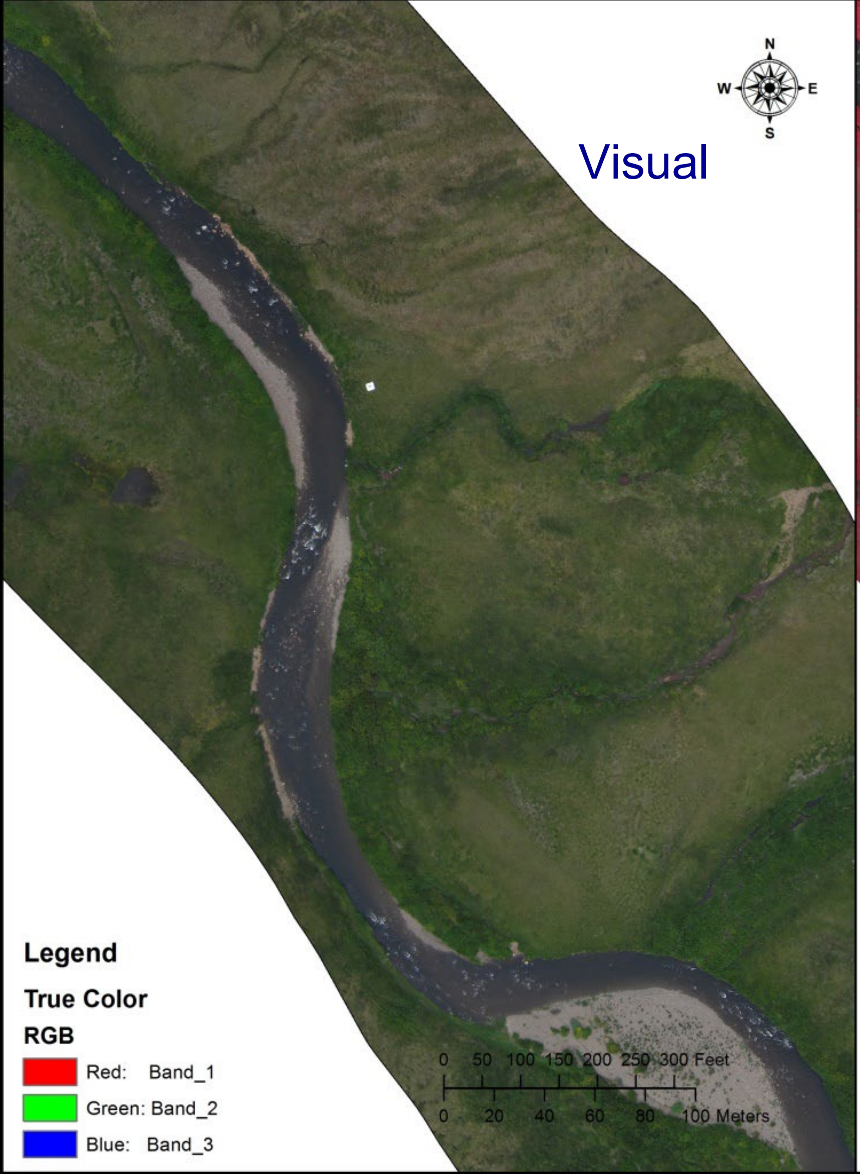
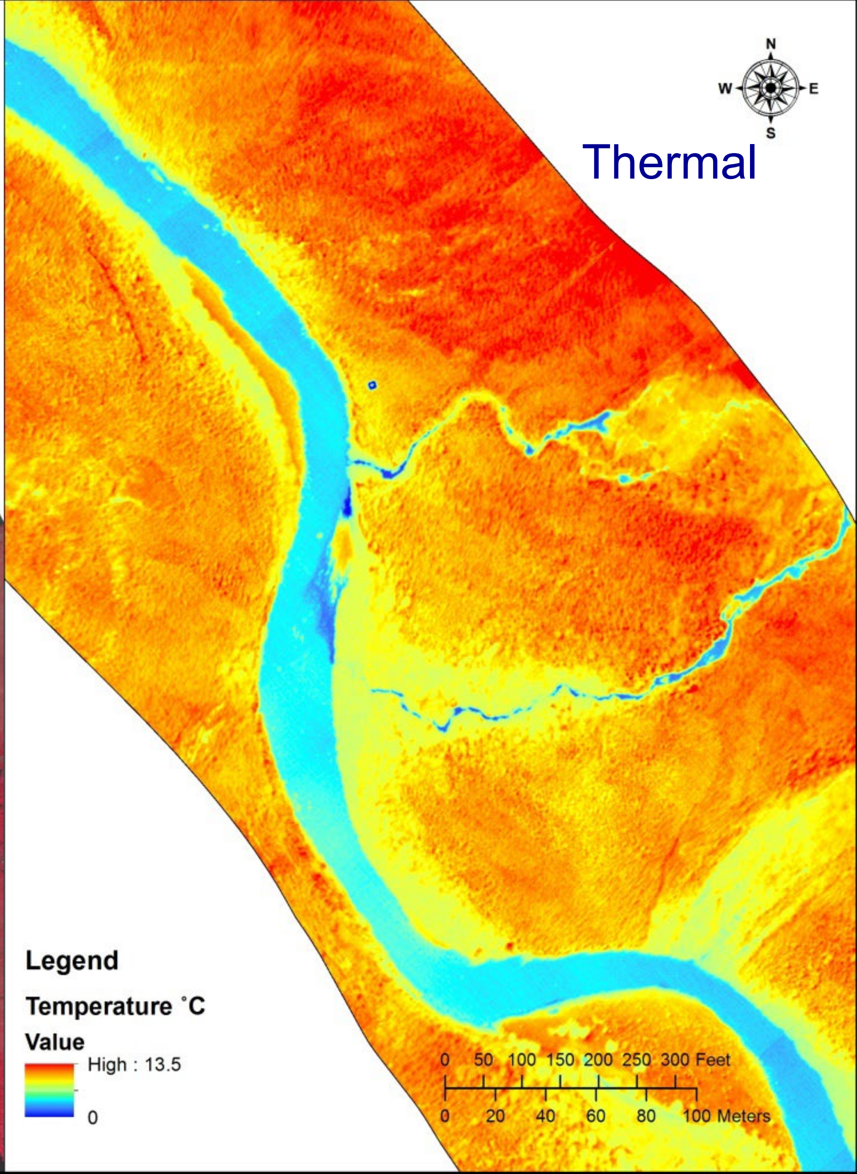
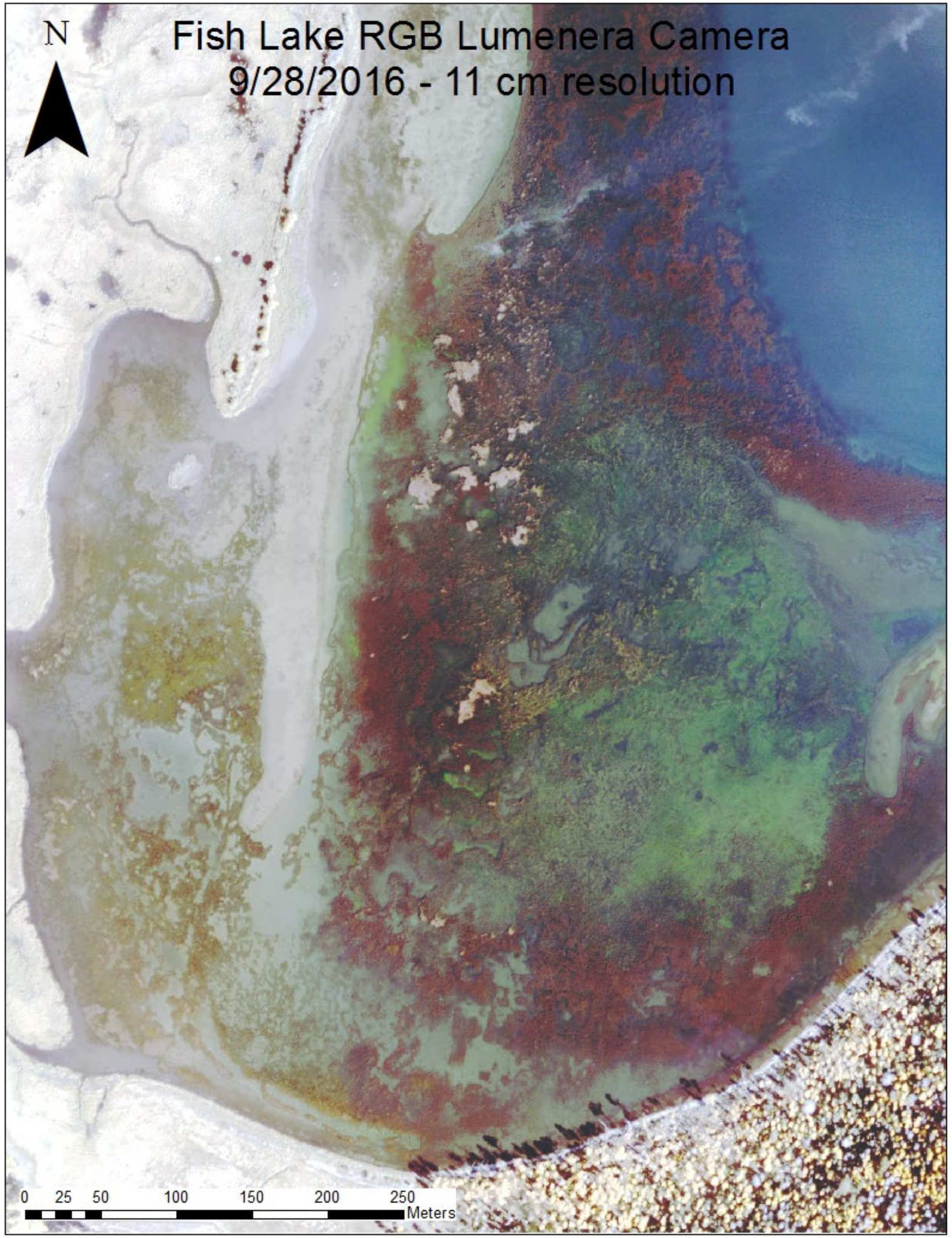




Introduction to Remote Sensing Technologies

by: Mac McKee
Prof. Emeritus, Utah State University

for the ELI Remote Sensing Workshop
March 2024

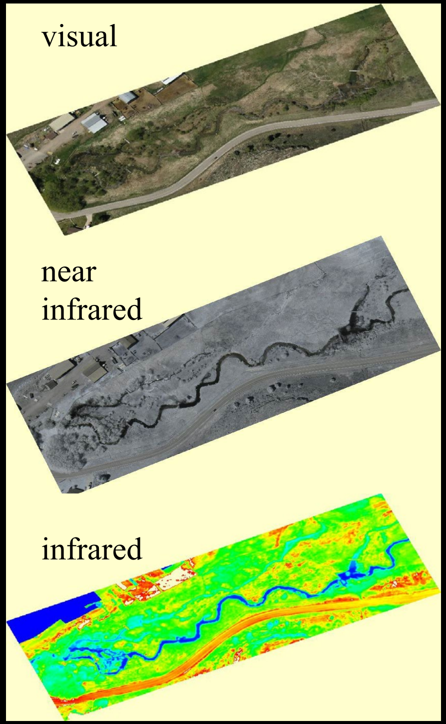


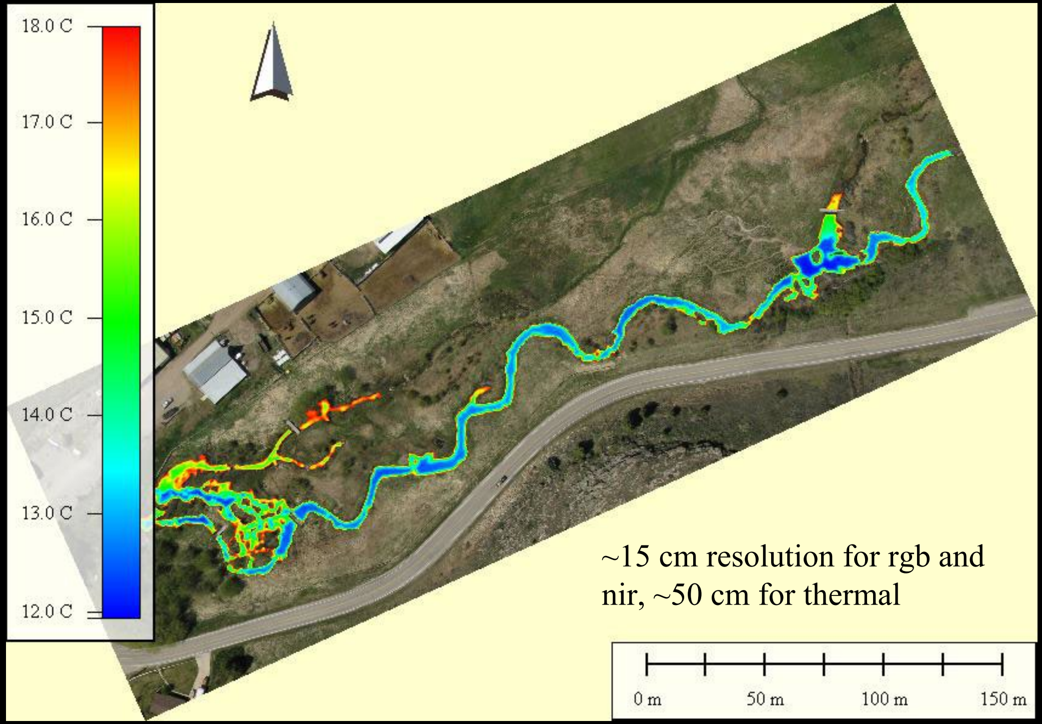
Flight Plan:

- Remote Sensing (RS): What is it?
- (Super) Basic Principles of RS
- A few examples from AggieAir
- Challenges to UAS-based RS
- Questions

Remote Sensing ("RS"):

- Acquire data without disturbing the object(s) of interest
- Transform data into information
- Information needs should drive everything else
- Tradeoffs between satellite and airborne/UAS for RS





- Tradeoffs among UAS platforms:

VTOL

Fixed-Wing

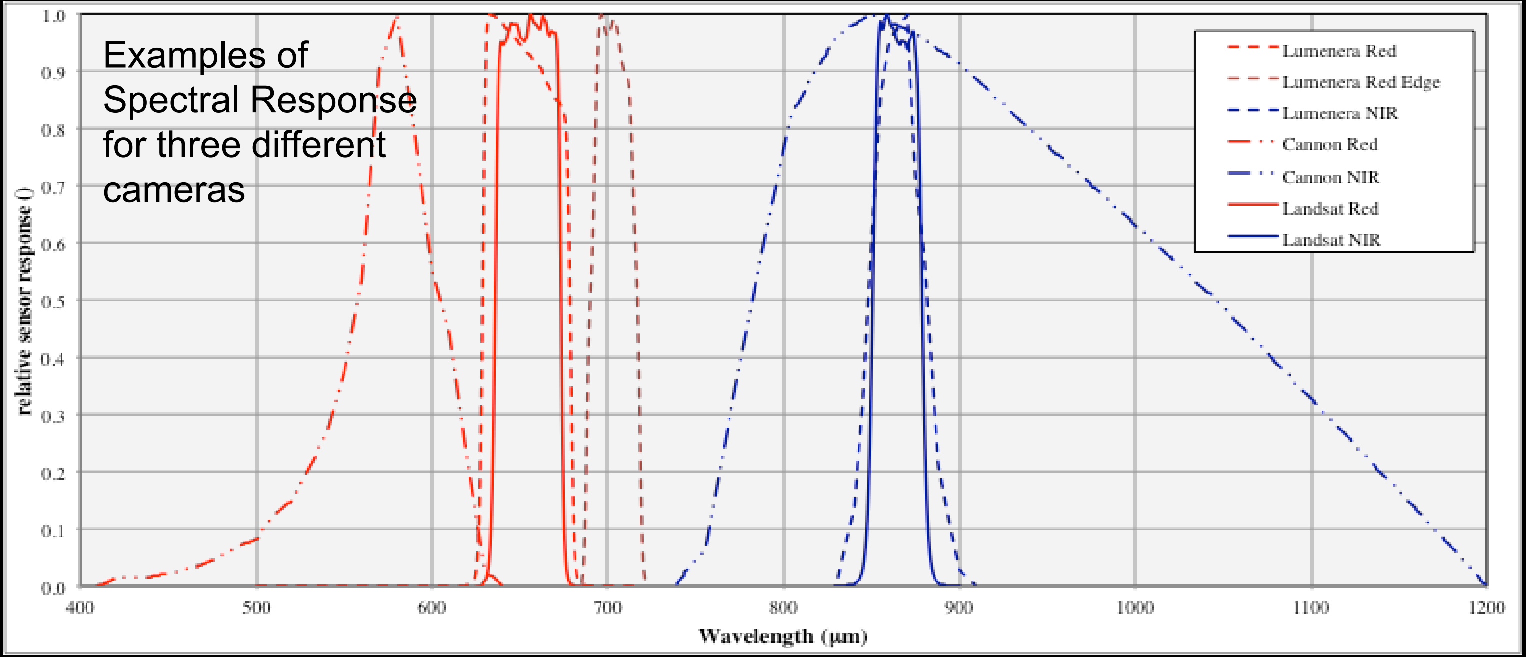
Hybrid

	VTOL	Fixed-Wing	Hybrid
Cost:	Low	High	High
Difficulty:	Low	High	Intermediate
Coverage:	Low	Intermediate	High

Remote Sensing Basic Principles:

Background:

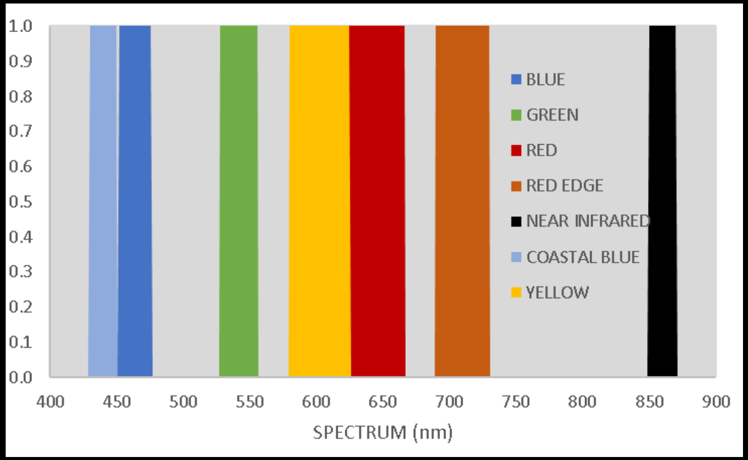
- Millions of pixels for each image; hundreds or thousands of images per RS flight
- Each pixel holds a digital number ("DN") = amount of light energy reflected (called "reflectance") from a corresponding point on the earth's surface
- The quality of this data is a function of:
  - ➢ Spectral fidelity
  - ➢ Positional accuracy
  - ➢ Spatial resolution
  - ➢ Radiometric resolution



Remote Sensing (Super-) Basic Principles:

Spectral Fidelity:

- Most analyses require data from specific, narrowly defined spectral bands.
- Transforming “data” into “information” requires that the data meet specific scientific standards.
- Thus, sensors must be carefully selected and field protocols must be rigorously followed.



Selection of sensors with the desired spectral performance; addition of narrowband optical filters that match desired light wavelengths.

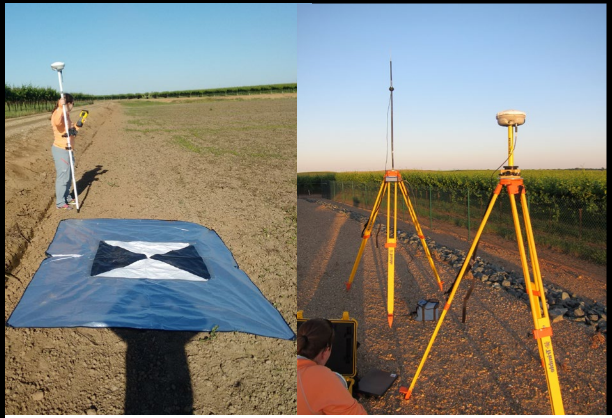
Lambertian calibration for every flight to correct for:

- Camera vignetting
- Camera exposure and gain

Remote Sensing Basic Principles:

Positional Accuracy:

- The overlapping images collected in a single RS flight must be stitched into a composite image, or “mosaic”.
- This requires ground control points whose GPS coordinates are precisely known.
- Expected positional error of the mosaic pixels should be minimized, especially if repeat flights are planned.



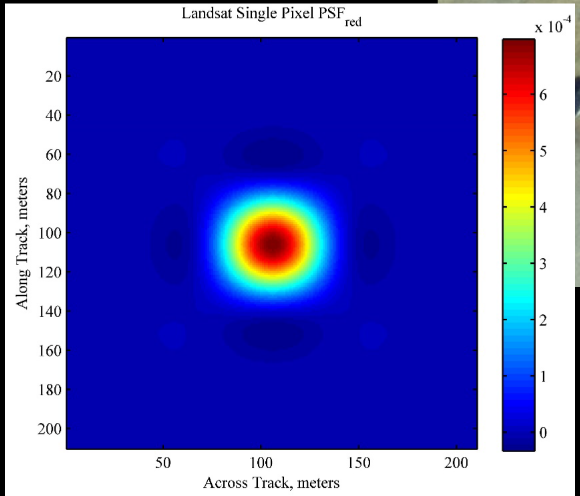
Survey-grade GPS and a significant number of ground control points for accurate image stitching

Remote Sensing Basic Principles:

Spatial Resolution:

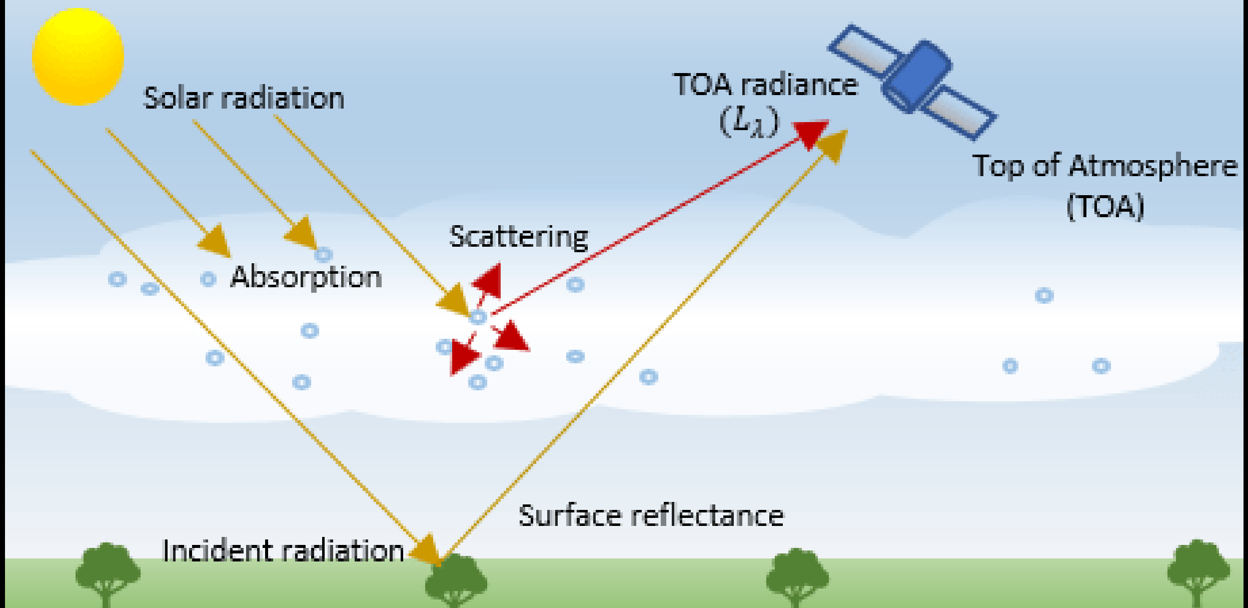
- Sensor/camera characteristics and flight elevations must be selected to achieve the spatial resolution required by the problem.
- However, more megapixels does not necessarily mean more, or better, data (e.g., diffraction!)

The dreaded "point spread function"



Remote Sensing Basic Principles:

Radiometric Calibration and Resolution:

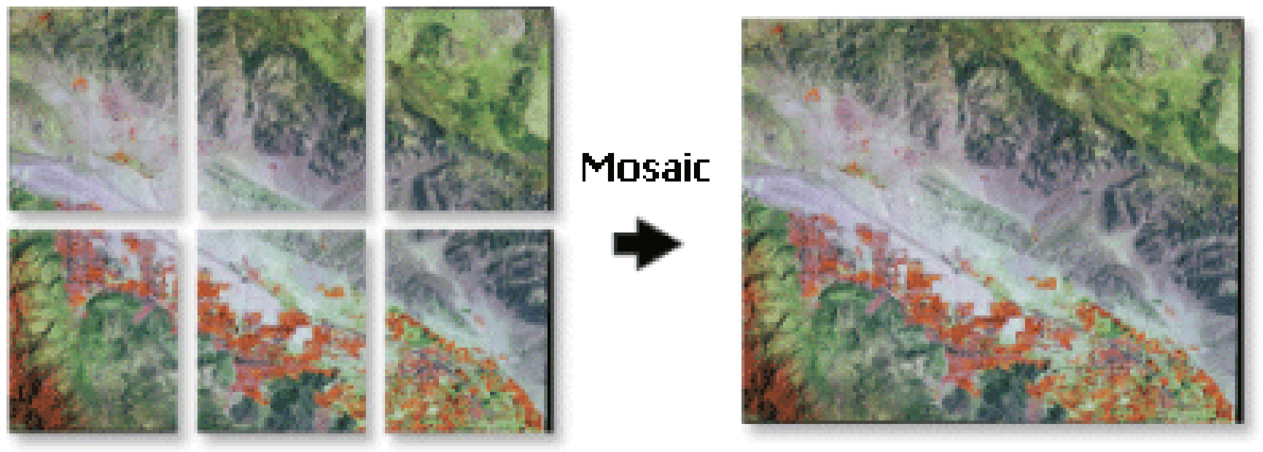


(image from: https://de.mathworks.com/help/images/hyperspectral-data-correction.html)

- Calibration: Correction of RS data to accurately represent reflectance
- Resolution: The precision with which a DN for a pixel can represent the light reflectance.
- Expressed as "bit depth", e.g., 0 to 255 for an 8-bit DN, 0 to 65,535 for a 16-bit, and so on.
- Greater bit depth means that the reflectance measured for a pixel will have greater resolution. This might have implications for the quality of the information generated from the DN data.
- Note: the size of the file that contains an image grows larger as bit depth increases.

Remote Sensing Basic Principles:

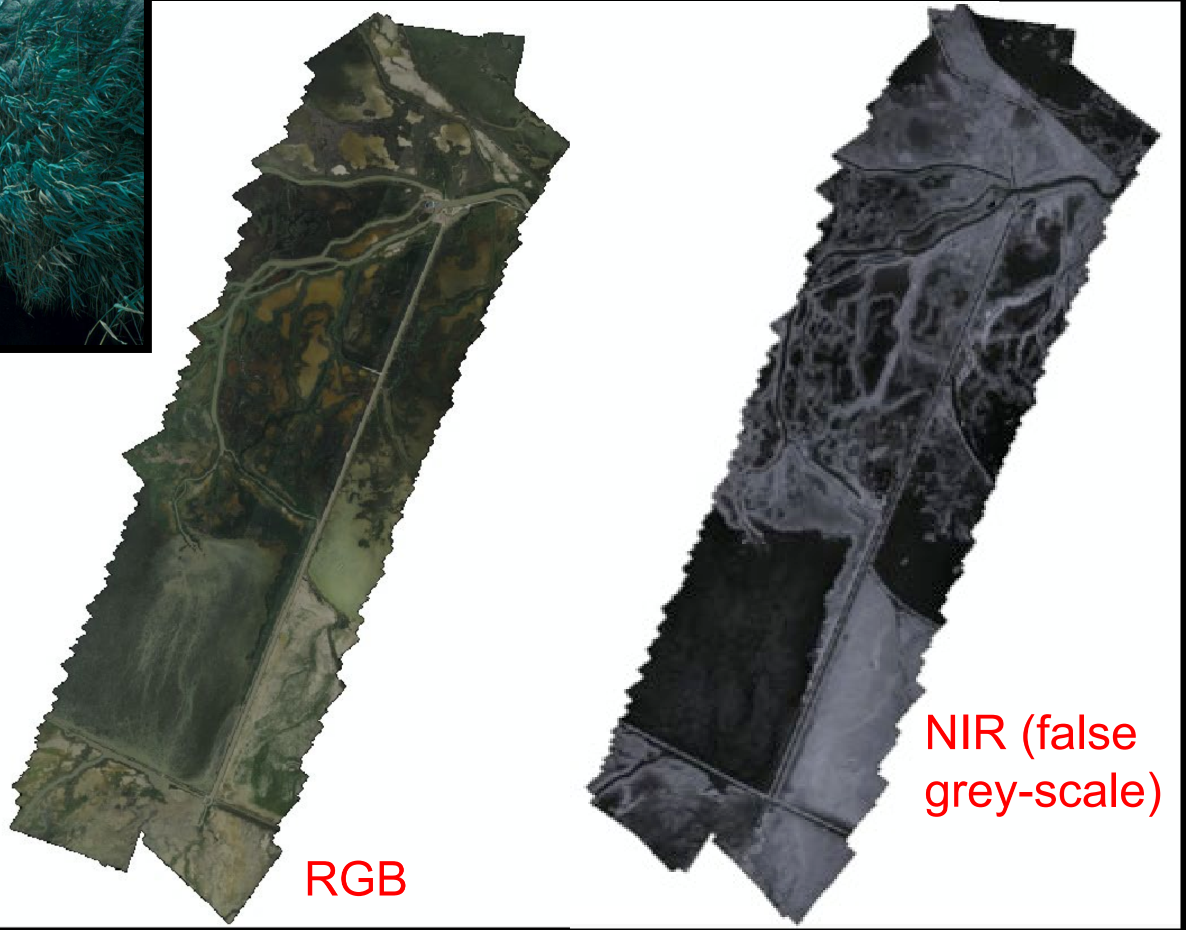
Image Processing Software for UAV RS:



(from: https://desktop.arcgis.com/en/arcmap/latest/manage-data/raster-and-images/what-is-a-mosaic.htm)

- Commercially available
- Based on classical photogrammetry (i.e., a ton of trigonometry and optimization)
- Easy to use, but buyer beware
- Does not scale well as geographic coverage increases:
  - Probably fine for most applications at, say, ~50 to 100 ha.
  - Not so much for a flight covering 10,000 ha.

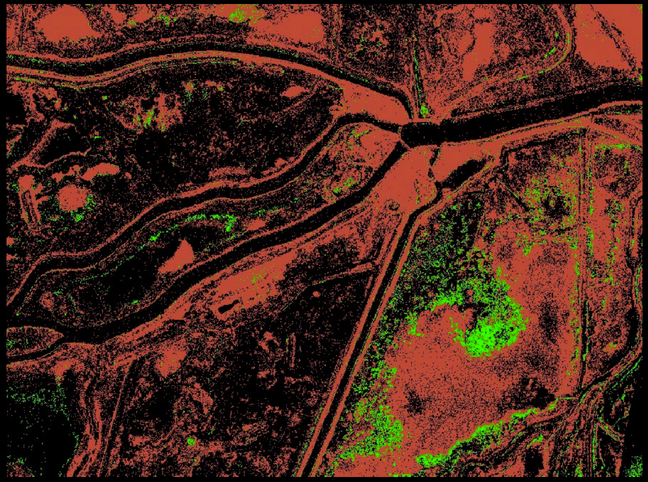
AggieAir Example: *Phragmites australis*



A wetlands on the Great Salt Lake, ~0.25 m resolution @ ~1,000 meters AGL

Post-flight Analyses:

Classification



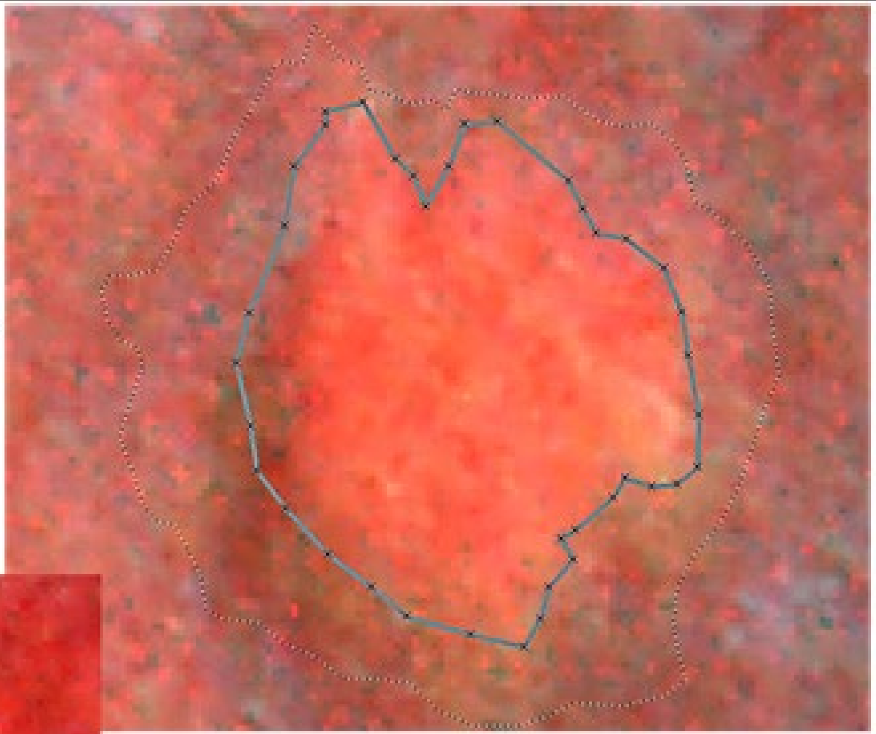
Change Detection

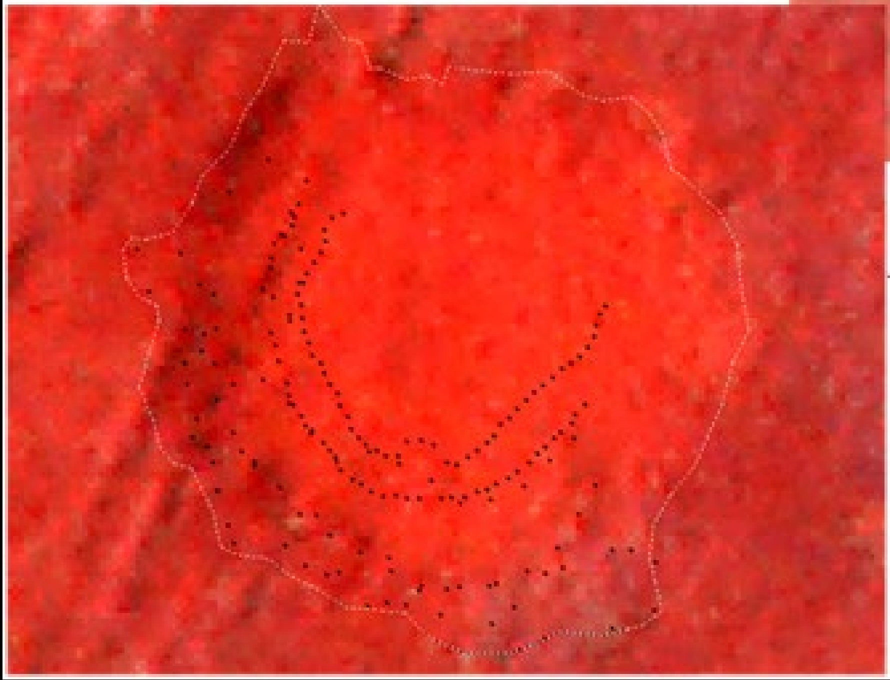
AggieAir Example: *Phragmites australis*

Patch 3A_01

Year 2010

- Imagery acquired on 17 June 2010
- Area of the Patch – 257 sq. meters





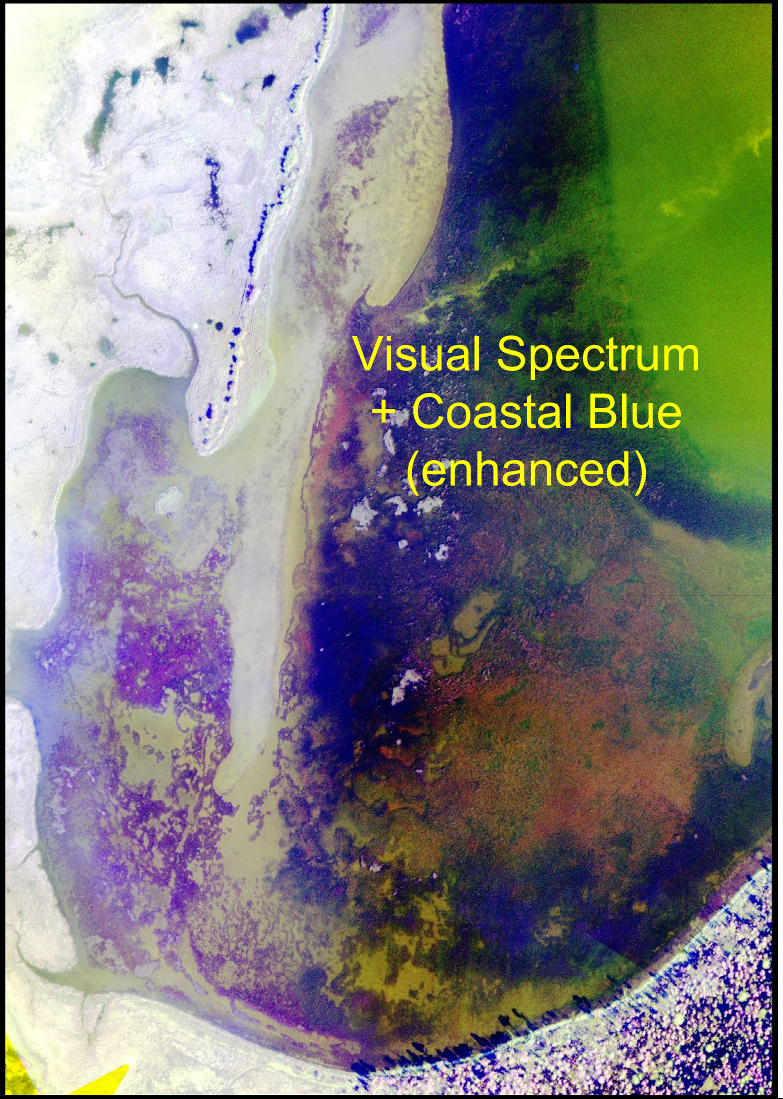
Year 2011

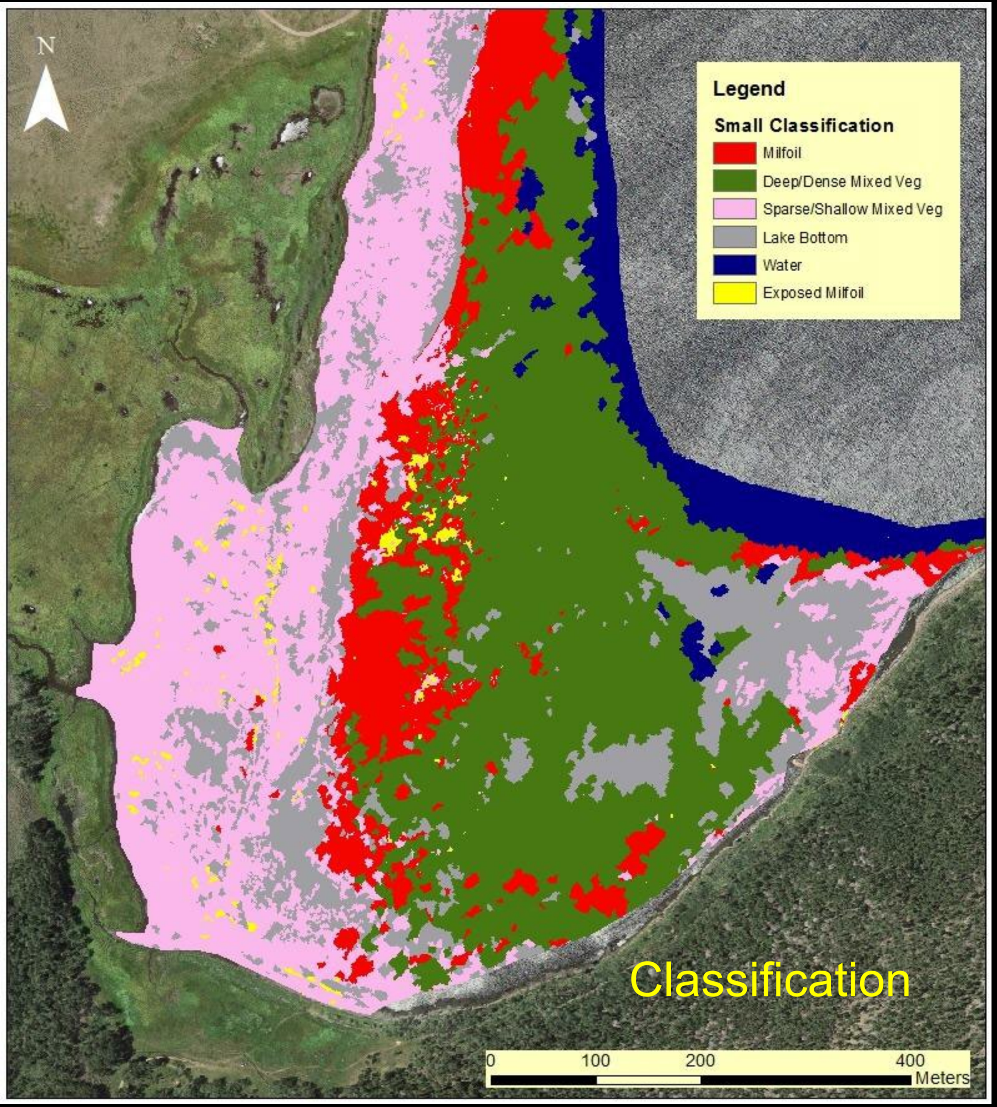
- Imagery acquired on 23 July 2011
- Area of the Patch – 503 sq. meters

Increase in size of patch from 2010 to 2011 is 246 sq. meters

AggieAir Example: Milfoil Monitoring

(from Fish Lake in south-central Utah)





Challenges (for UAS-based RS):

- Airspace access (a.k.a., dragging the FAA out of the 12th Century and into the 21st):

    Regulations have retarded development of drones and sensors

- Recently adopted drone policies by some Federal agencies are intended to ban Chinese technology.

    For economic and national security concerns

- Lack of funding for on-going monitoring:

    Funding can always be found to determine the extent of our problem with *[Phragmites or milfoil or endangered species or fill-in-the-blank]*, but funding for on-going monitoring work to assess the effectiveness of management activity or quantify the amount of change through time is often very difficult to obtain.

Questions?

Other AggieAir Monitoring Applications

Selected AggieAir Monitoring Examples:

- Phragmites in GSL wetlands
- Milfoil in Fish Lake, Utah
- Beaver dam restoration
- Forest fire recovery
- Rapid river morphological changes
- Phreatophyte control
- Energy balance of Arctic rivers
- Endangered fish species
- Stream water surface temperature monitoring
- Pelican population estimation
- Floodplain monitoring
- Earthquake recovery
- Tracking of radio-tagged fish (experimental)

(For more information, see https://uwrl.usu.edu/aggieair/)