The Promise and Challenges of Small Unmanned Aerial Systems (sUAS) for Agricultural Research in the Long-term Agroecosystem Research (LTAR) network

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LTAR: Long-Term Agroecosystem Research Network

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The promise of sUAS for agricultural research

- Tools to monitor crop conditions with fine resolution and low latency.
- Rangelands are also benefiting from the increased resolution and frequency of sUAS vegetation monitoring systems.
- For producers: low-cost solutions promise high-performance decision tools.
  - Adequate data quality to quickly spot problems, such as pest and disease outbreaks.
- For researchers: the promise of filling gaps where satellite data are poor quality or non-existent
  - UAVs complement proximal and remote sensing programs
What do we want to know from remote sensing?

- What kind - classification
- How big - total biomass or yield, net primary productivity
- How fast - growth rates
- How healthy - stressed from water, nutrients, pests

(Hatfield and Prueger, “Remote Sensing in Agriculture: Achieving the potential from this technology for agriculture” 2018 ASA meeting, Baltimore, MD)
Field data and Satellite data

Spatial scale of data (meters)

Range of data

Field data
Satellite data
UAV data and Farm scale

Spatial scale of data (meters)

Range of data

Field data  Satellite data  UAV data

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What do we need to use UAVs?

- Appropriate equipment specification
- Mission planning and preparation
- Resources for data handling, processing and storage
- Sufficient data quality to extract necessary information
  - e.g. is it a warm body? is it burnt or unburnt? Is the plant healthy?
But, scientific research with small UAVs also requires

- Particular attention to final data quality and documentation
- Evaluation of instruments for adequacy to the science
- Proper use of instrumentation to produce sound measurements using repeatable protocols
- Outputs with known accuracies and uncertainties
  - e.g. *what are the spectral characteristics? How does this compare to other multi-frequency rs images?*
GACP LTAR
Tifton, GA

- Research objectives 2017-2022:
  - Quantify and assess the effects of...
    - Runoff, erosion and sediment properties on contaminant transport
    - Agricultural conservation practices at multiple spatial and temporal scales
    - Interactions among agroecosystems and landscape components on water supply, water quality and other ecosystem services

- Collection efforts include extensive monitoring of stream flow and water quality

- But,
  - Scale and availability of rs datasets limit quantification at the field scale
  - High costs to carry out intensive ground-based collection

- Therefore, sUAS program is supporting this with
  - Fine scale surface measurements
  - Supplement to traditional field data collection
  - Filling gaps of satellite data at whole field scales
GACP UAV program elements

- **Aircraft**
  - DJI Matrice 100
  - DJI Matrice 210 RTK
  - DJI Spark

- **Sensors**
  - Navigation cameras
  - High resolution RGB cameras
  - MicaSense RedEdge
  - FLIR XTr

- **Computing system**
  - High performance rack mounted PC
    - 2 quad-core 3.6 GHz processors
    - 256 Gb RAM
    - 7 Tb storage
  - File server 9 Tb storage

- **People**
  - 2 Part 107 certified pilots
  - IT support
  - Farmers (cooperators)
Flights to date

- **2017**
  - 69 missions
  - 5 farms: Ogletree, *Ponder (7)*, *Williford (7)*, Wilson, Gibbs

- **2018**
  - 64 missions
  - 5 farms: Gibbs, Wilson, *Ponder (15)*, *Williford (12)*, Belflower
Landsat 8 & Sentinel 2

eos.com/landviewer
Western rangeland monitoring and assessment efforts face different set of challenges.

Ground-based field techniques are typically used to assess rangeland

But

- extensive spatial scope and spatiotemporal variability
- huge time and material costs
- data collections tend to be localized and sparsely distributed
- difficult to adequately sample vegetation parameters,

Therefore, UAVs can greatly enhance data collection and inform assessment efforts
Quantifying Fine-Scale Vegetation Dynamics across Time and Space

Parameters
- Cover (Abundance)
- Canopy Gap (Fuel Connectivity)
- Basal Gap (Bare Ground Connectivity)
- Vegetation Structure
- Biomass (Productivity)
- Greenness (Vigor/Phenology)

Applications
- Runoff and Erosion Prediction
- Fire Behavior (Next-Gen Fuel Models)
- ANPP, Ecosystem Health, and Forages
- Habitat Quality Assessment (sage-grouse)
Challenges Potentially Requiring Advanced Sensor Technologies

Parameters
• Bare Ground
• Litter Cover
• Plant Species Composition
• Invasive Plant Species

Applications
• Runoff and Erosion Prediction
• Nutrient/Carbon Cycling Quantification
• Biodiversity Measurement
• Integrated Pest Management

SWIR Imagery needed to tease apart litter from bare ground.

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AIM-Monitoring: A Component of the BLM Assessment, Inventory, and Monitoring Strategy

Terrestrial Core Indicators

- Bare Ground
- Non-Native Invasive Sp.
- Plant Species of Concern
- Plant Canopy Gap
- Vegetation Composition
- Vegetation Structure

Goal:
Extend, scale and/or replace ground-based measurements with those acquired with UAVs.

UAV-Based Canopy Gap

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Quantifying Snow Depth using UAV imagery and Structure-from-Motion for Water Supply Forecasting.

Differencing of Snow-Off and Snow-On DSMs yields Snow Depth.
The challenges of sUAS for agricultural research

<table>
<thead>
<tr>
<th>Data type</th>
<th>Precision</th>
<th>Accuracy</th>
<th>Frequency</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field data</td>
<td>Very high</td>
<td>Very high</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Satellite data</td>
<td>High</td>
<td>High</td>
<td>Variable</td>
<td>Low</td>
</tr>
<tr>
<td>UAV data</td>
<td>Very high</td>
<td>Variable</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

- Satellites – high overpass frequency, but clouds may obscure the view, so data frequency can be low for optical imagery
- UAVs –
  - in south Georgia lighting conditions change very quickly;
  - in the Western US, haze in the afternoons; dealing with smoke and shadows;
- Need to quantify impacts for sUAS data.
Working on these:
UAVs can be very useful IF...

1. We can manage for and correct data quality problems due to uneven illumination
2. We can quickly evaluate issues of spectral data quality in post-processing
3. We can show a linkage between our field data and drone imagery
   1. *Which parameters are better with drone vs. field data?*
   2. *In the Western US, potential benefit is high due to cost and sparcity of field data.*
4. We can downscale satellite imagery to our fields
5. We can manage UAV data at the network level

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Main features of this plan, when it is fully developed, will include:
- best practices for mission planning,
- data collection,
- storage protocols,
- metadata collection,
- and a transfer mechanism for archiving and network-wide research use.
What is required for coordinated network level research using UAVs?

- Across LTAR, sUAS data provide a means of “bridging the gap” between low repeat, high resolution, and high repeat, low resolution satellite imagery.
- Scientists in LTAR are integrating sUAS datasets as inputs to models that characterize and forecast agroecosystem dynamics.
- Further steps are required to curate sUAS data that is incorporated into research projects.
Thank you

ANY QUESTIONS?

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