Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Reflections on using Remote Sensing for Irrigated Agriculture

Anne M. Smith

Agriculture and Agri-Food Canada

Research Centre, Lethbridge, Alberta

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Canada

Agricultural Production

Optimize inputs

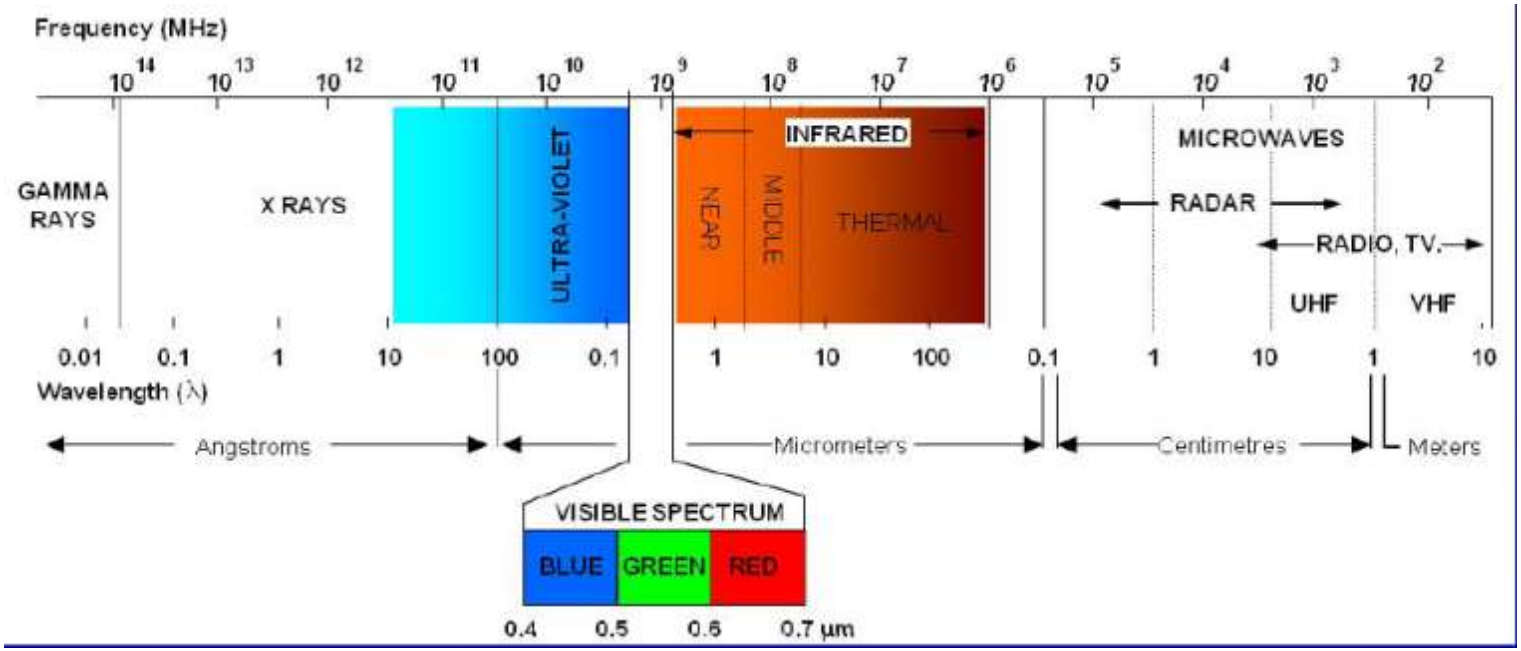
Maximize yield and quality

Maximise profit

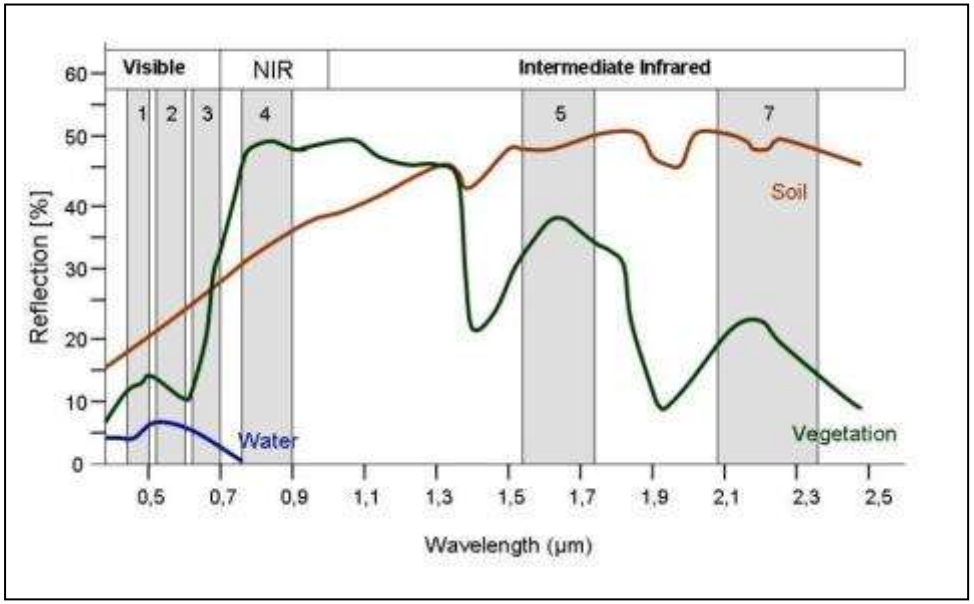
Can remote sensing help?
What are the considerations?

What is remote sensing?

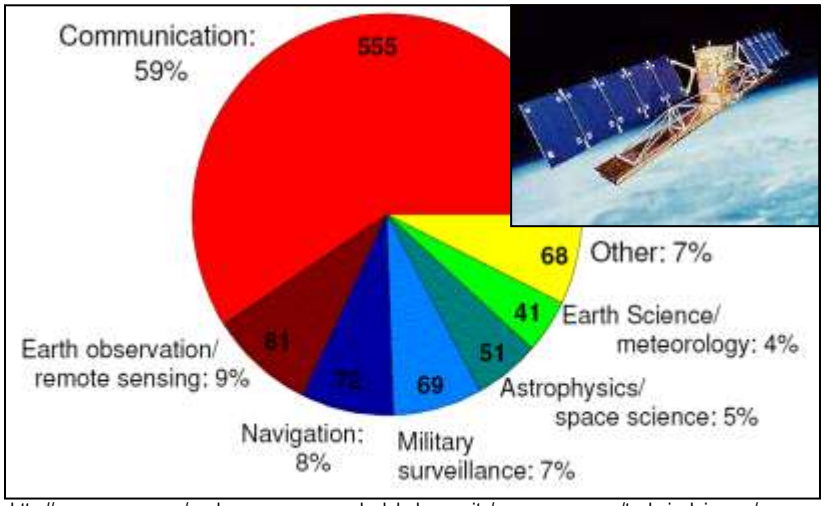
- Acquisition of information about the Earth's surface from a distance.



- Hyperspectral
  - many contiguous bands
- Multispectral
  - fewer broad bands



Remote sensing platforms



http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ucs-satellite-database.html

Variety of platforms

Considerations in selection of sensor system

- Swath width and spatial resolution
  - regional or field level
- Temporal resolution
  - frequency of information, changes over time
- Spectral resolution
  - visible-infrared, thermal, broad bands versus narrow bands,
- Cost
  - is the return sufficient to justify the cost
- Qualitative versus quantitative information
  - general patterns, relative differences within a time frame or a field or absolute difference across fields and time, calibrated versus non-calibrated images

Satellite sensors

Sensor	Swath width (km)	Spatial resolution (m)	Spectral bands	Temporal resolution (Days)	Cost
AVHRR	2399	1100	4	1	$0.00 /km^2
MODIS	2330	250 500 1000	2 5 29	1	$0.00 /km^2
Landsat-5 Landsat 7 ETM$^+$	185	30 60	6 1	16	$0.00/km^2
SPOT-5	60	5 10-20	1 4	26	4.00^\#$/km^2
RapidEye	77	5	5	5.5	1.40^\#$/km^2
Quickbird/ Worldview	16.5	0.5/0.6 2.0/2.4	1 4	3.5	22.00^\#$/km^2
Airborne/UAS	Variable	Variable	Variable	As required	$4.00-$7.00 /ac

minimum area requirement (differs based on archived or tasked acquisitions)

Spatial resolution

UAS – 0.075 m
(> 1 million)

Worldview – 2.4 m (~110,000)

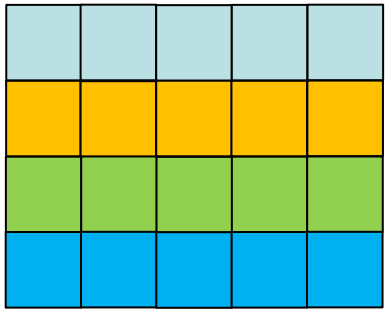
RapidEye – 5 m (~26,000)

SPOT 20 m (~1600)

Landsat, Radarsat – 30 m (~900)

Spatial resolution

For a homogeneous feature to be detected, its size generally has to be equal to or larger than the resolution cell.

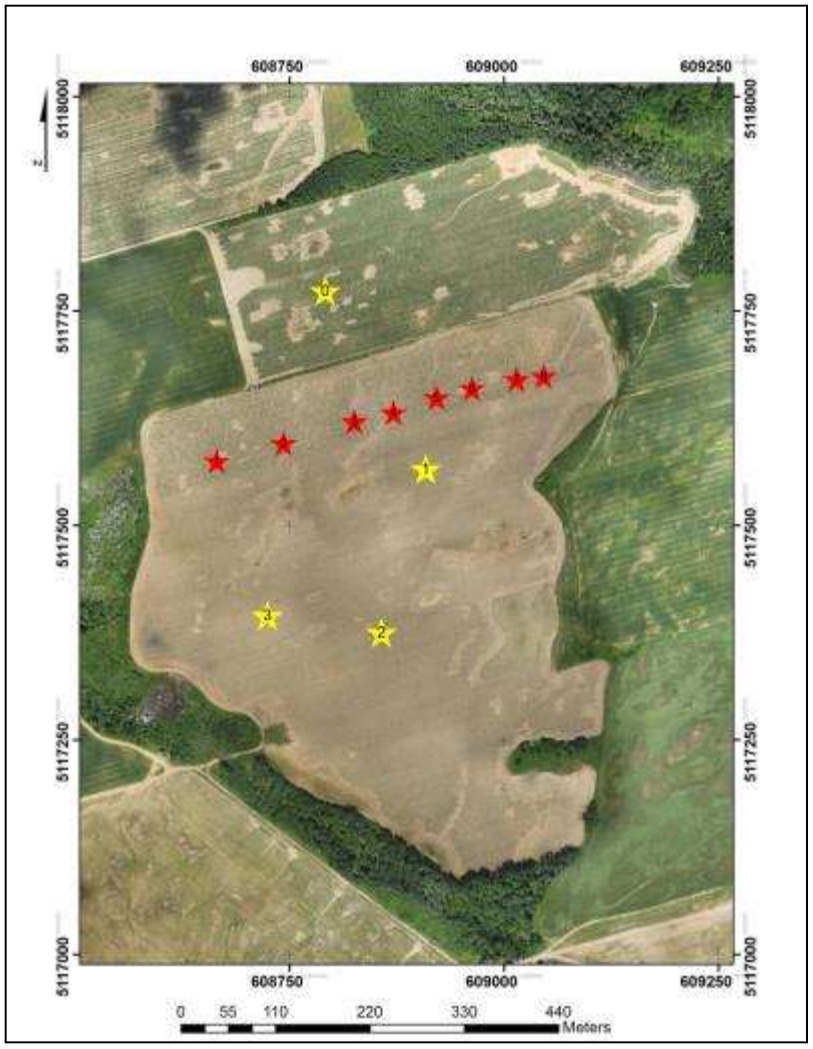


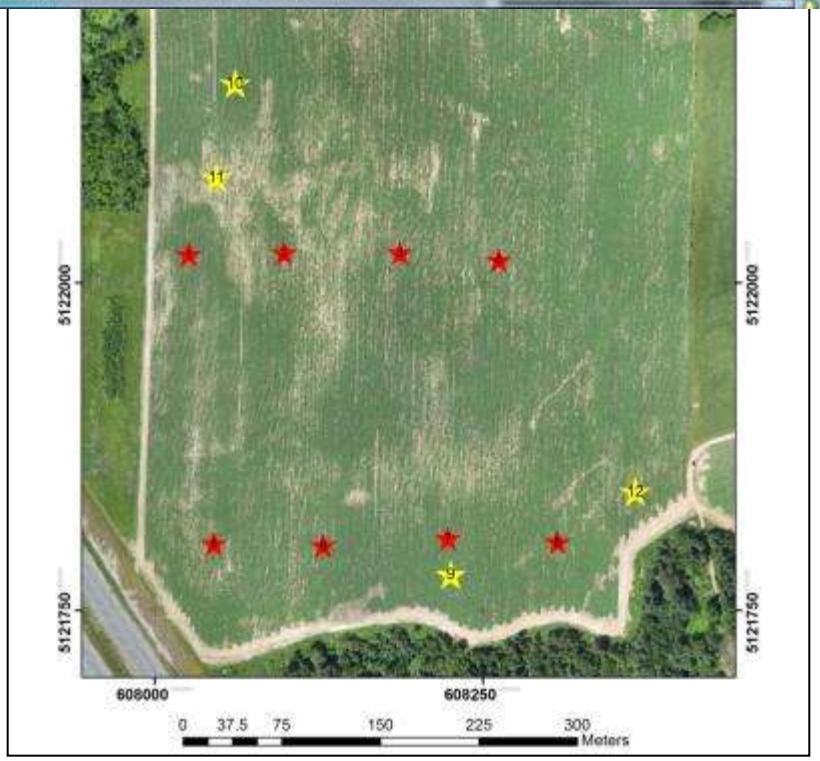
Spatial resolution

Landsat 7 ETM+
multispectral

IKONOS
multispectral

Spatial resolution





True colour composite images from an Unmanned Airborne System (spatial resolution 7.5 cm)

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Airborne/UAS	-	cm	Variable	As required	$4.00-$7.00 /ac

minimum area requirement (differs based on archived or tasked acquisitions)

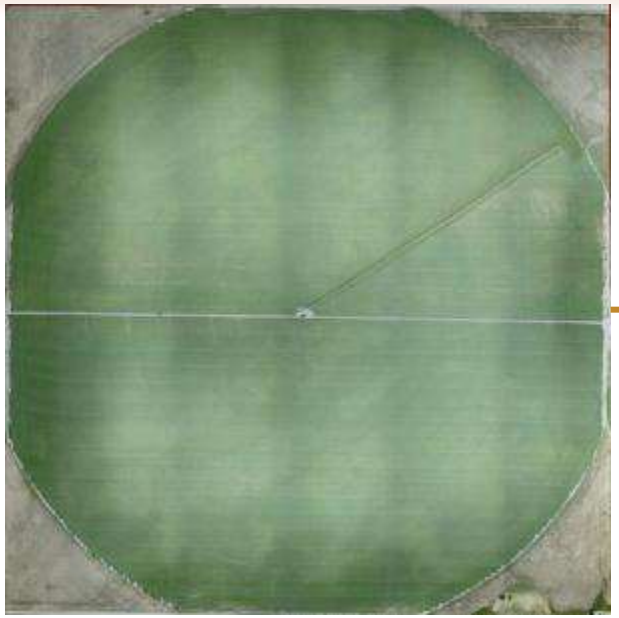
Unmanned Aerial Systems

UAS Imagery

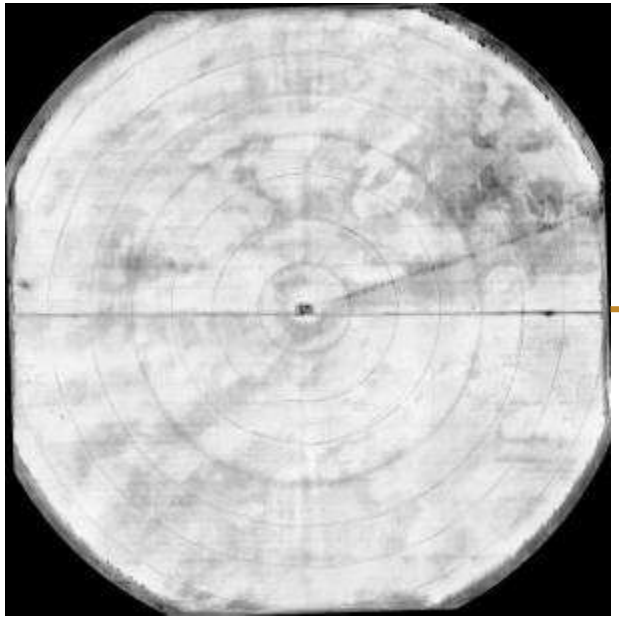
- Flexibility in time
- High spatial resolution
- Spectral resolution
- Tailor to site
- Turnaround time
- Atmospheric effects

Unmanned Aerial Systems

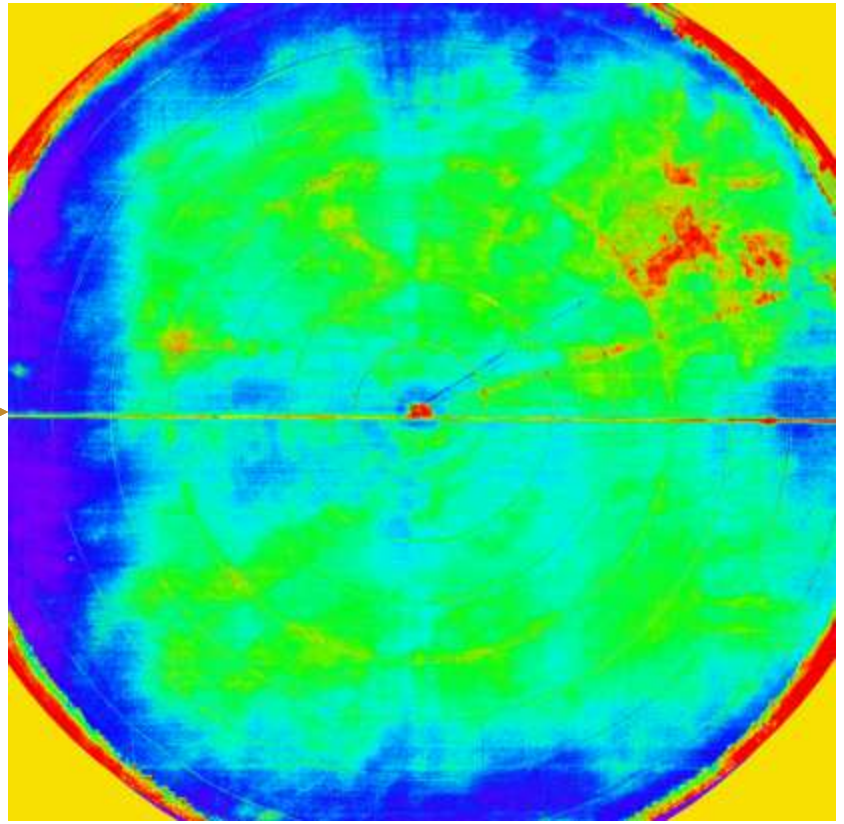
True colour composite image



Infrared image



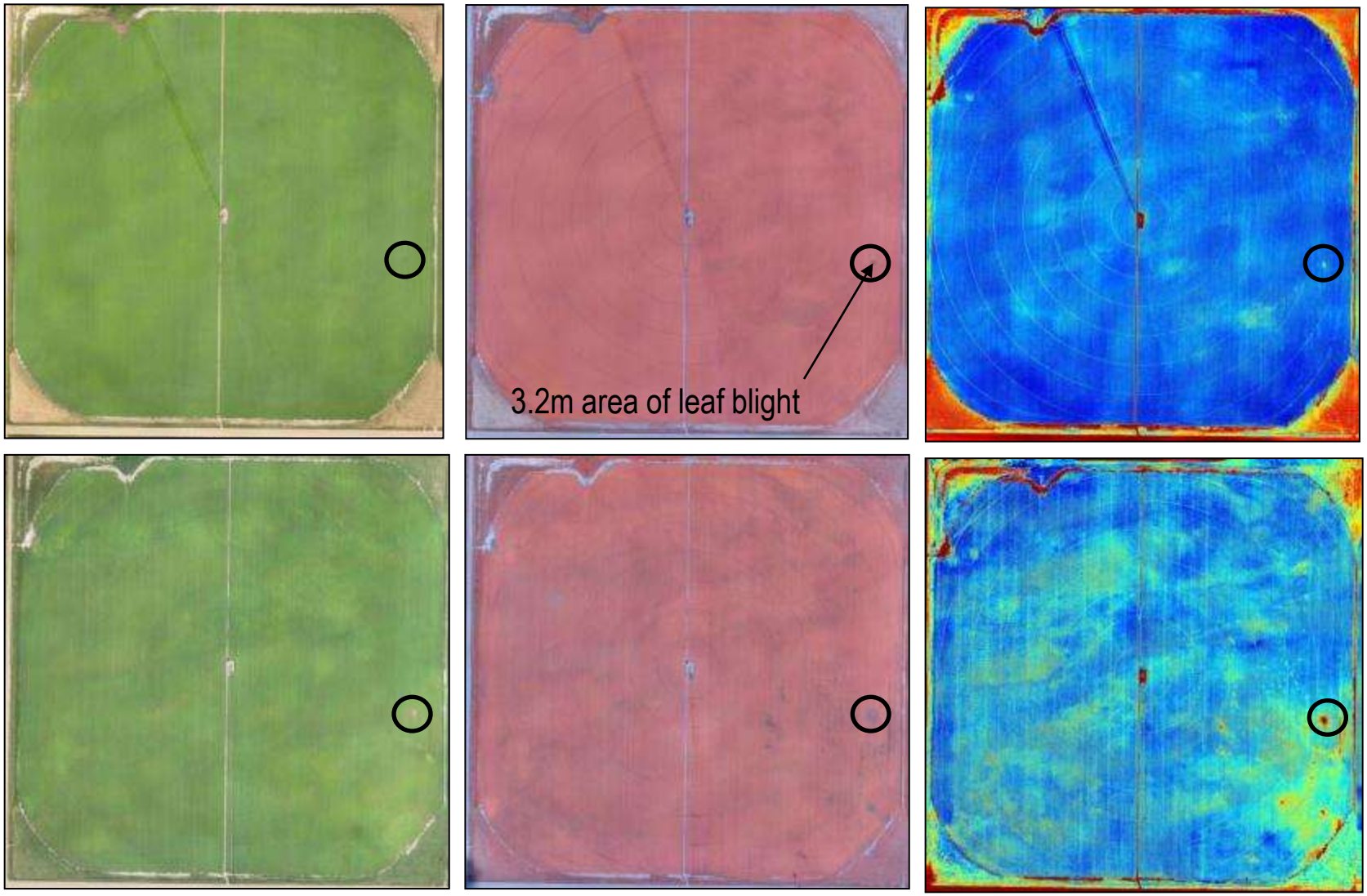
$$\text{NDVI} = \frac{(\text{NIR} + \text{red})}{(\text{NIR} - \text{red})}$$



Blue = Dense or healthy vegetation,
Yellow and red = Less dense or unhealthy vegetation

Images courtesy of ISIS Geomatics and CKP Farms

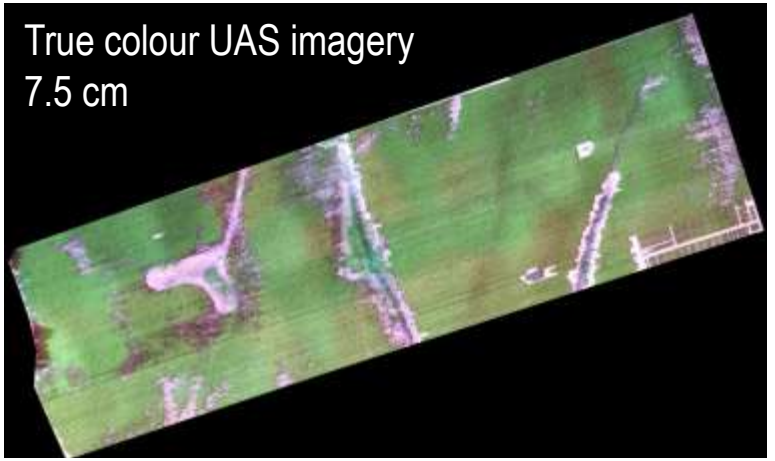
True colour composite | False colour composite | NDVI image



UAS Images acquired July 14, 2013 (top) and July 30, 2013 (bottom)

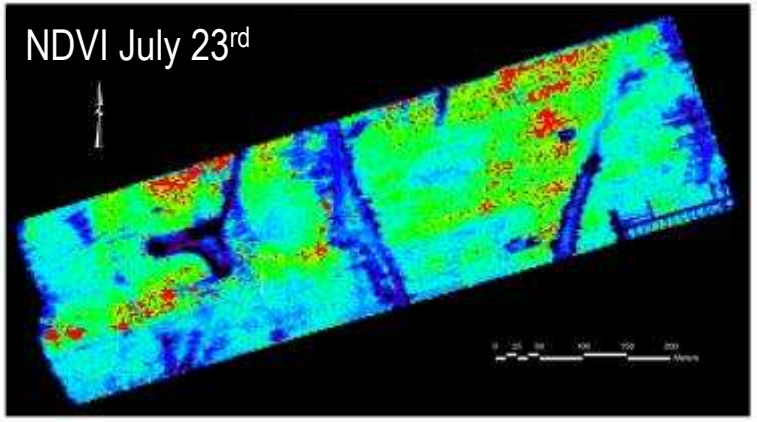
Unmanned Aerial Systems

Project Title: Improving Grower Profitability and Competitiveness Through Mitigation of Limitations to Potato Yield

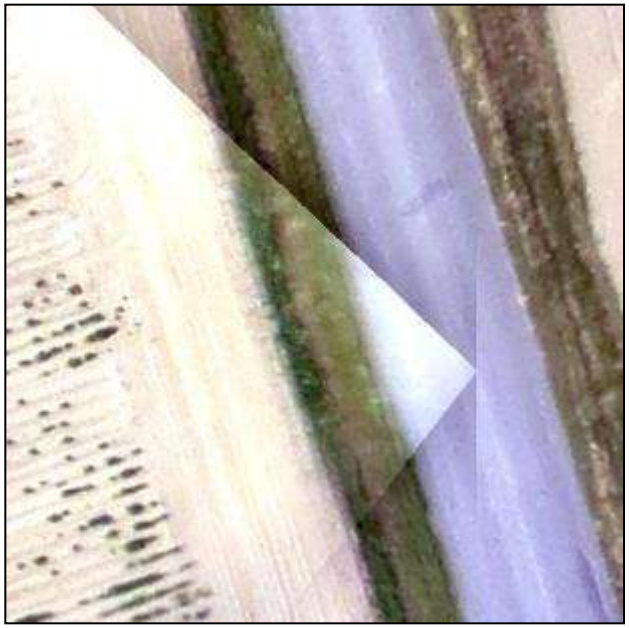


Challenges

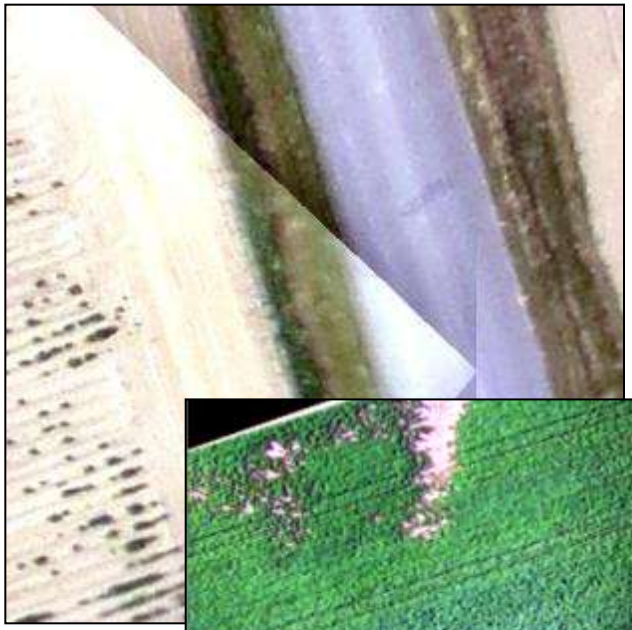
- Mosaic of images
- Illumination
- Time to acquire images
- Calibration
- Size of images

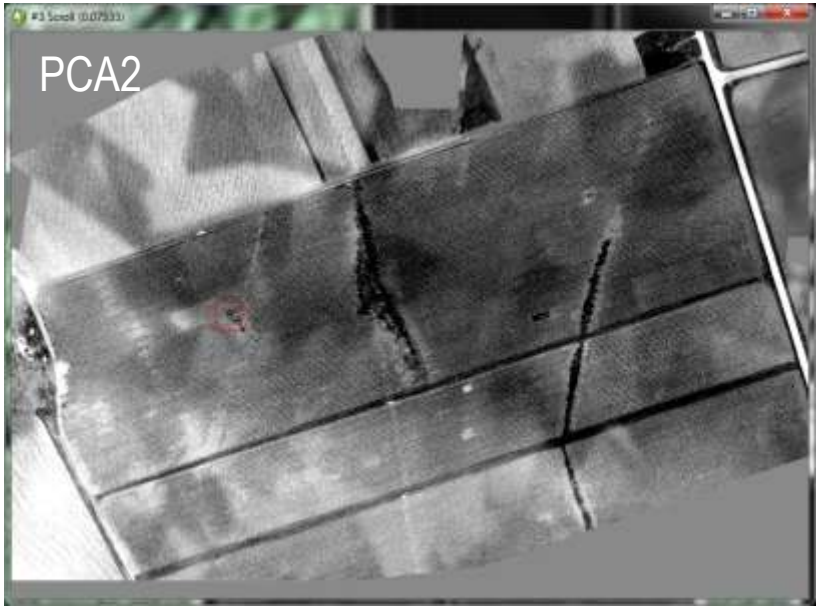


Unmanned Airborne System Images



Unmanned Airborne System Images





Unmanned Airborne System Image Acquisition

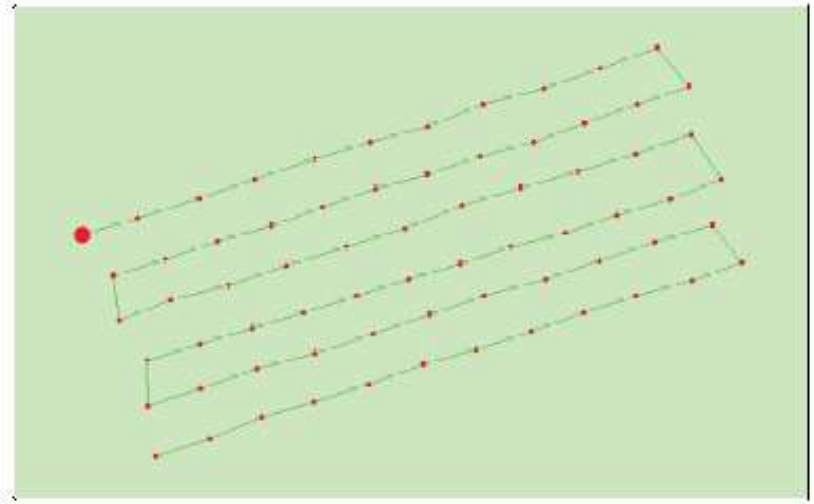
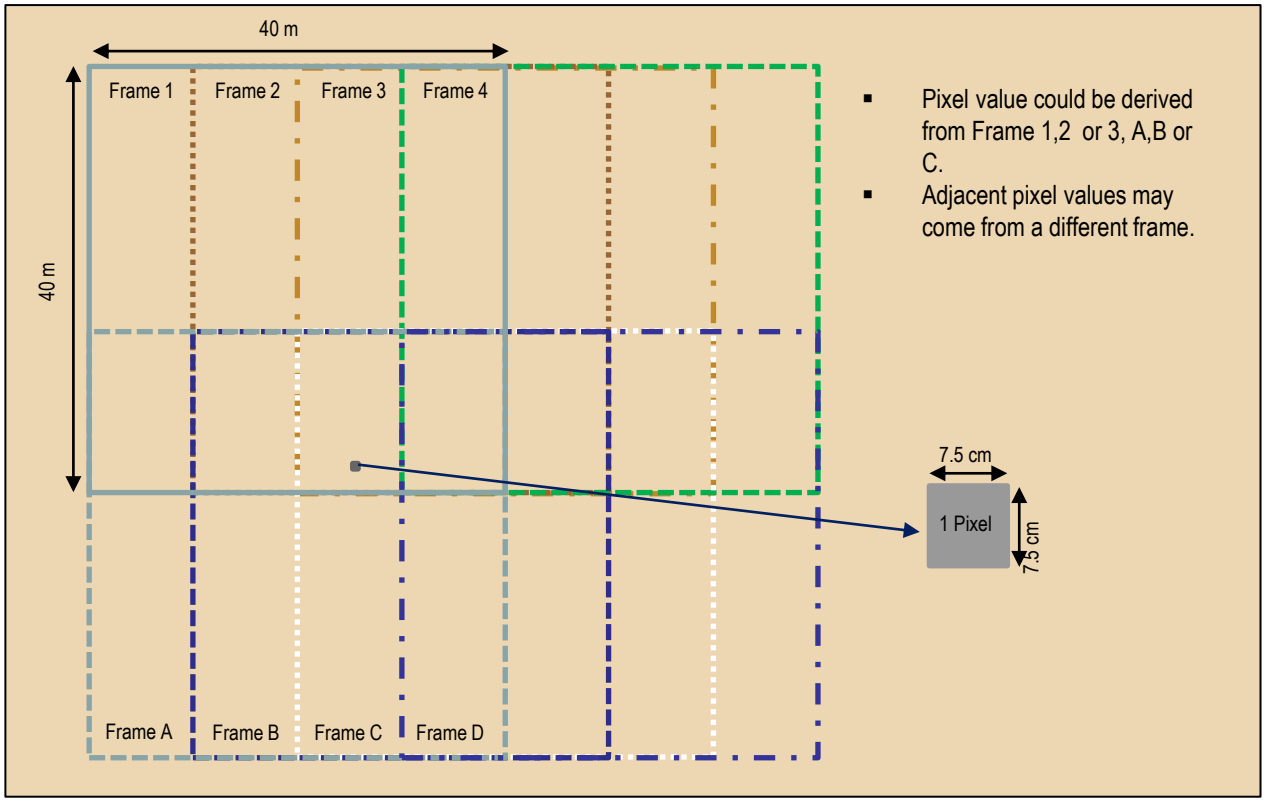


Figure 2: Top view of the geotags. The green line follows the geotag in time staring from the large red dot.

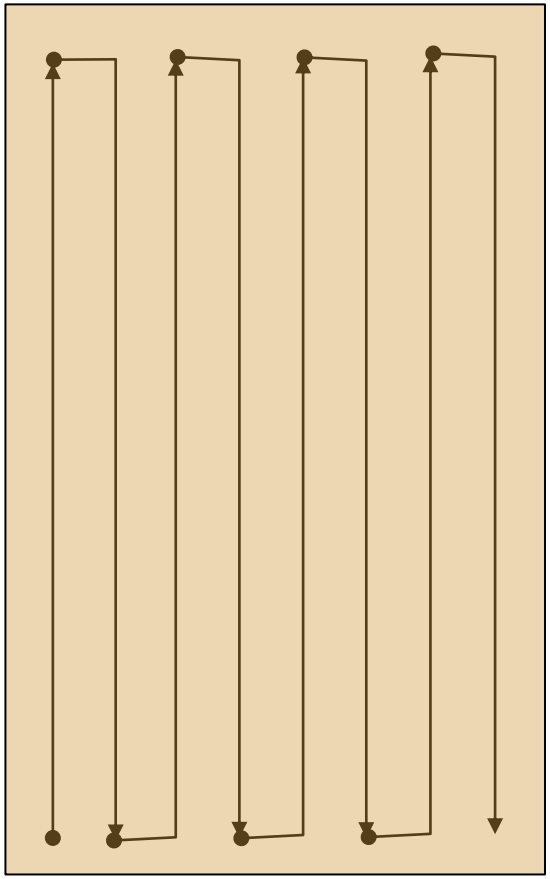
Quality Check

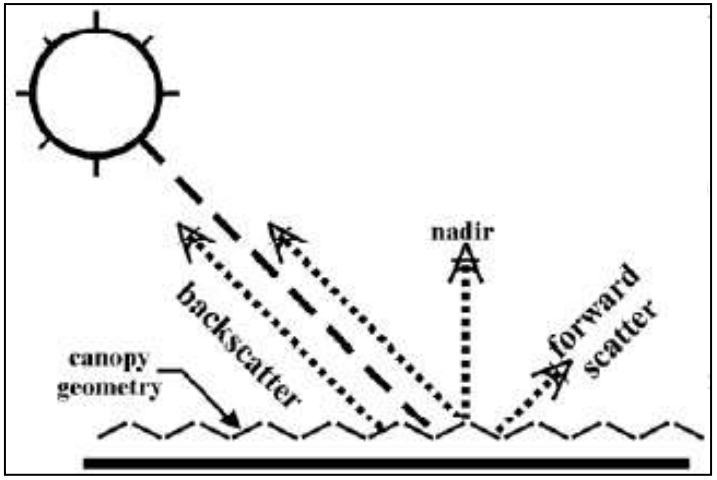
Images:	median of 102684 keypoints per image	✓
Dataset:	69 out of 69 images calibrated (100%)	✓
Camera optimization quality:	0.37 % relative difference between initial and final focal length	✓
Matching quality:	median of 10086 matches per calibrated image	✓
Georeferencing:	no GCP	⚠

Unmanned Airborne System Image Acquisition



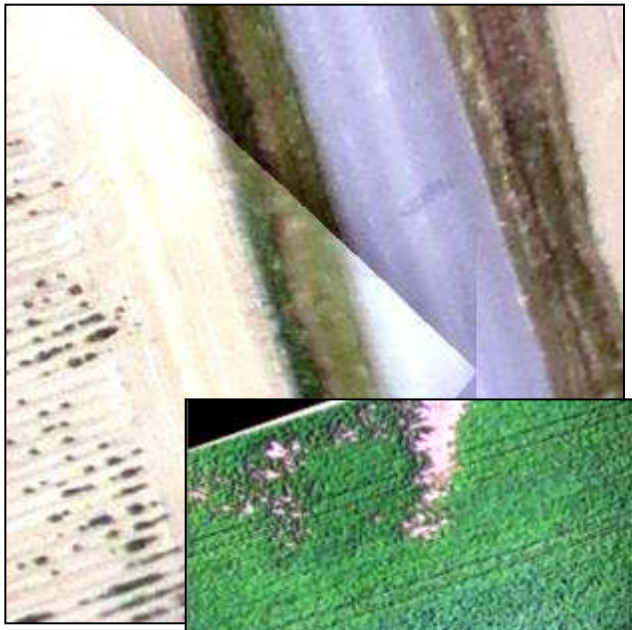
Unmanned Airborne System Image Acquisition



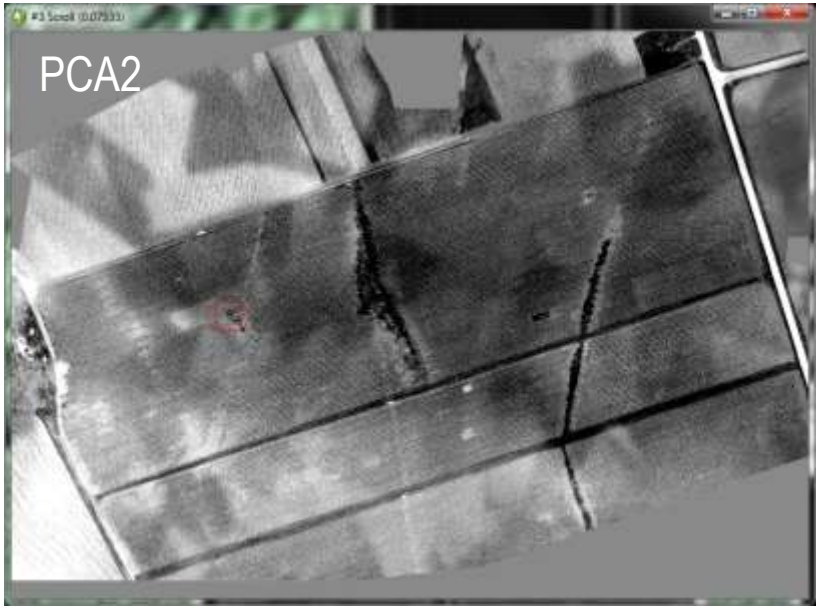


Pixel values based on single frame or average of all frames?

Unmanned Airborne System Images

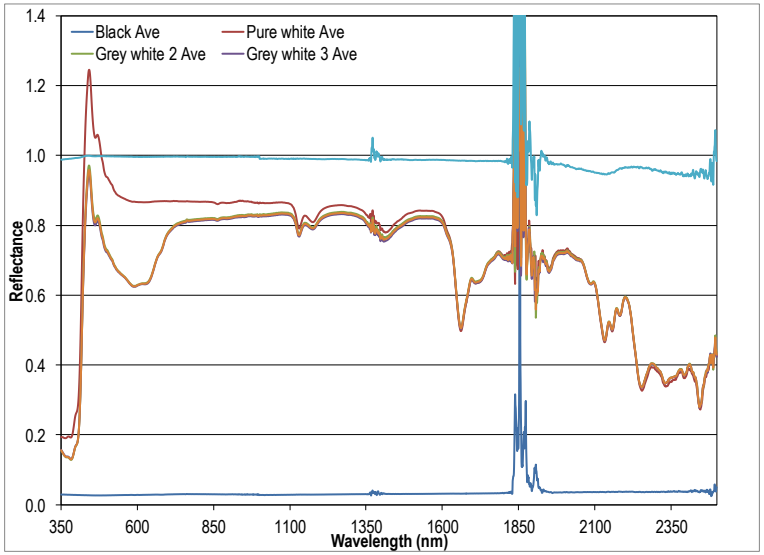


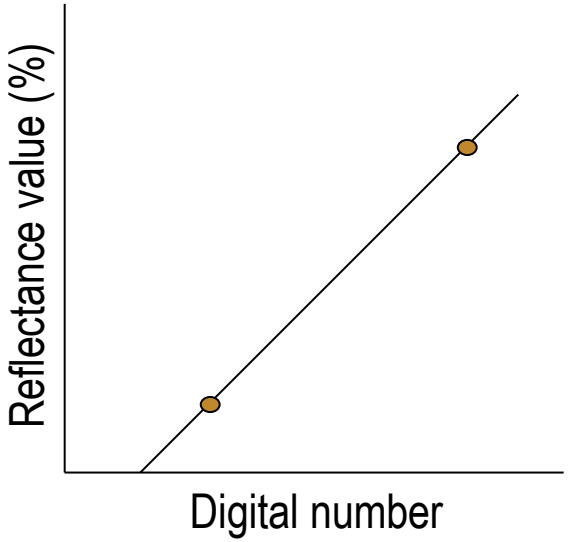
Are these problems?



Unmanned Airborne System Image Acquisition

- Images delivered as digital numbers
- 0-255 DN
- Rescale to reflectance
- Compare across dates and fields





Factors influencing image pixel values

- Agronomic factors
  - Soil factors
    - organic matter, texture, mineralogy, crop residue, water content
  - Plant factors
    - canopy closure/fractional cover, growth stage, varietal differences, canopy architecture, “greenness”, moisture content
- Non-Agronomic factors
  - illumination, view angle, row orientation, topography, meteorological phenomena

Challenge

- Limited number of bands of data with response often being due to an interaction of factors

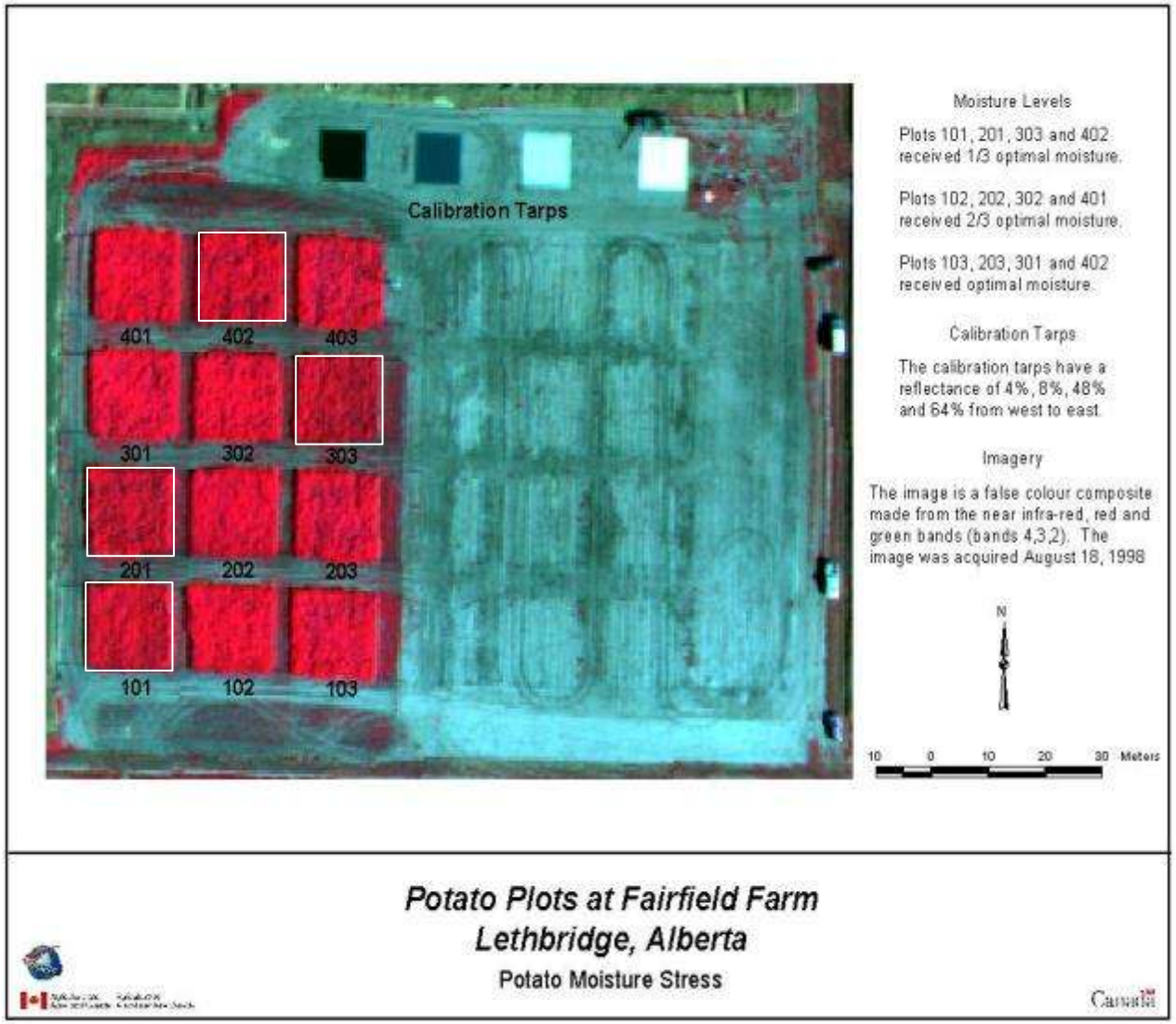
- “A significant challenge for agricultural remote sensing applications is to be able to separate spectral signals originating with a plant response to a specific stress from signals associated with normal plant biomass or the background “noise” that is introduced by exogenous non-plant factors.”

Pinter et al 2003. PERS 69:647-664

Applications of remote sensing?

- Mapping variability
  - Soil variability
  - Crop growth, biomass and yield
  - Crop stress due to moisture, nutrient, weeds, disease
  - Crop growth stage
  - Crop evapotranspiration
- Management zones
- Targeted sampling or scouting
- Quantitative measures of plant characteristics and potential yield implications

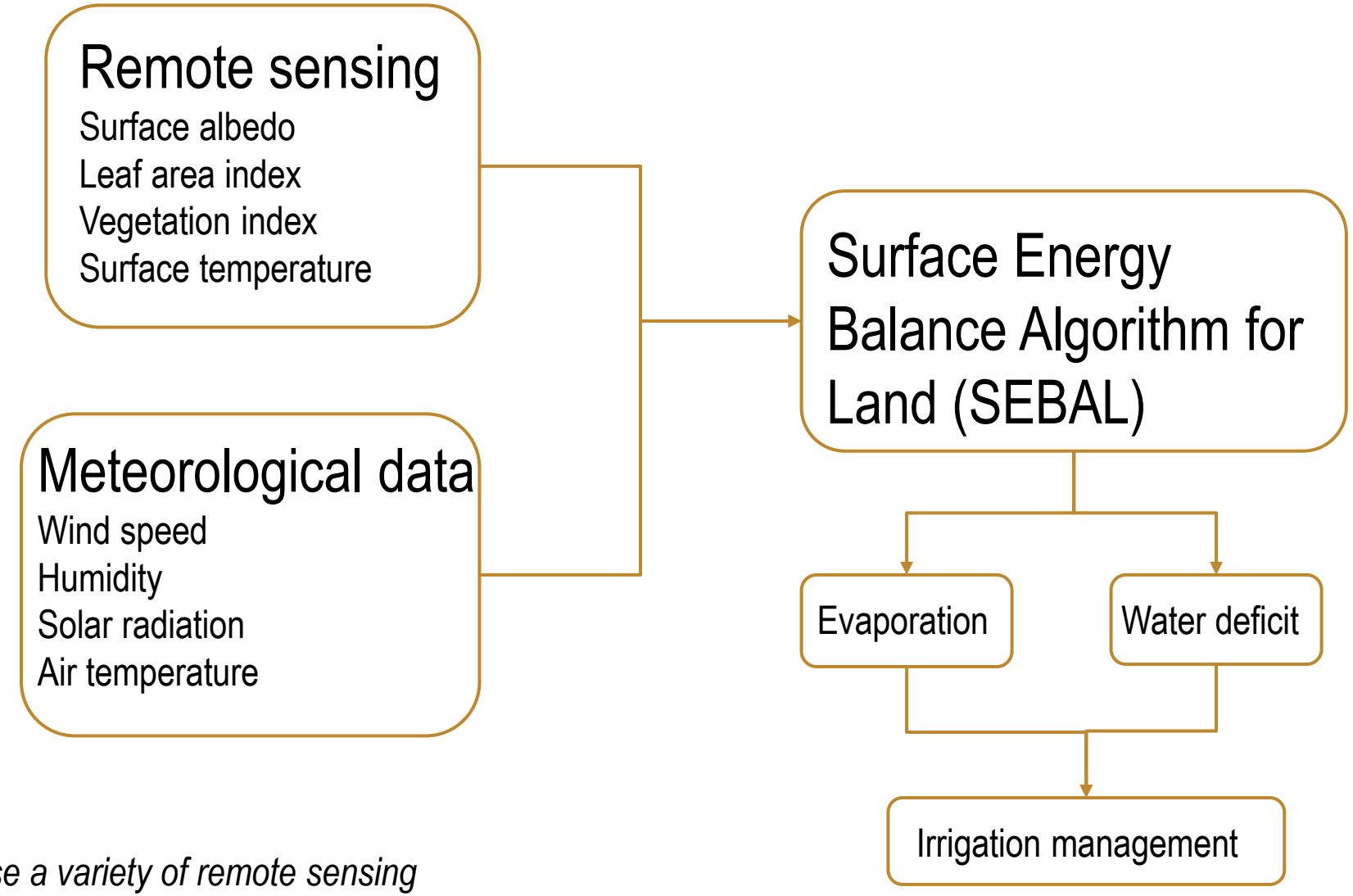
Mapping moisture stress using visible-infrared remote sensing



- Reflectance differed in with moisture treatments.
- Chronic versus acute moisture stress

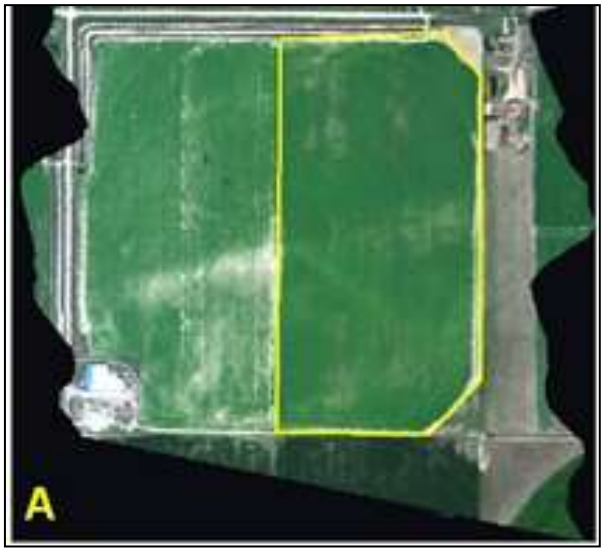
Sensor systems may not be optimal for identifying acute moisture stress

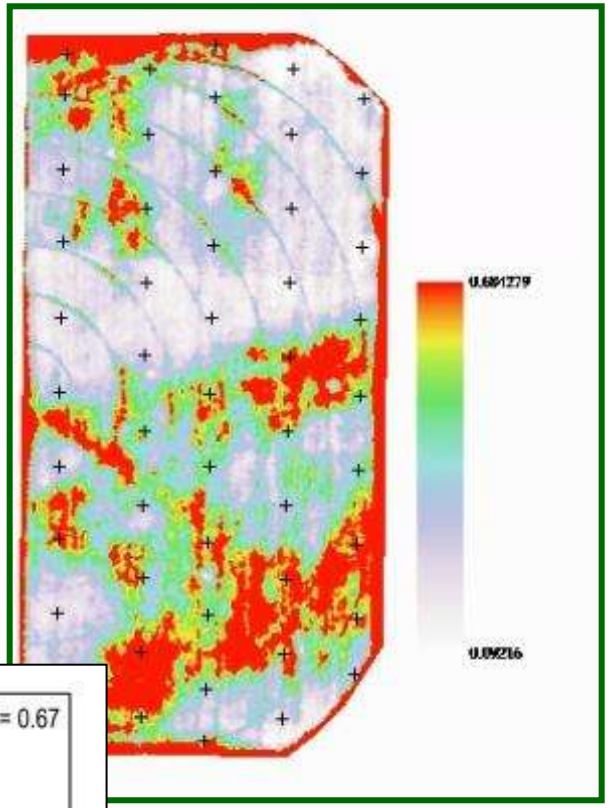
Integration of remote sensing data to derived information



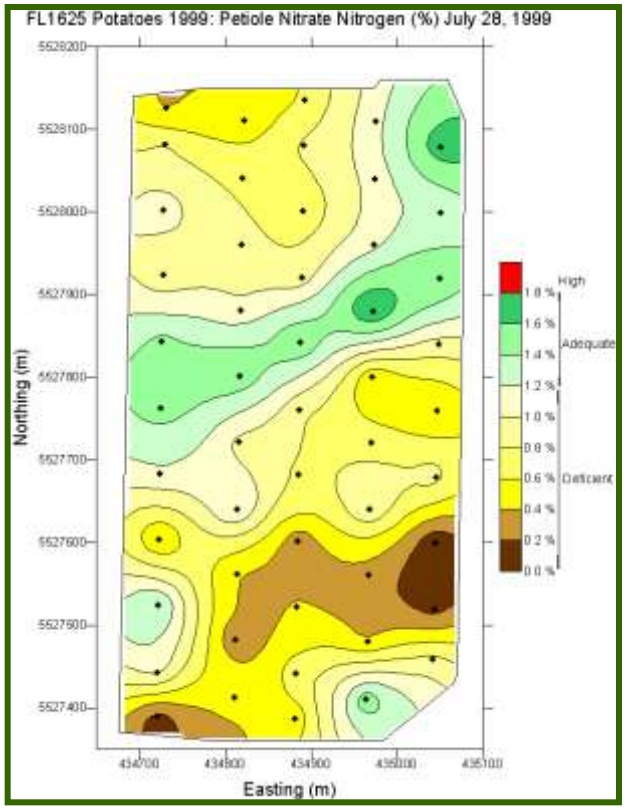
Can use a variety of remote sensing images of different spatial resolutions

Nitrogen management

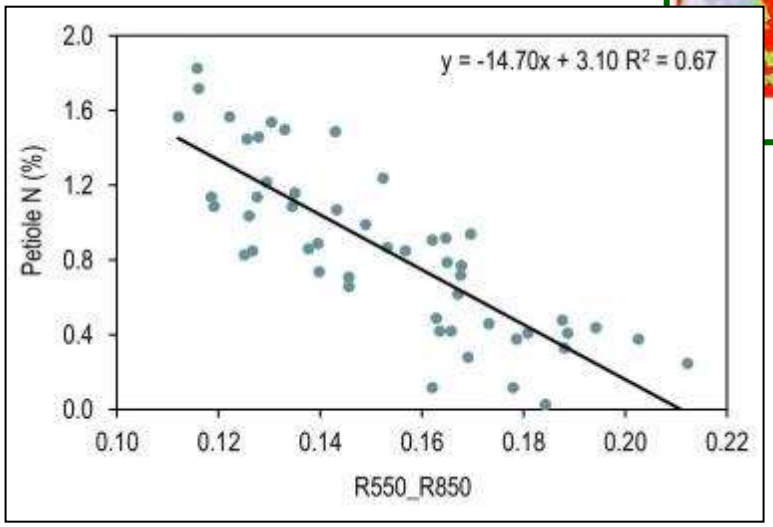




Green/NIR ratio



Petiole N sampling



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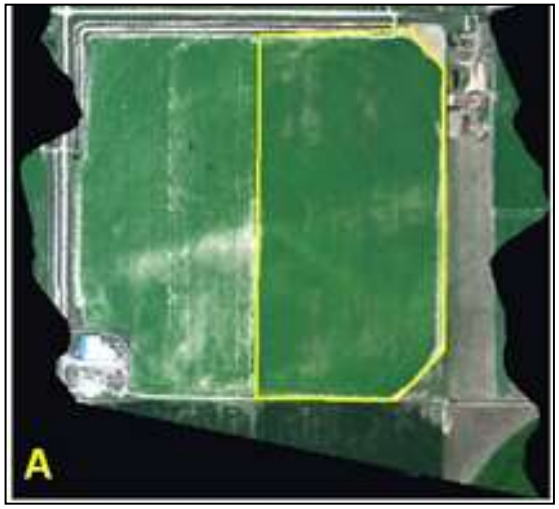
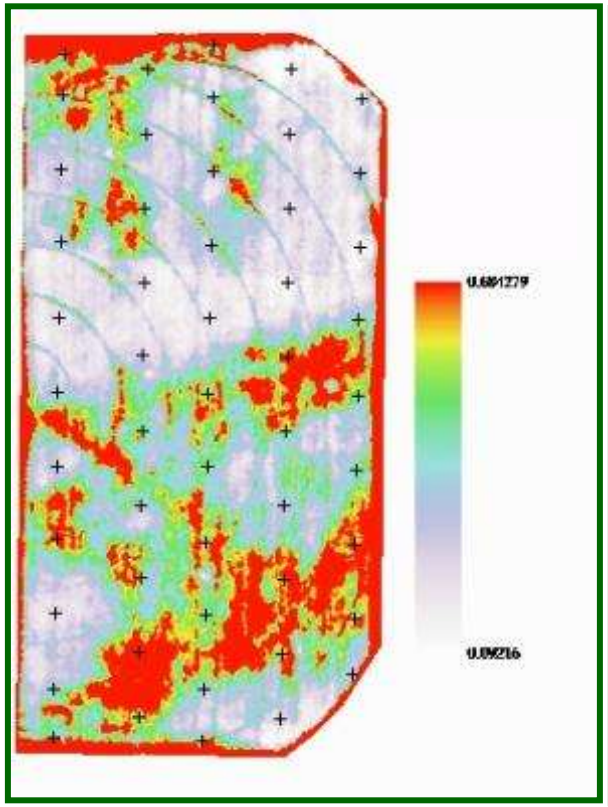
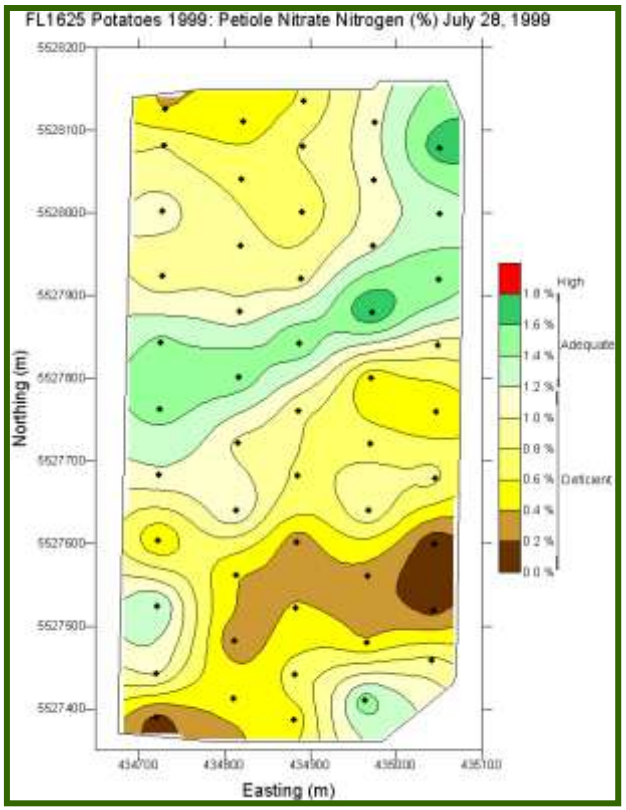




Green/NIR ratio



Petiole N sampling

$$\text{Nitrogen sufficiency index} = \frac{(NIR/green)_{area\ of\ interest}}{(NIR/green)_{reference}}$$

Nitrogen rich strips, natural local reference areas

Final thoughts

- Remote sensing can provide valuable information on spatial variability of plant and soil biophysical parameters which can be used directly or indirectly in management practices
- Substantial advances in enhancing spatial, temporal and spectral resolution of remote sensing data
- Unmanned aerial systems
  - can improve the timeliness of data collection and enable collection of data at a scale that allows management of within field variability
  - challenges in using the data that require further investigation

Final thoughts

- Remote sensing offers a simple scouting tool or can be integrated with other datasets to provide information

What is the information you want?

What spatial resolution do you want to manage?

Stand-alone or part of an integrated dataset?

Is remote sensing the best solution?