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

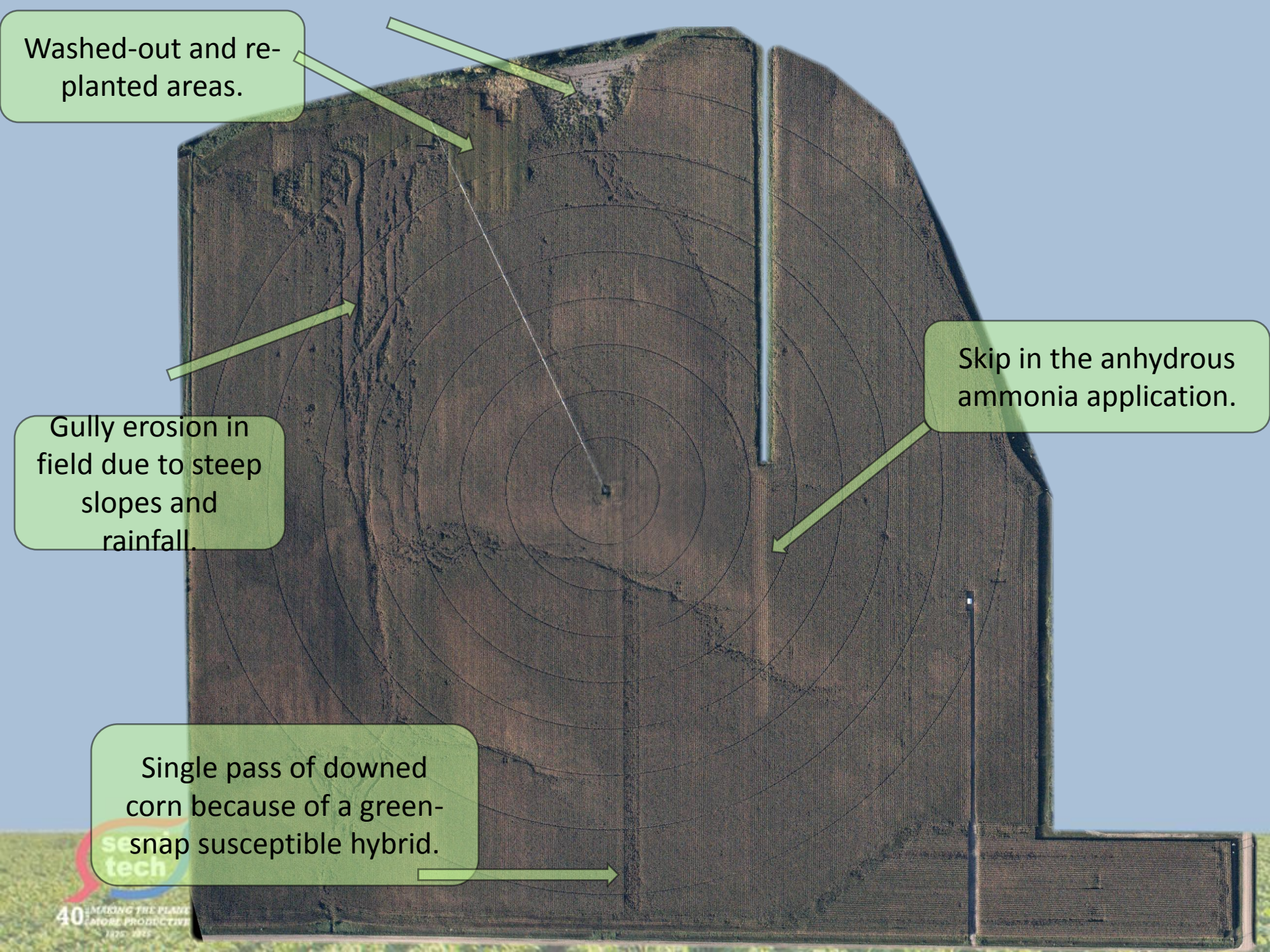
Short-term conditions or events

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

Why collect field imagery?

Fix something this year.

Improve how I farm next year.


Washed-out and re-planted areas.
Gully erosion in field due to steep slopes and rainfall.
Skip in the anhydrous ammonia application.
Single pass of downed corn because of a green-snap susceptible hybrid.

Why collect field imagery?

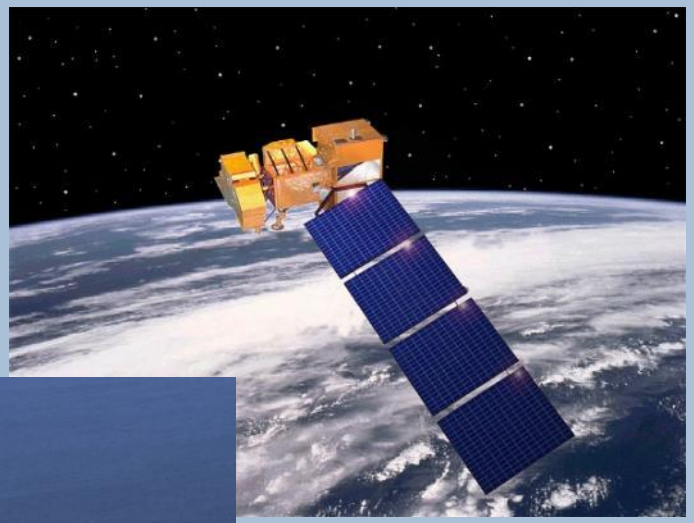
- Imagery is collected so a grower can make a *change* to their operation, or so the scouting method can change.
- Are they *willing* and *able* to change how they plant, fertilize, irrigate, spray, or harvest?
- Will the consultant change how they scout the field?
- **Do you just need a really cool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

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.

Sources of Imagery



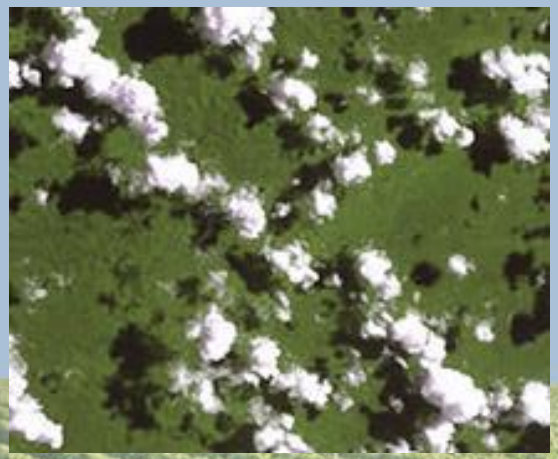
- Satellite

- 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.
- You don’t have to rely on someone else to collect it.
- Very expensive (or time consuming) to collect and process at this point.
- Can provide instant feedback about the field.

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

- **Yield to other aircraft!**
- 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?

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

How are you going to use your UAV?

- The UAS is used as a tool by the person who is already checking the field.
  - How much time will it add/save to the field check?

- The imagery sold as a separate service that compliments other agronomic services.
  - Will the customer pay enough to make it worth your time?

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.

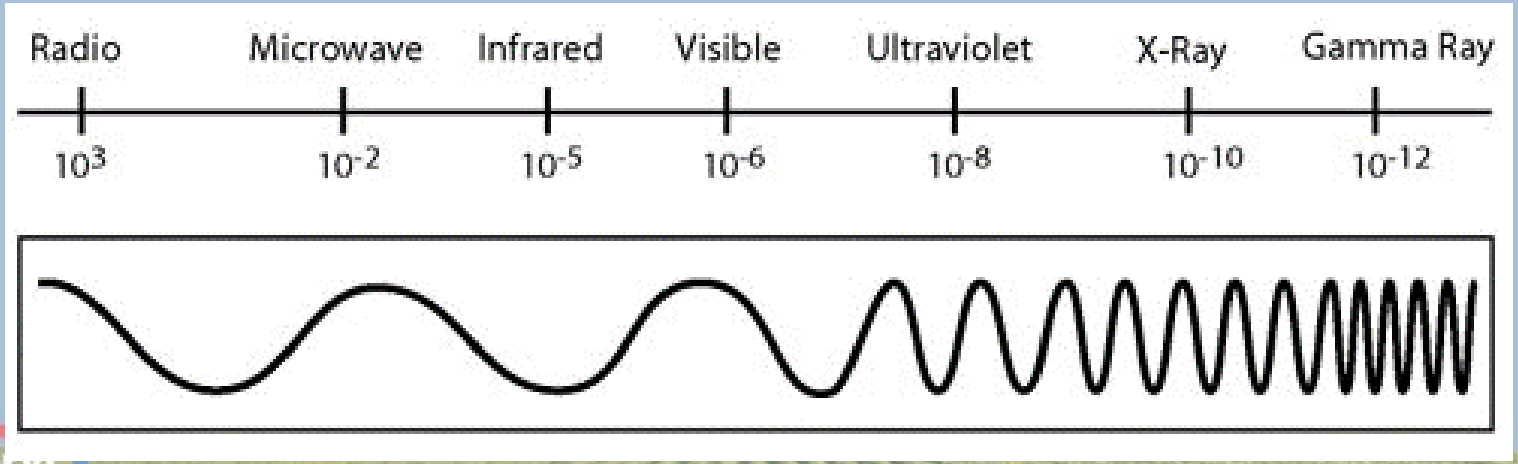
Image source: http://www.miniquadclub.com/5-tips-to-flying-fpv-for-the-newbie/

Which camera/sensor?

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

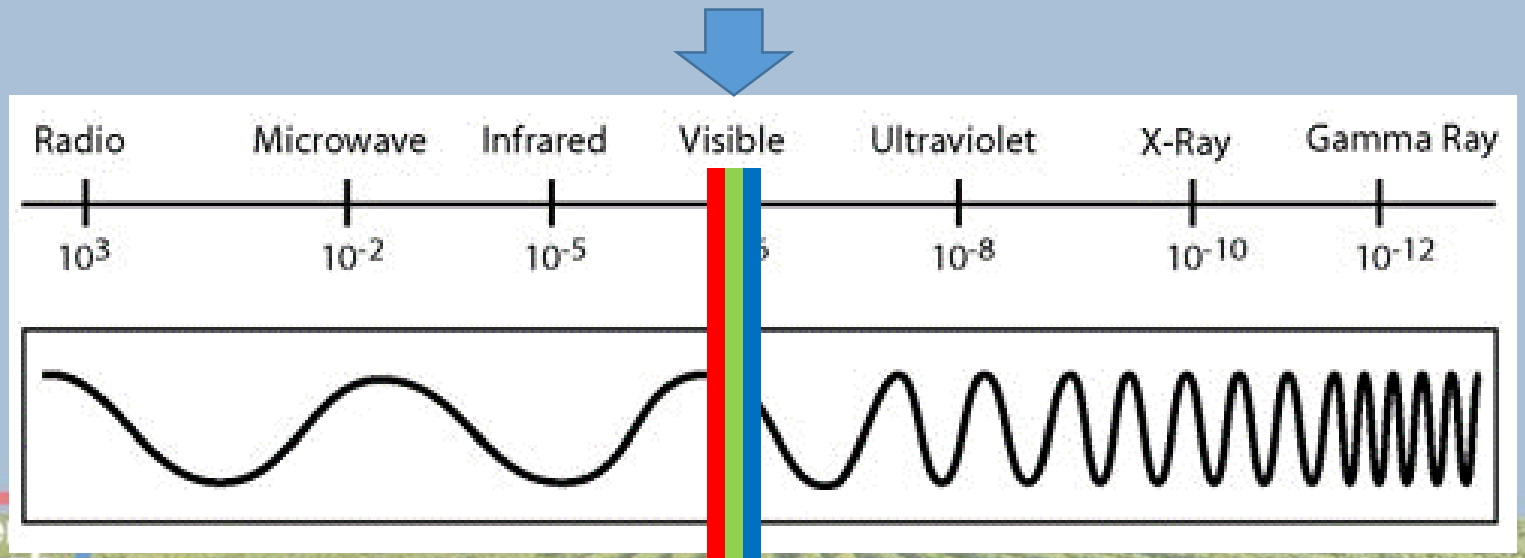
Science lesson about light

- Visible light
- Near Infrared
- Long-wavelength Infrared



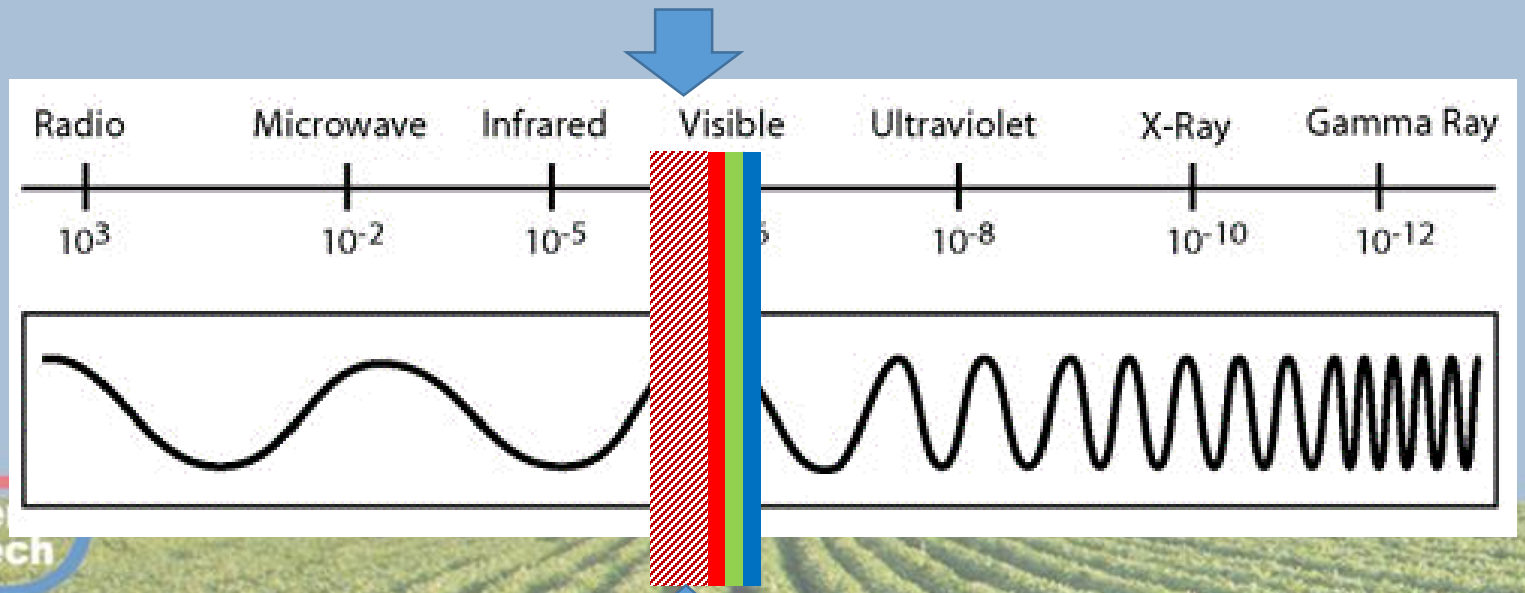
Visible Light

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

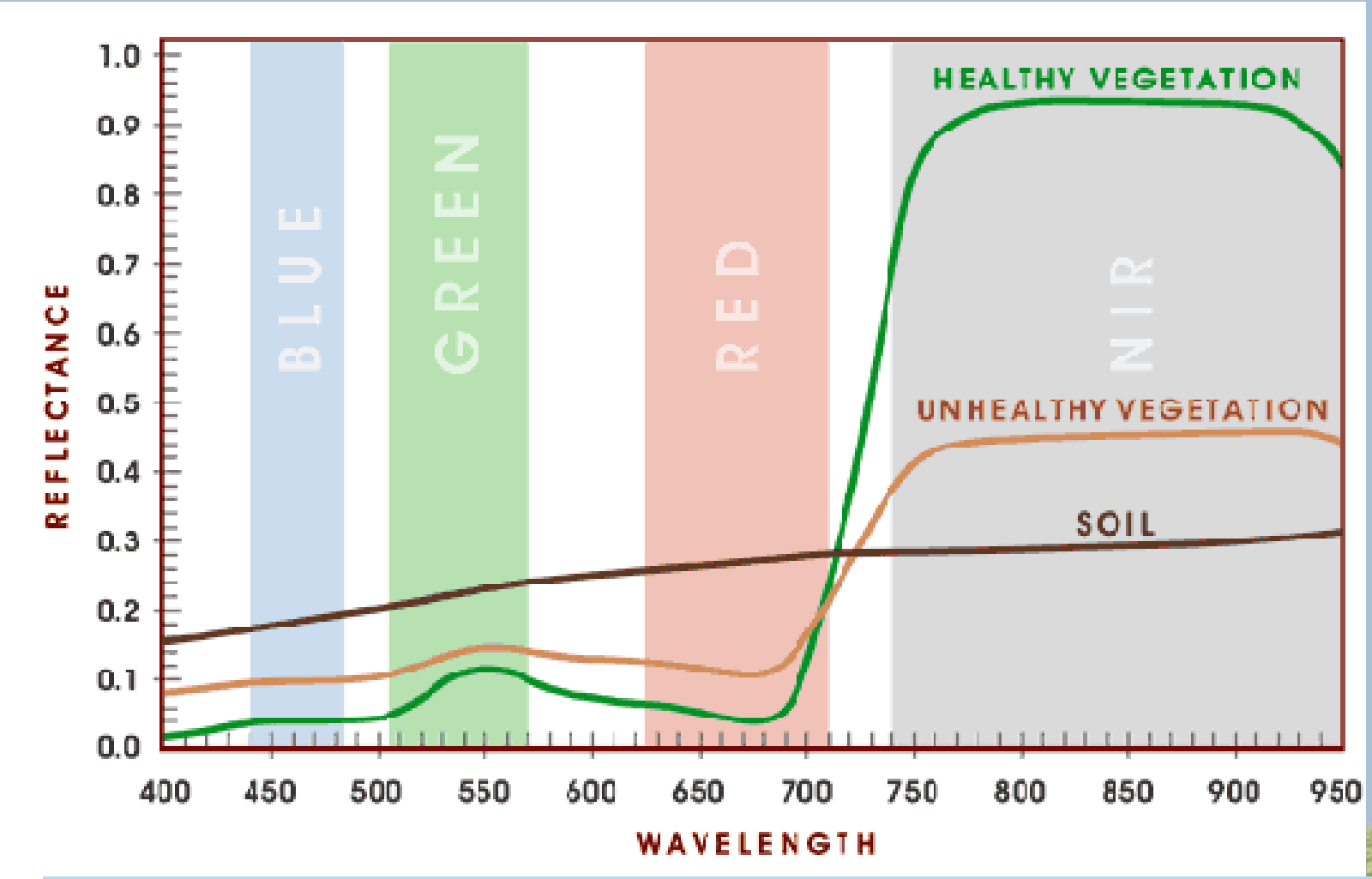


Near Infrared (NIR)

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

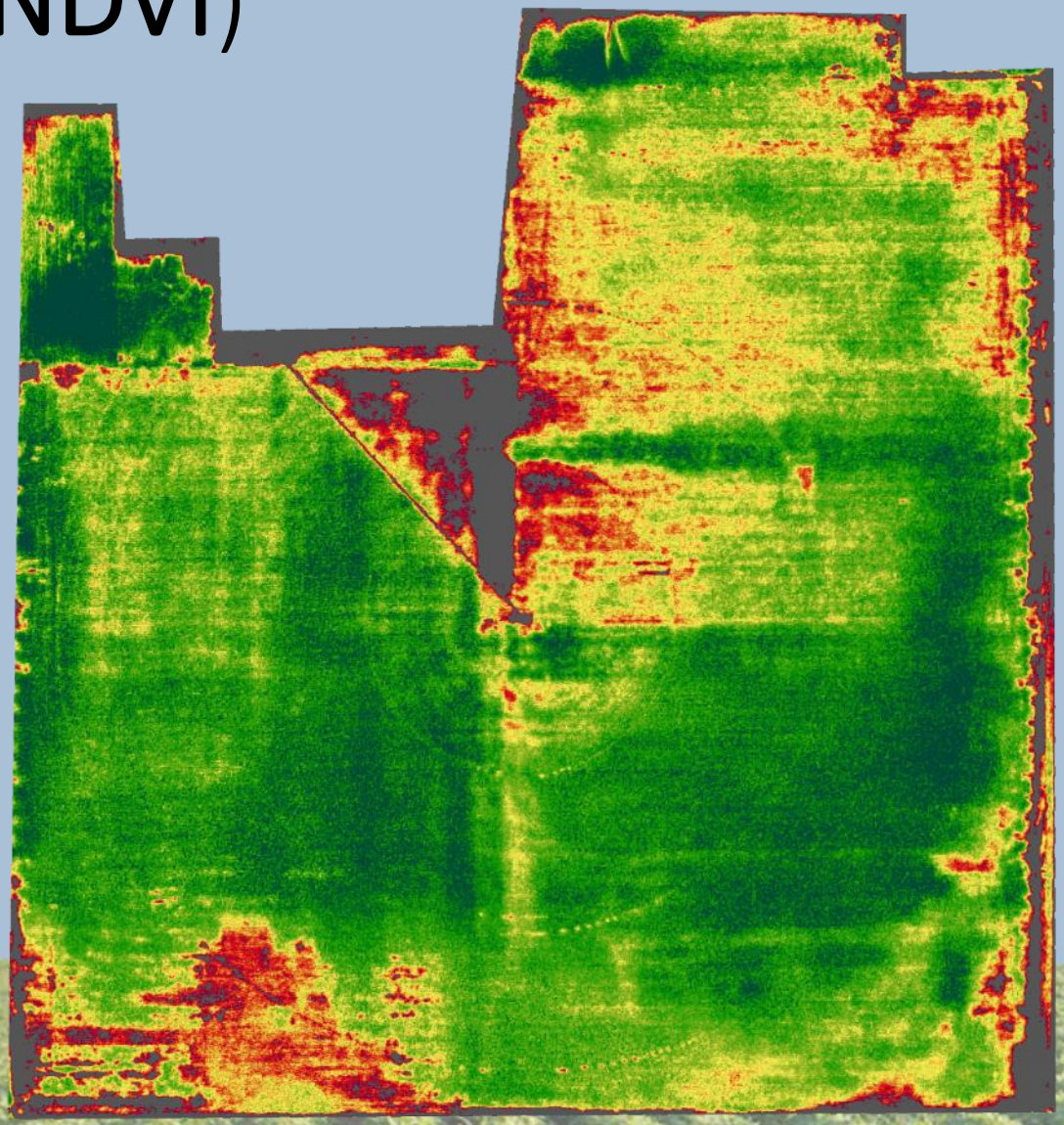


What is a “vegetation index?”



It’s a comparison between visible light and NIR light.

Normalized Difference Vegetation Index (**NDVI**)



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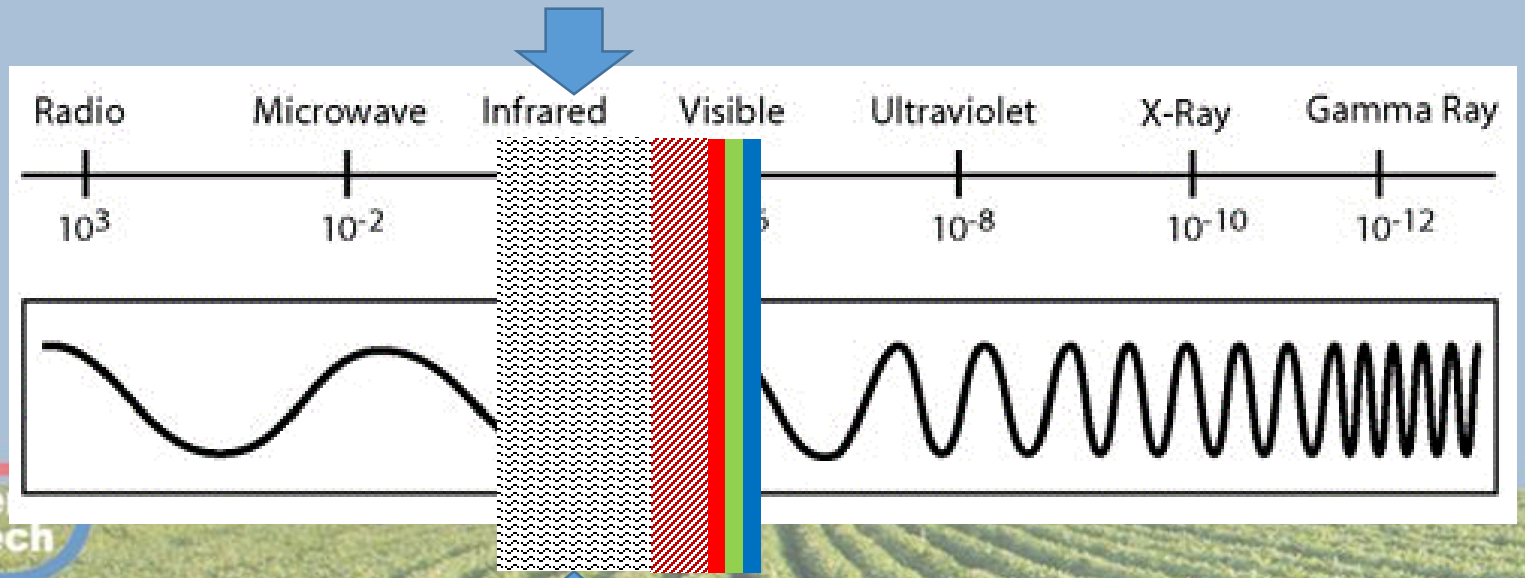
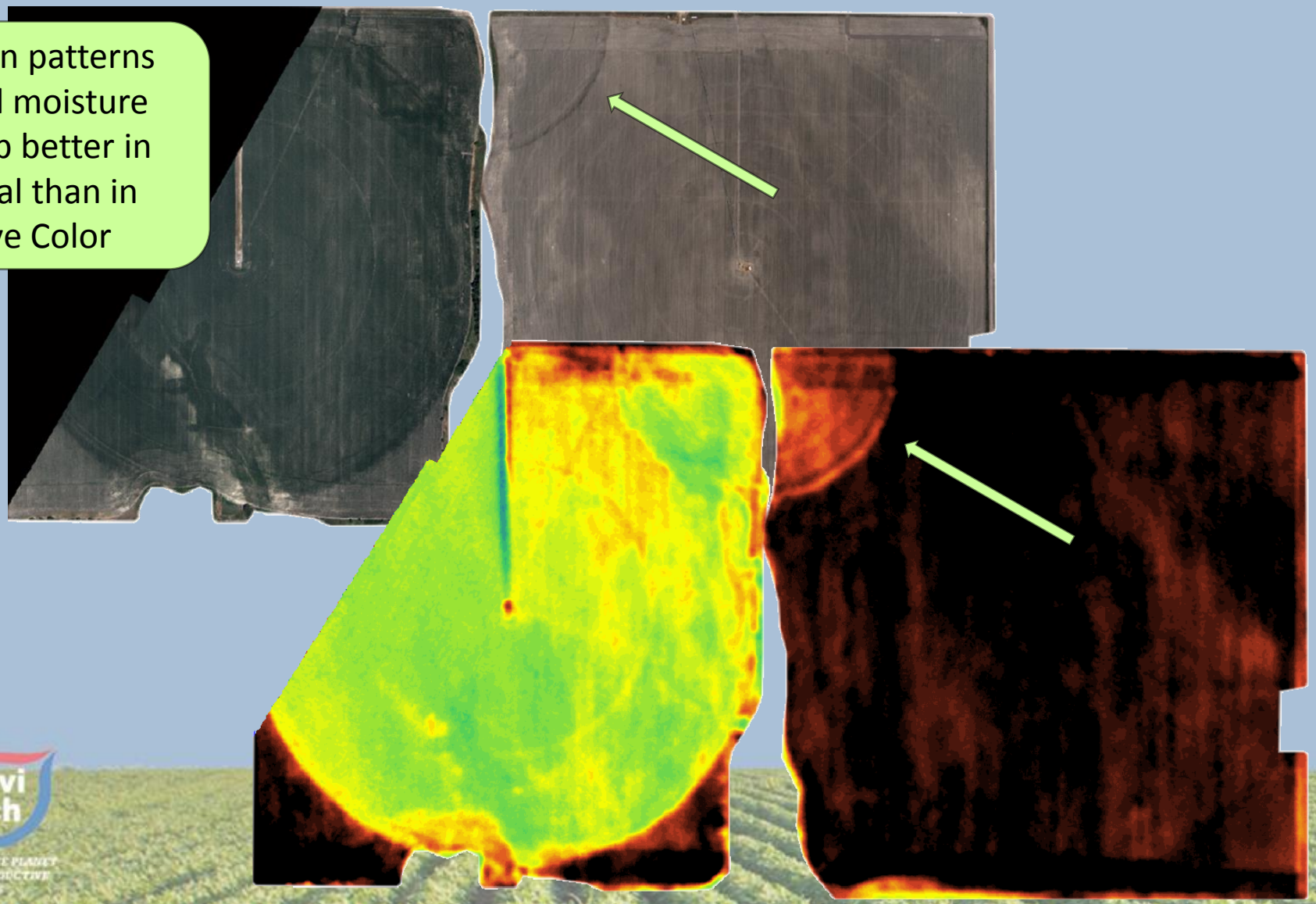
Long-wavelength Infrared

- “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

Irrigation patterns and soil moisture show up better in Thermal than in Native Color



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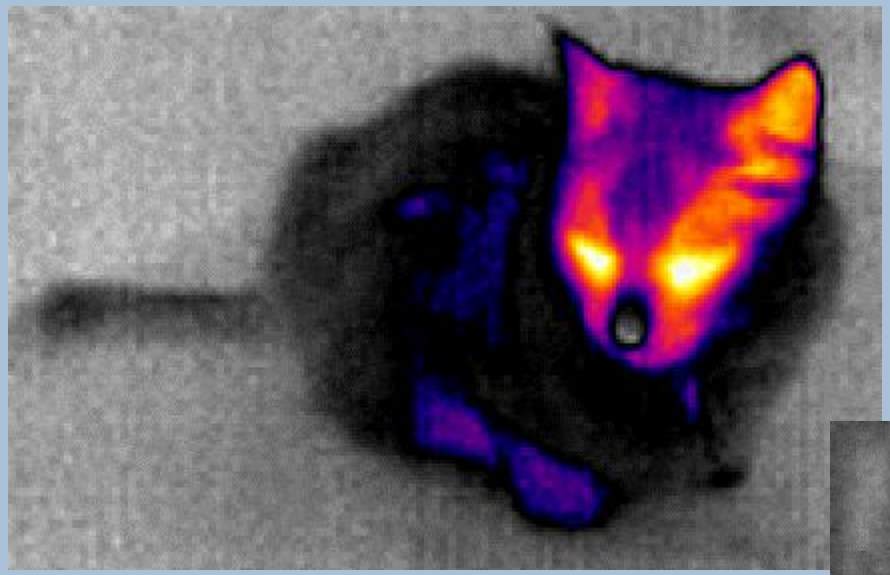
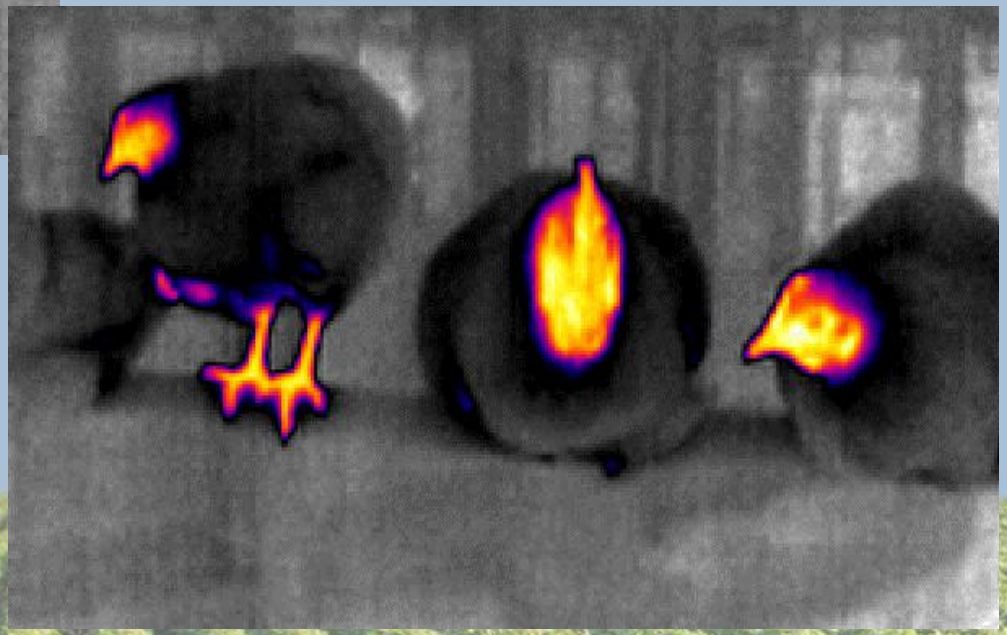
Long-wavelength Infrared





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Which type of camera/sensor is better?

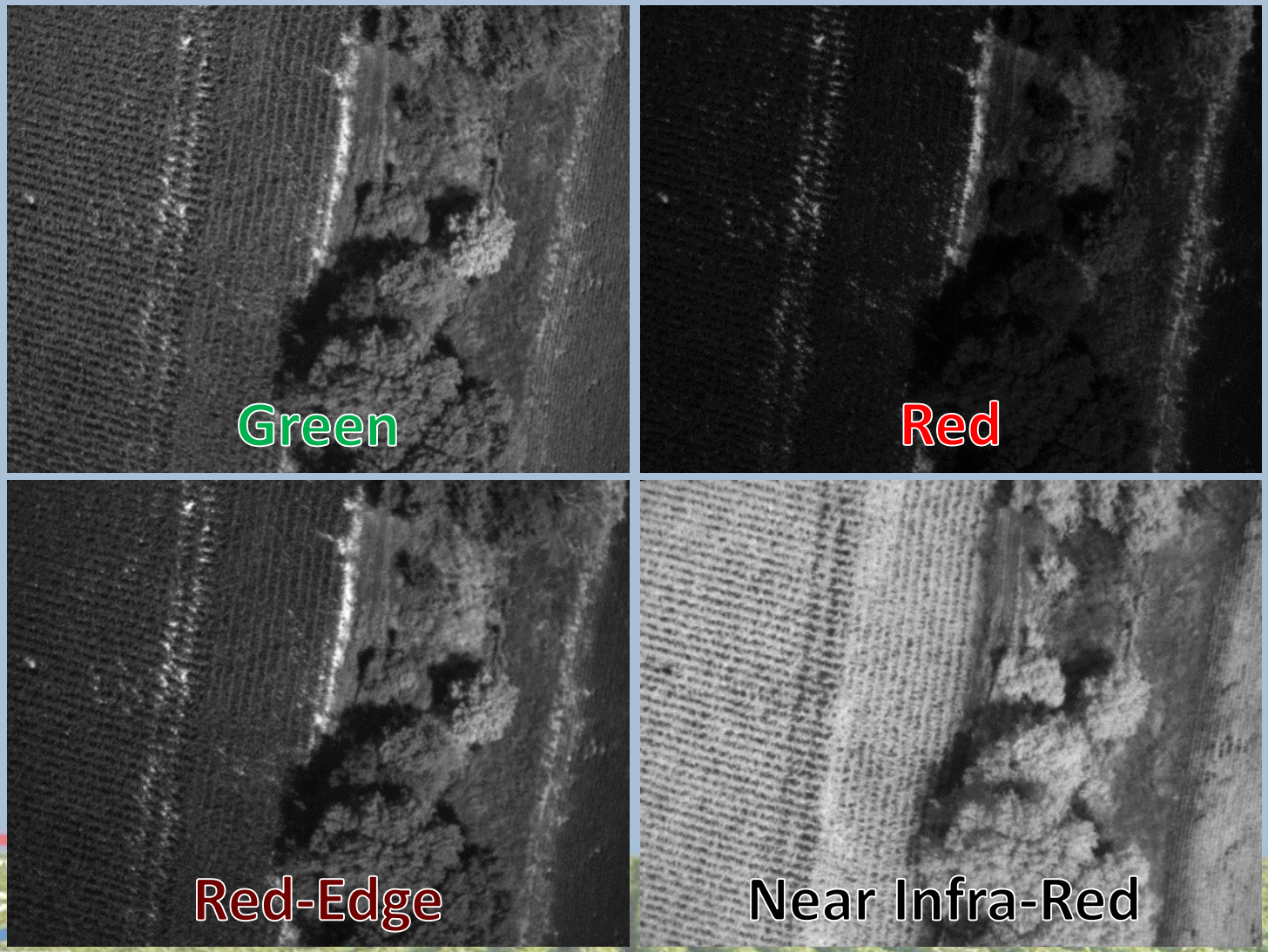
- A true Multi-Spec camera has *much better* final map quality than a filter swap-job. (Less “noise” and better contrast.)

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

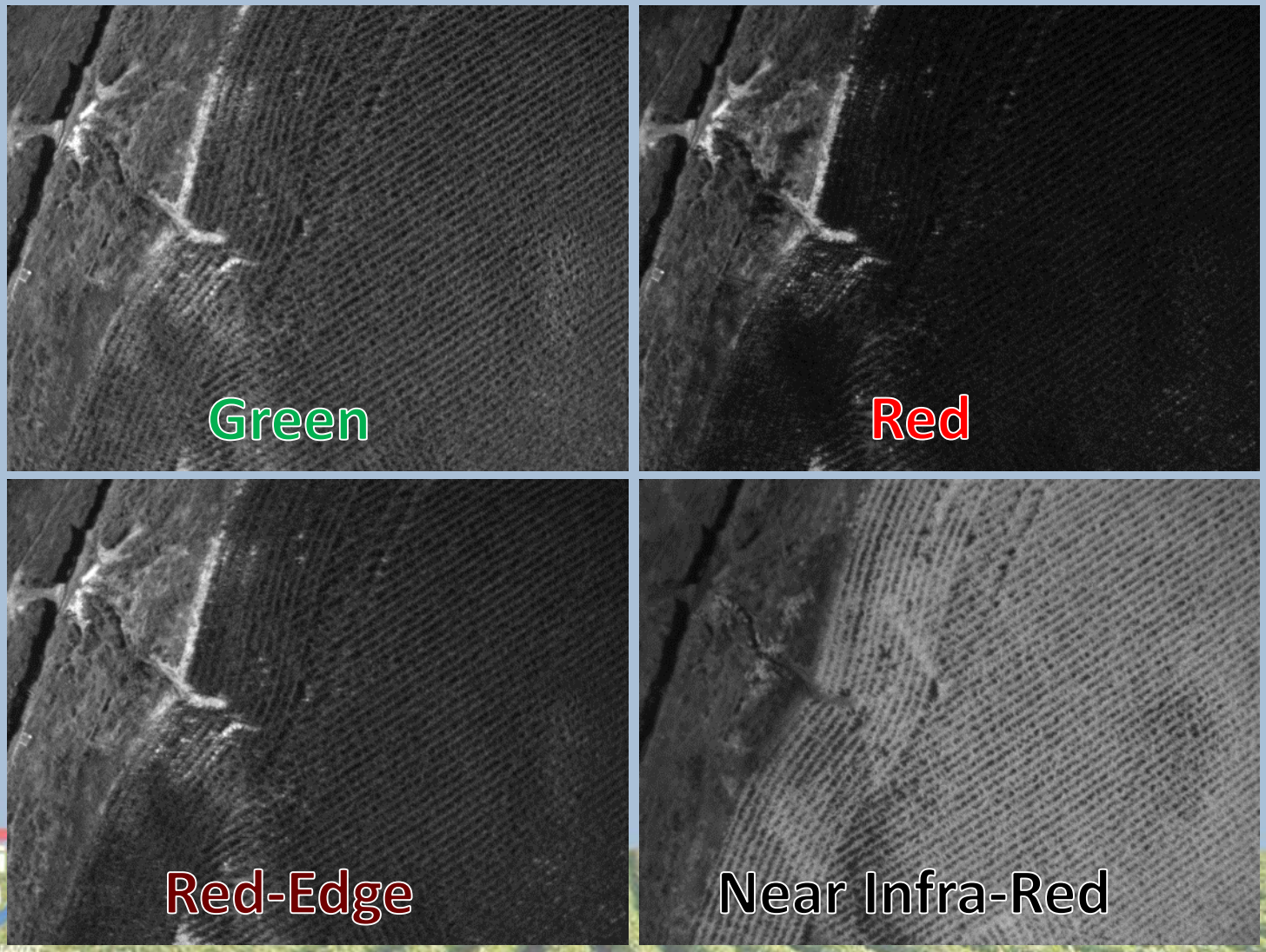
Modified RGB to “NIR” camera

Modified RGB to “NIR” camera

4-channel multi-spectral sensor

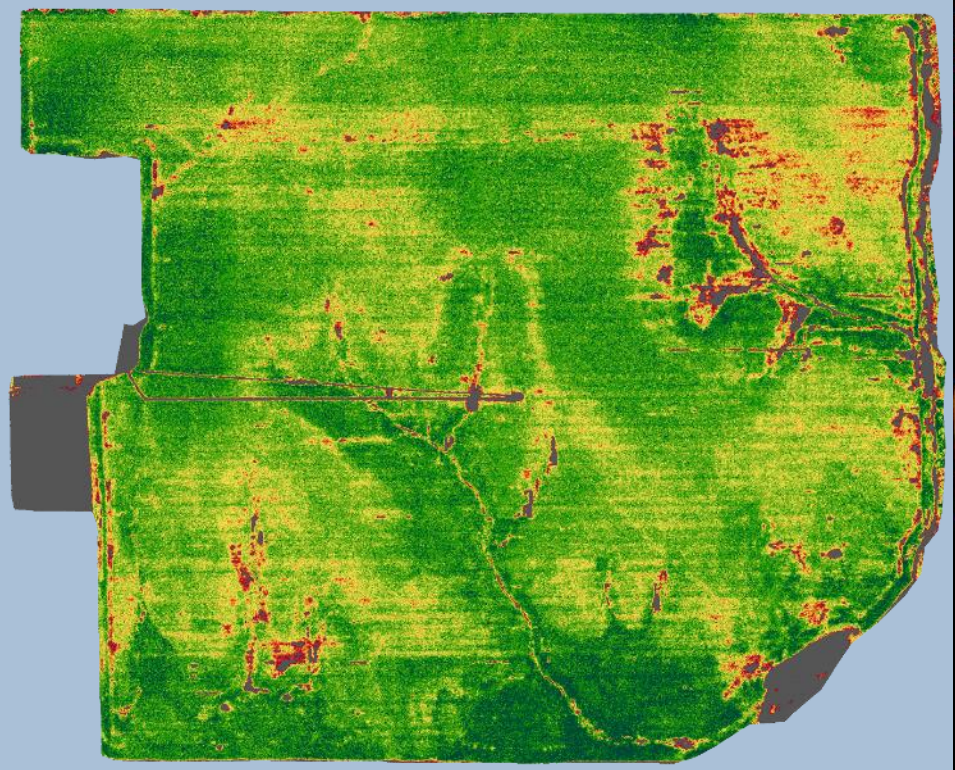


4-channel multi-spectral sensor

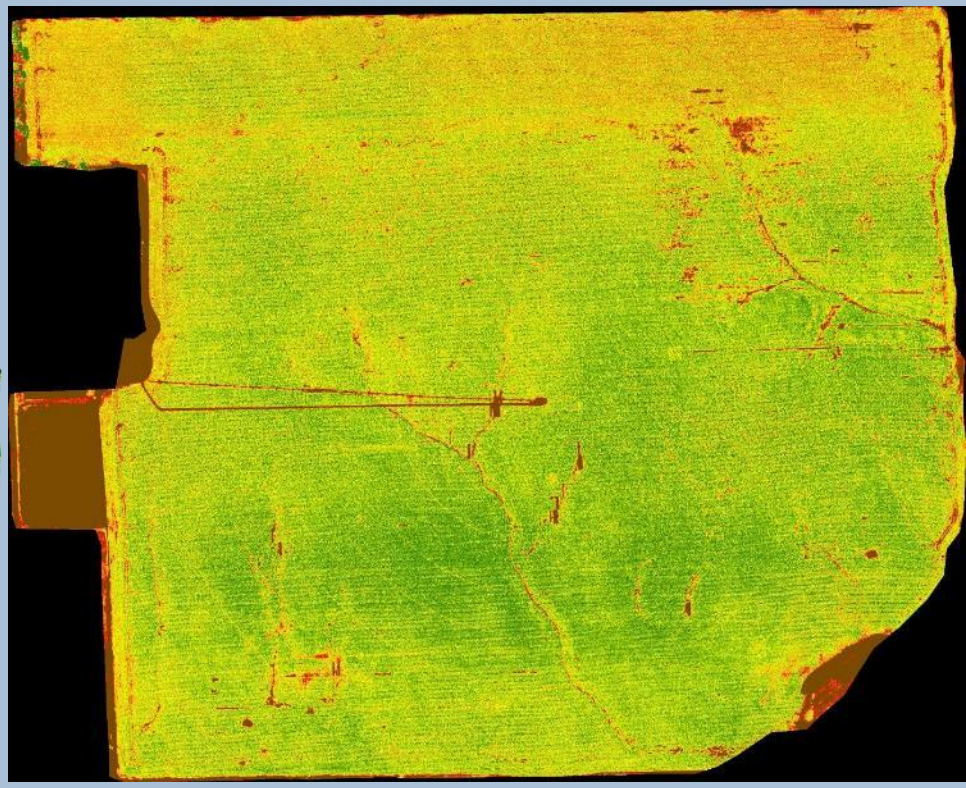


Sensor Package	Good/Bad	Price
Unmodified RGB 	✓ Good for taking "Glamour shots" ✓ Checking equipment or "drone scouting" ✗ Can't do NDVI mapping	$
One-camera "NIR" filter modification. 	✗ NDVI maps have poor reliability and quantitative value. ✗ Bad compromise between better alternatives.	$$
Two-camera system. (RGB & NIR) 	✓ *Production*-grade NDVI maps. ✗ Bulkier than single camera.	$$$
"True" multi-spectral sensor system.  	✓ *Research*-grade maps and NDVI plot measurements. ✗ Narrow field-of-view and complex software makes data collection/processing more difficult. ✗ Low sensor resolution requires lower-altitude flights.	$$$$$

Is “true multi-spec” worth it?



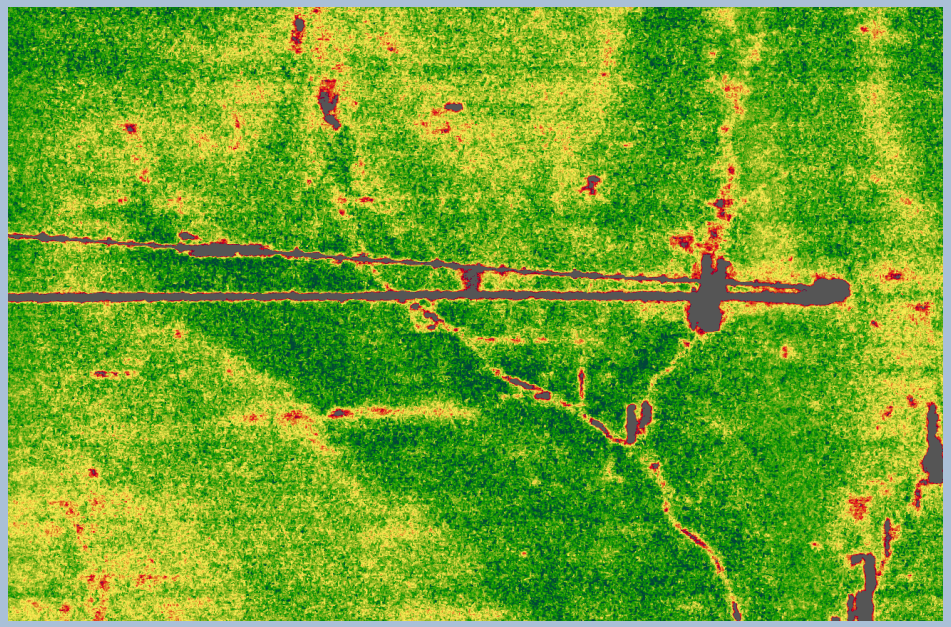
True Multi-Spec sensor



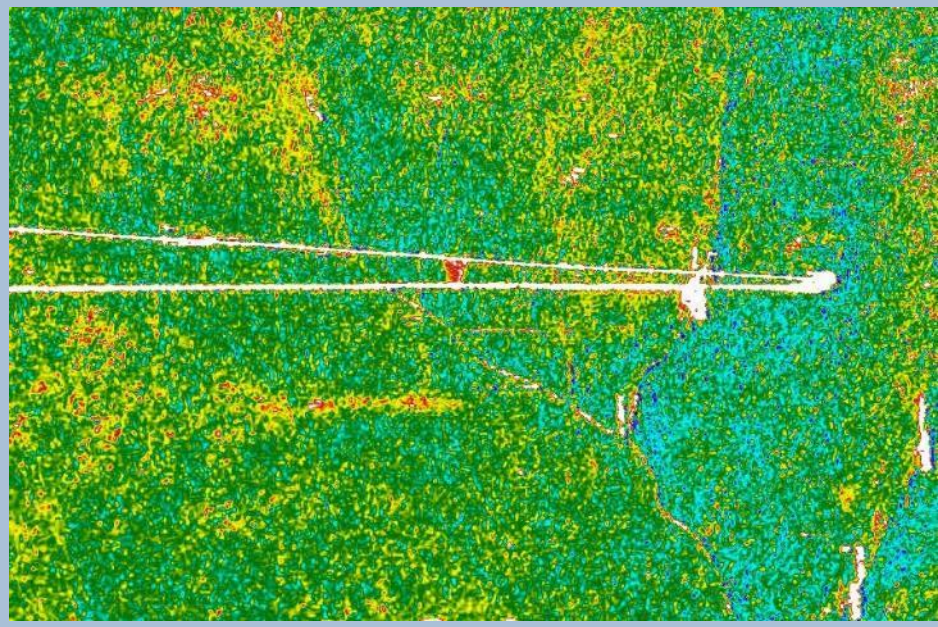
Filter-swapped “NIR” camera

Why not use an 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

It’s not rocket science…

…rockets are easier!

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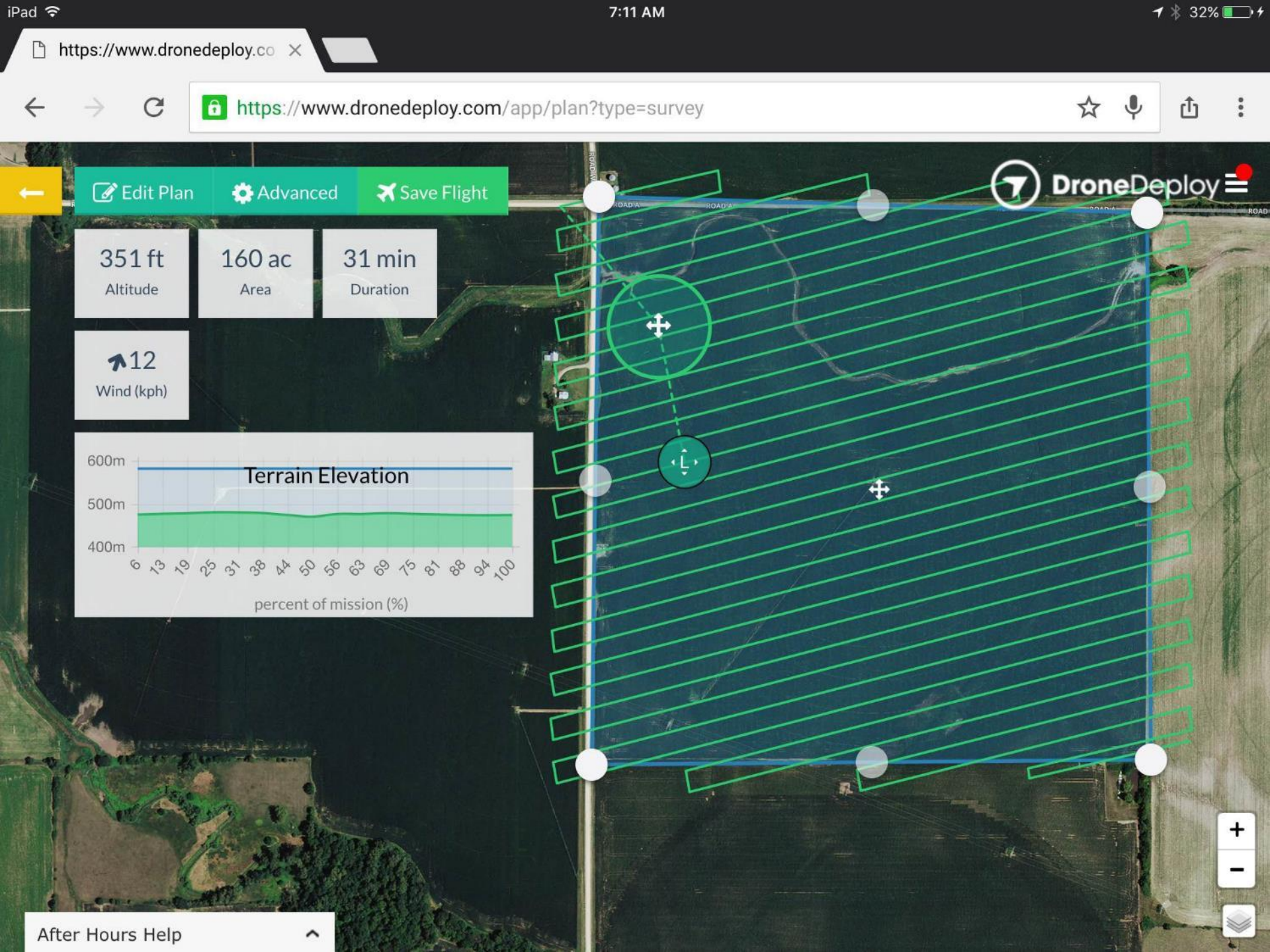
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160 ac
Area
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Duration
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Wind (kph)
Terrain Elevation
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500m
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percent of mission (%)
After Hours Help

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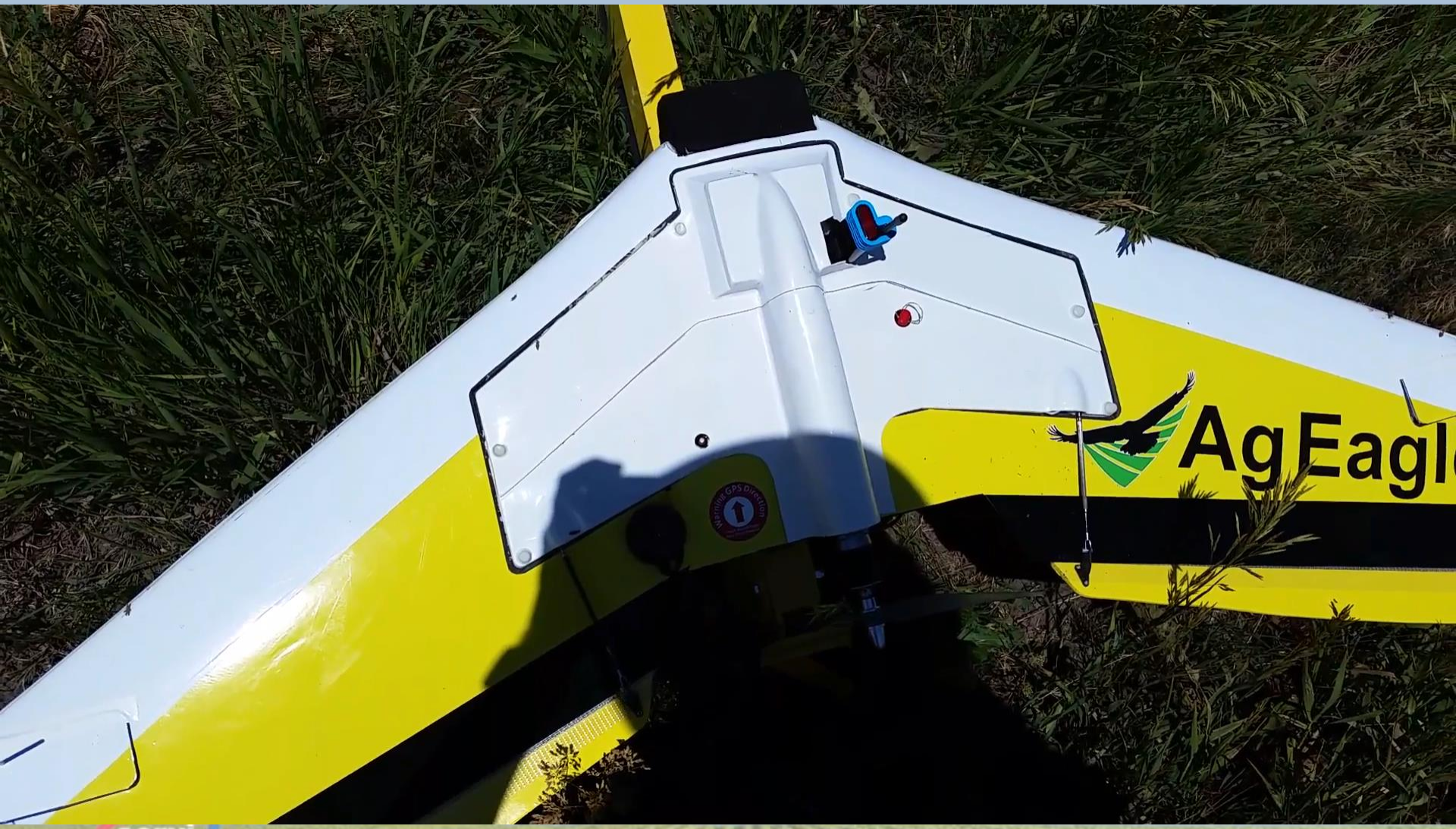

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Launching by hand

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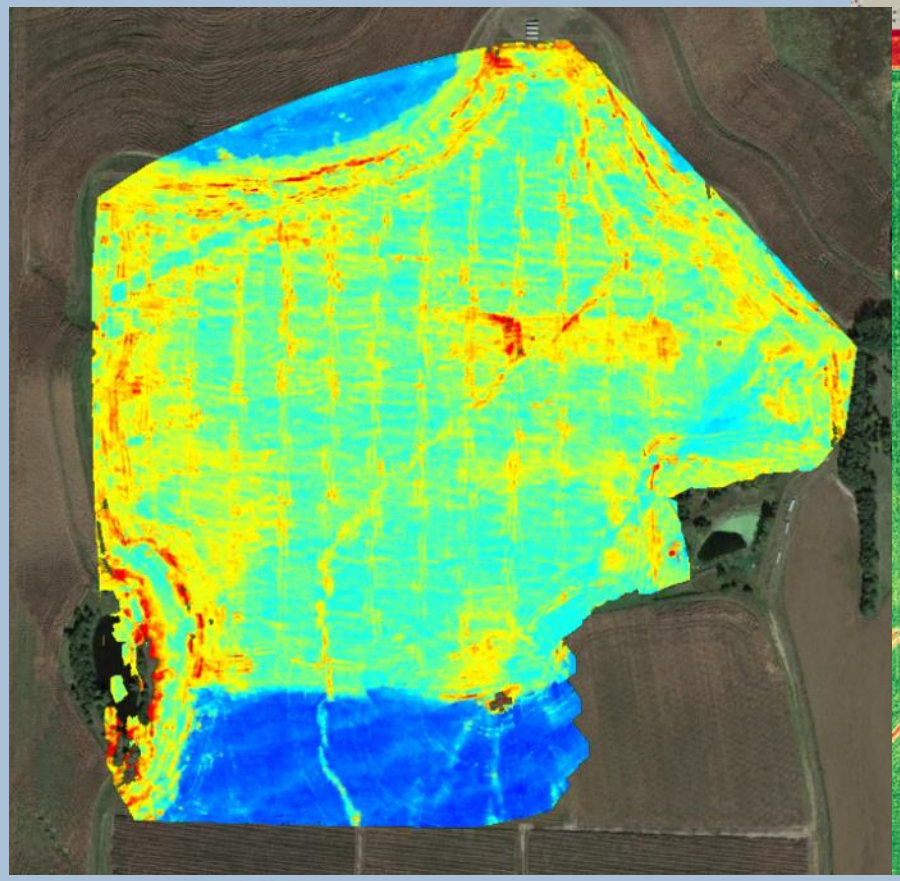
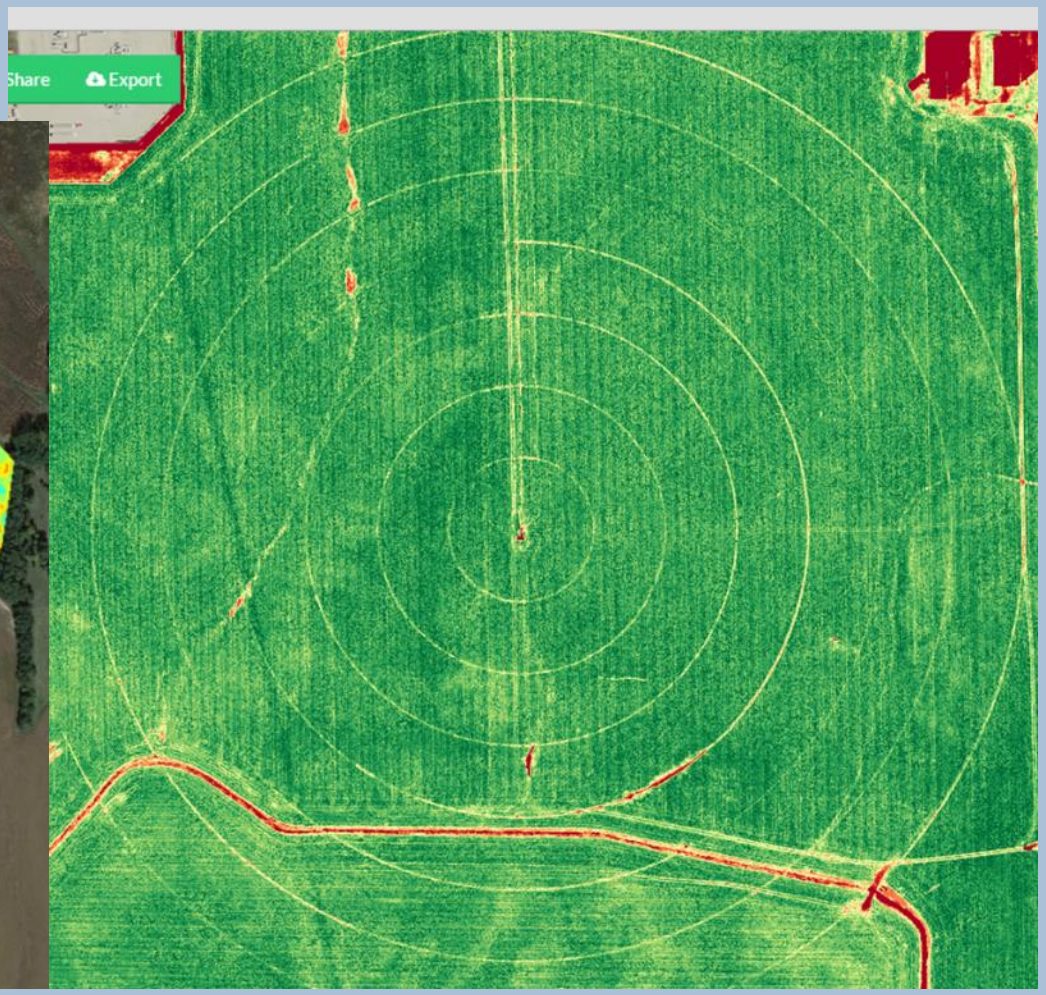
UAV imagery





UAV imagery

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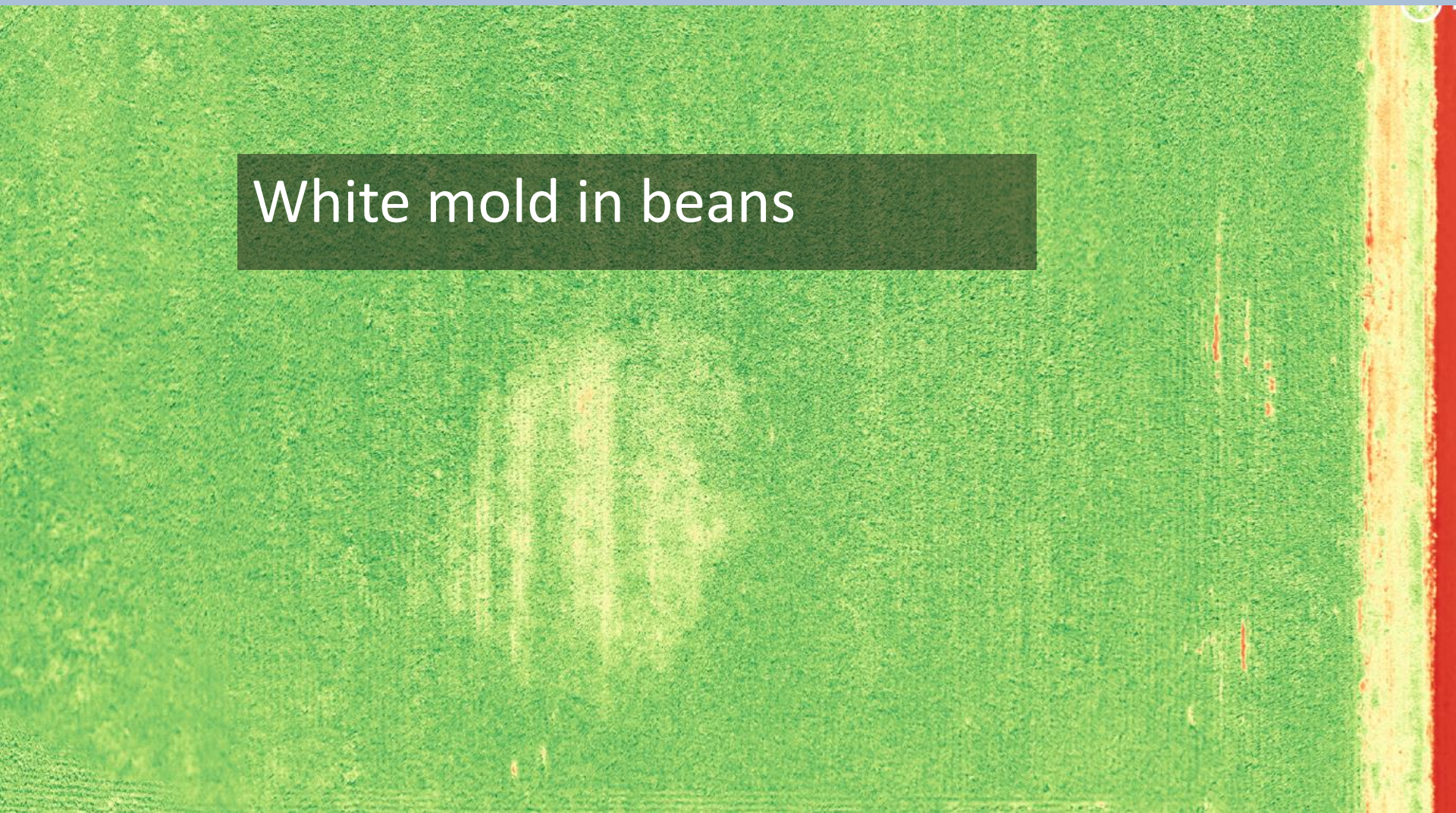

UAV imagery

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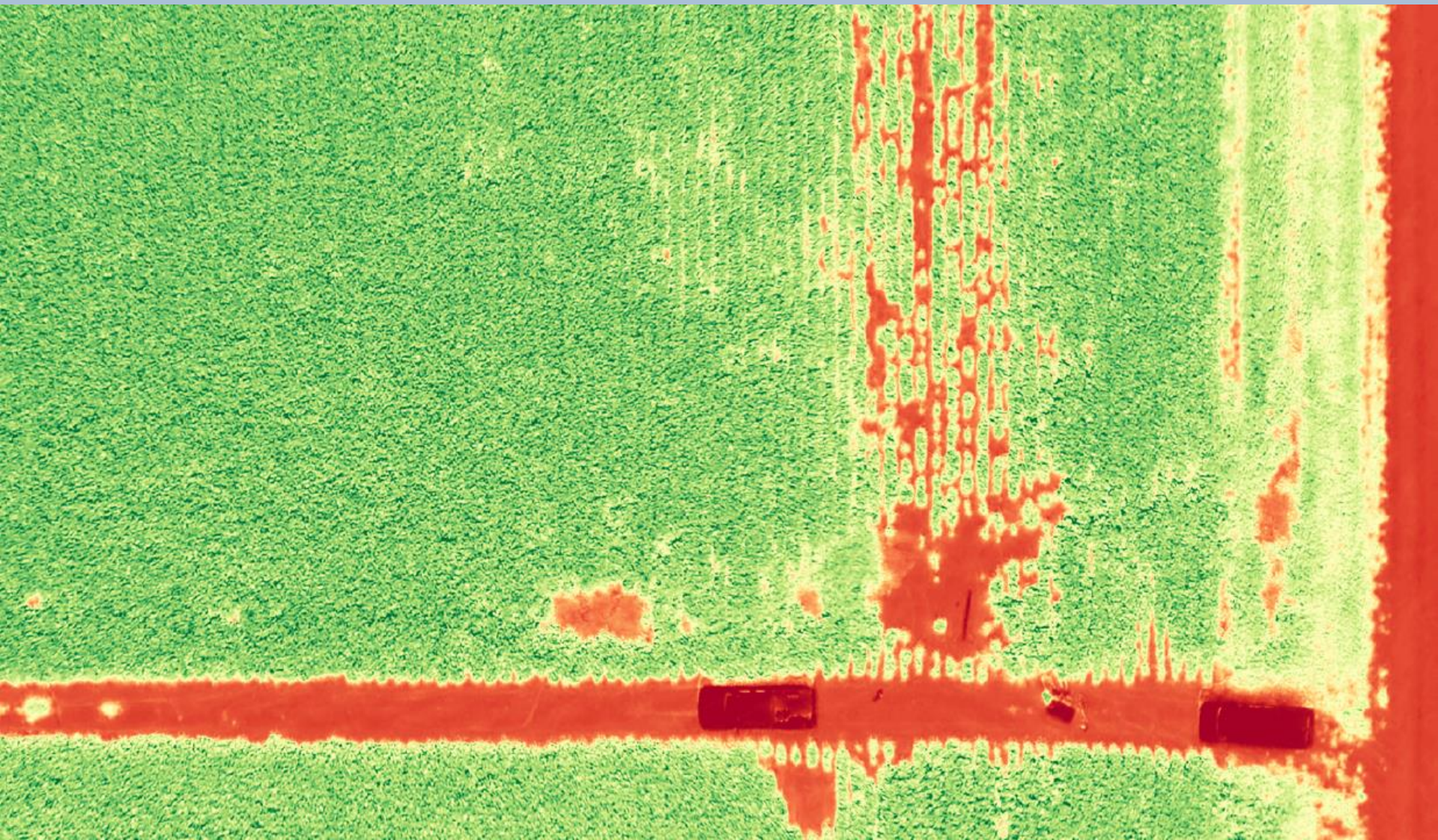

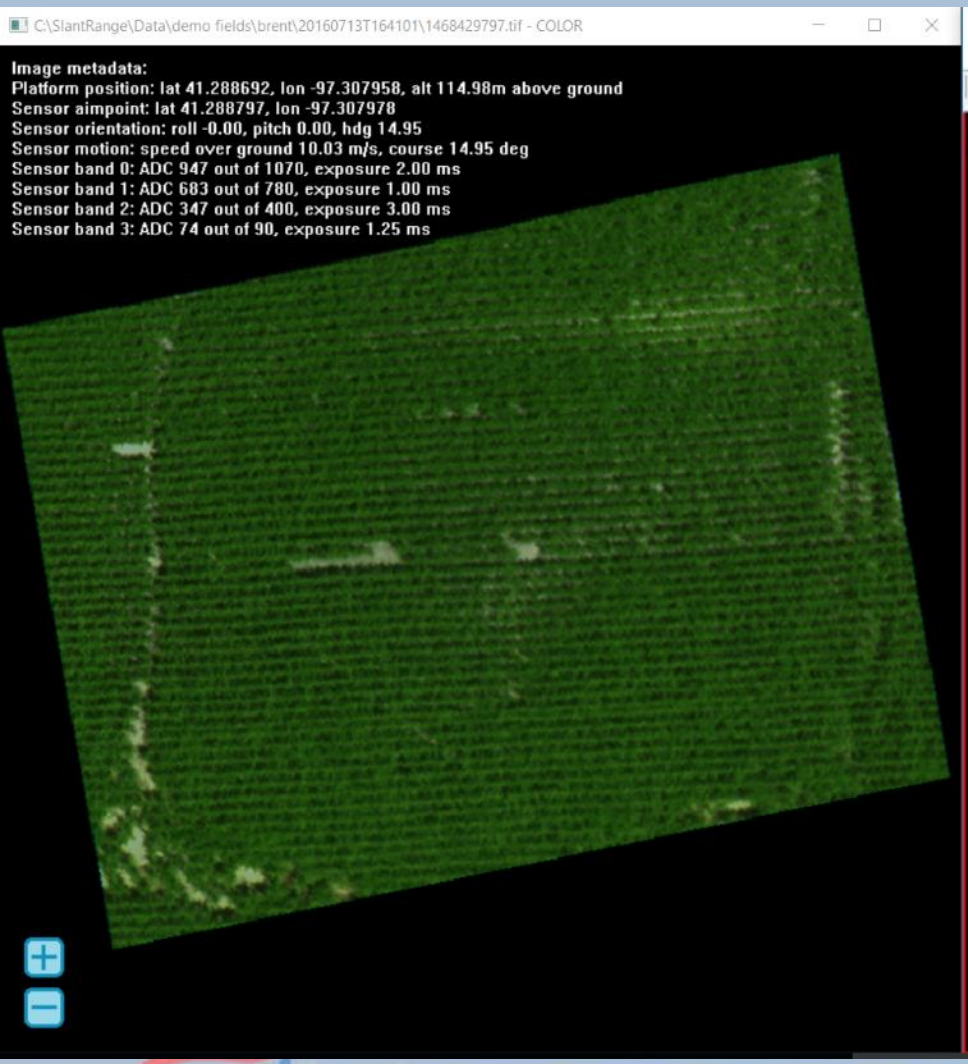

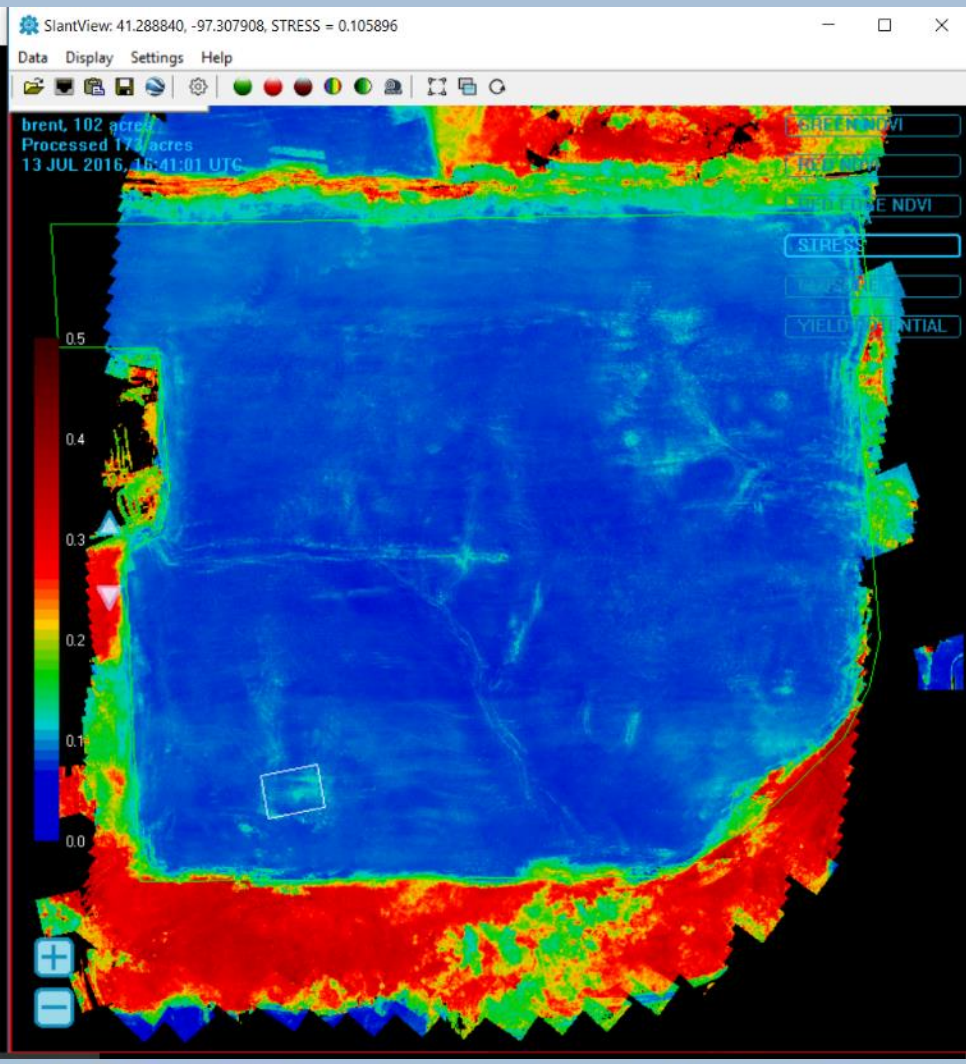

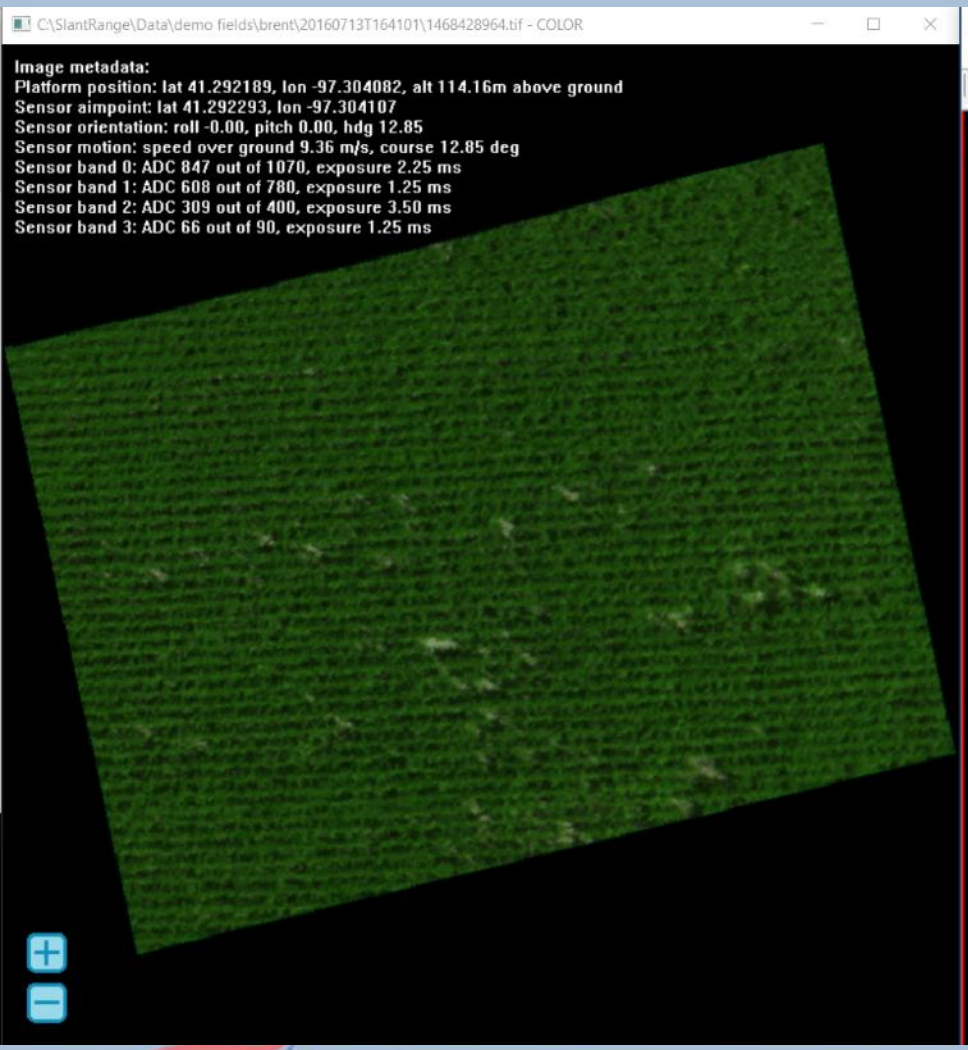

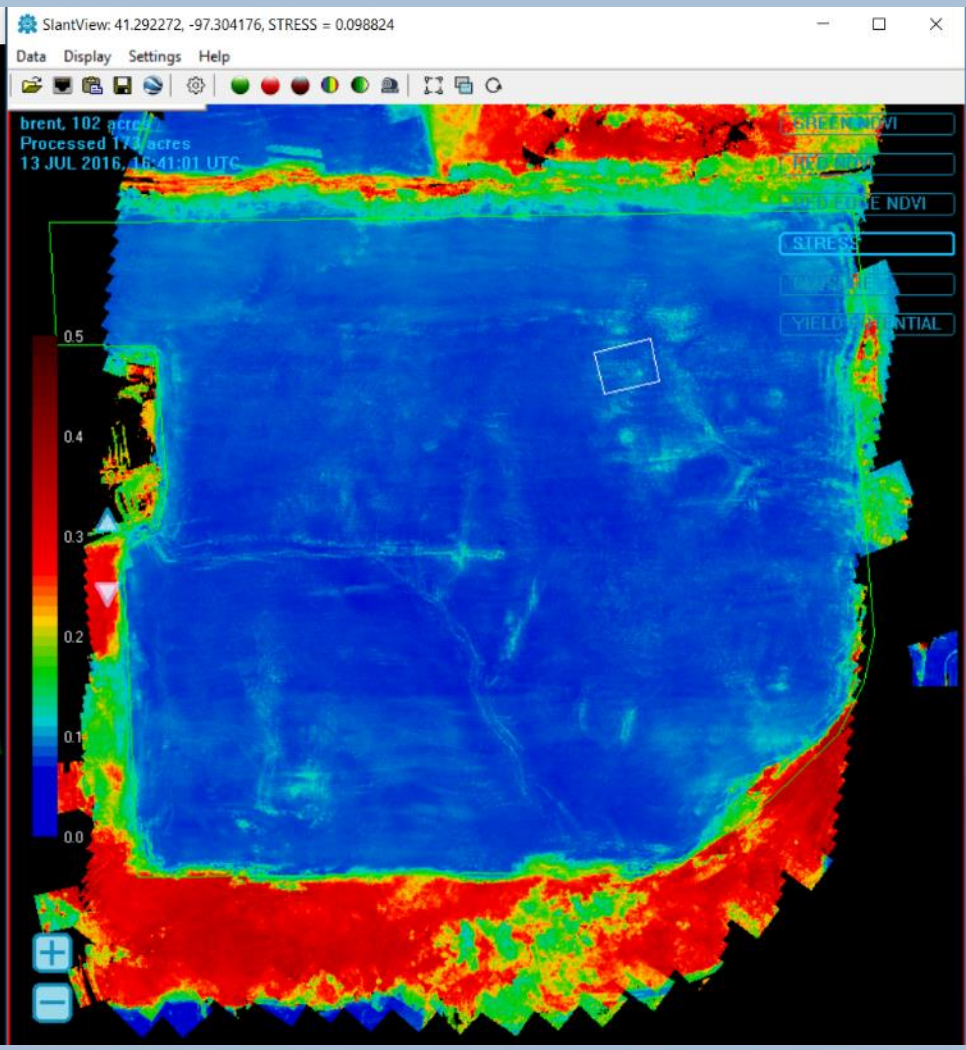

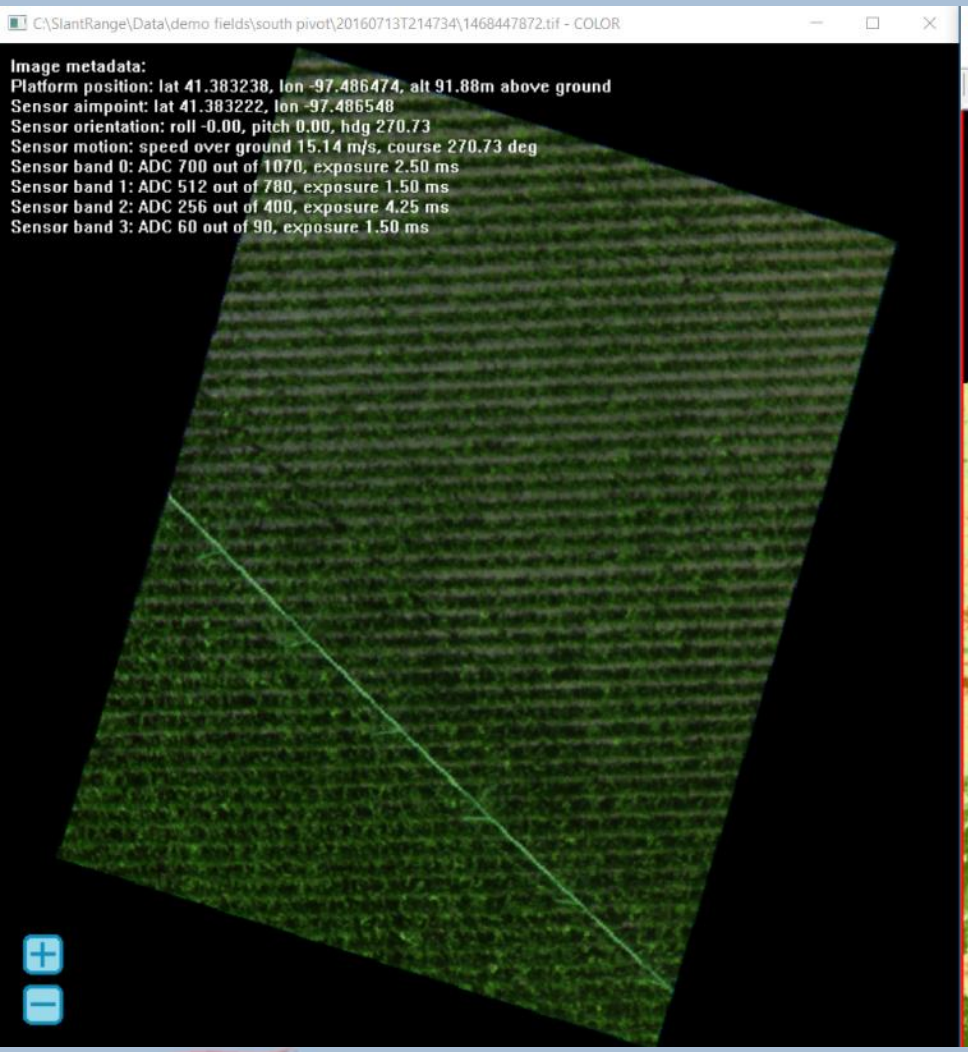
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Sensor aimpoint: lat 41.383222, lon -97.486548
Sensor orientation: roll -0.00, pitch 0.00, hdg 270.73
Sensor motion: speed over ground 15.14 m/s, course 270.73 deg
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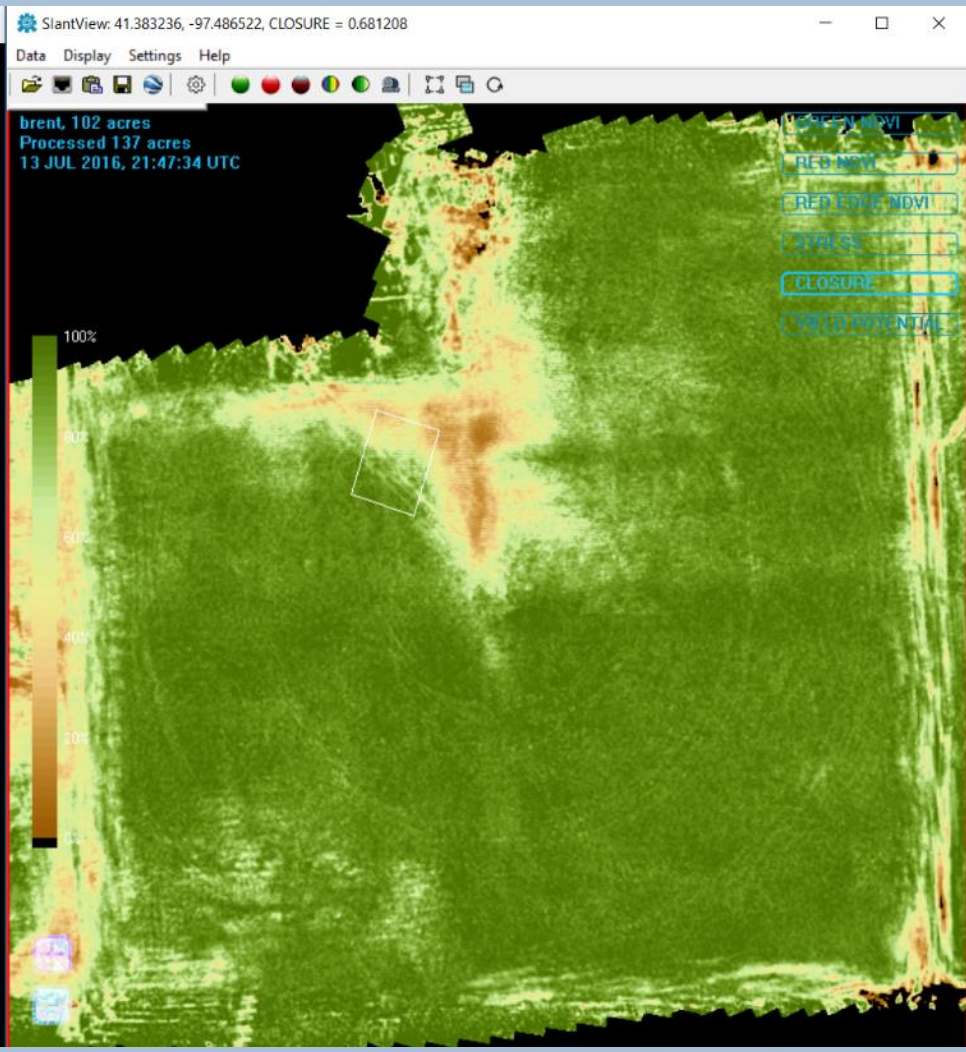
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RED EDGE NDVI
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100%


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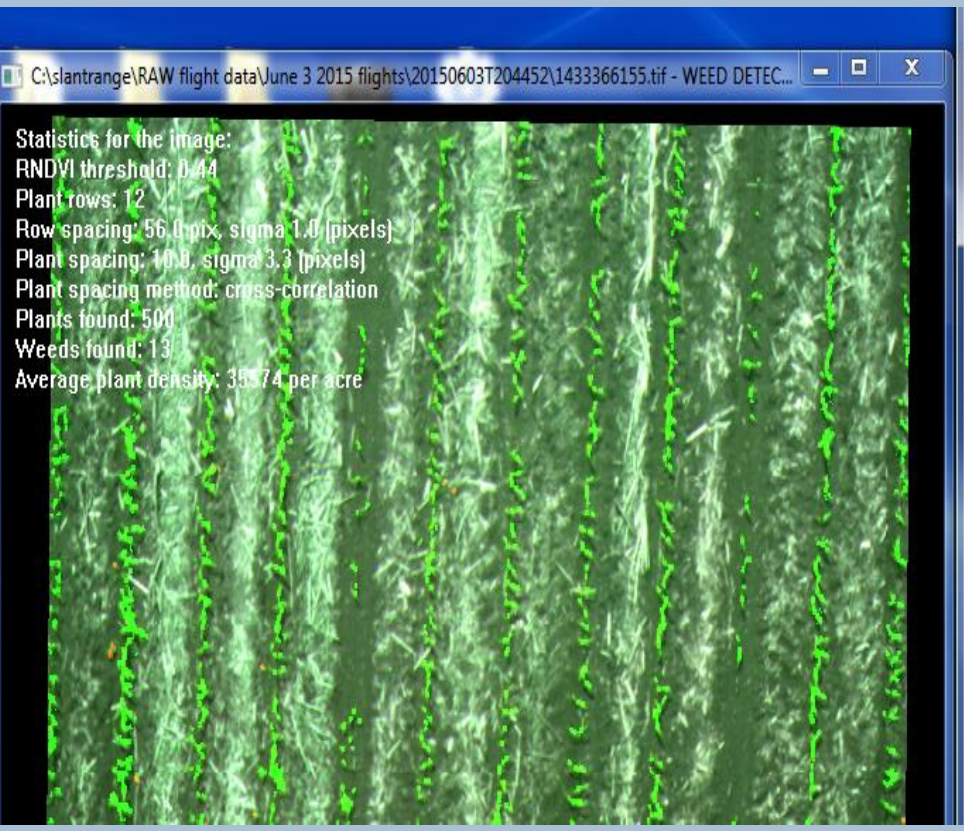
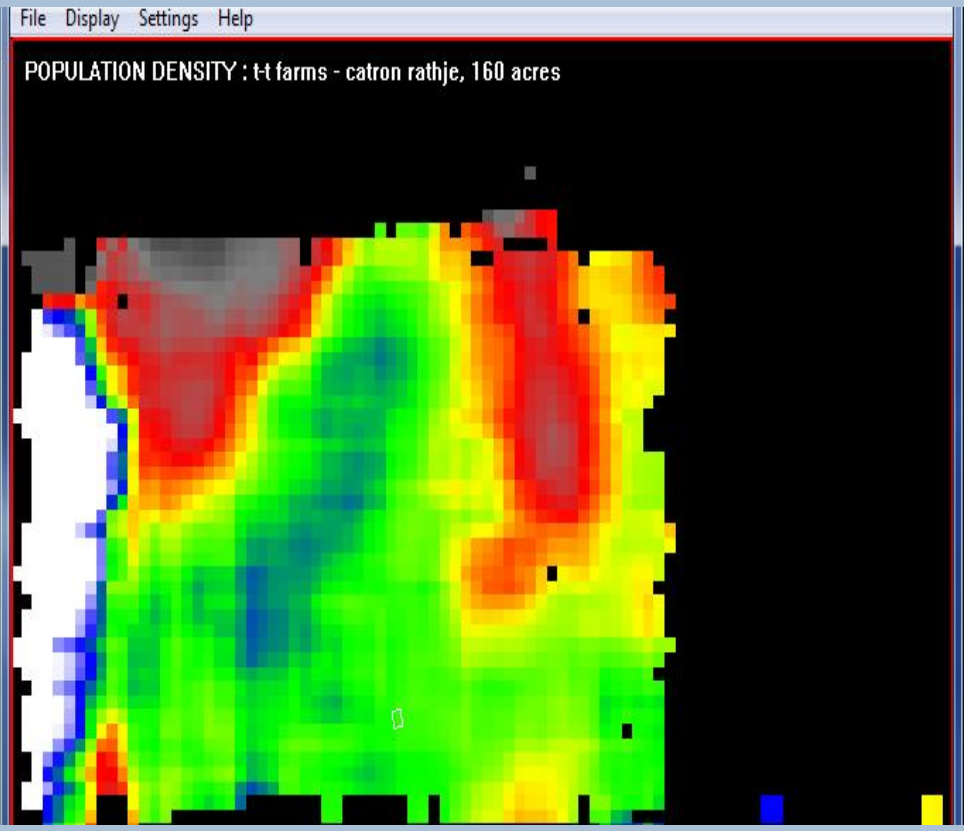
UAV imagery – counting plants and weeds





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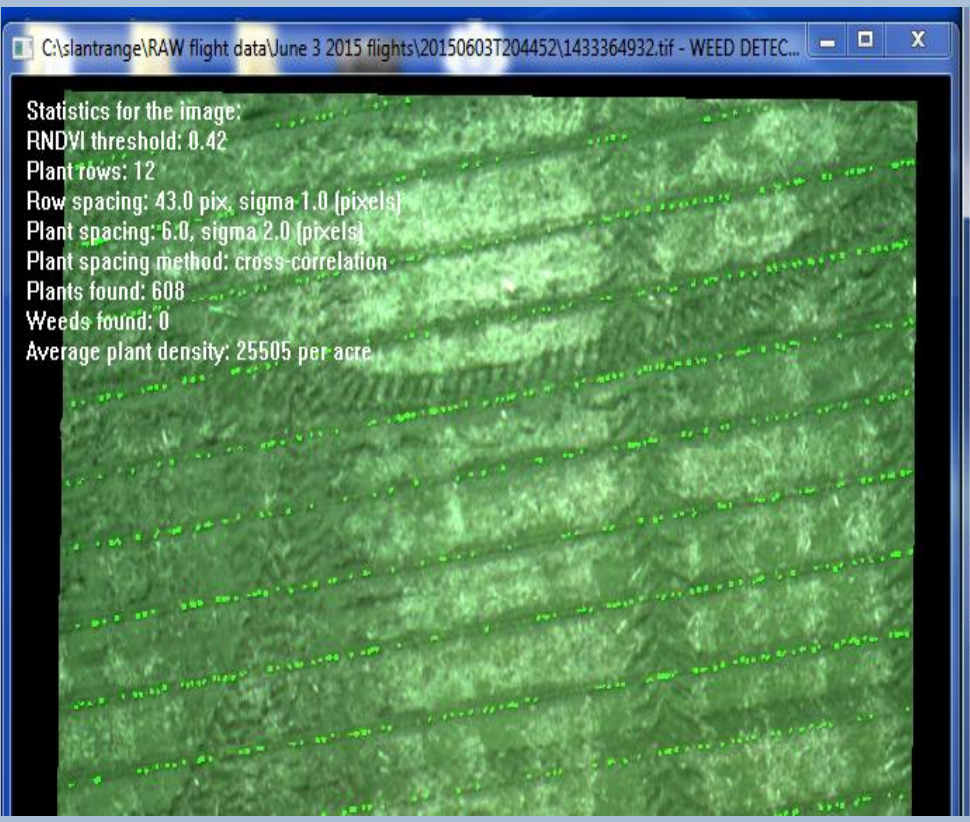

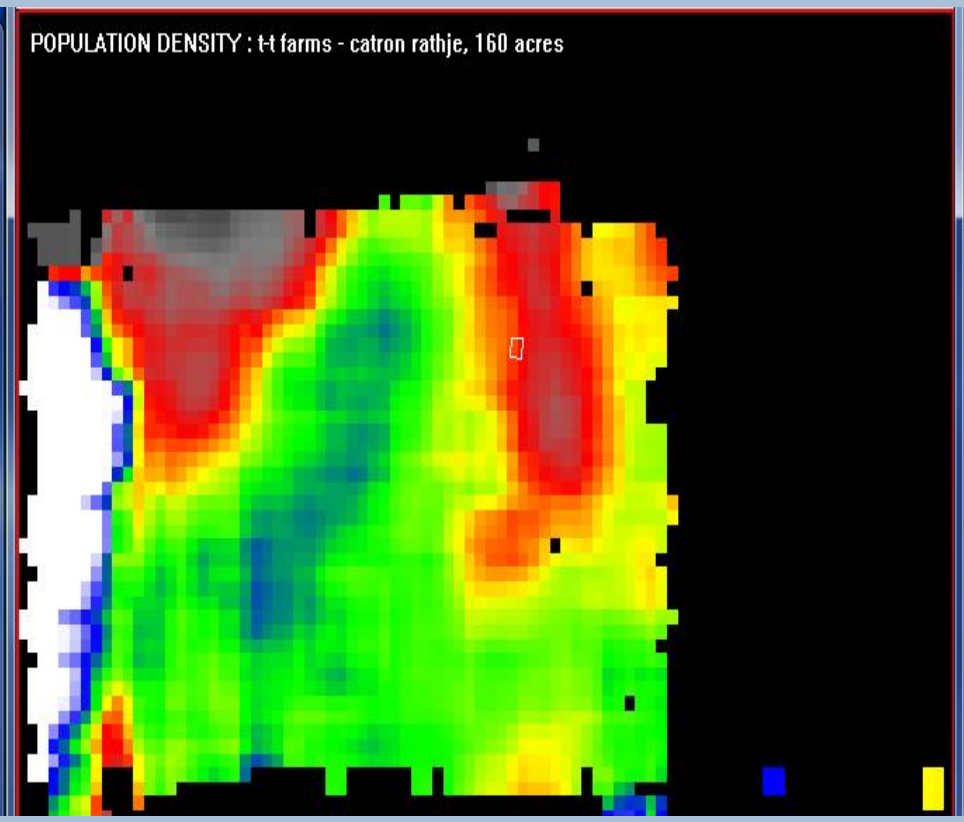

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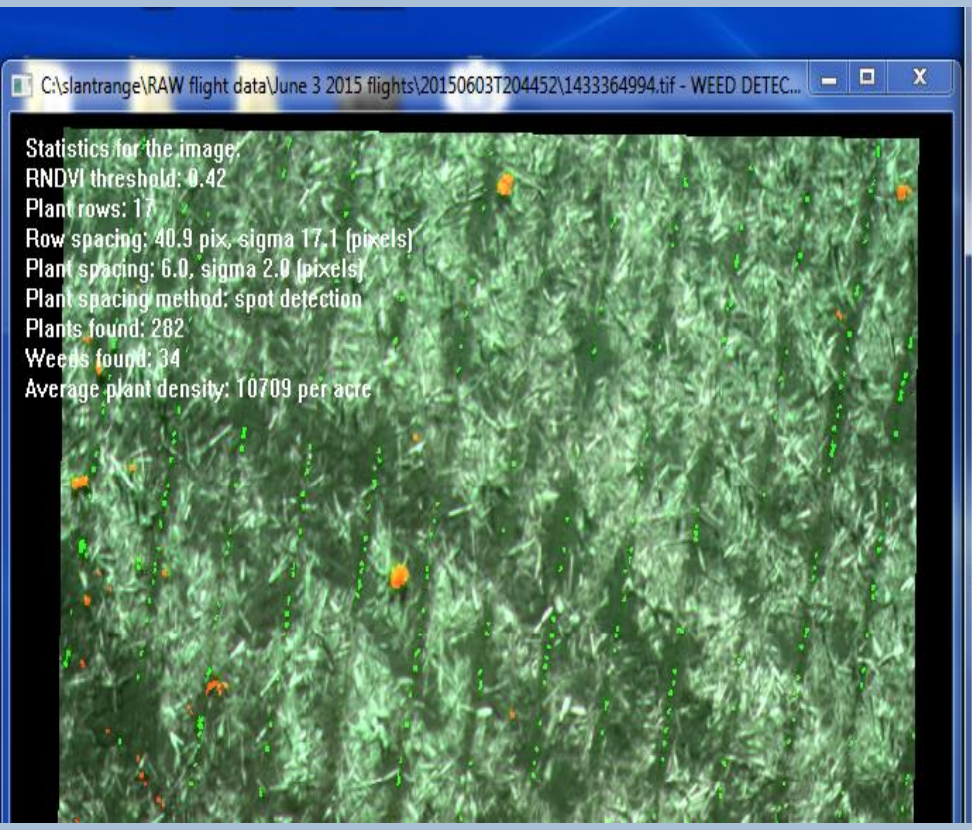
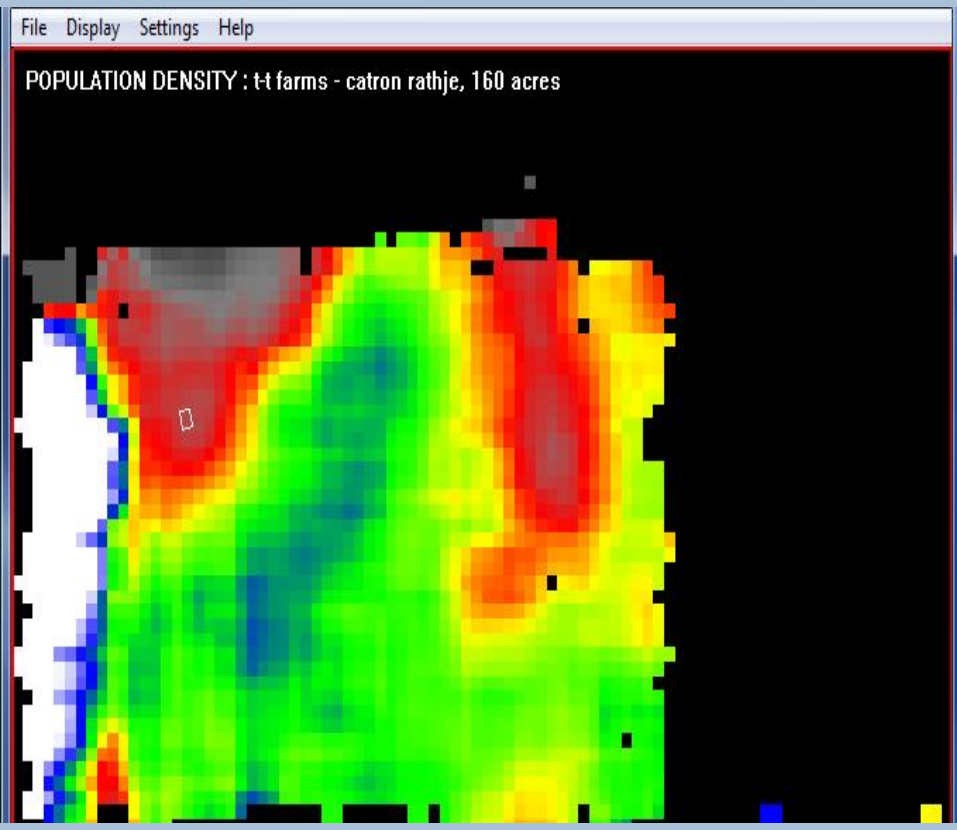
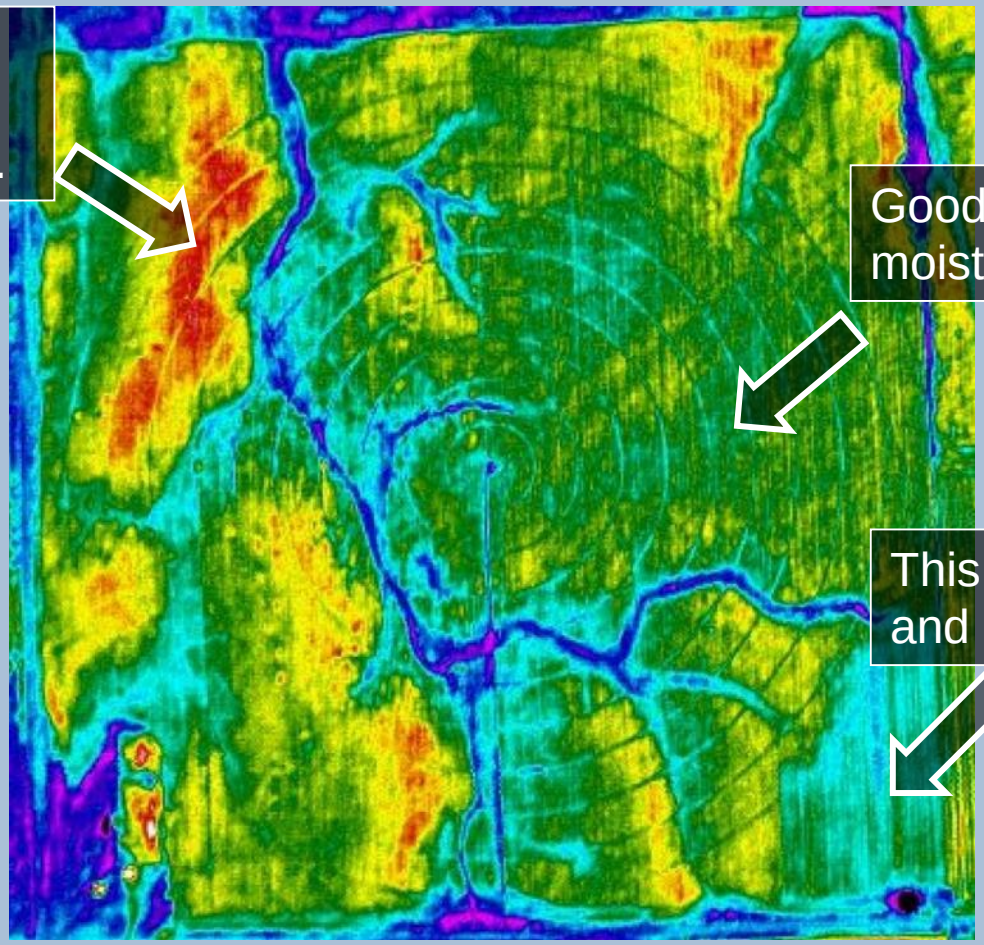




Manned-Aircraft Imagery
Bare Ground Thermal

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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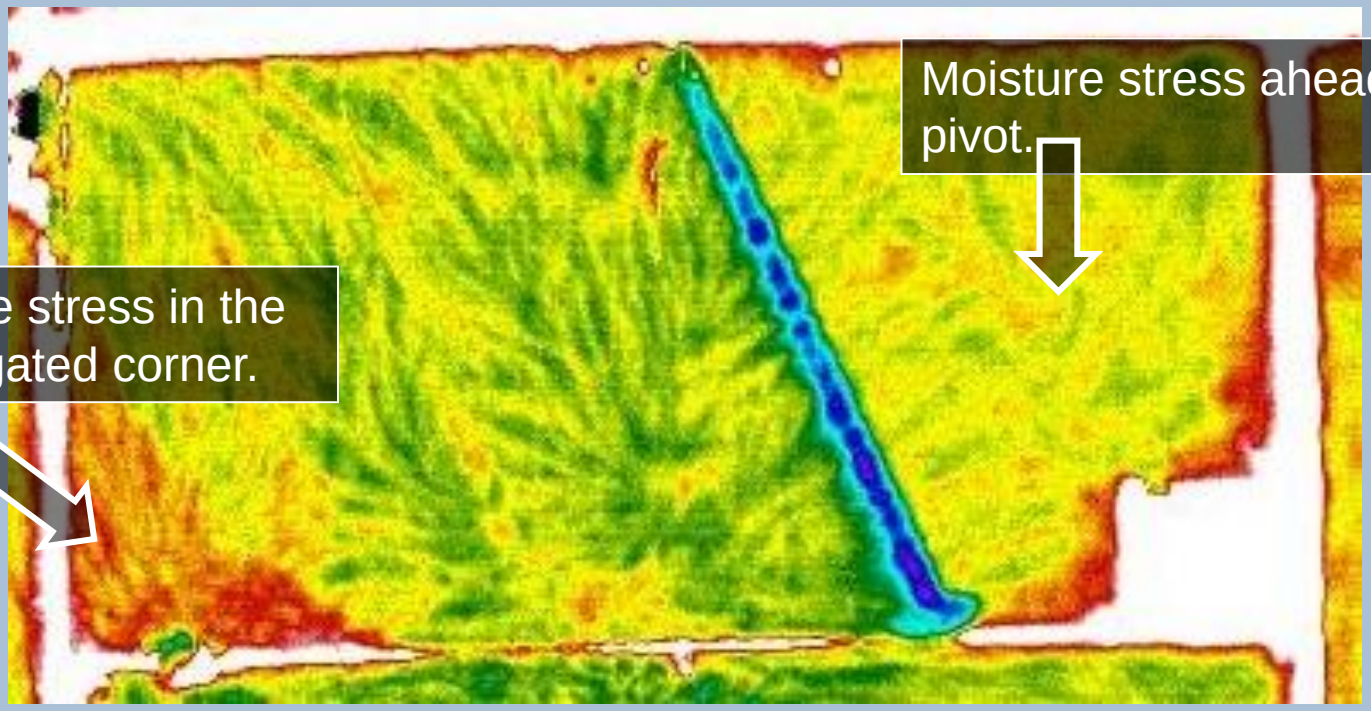
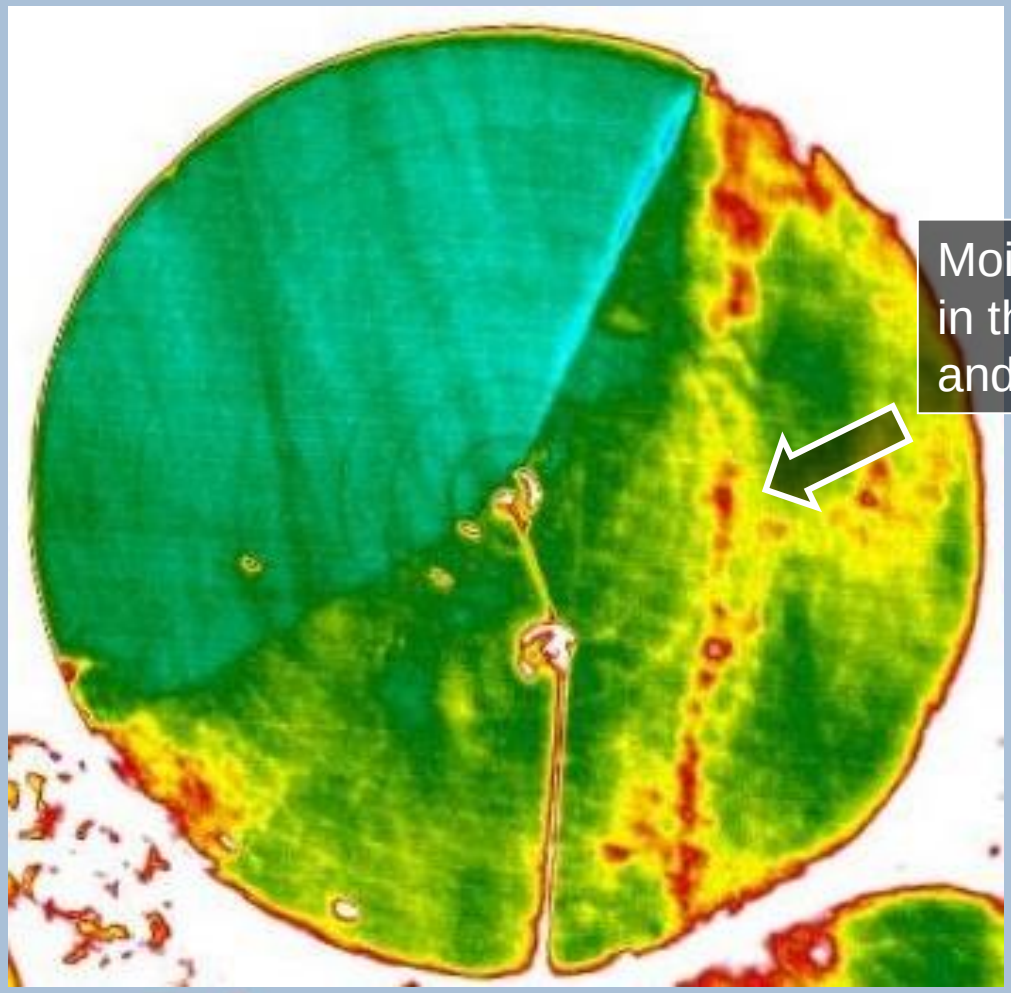
Manned-Aircraft Imagery
In-Season Thermal



Moisture stress ahead of the pivot.

Moisture stress in the non-irrigated corner.

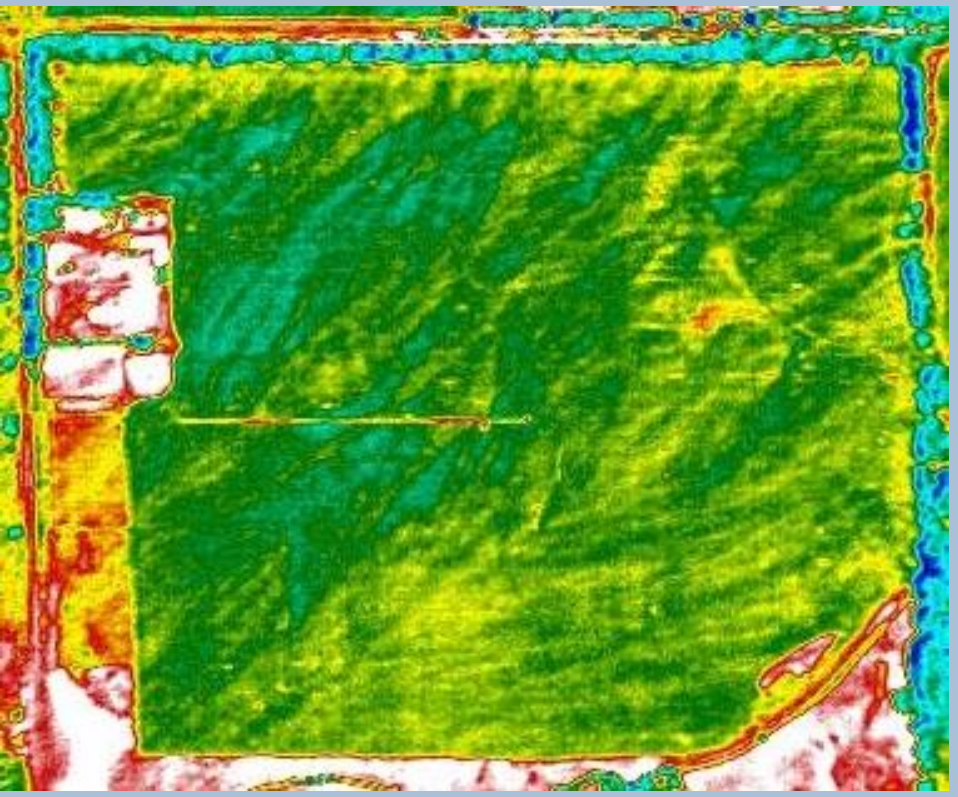
Manned-Aircraft Imagery
In-Season Thermal

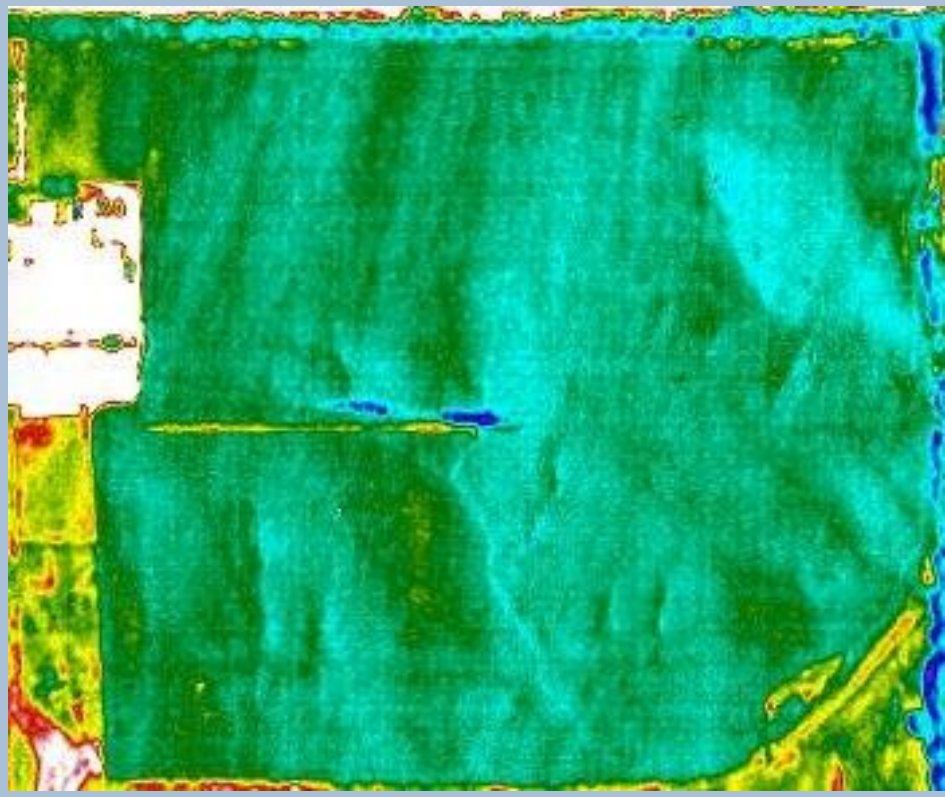


Moisture stress varies greatly in this field due to soil type and topography.

This information can be used to better manage irrigation.

Manned-Aircraft Imagery
In-Season Thermal





Sometimes thermal doesn’t tell you much!

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Challenges

What are some challenges with UAV use?

…


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Challenges

What are some challenges with UAV use?

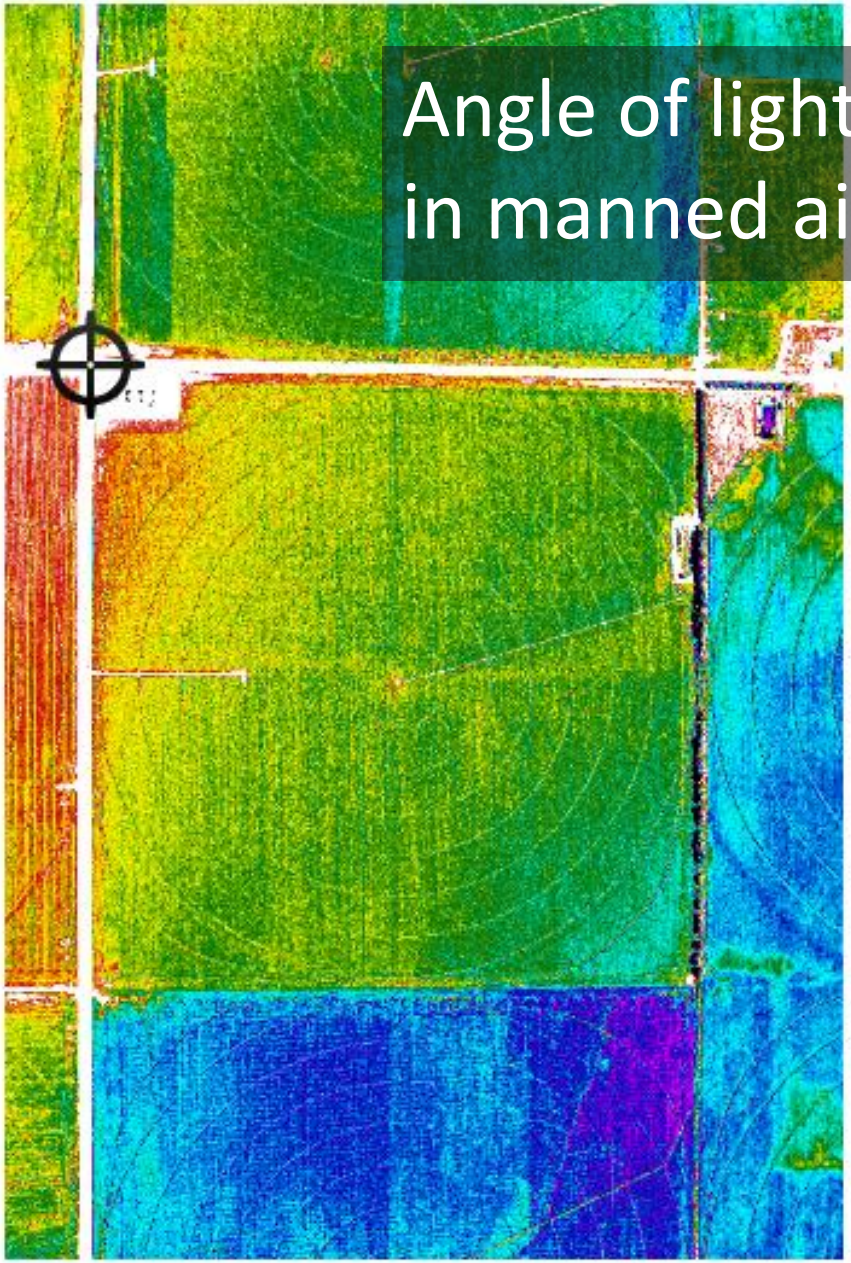
- Safely sharing the air with aerial applicators.
- *Lots* of maintenance and repair.
- Maximizing time/cost efficiency.
  - Flying 160 acres may take up to an hour.
- Requires skill, experience, (and a little luck) to operate.
- Weather conditions. (Wind, rain.)

Imagery Problems

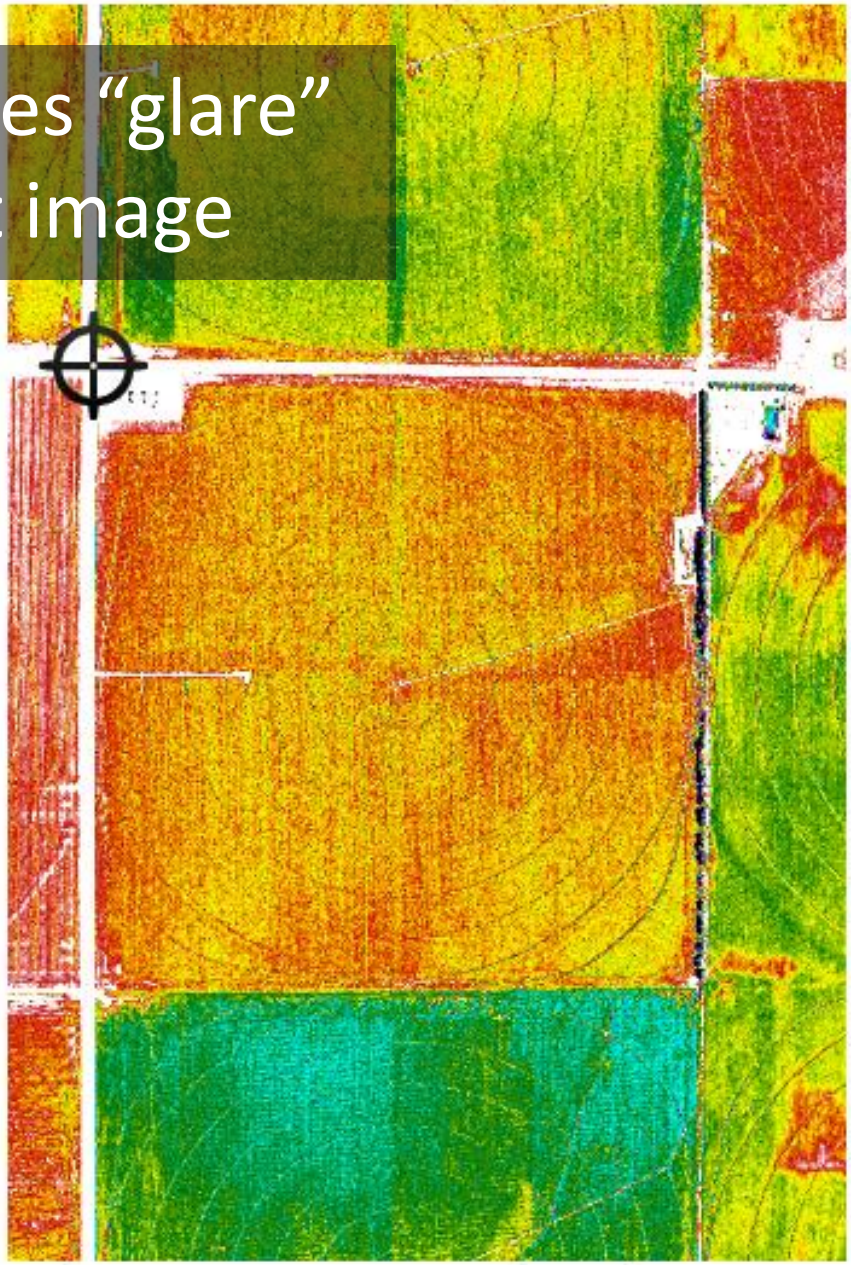
- Light angle / time of day effects
- Shadows and uneven “glare”
- Image stitching / overlap errors
- Cloud shadows and changing light conditions

Problem with these fields?

Angle of light causes “glare” in manned aircraft image



Uncorrected



Corrected

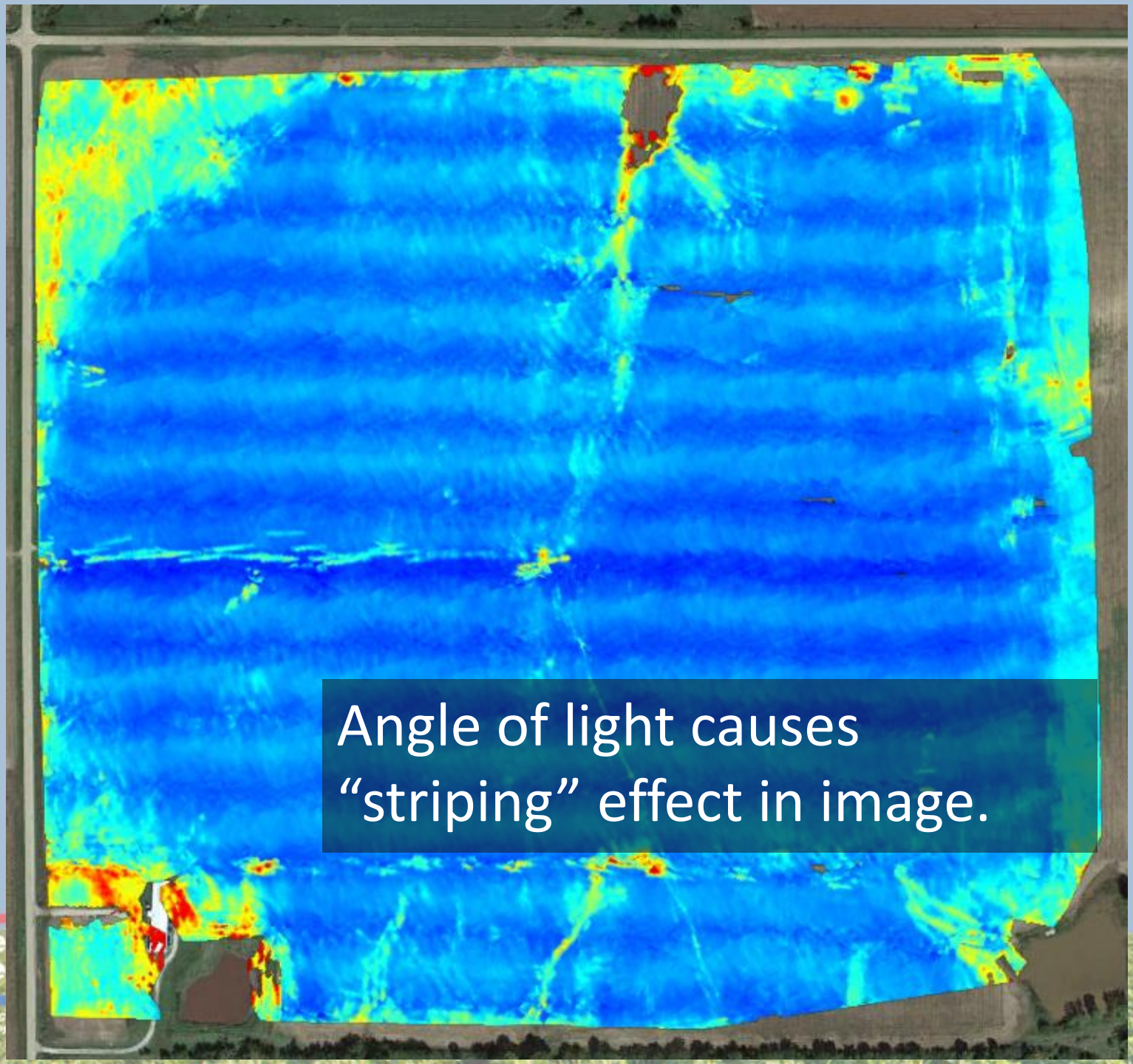

Angle of light causes
“striping” effect in image.

Image Stitching

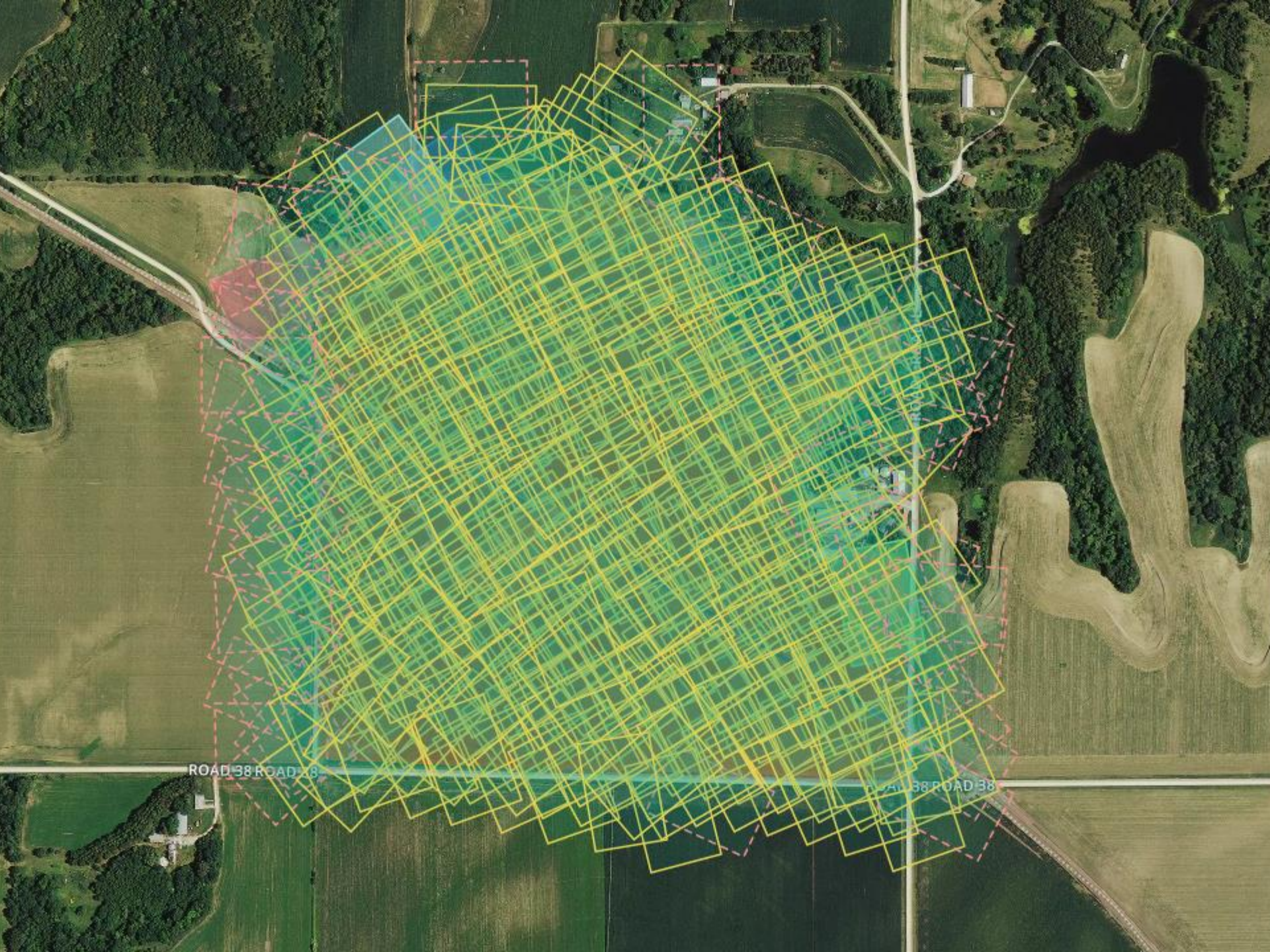
Two main ways to combine many small images into one big image:

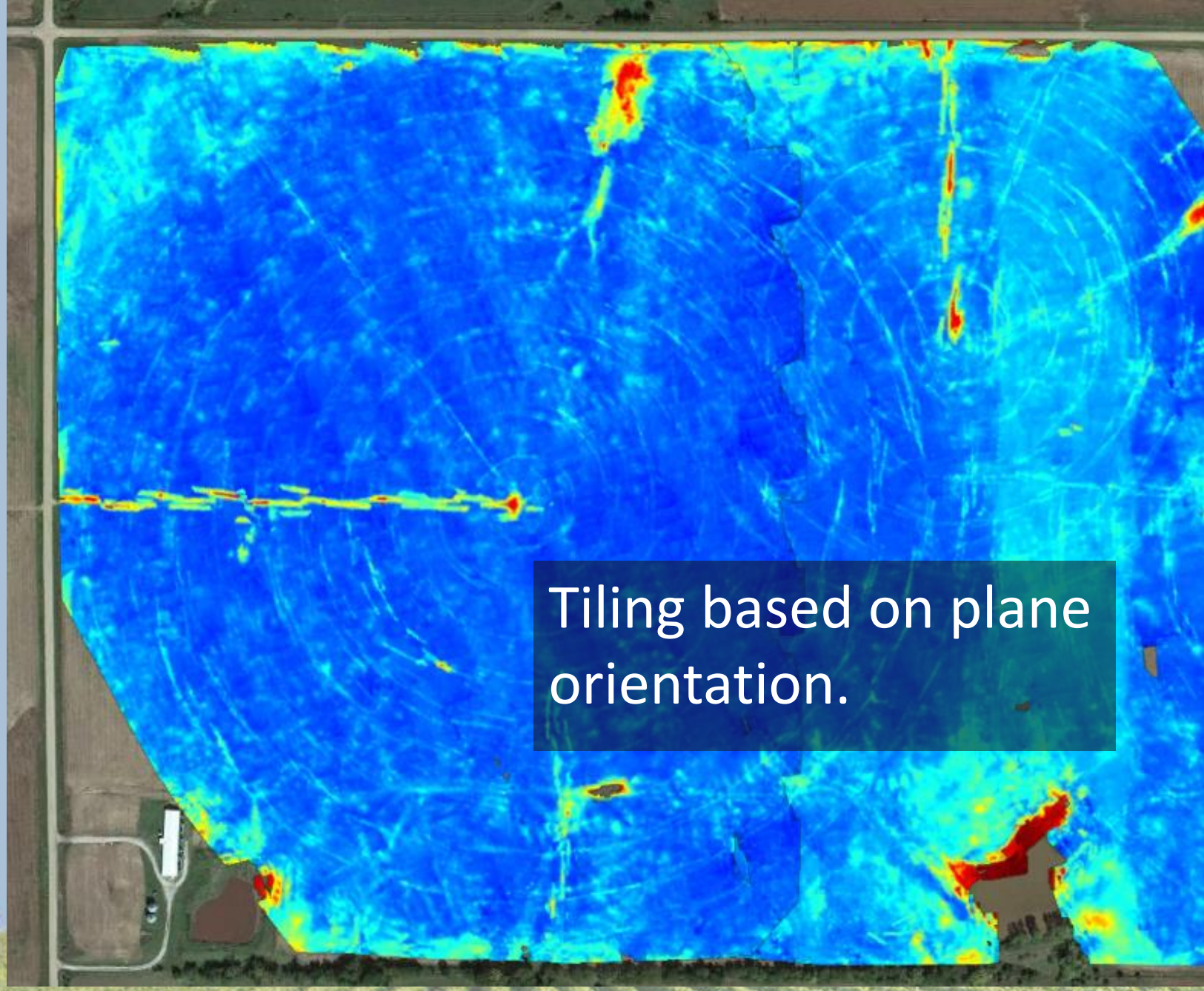
1) Tile images based on plane position and orientation.

- Reliable but never “clean and 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 ROAD 38



Tiling based on plane orientation.

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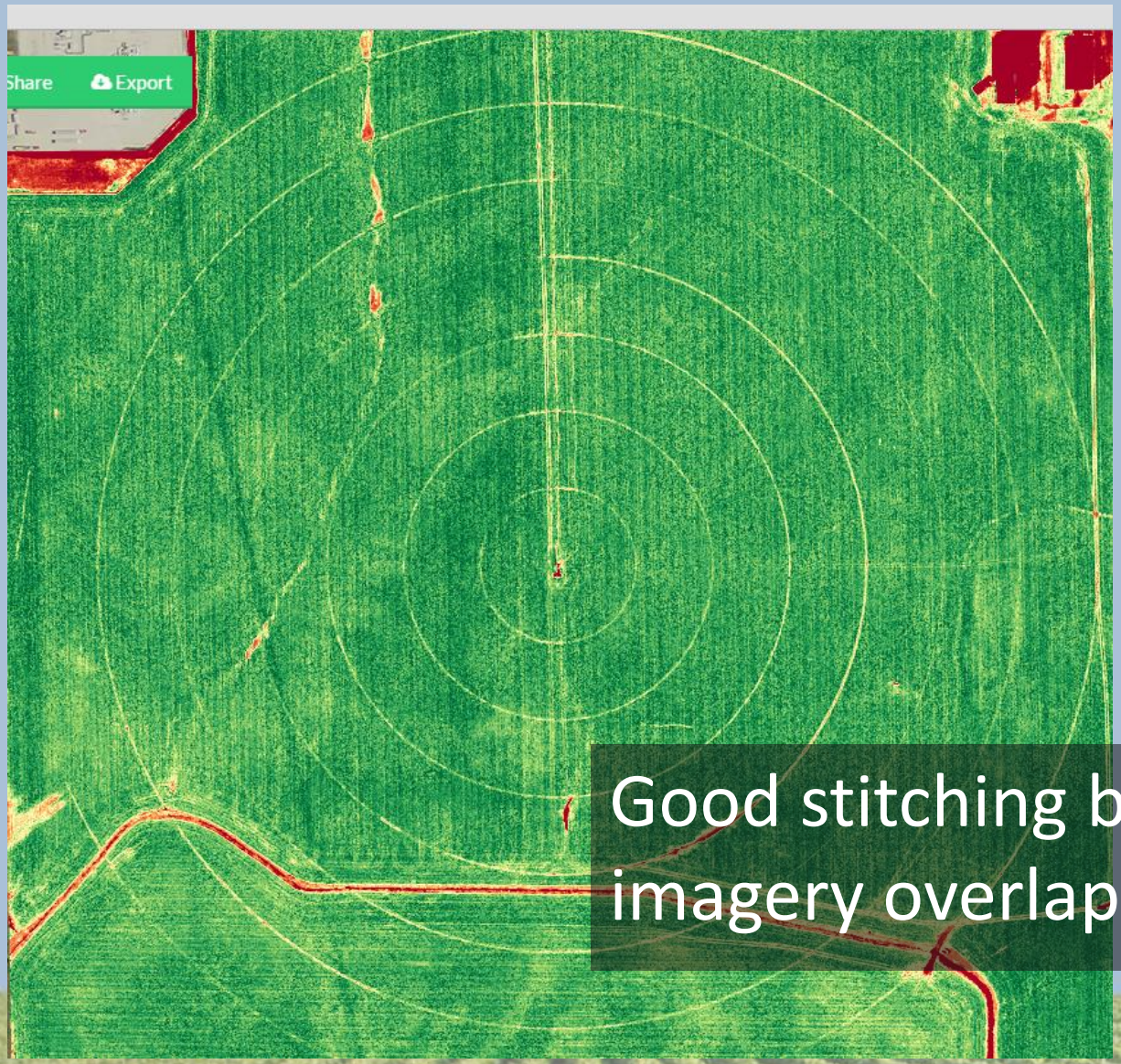
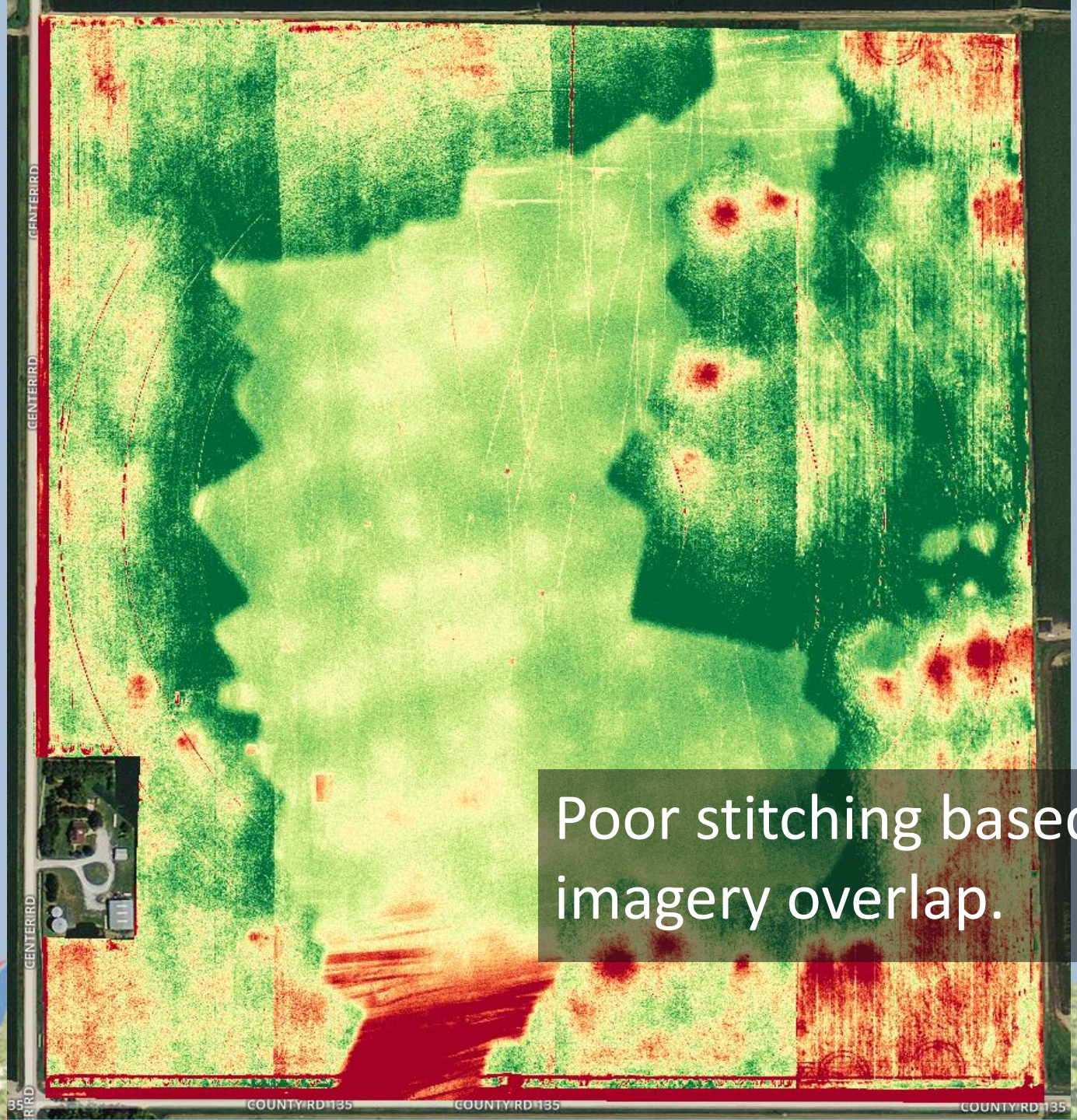


Good stitching based on imagery overlap.



Poor stitching based on imagery overlap.

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Bad spot due to one faulty picture

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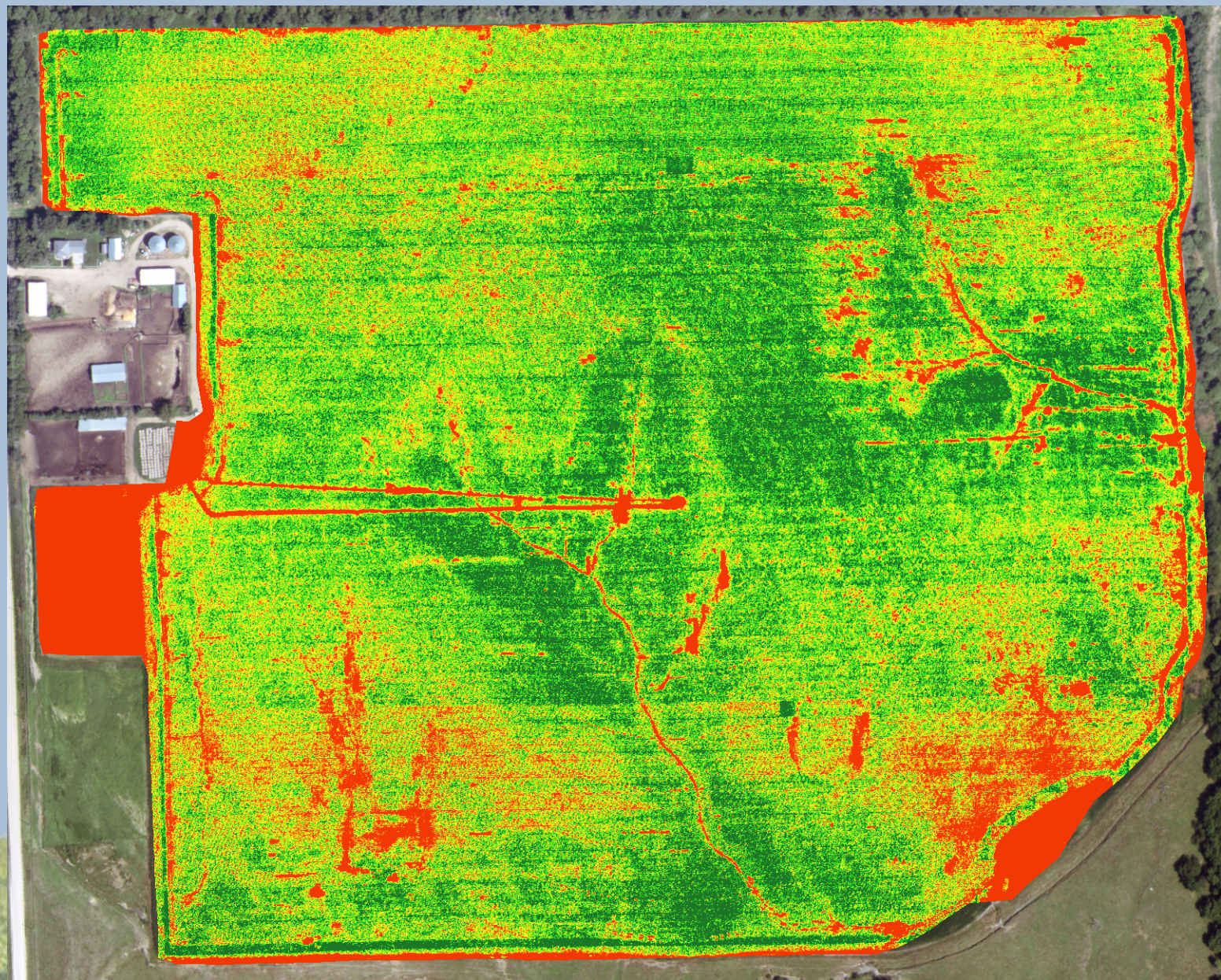
To drone or not to drone?

- 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?

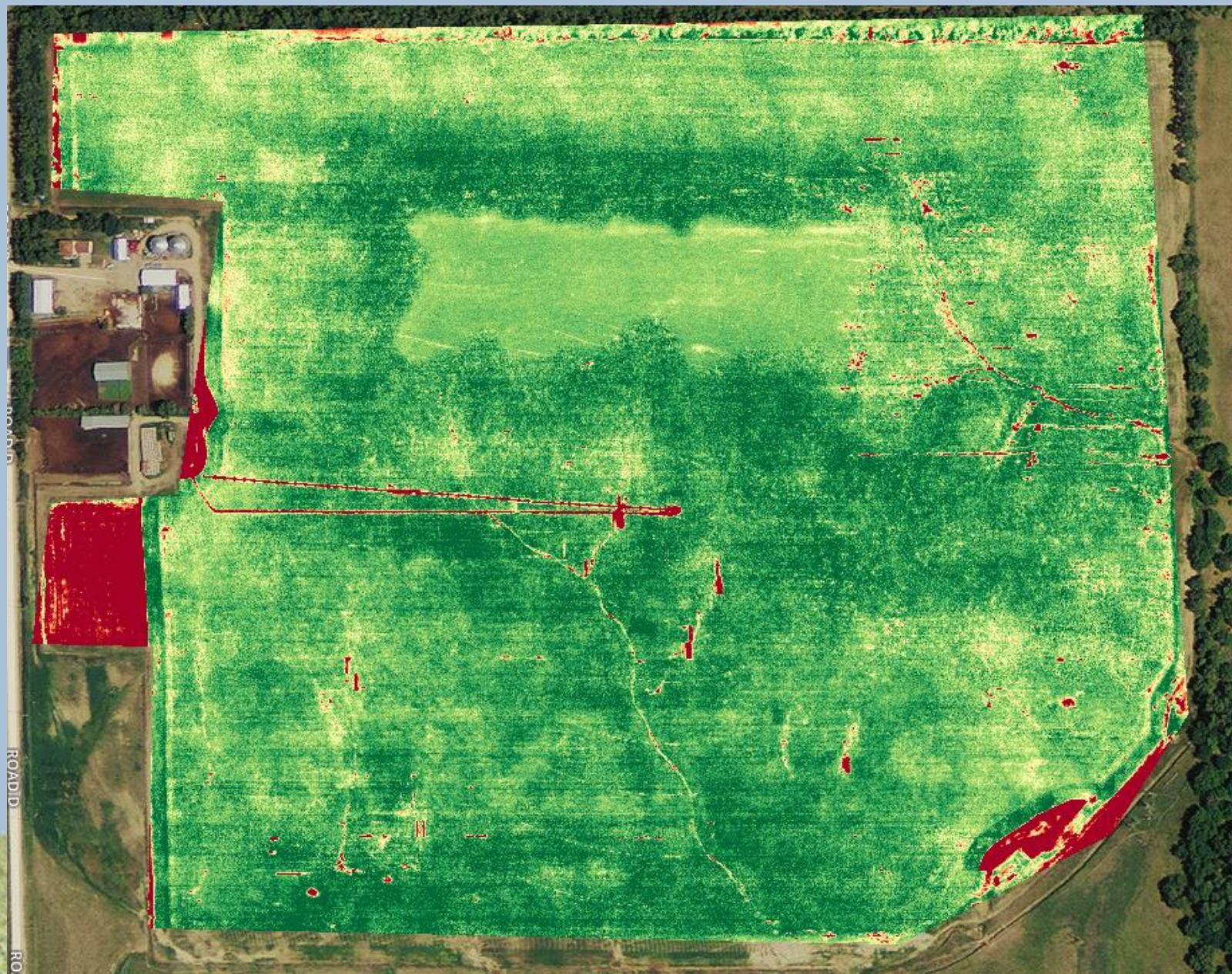
To drone or not to drone?

- Do you need ultra-high detail imagery of a small plot, or “good enough” imagery of many acres?
- Do you need **absolute control** over when the field is flown, or can you rely on another group to fly within a range of dates?
- Do you need *exact* NDVI values or just a good idea of where the crop is healthy or not?

Manned-Aerial



UAV



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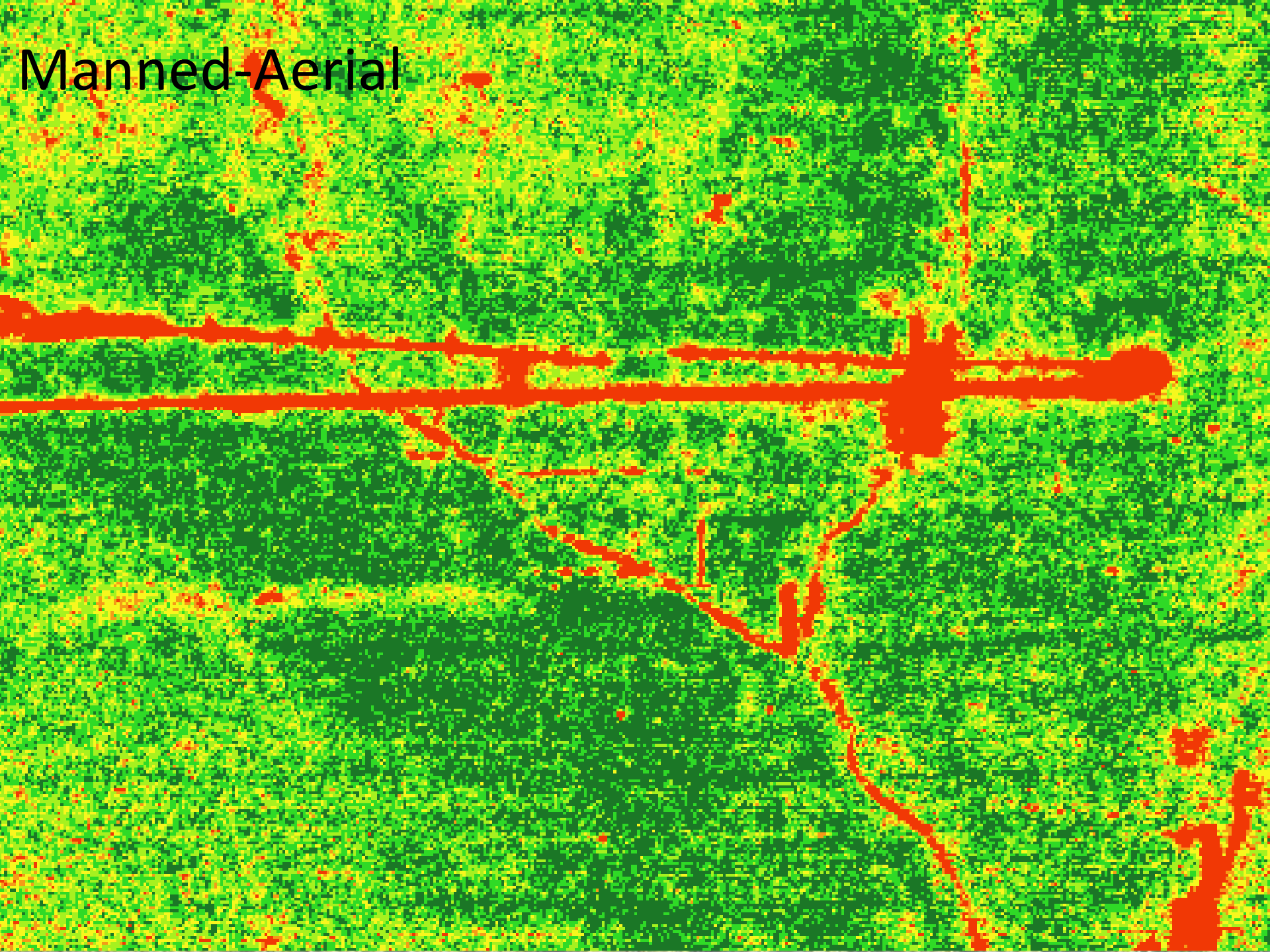
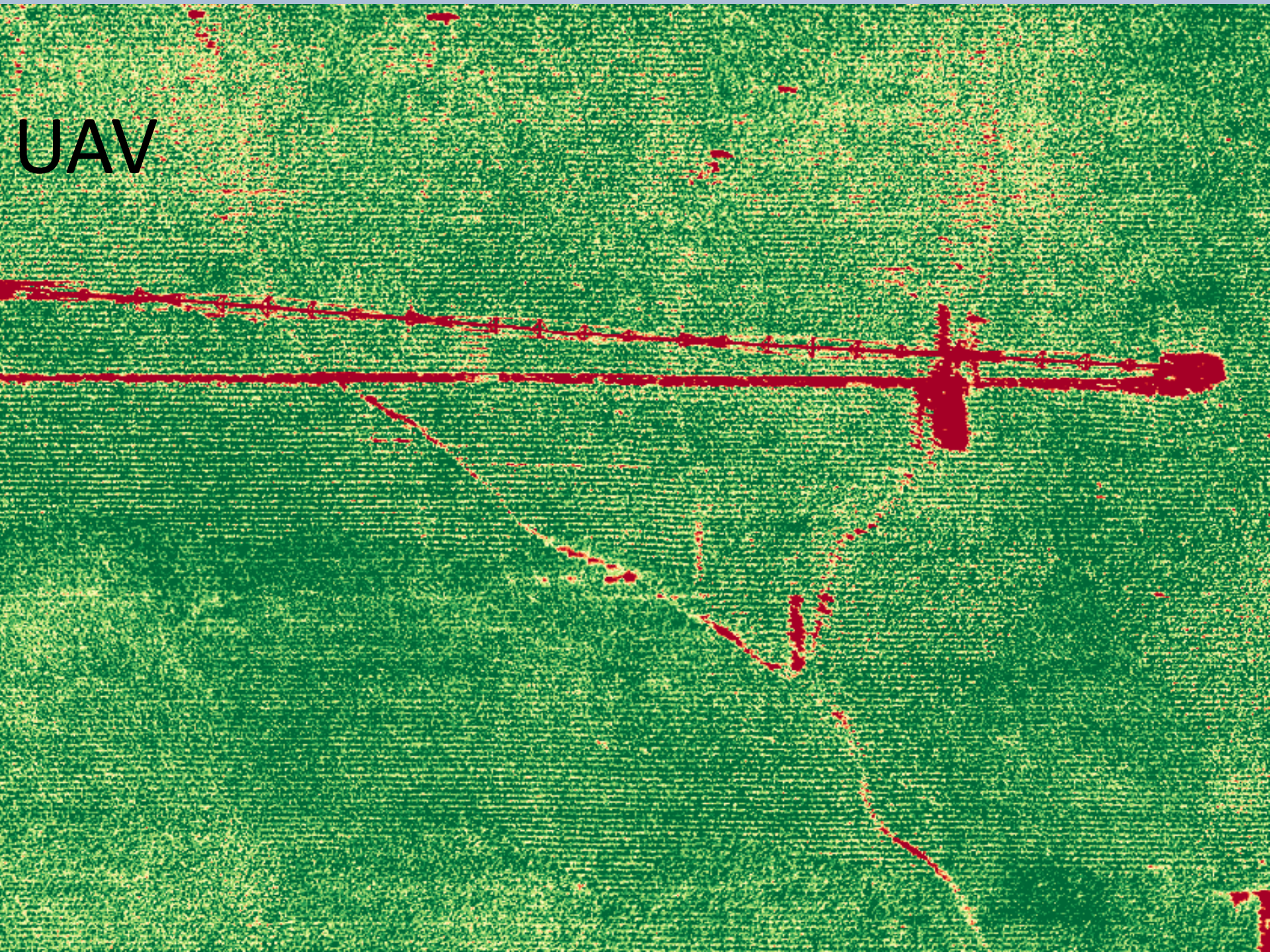

Manned-Aerial


UAV

Questions?

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