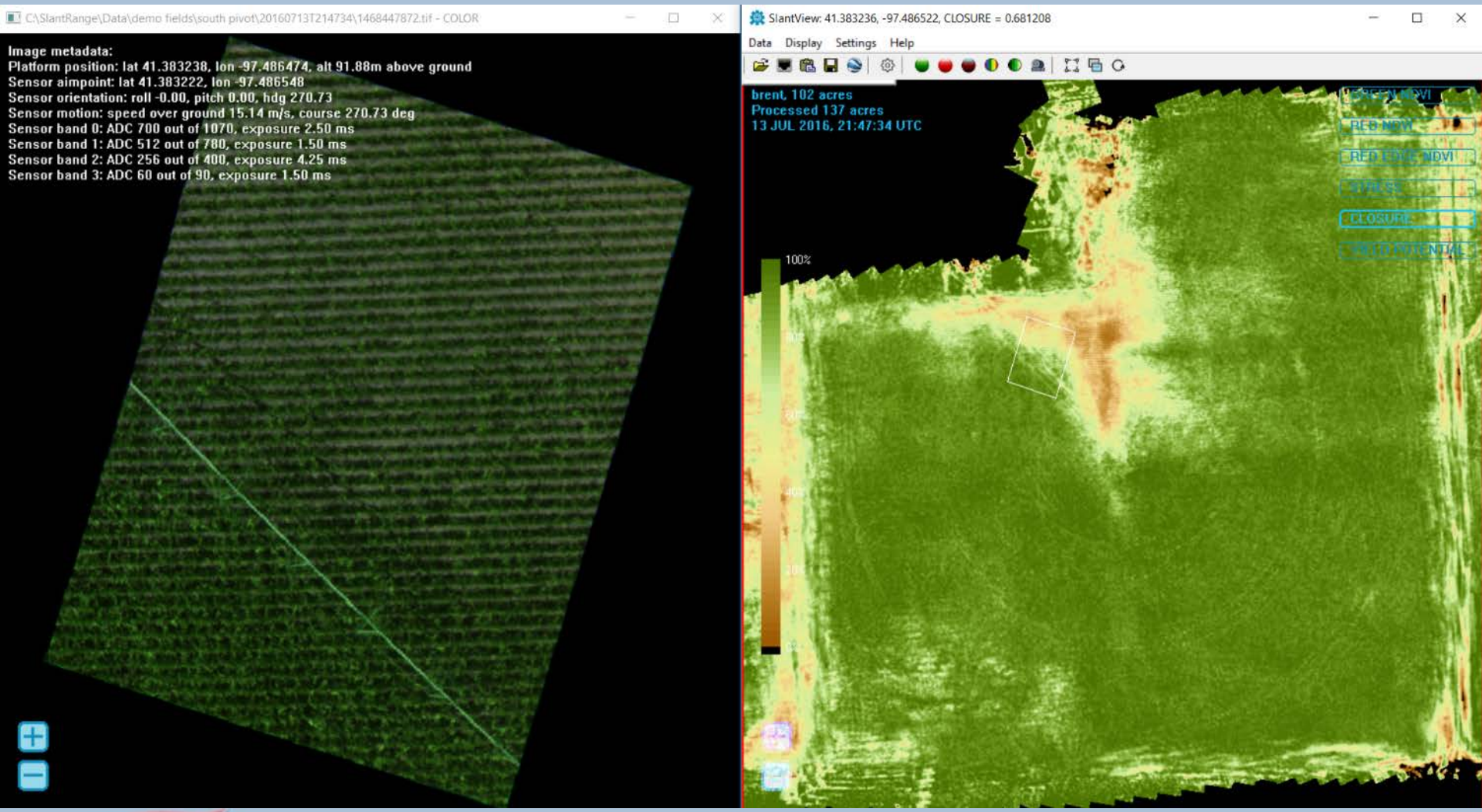
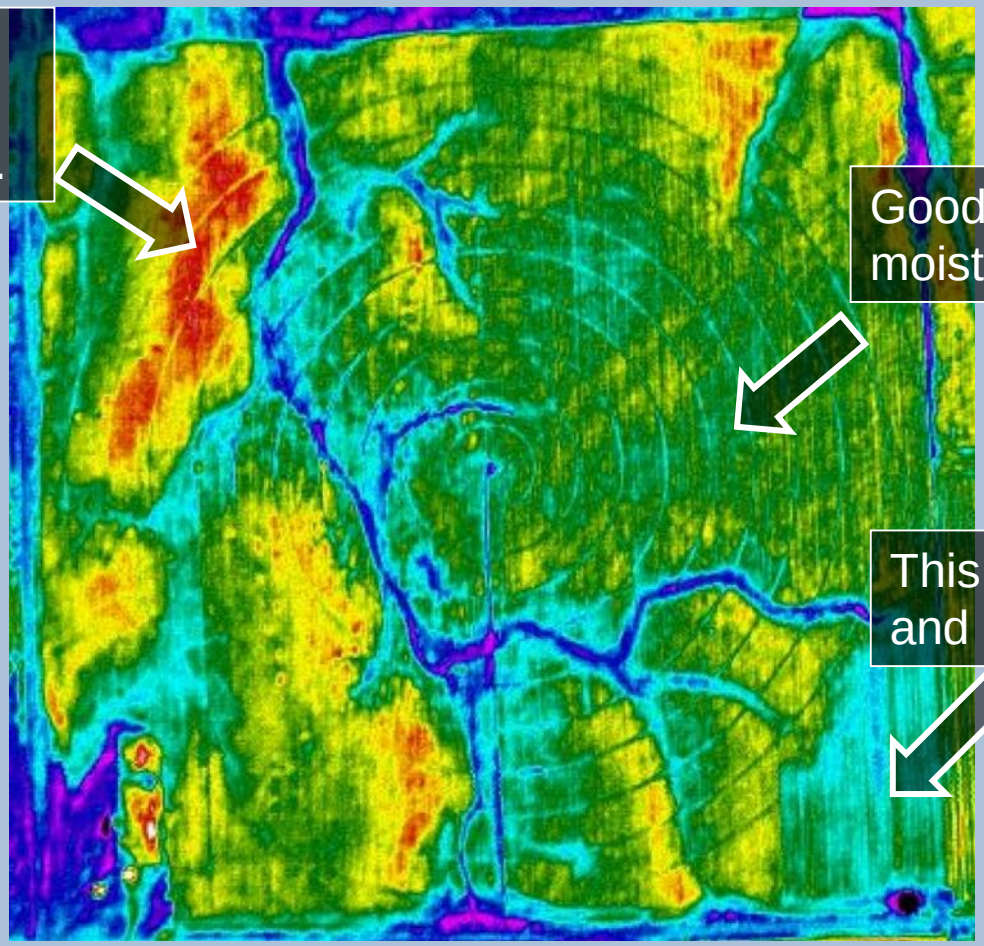


Manned-Aircraft Imagery
Bare Ground Thermal

Very dry ridge! Consider a drought-resistant hybrid here.



Good placement for a moisture probe.

This corner is disked and ridged for pipe.

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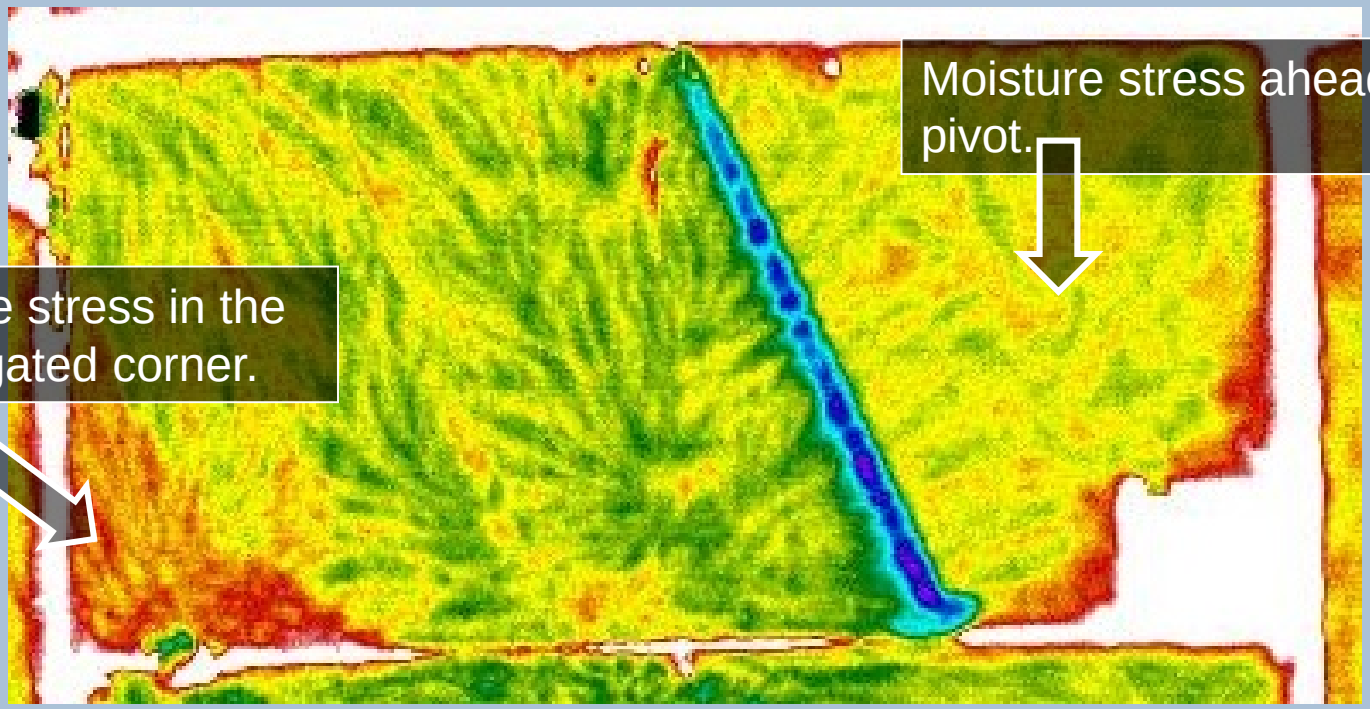
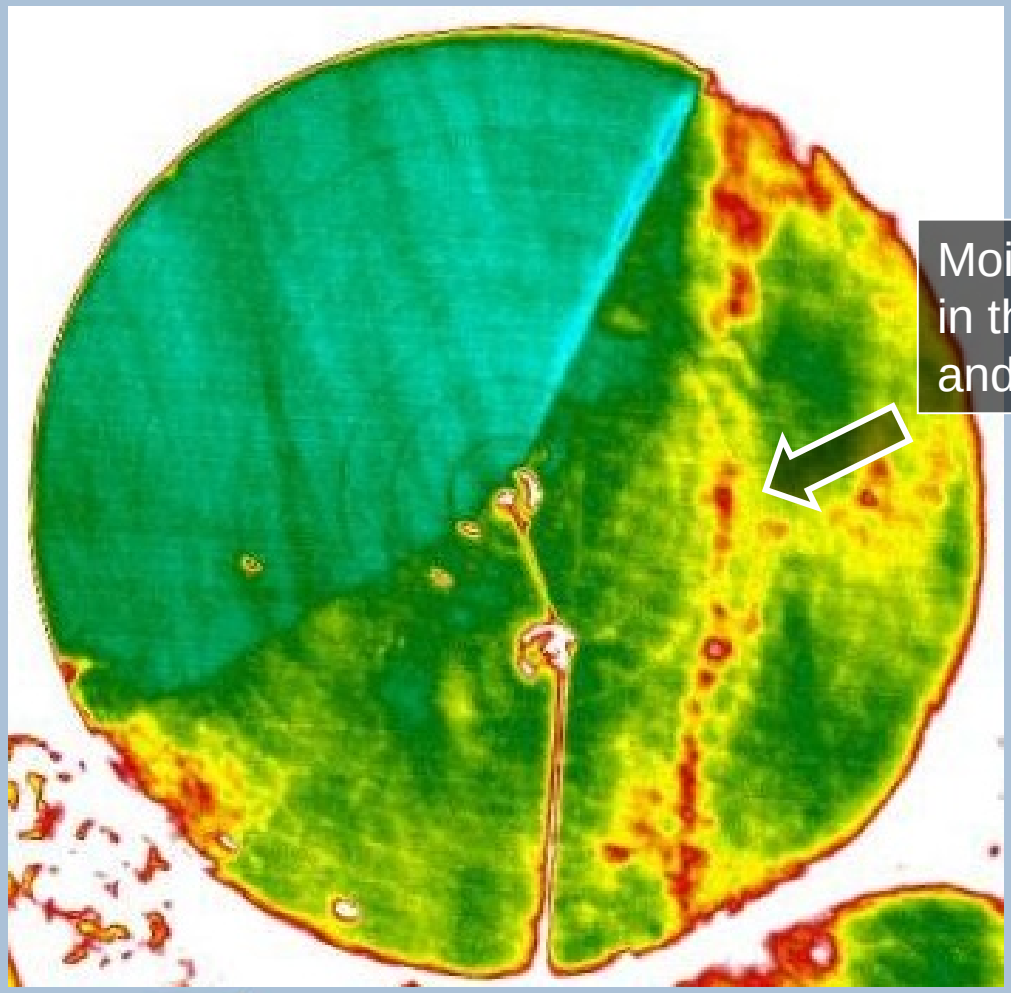
Manned-Aircraft Imagery
In-Season Thermal



Manned-Aircraft Imagery
In-Season Thermal



Moisture stress varies greatly in this field due to soil type and topography.

This information can be used to better manage irrigation.

Challenges

What are some challenges with UAV use?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Challenges

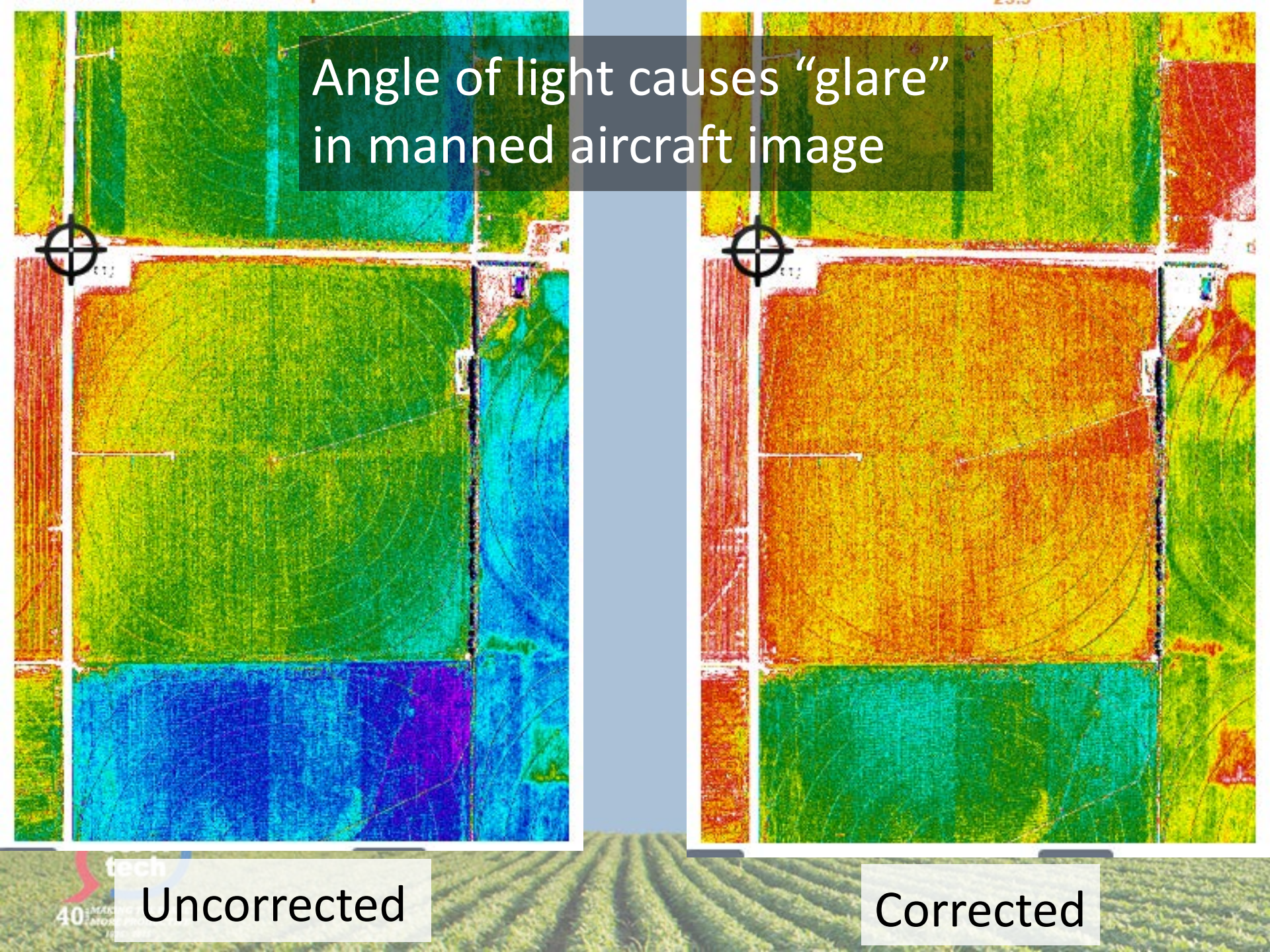
What are some challenges with UAV use?

- Safely sharing the air with aerial applicators.
- *Lots* of maintenance and repair.
- Maximizing time/cost efficiency.
  - Flying 160 acres may take up to an hour.
- Requires skill, experience, (and a little luck) to operate.
- Weather conditions. (Wind, rain.)

Imagery Problems

- Light angle / time of day effects
- Shadows and uneven “glare”
- Image stitching / overlap errors
- Cloud shadows and changing light conditions


Problem with these fields?


Angle of light causes “glare” in manned aircraft image
Uncorrected
Corrected

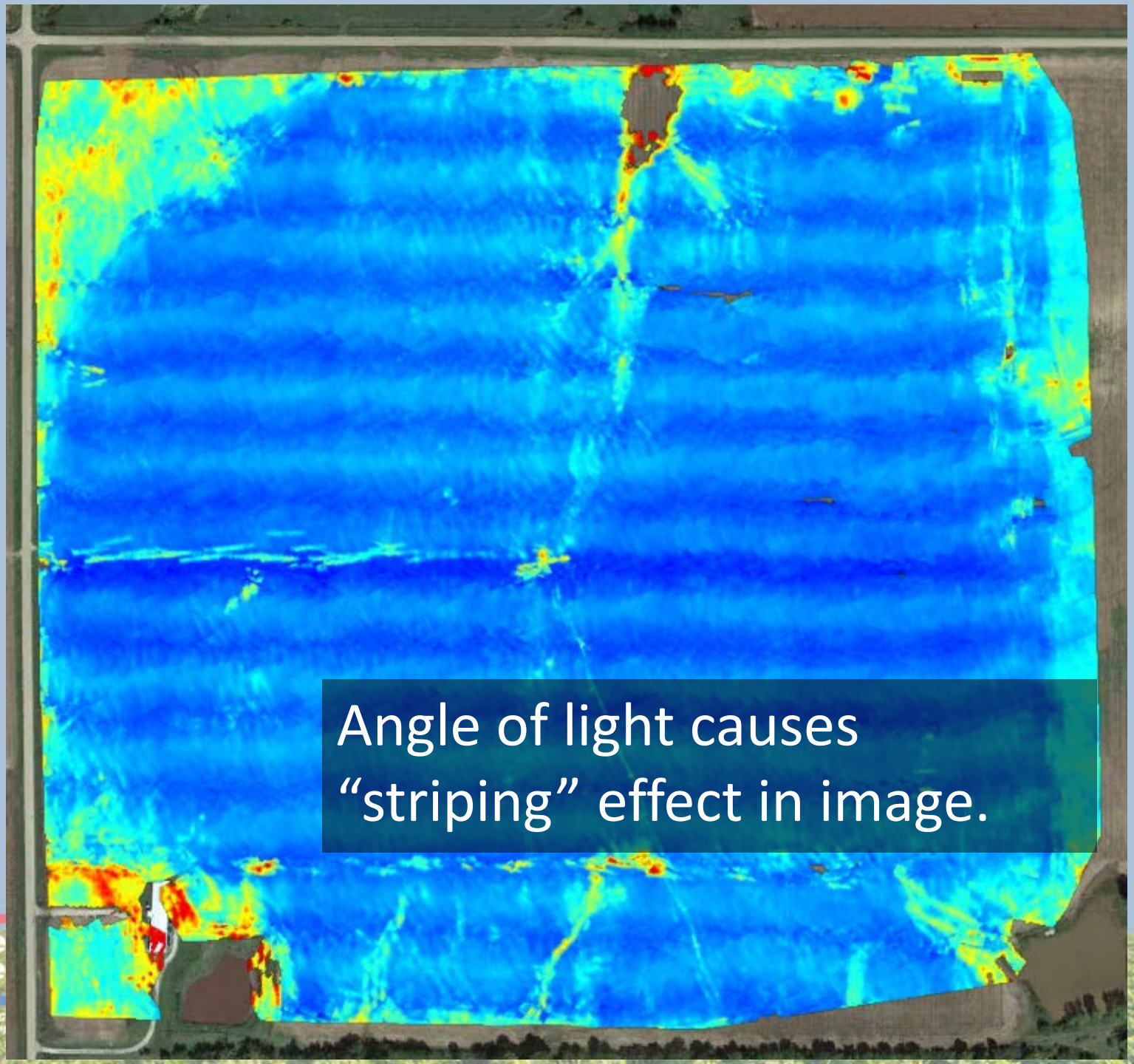

Angle of light causes
“striping” effect in image.

Image Stitching

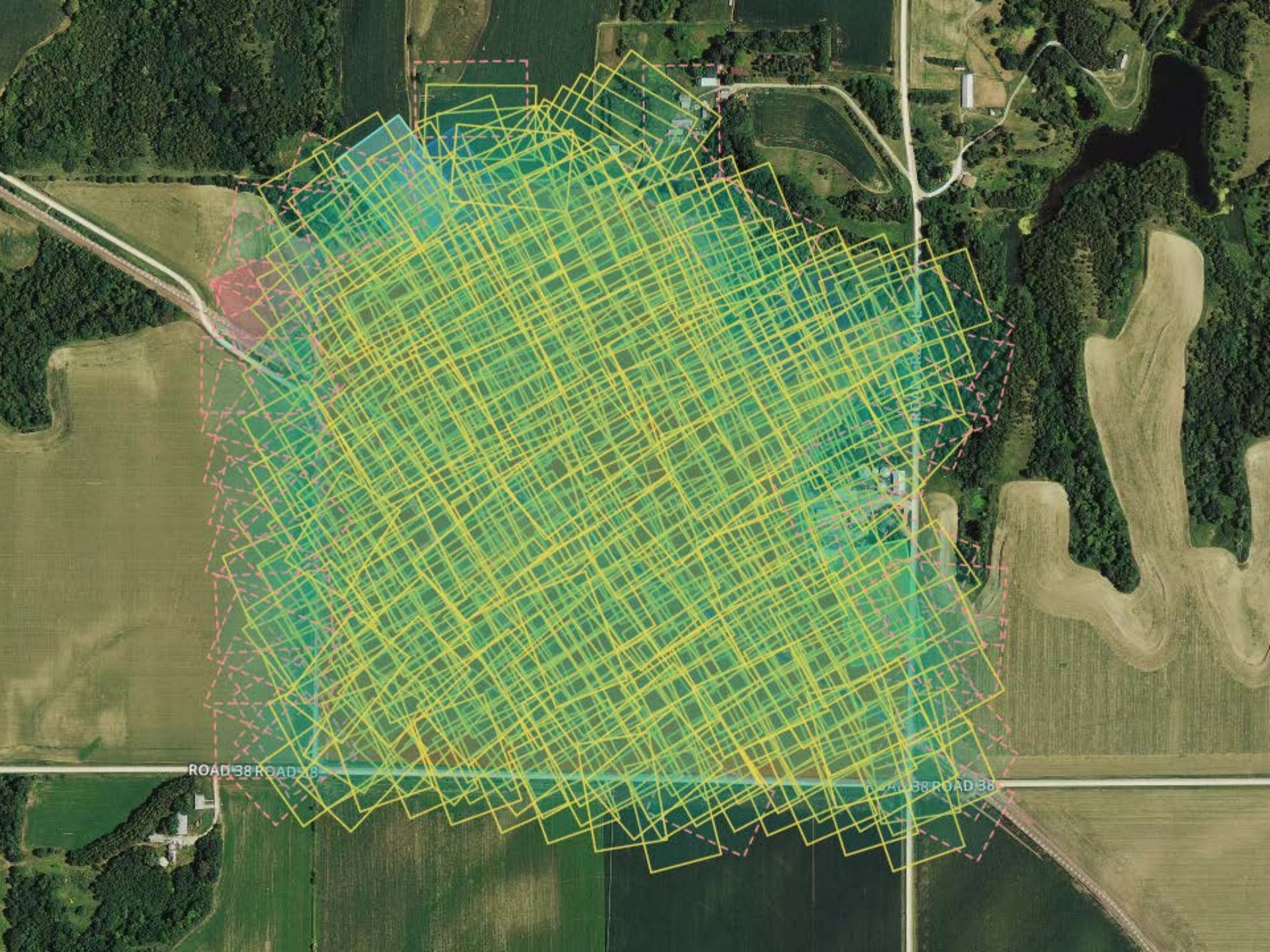
Two main ways to combine many small images into one big image:

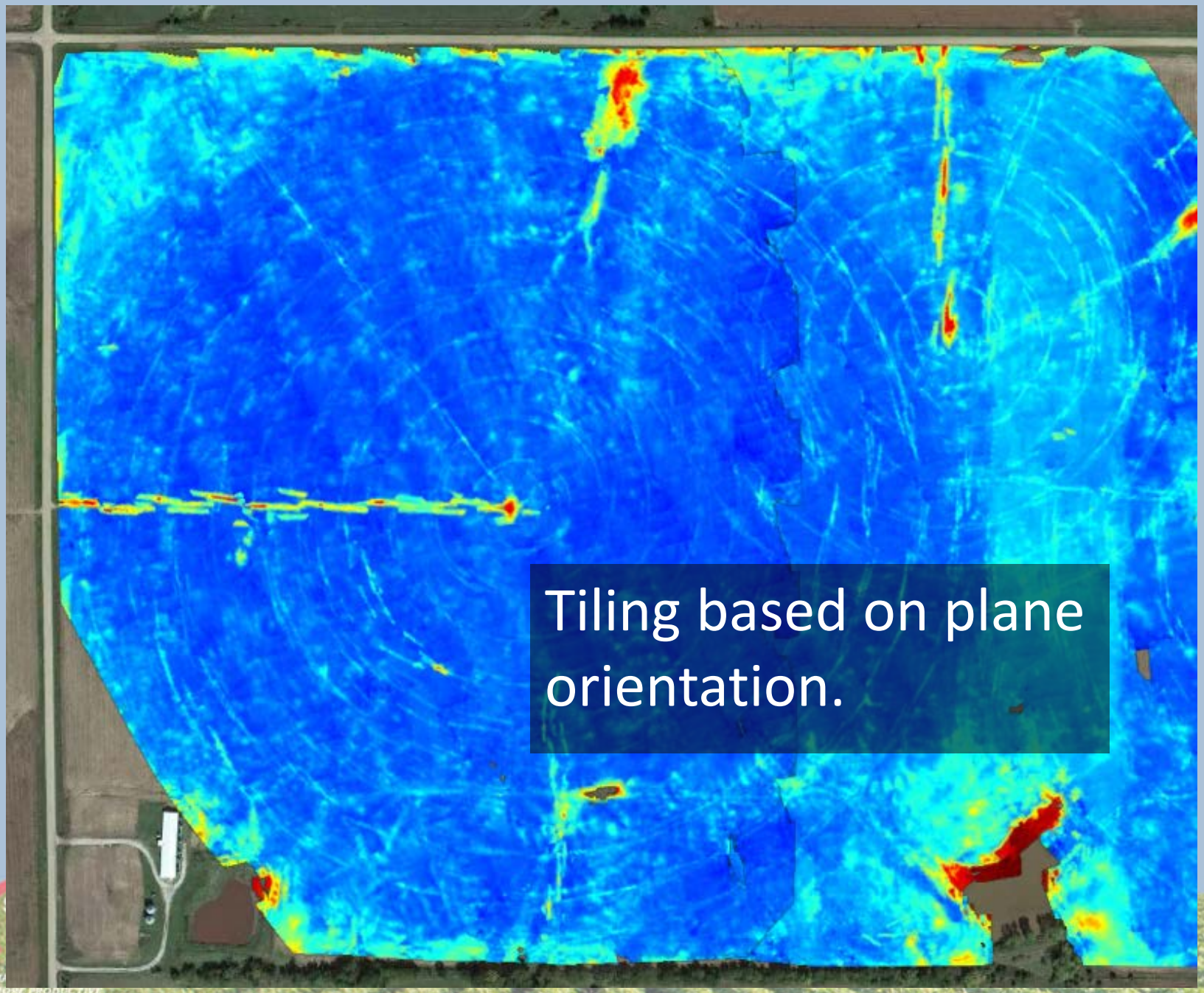
1) Tile images based on plane position and orientation.

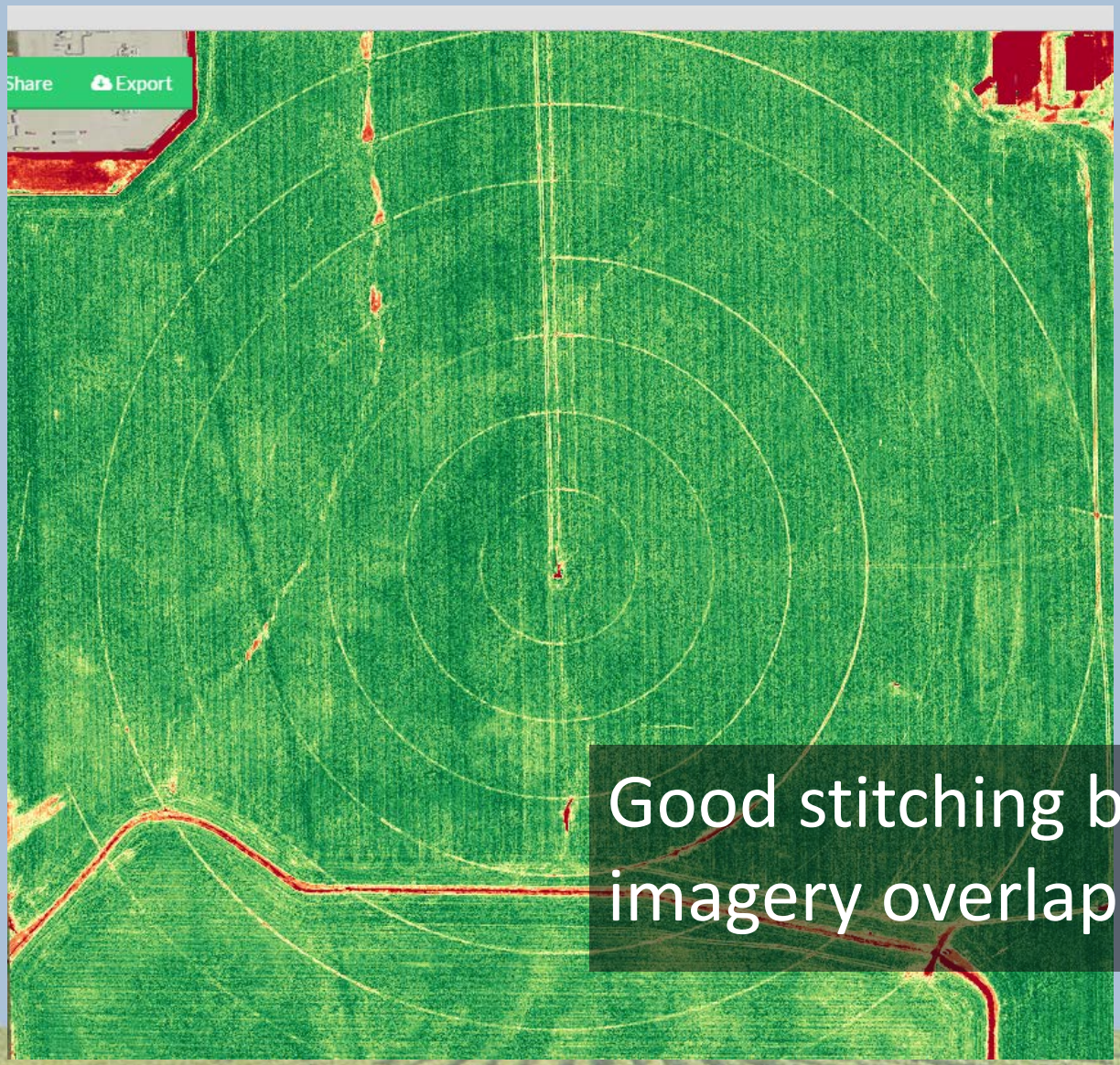
- Fairly reliable but never perfect.

2)Stitch images based on overlapping parts of the image.

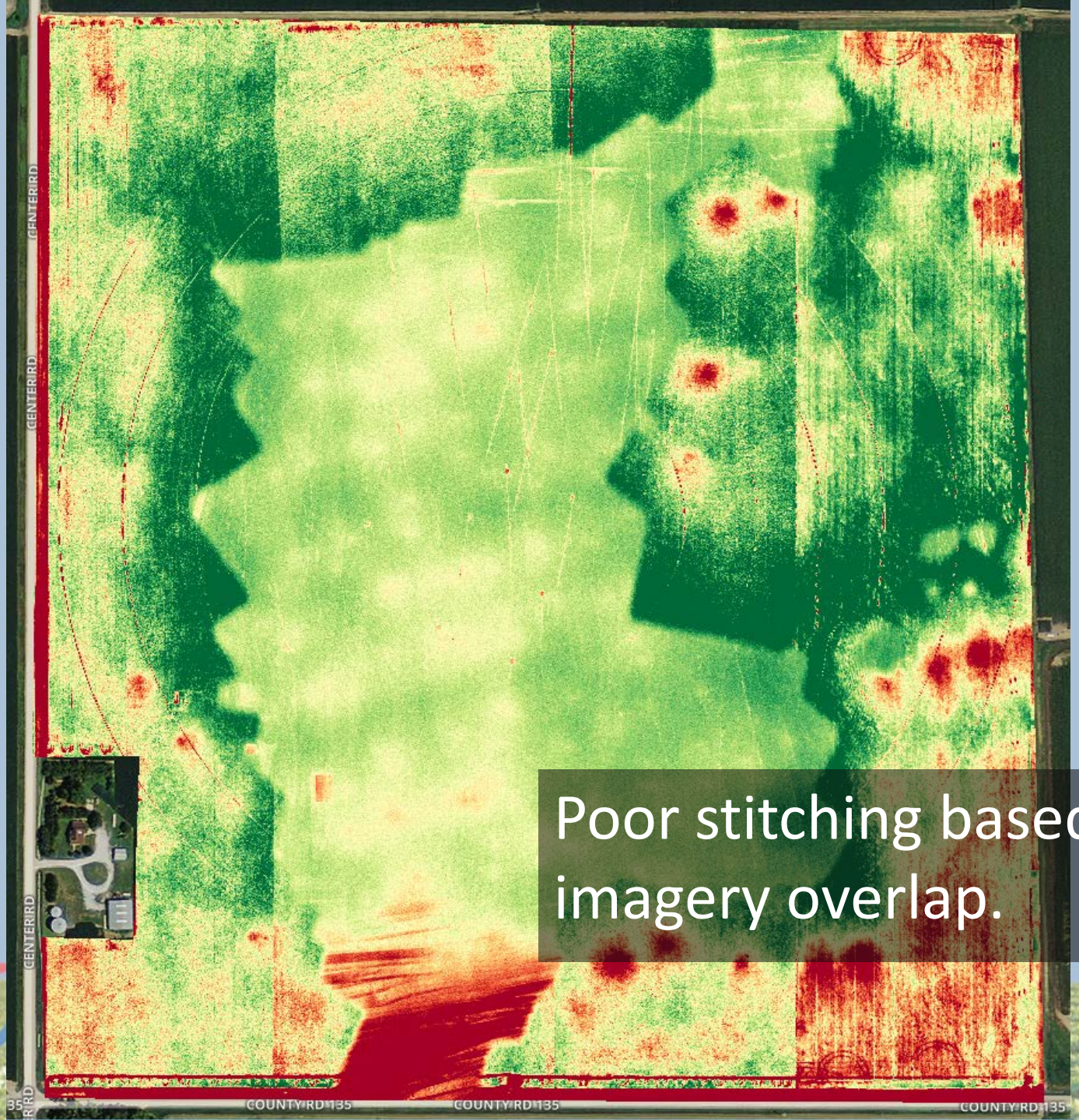
- Better final product.
- Requires more overlap of images.


ROAD 38
ROAD 38
ROAD 38


Tiling based on plane orientation.



Good stitching based on imagery overlap.



Poor stitching based on imagery overlap.

Bad spot due to one faulty picture

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Technology Use

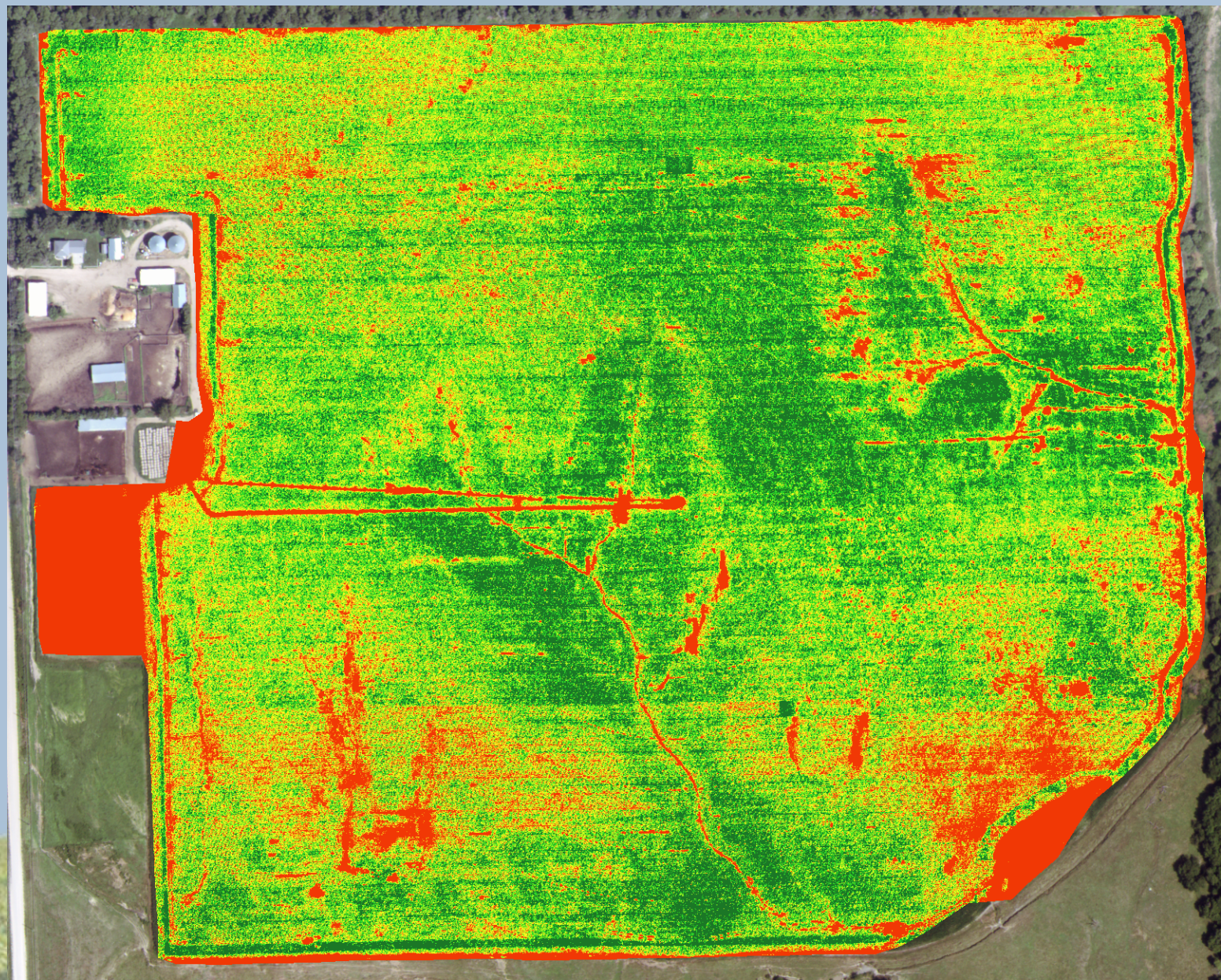
None of these technologies are a replacement for regularly checking the field!

- They *do* let you be smarter about where you spend your time.
- They can help you catch problems you may otherwise miss.
- They can create variable-rate prescription maps to allow the smartest use of inputs.

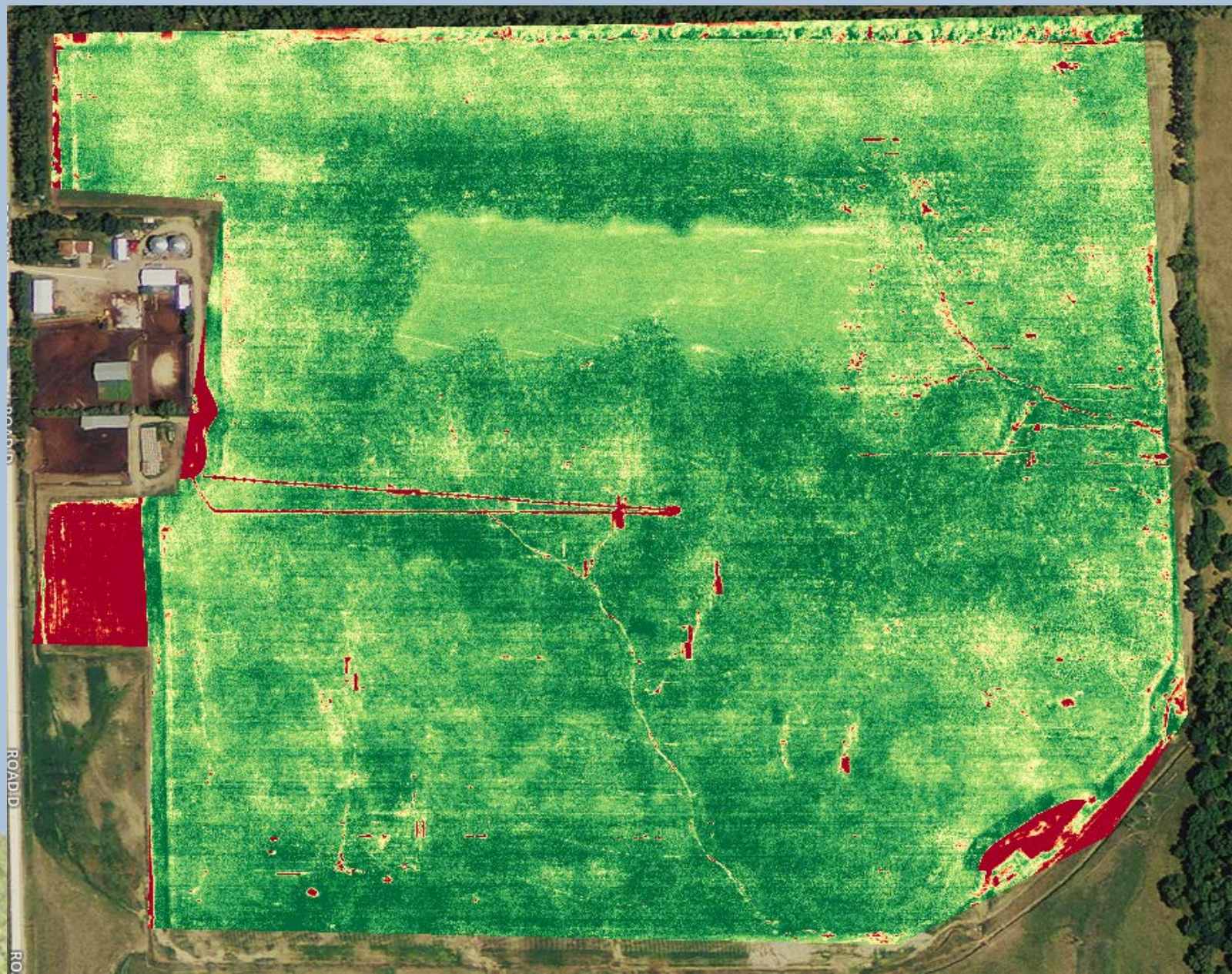
To drone or not to drone?

- Do you need better resolution than manned-aircraft?
- Do you have free time that can't be profitable otherwise?
- Do you have a very high tolerance for risk and failure?
- Do you want video instead of a field map?

Manned-Aerial



UAV



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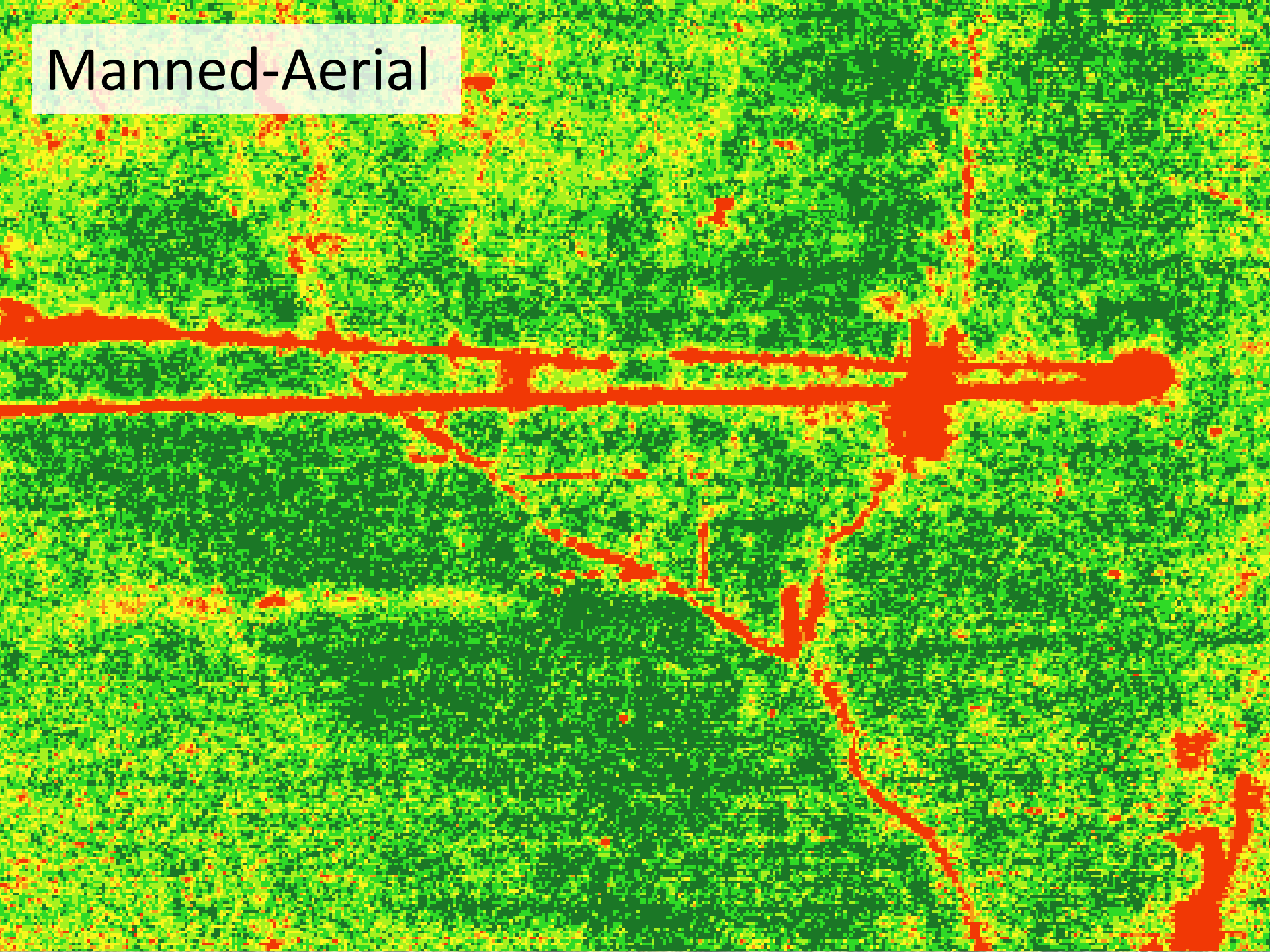
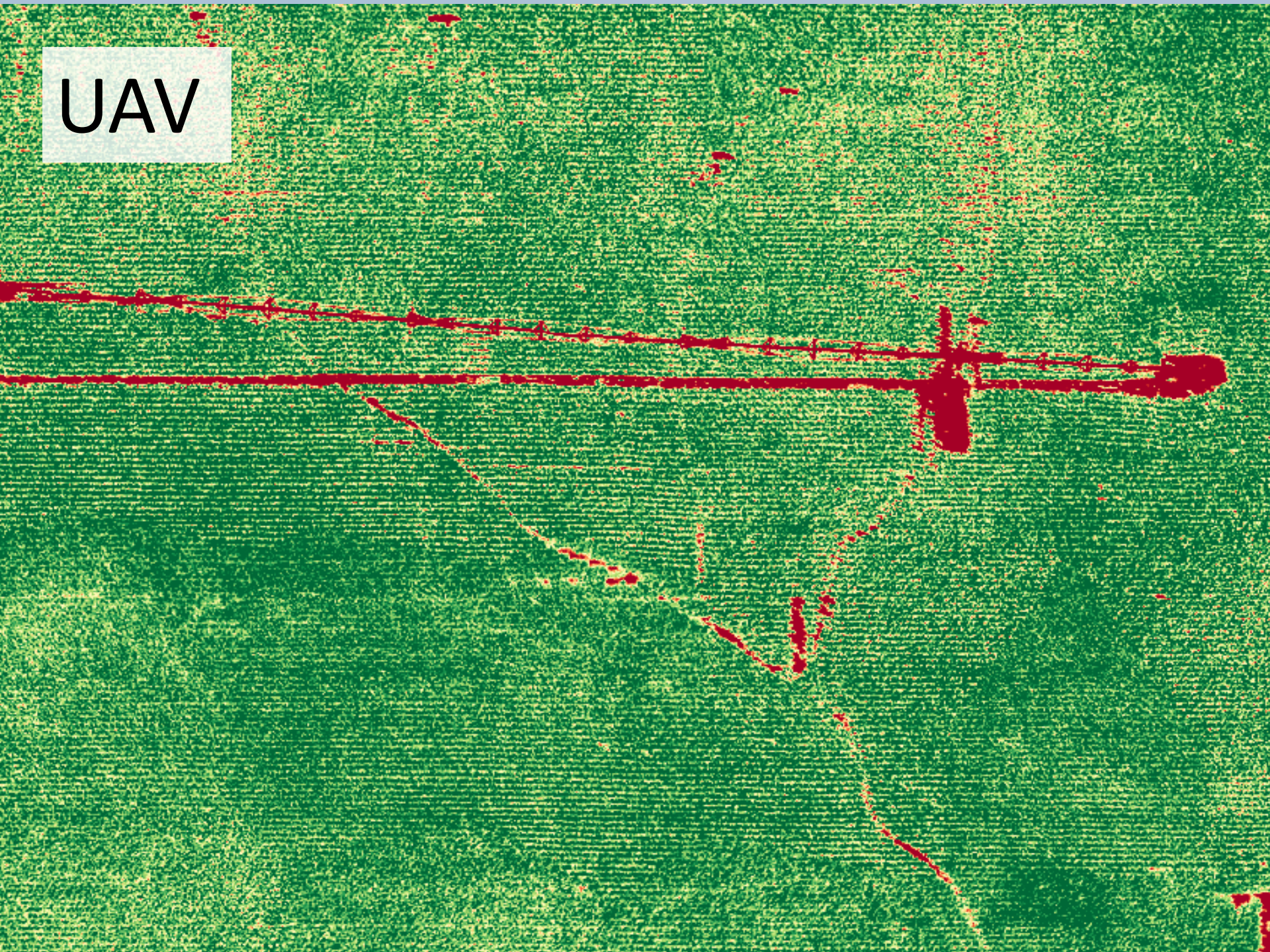

Manned-Aerial


UAV

Questions?

Austin Bontrager

Servi-Tech Expanded Premium Services

austin.bontrager@servitech.com

234-567-9182