The Evolution of UAS:
Applications in Research and the Private Sector

MSU, RS&GIS
http://www.rsgis.msu.edu

Robert Goodwin, GISP
Senior Geospatial Analyst
UAS Manager & Pilot-in-Command

Statewide GIS Users Group Meeting
2/4/2016

RS&GIS

MICHIGAN DEPARTMENT OF TECHNOLOGY, MANAGEMENT AND BUDGET
DTMB Center for Shared Solutions

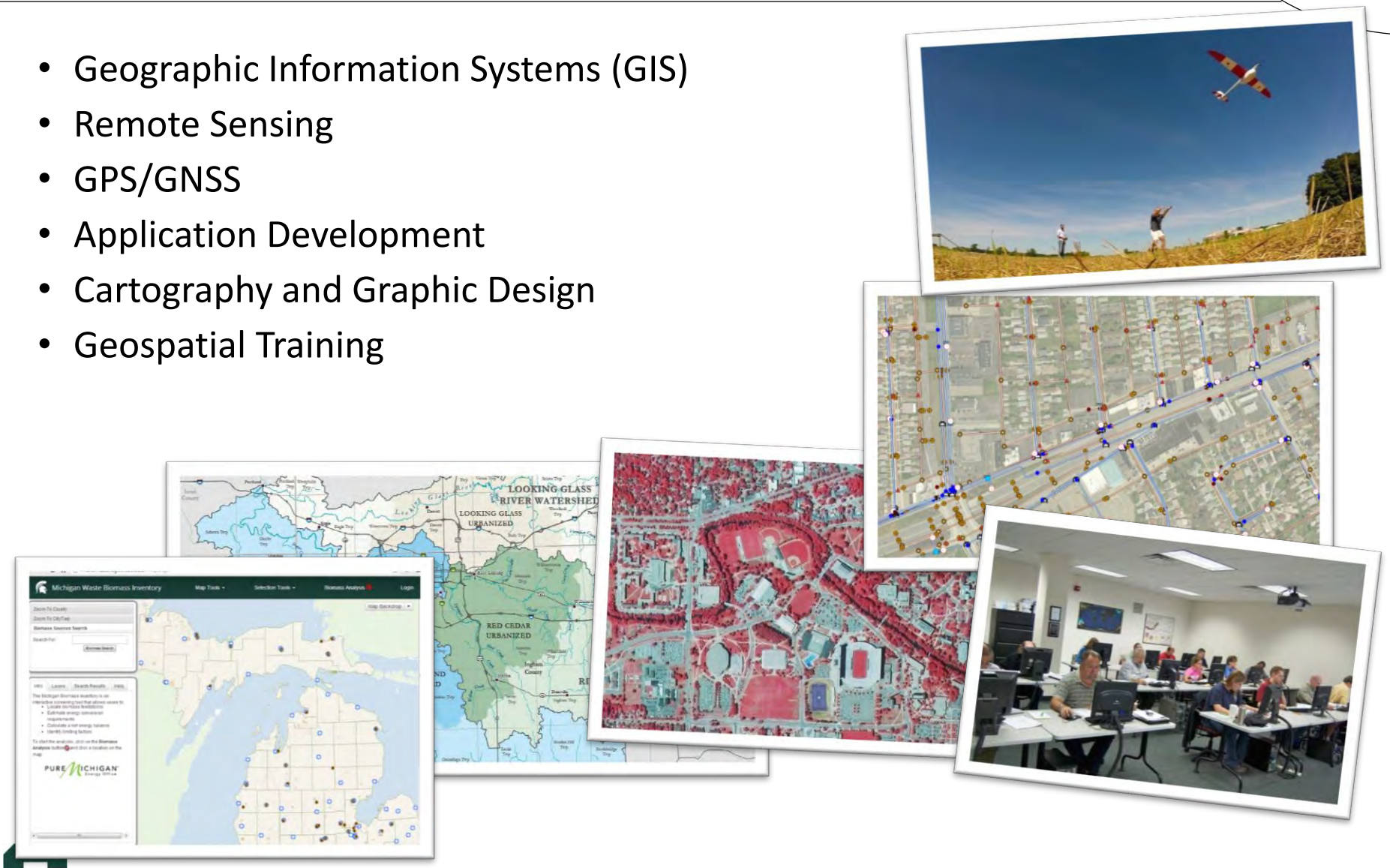
RS&GIS @ Michigan State University

- Geospatial Research and Outreach services group at MSU
  - Department of Geography, College of Social Sciences
- Established in 1972 as the Remote Sensing Project
- Serving
  - Research community,
  - Local/State/Federal government
  - Municipalities, Not-for-Profits and the private sector

©Remote Sensing & GIS, MSU

RS&GIS @ Michigan State University

- Geographic Information Systems (GIS)
- Remote Sensing
- GPS/GNSS
- Application Development
- Cartography and Graphic Design
- Geospatial Training



©Remote Sensing & GIS, MSU

Unmanned Aerial Systems (UAS)

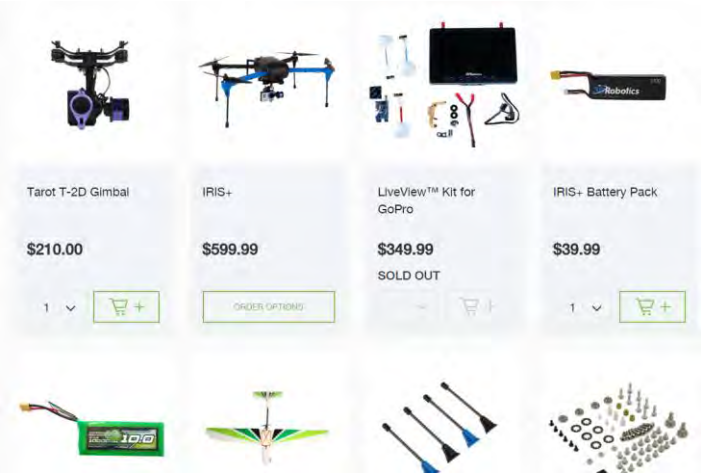
RS&GIS

- UAS are aerial systems that navigate autonomously using GPS or other techniques
- Extra-small → Small → Large → Extra Large
- Size is determined by application
- Smaller UAS are easier to deploy…duh.

©Remote Sensing & GIS, MSU

Drones Now….

- Flood of new manufacturers over the past 5 years
  - Nearly 100 in the U.S. Alone
  - Hobby, Commercial, Military/Homeland Security
- DIY vs. Ready-to-Fly
  - Build my own or pay someone else?
- Turnkey solution vs. User-assembled solution (hardware, software)
  - $$$$$ vs. $$
- Safety and reliability concerns



©Remote Sensing & GIS, MSU

Drones Tomorrow….(my view)

- Modular
  - Plug and Play just like desktop PCs
  - Little to no experience will be needed to assemble
- Open Source Applications will rule
- Much more affordable
  - More competition = lower prices
- Just another tool in the toolbox
  - Why not have a drone?
- Improved safety
  - See and Avoid Technology
  - Protective measures
  - New regulations

©Remote Sensing & GIS, MSU

What About Regulations? Current UAS FAA Requirements

RS&GIS

- No Commercial Use*
- Must apply for a Certificate of Authorization (3-6 month process) – Public Universities and Law Enforcement agencies only (with some exceptions)
- Must register your UAS with the FAA
- Pilots must pass private pilot knowledge exam
- Flights to occur at or below 400 feet above ground level only
- No flights over buildings or high-trafficked roads
- No flights over urban areas or gatherings of people
- Daylight operations only
- Visual contact of UAS at all times
- Two observers required in addition to Pilot-In-Command

- Radio/Cellular contact at all times between PIC and Observers
- Required to have the following in place
  - Emergency procedures
  - Lost radio link procedures
  - Communications procedures
  - Launch and Recovery procedures
  - Observation procedures
  - Procedures for special circumstances

*Commercial use allowed under Section 333 waiver

- Requires operator to have pilot license
- Altutude limited to 200’ above ground

©Remote Sensing & GIS, MSU

Expected UAS FAA Requirements - 2016

RS&GIS

- **Commercial Use Allowed**
- ~~Must apply for a Certificate of Authorization (3-6 month process) – Public Universities and Law Enforcement agencies only (with some exceptions)~~
- Must register your UAS with the FAA
- Pilots must pass **UAS Operator** knowledge exam
- Flights to occur at or below **500** feet above ground level only
- ~~No flights over buildings or high-trafficked roads~~
- ~~No flights over urban areas or gatherings of people~~
- Daylight operations only
- Visual contact of UAS at all times
- ~~Two observers required in addition to Pilot-In-Command~~
- ~~Radio/Cellular contact at all times between PIC and Observers~~
- **Must receive permission from any airport or heliport within 5 nautical miles of flight area**
- **Certain airspace restrictions**
- ~~Required to have the following in place~~
  - ~~Emergency procedures~~
  - ~~Lost radio link procedures~~
  - ~~Communications procedures~~
  - ~~Launch and Recovery procedures~~
  - ~~Observation procedures~~
  - ~~Procedures for special circumstances~~

©Remote Sensing & GIS, MSU

Research involving UAS

- What awesome sensor can I strap to this thing?
- How long can I get this thing to fly?
- How can I program this thing to do what I want?
- What information can I extract from data collected by this thing?
- How accurately can I navigate with this thing?
- Can I get these things to talk to one another?

©Remote Sensing & GIS, MSU

Commercial Uses of UAS

©Remote Sensing & GIS, MSU

RS&GIS UAS Platforms

- Aeromapper
  - 50 minutes of flight time
  - Parachute recovery
  - Large-area acquisition
  - 100 acres+ per battery
- DJI Phantom 2
  - 10 - 15 minutes of flight time
  - Agile and flexible payload
  - Close proximity, smaller-area collection
  - 20 acres per battery
- 3D Robotics X8 and X8+
  - 10 - 15 minutes of flight time
  - Agile and flexible payload
  - Close proximity, smaller-area collection
  - 20 acres per battery

RS&GIS UAS Platforms – COMING in 2016!

- Custom Quad-Copters (2)
  - Large props and low rpm motors
  - 25+ minutes of flight time
  - 2 kg + payload
  - First-Person View (FPV)
  - *Realtime-Kinematic GNSS*

©Remote Sensing & GIS, MSU

RS&GIS UAS Activities and Personnel

- RS&GIS provides UAS services in the context of platform research
  - FAA-certified pilots-in-command (PIC) and Observers
  - FAA certificate of authorization (COA) application process
  - Sensor integration and project flight planning
  - Ground reference data collection (GPS)
  - Imagery acquisition
  - Image processing

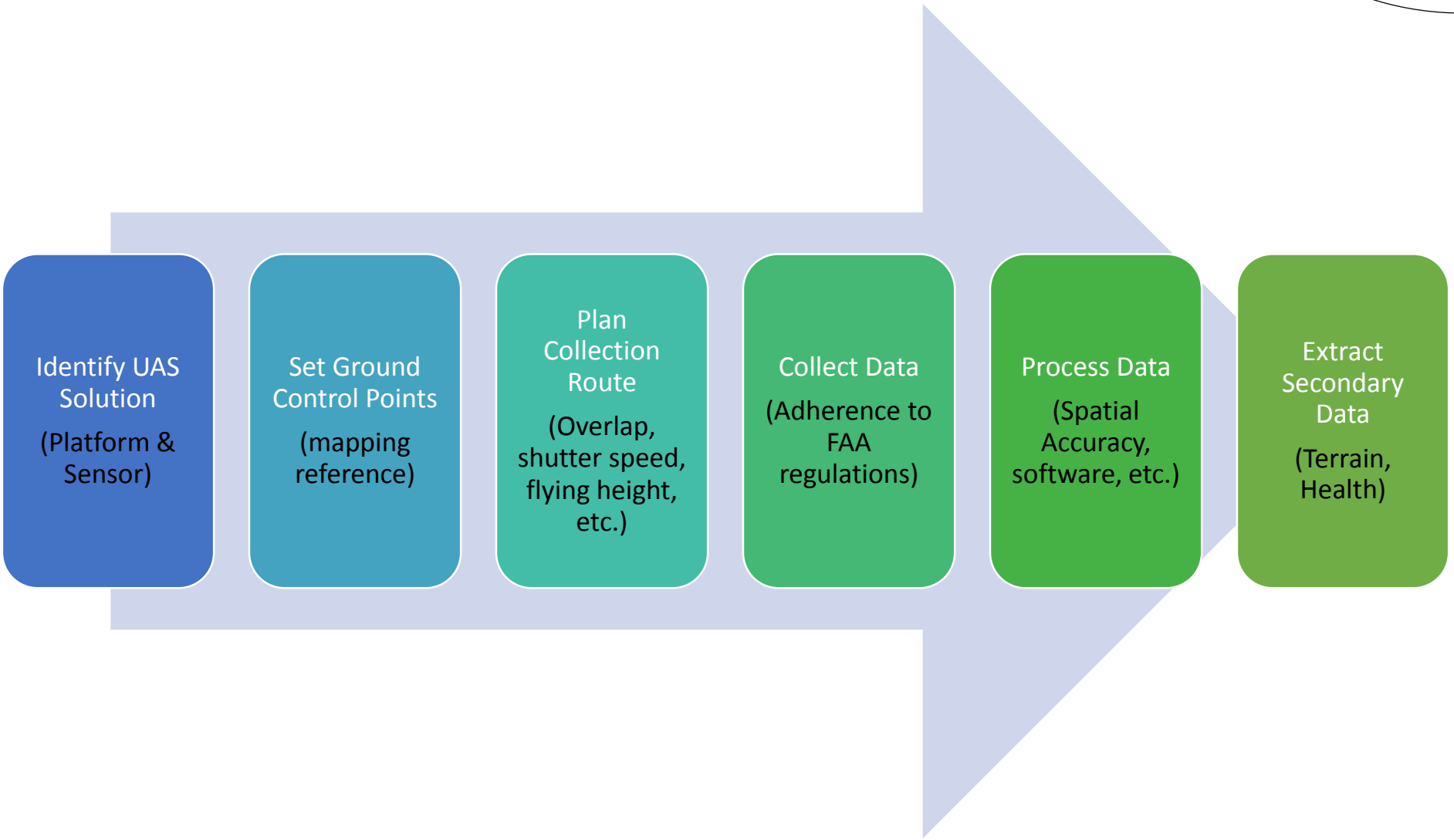
©Remote Sensing & GIS, MSU

Where can RS&GIS fly?

- RS&GIS has 5 current Certificates of Authorization covering…
  - MSU South Campus
  - MSU Experiment Stations
  - Several private properties
- RS&GIS has applied for additional COAs throughout the State of Michigan

©Remote Sensing & GIS, MSU

Typical UAS Project Workflow



©Remote Sensing & GIS, MSU

RS&GIS Project Examples

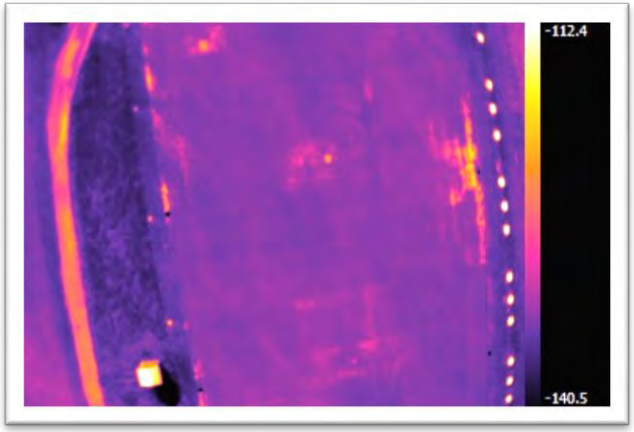
UAS Team @ RS&GIS:
Robert Goodwin, UAS Manager and PIC
Dave Lusch - Ph.D., Remote Sensing Specialist
Joe Welsh, Geospatial Analyst and PIC
Nick Weil, Geospatial Analyst

©Remote Sensing & GIS, MSU

Turf Imaging

RS&GIS

- Canon S100
  - Natural Color Image Mosaics
  - 3D Terrain Models
- Tetracam ADC Lite
  - False-Color Image Mosaics
  - Normalized Difference Vegetation Index (NDVI) analysis
- FLIR Tau-2 324p
  - Thermal Image Mosaics
  - Site-specific thermal images
  - Identification of Hot Spots
  - Analysis of temperature differences



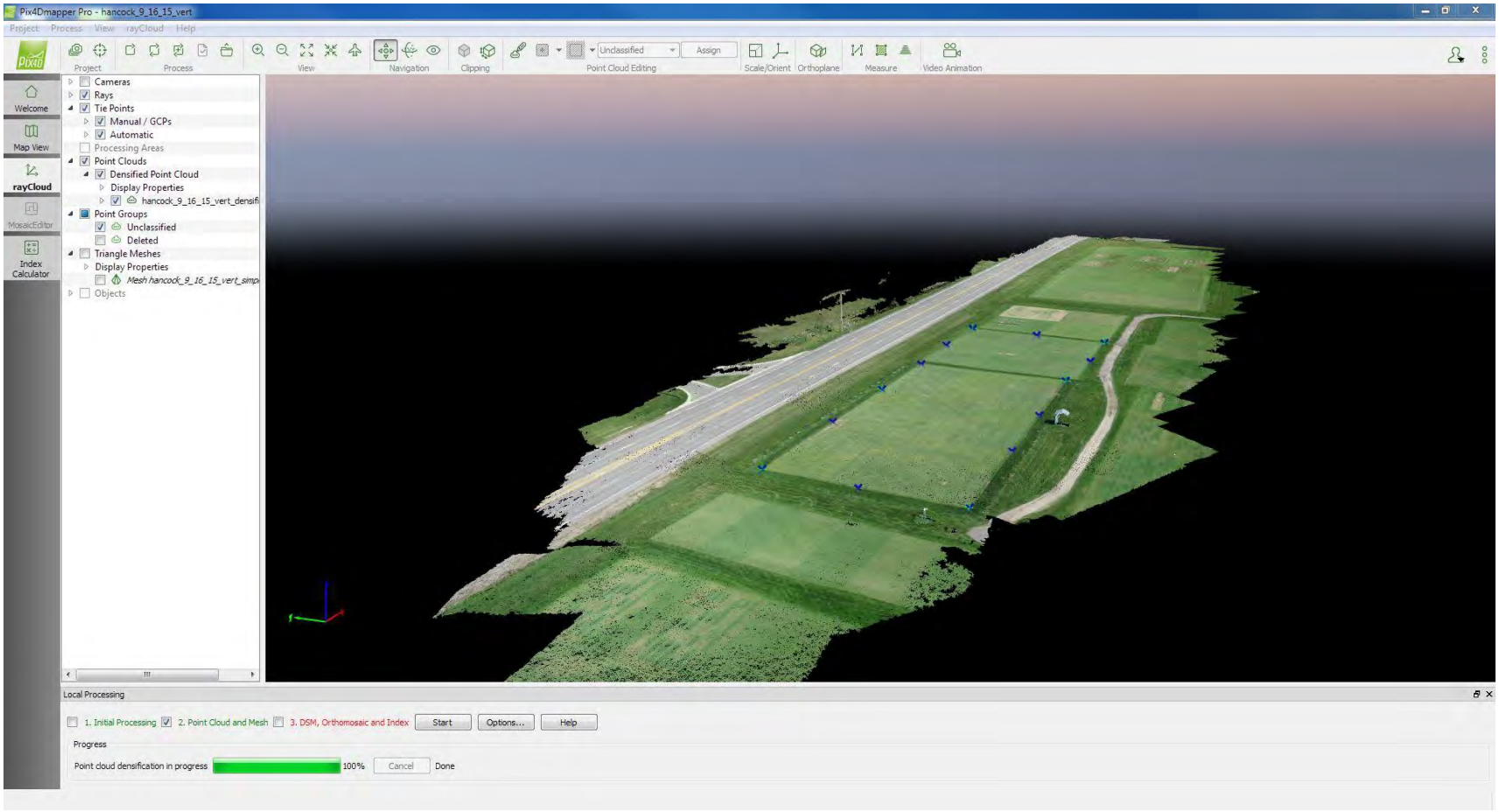
©Remote Sensing & GIS, MSU

Don’t Forget the Video!

©Remote Sensing & GIS, MSU

Data Processing – Point Cloud

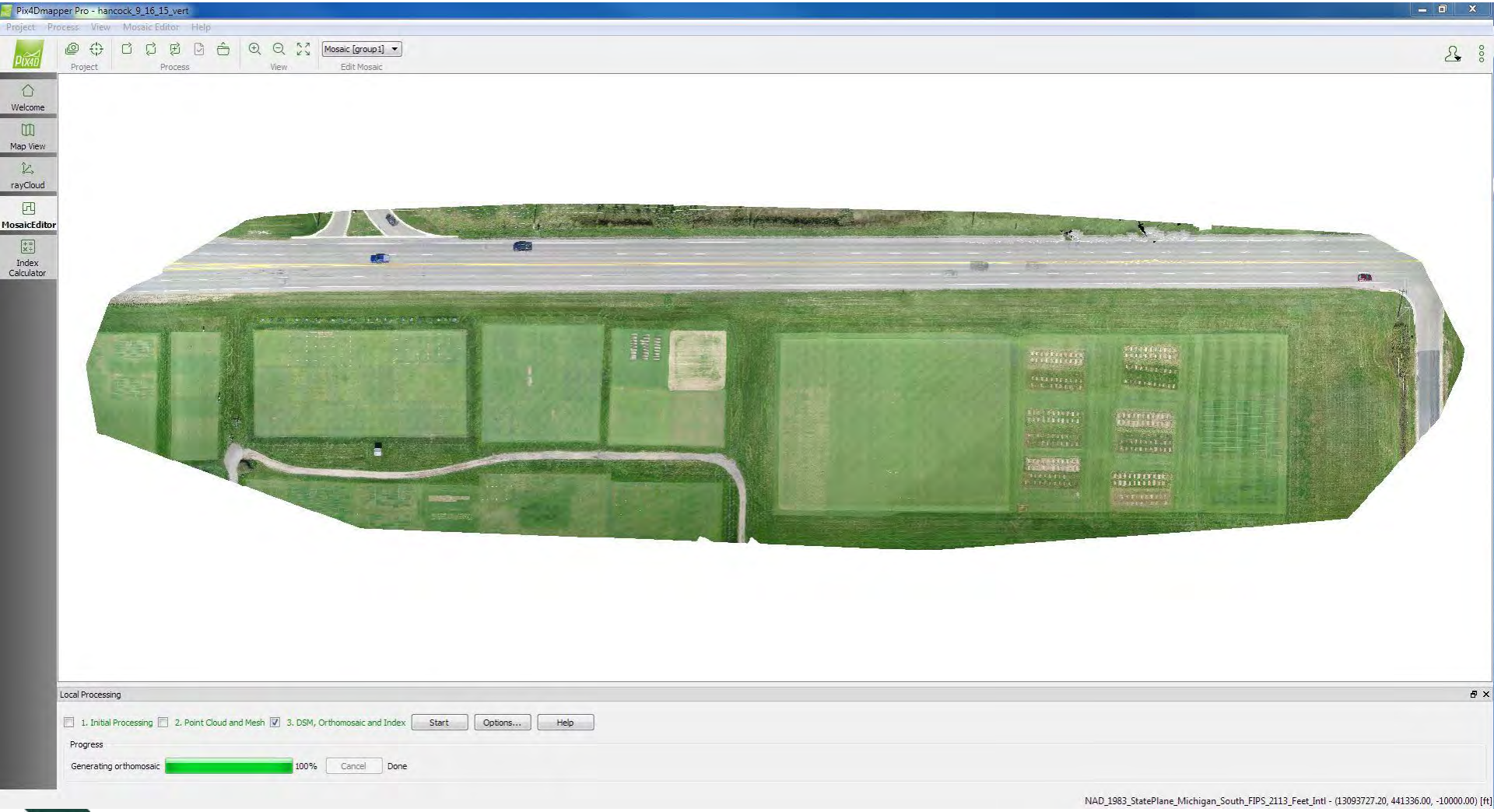
- Densification of Point Cloud (Pix4D)



©Remote Sensing & GIS, MSU

Data Processing – Generating Outputs

- Referenced images, mosaics, 3D surface (Pix4D)

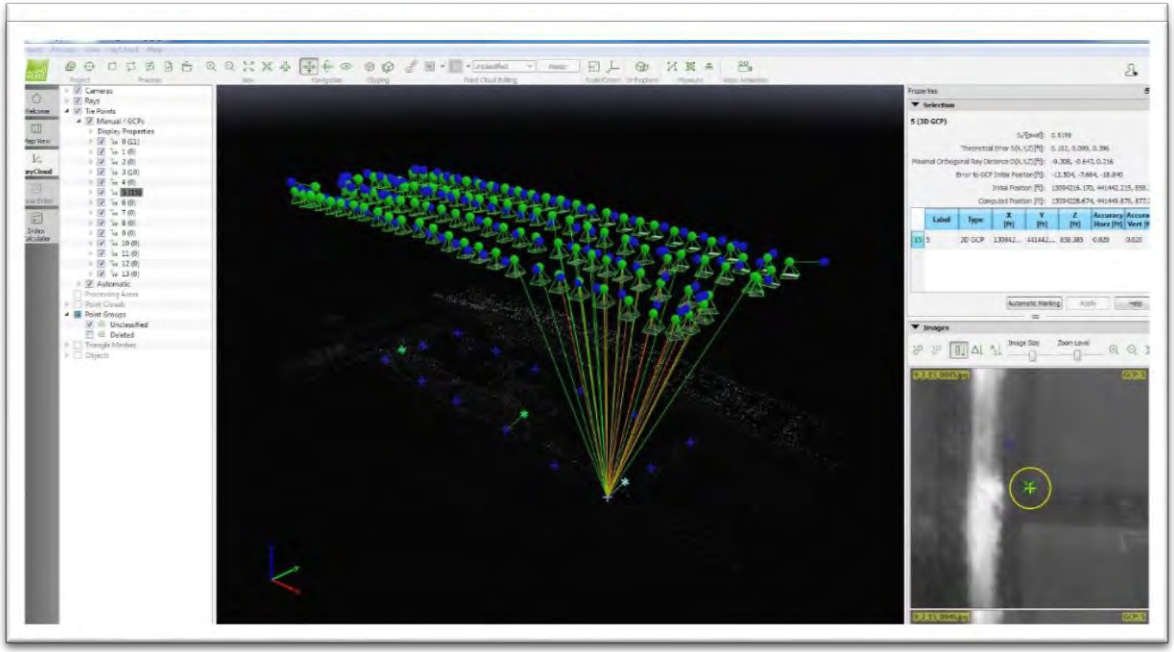


©Remote Sensing & GIS, MSU

Turf Research – UAS + Thermal IR

- Studying the relationship between moisture content and turf temperature

- FLIR Tau-2 324p
  - Mid-market Thermal camera
  - Video and Still Frames
  - Hot spot detection
  - High sensitivity to temperature changes

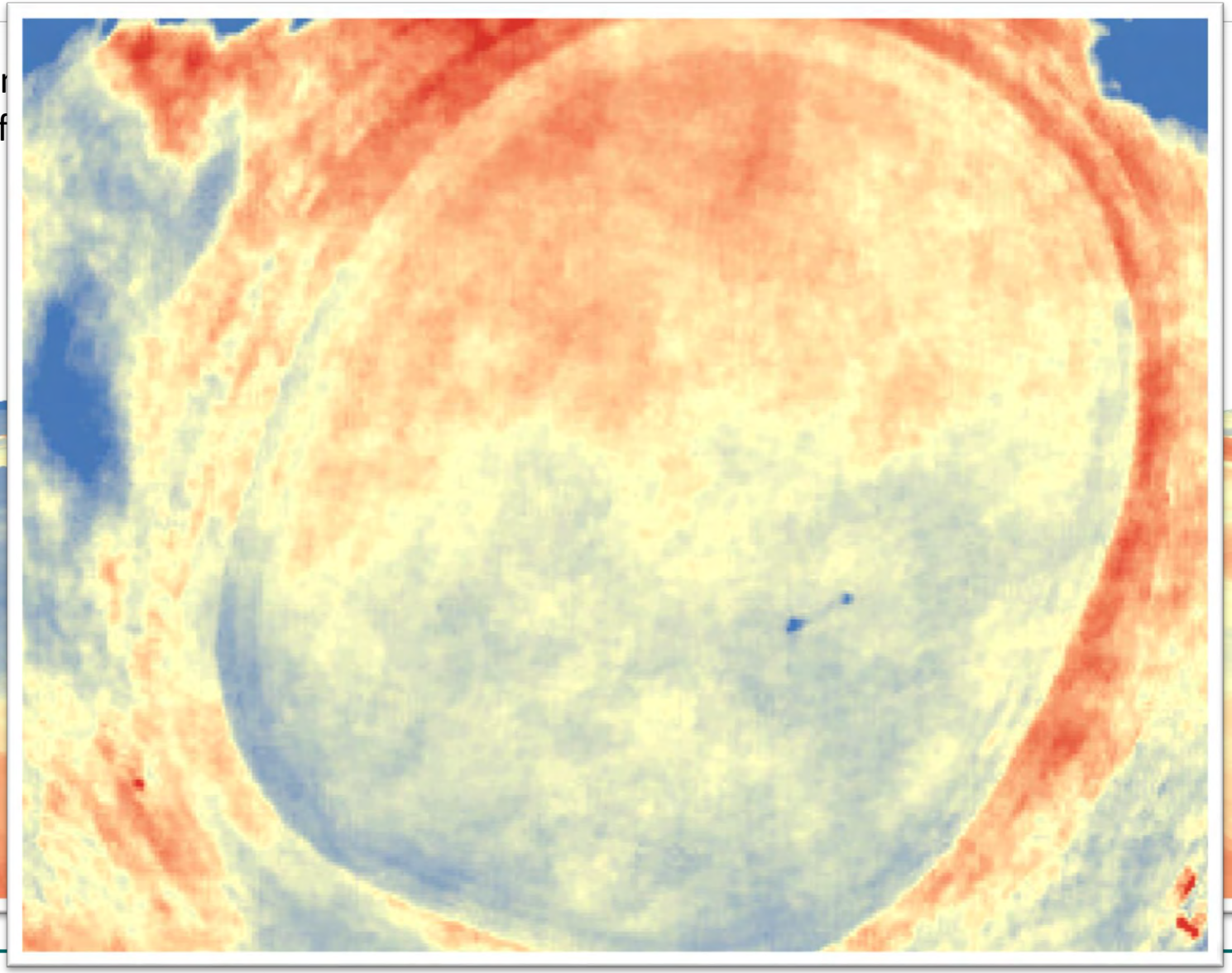


©Remote Sensing & GIS, MSU

Turf Research – UAS + Thermal IR

RS&GIS

Elevation
show dif

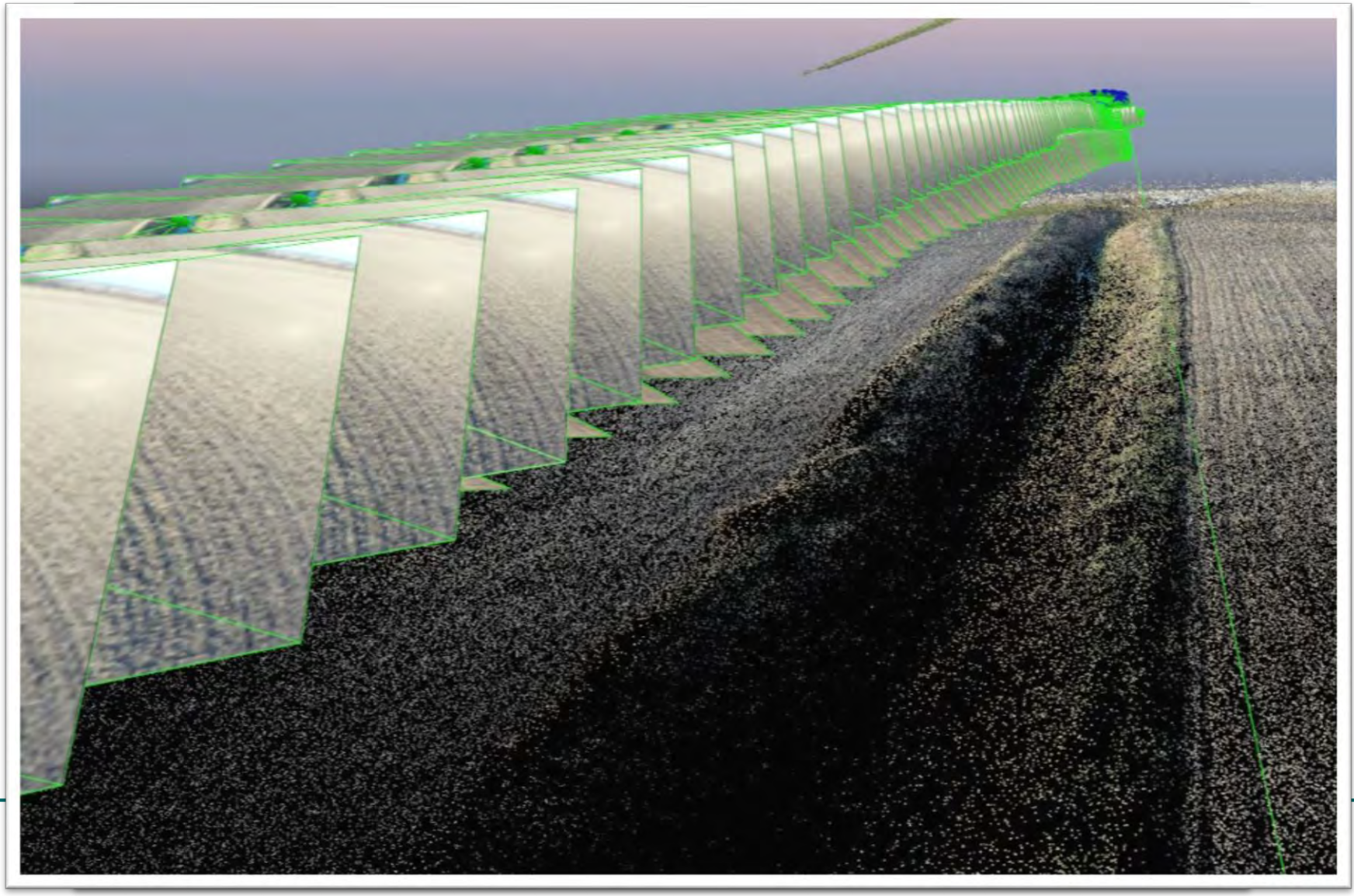


©Remote Sensing & GIS, MSU

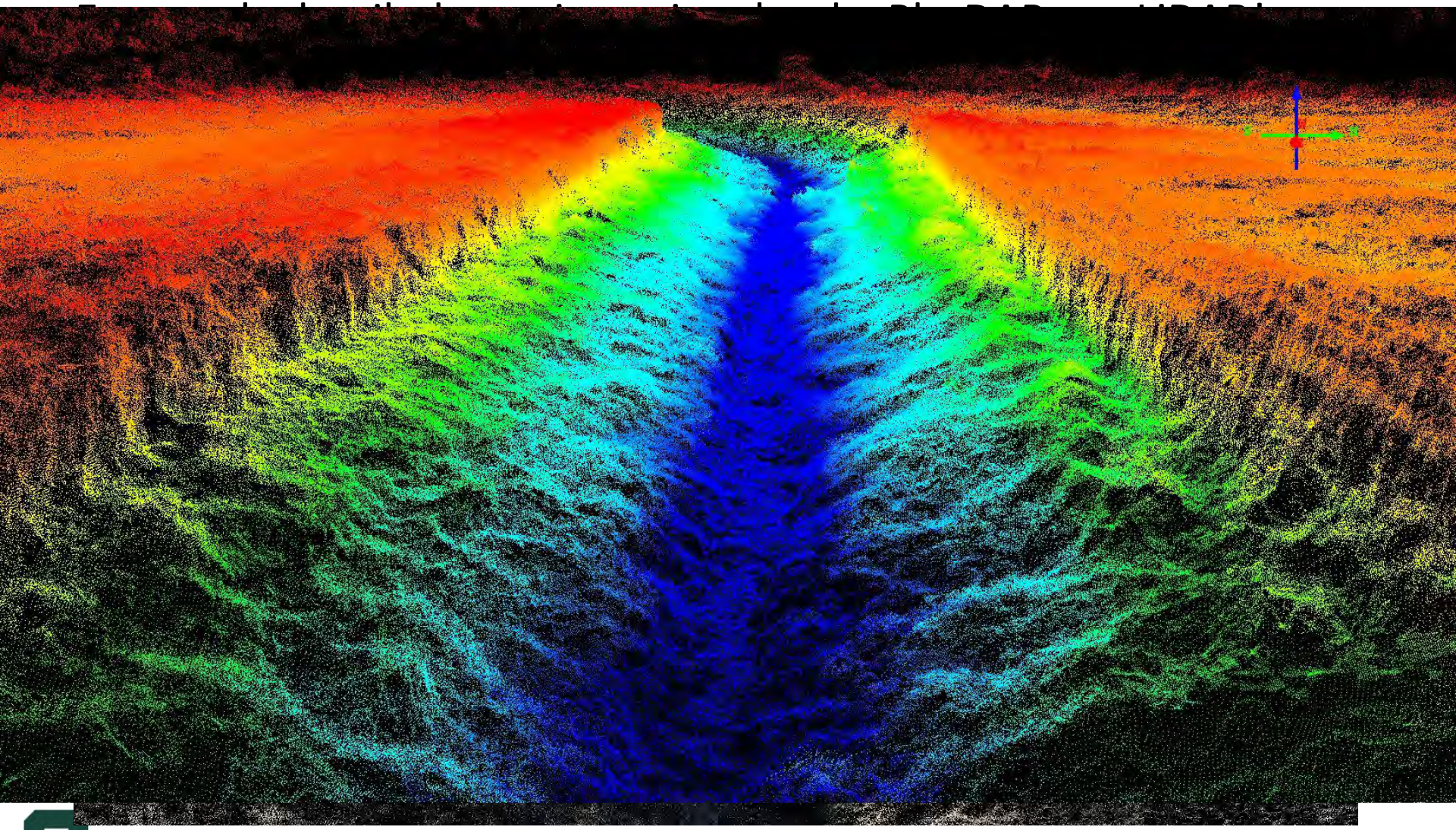
3D Modeling of Drains

RS&GIS

- Drain Inspection and 3D Mapping

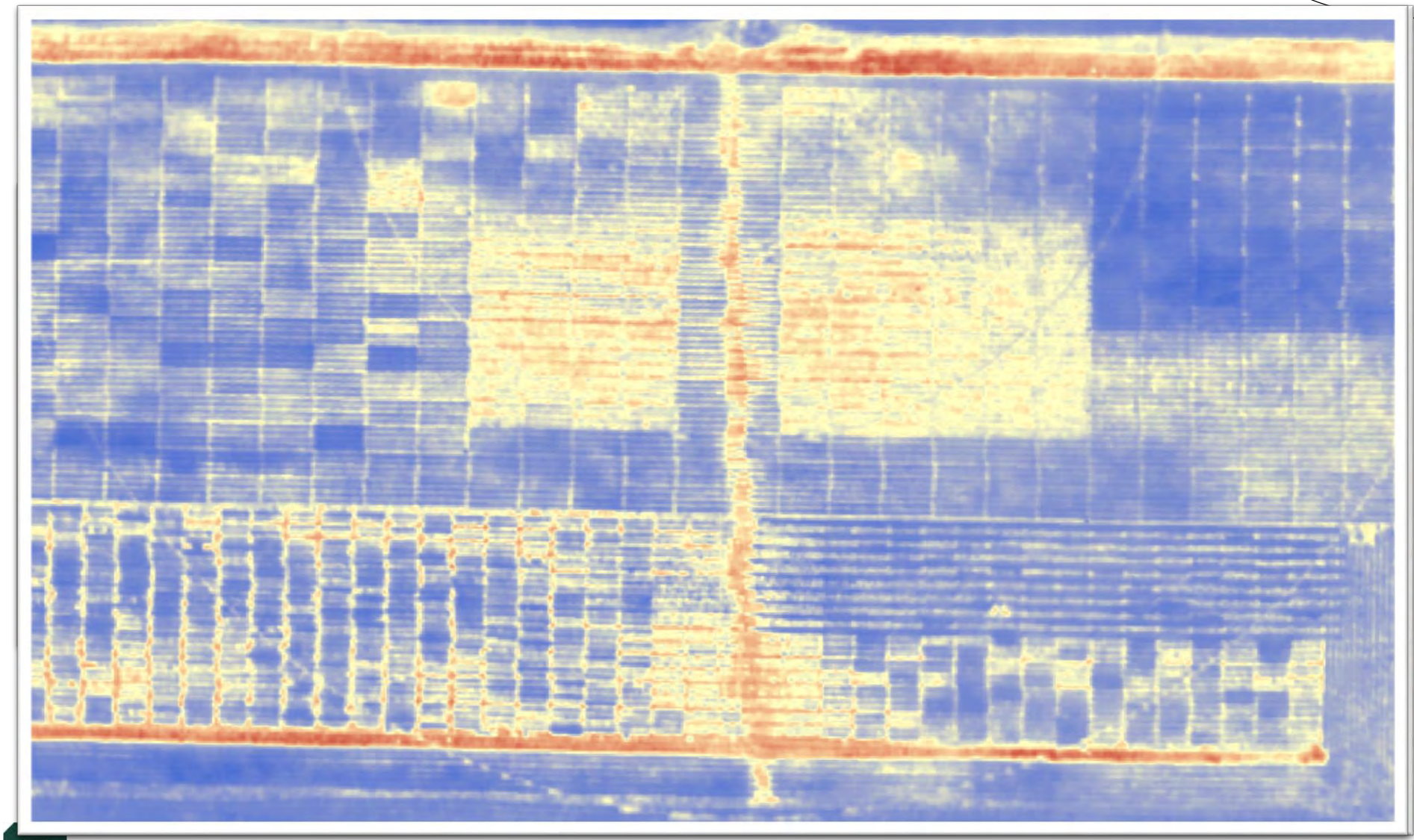


Real-Time Drain Assessment



©Remote Sensing & GIS, MSU

UAS Investigations of Soybeans



©Remote Sensing & GIS, MSU

Corn Hybrid UAS Research

RS&GIS

Crop Damage Assessment

RS&GIS

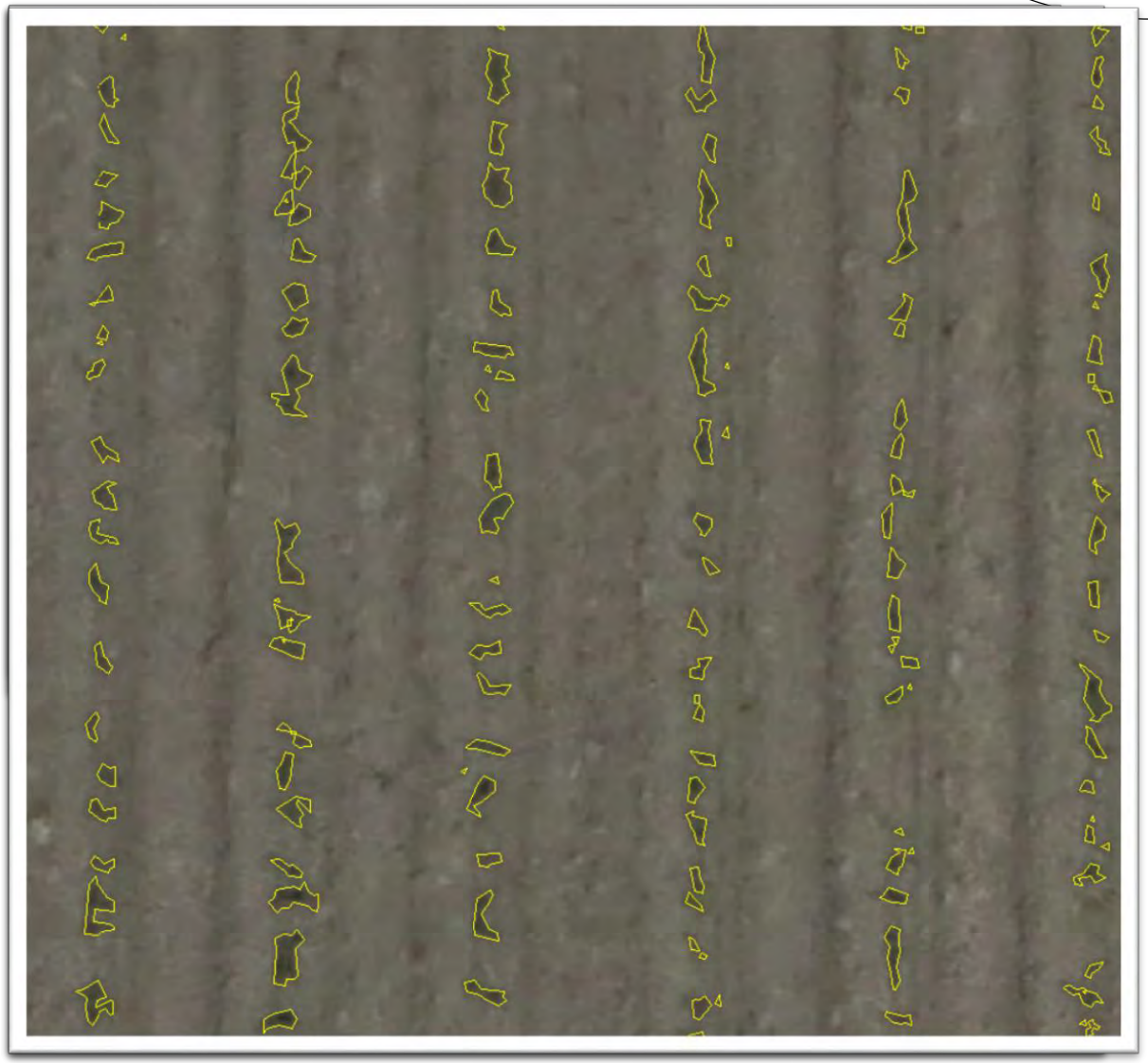
- Identification and quantification of damaged areas due to ponding, disease, etc.

©Remote Sensing & GIS, MSU

Plant Counts

RS&GIS

- Image field when plants are visible and have not merged with one another
- **Key:** Use high-resolution camera at low altitude
- Weeds complicate the process
- Use image processing techniques to extract plants
  - ISO Classification
  - Class Combination
  - Raster → Vector
  - Subset on Rows
  - Count



©Remote Sensing & GIS, MSU

3D Modeling of Sand Dunes

RS&GIS

- Generating Mosaics and Point Cloud Data for Dune Systems from Overlapping Photographs (PhoDAR)

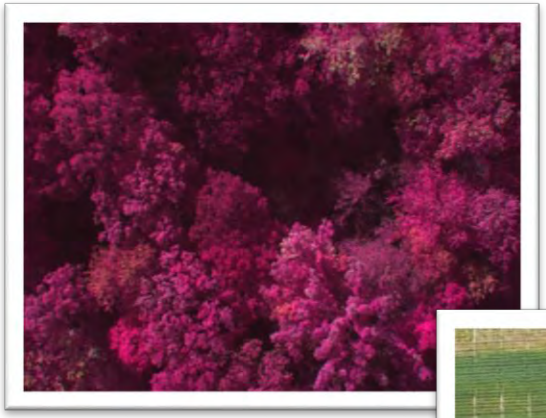
©Remote Sensing & GIS, MSU

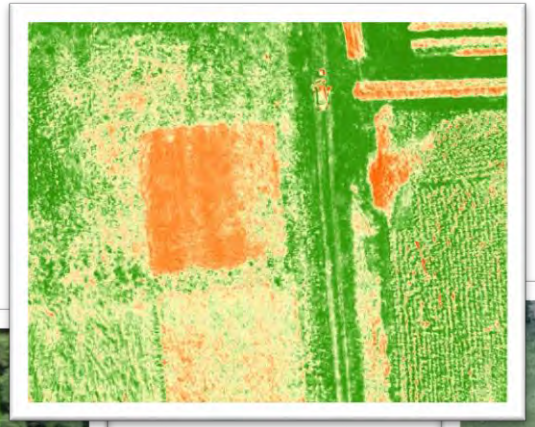
UAS Investigations for AgBioResearch

RS&GIS

- Biomass – Switchgrass
- Soybean disease patterns
- Chestnut estimation
- Forest Species Identification

Michigan State University
AgBioResearch





©Remote Sensing & GIS, MSU

What's Next for RS&GIS?

- Improve expertise in the area of PhoDAR (3D models)
- Expand platform capabilities to address needs requiring larger payloads and longer flight times
- Improve sensor packages, particularly multi-spectral
- Provide instruction to entities on and off campus
- Adapt to new Regulations from the FAA
- Fine-tune processing workflows and expand classification routines
- Pursue research opportunities on campus
- Move beyond research to business applications (as regulations allow)

©Remote Sensing & GIS, MSU

Questions?

goodwinr@msu.edu

RS&GIS