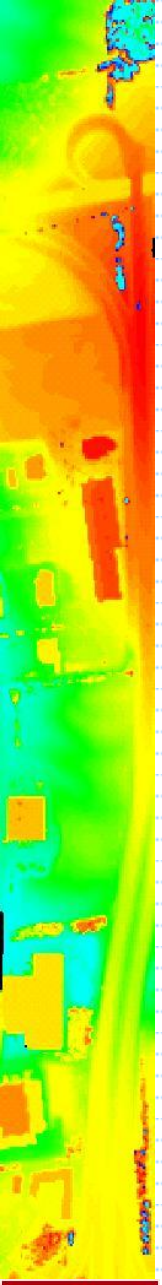

The potential uses of UAV-based remote sensing in the Great Lakes

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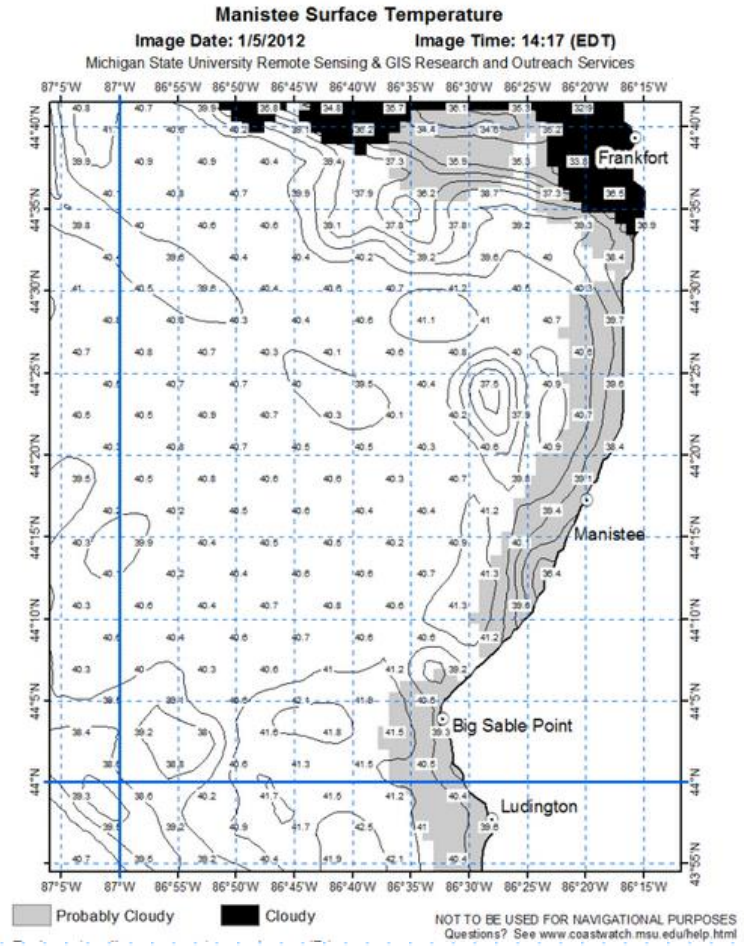
Outline

- ✓ Introduction
- ✓ State of the Art
- ✓ Platform Configuration
  - ❖ OSU test platform
- ✓ Research Topics thus far
  - ❖ Sensors, Integration, and Accuracy
  - ❖ Photogrammetry and Lidar
  - ❖ 3D modeling, River Widths, Snow
- ✓ Great Lakes Applications (for water quality)
  - ❖ Limitations and Future Solutions
- ✓ Conclusions and time for questions

Background

- ✓ Long before I was much of a scientist*, I was a fisherman



Introduction

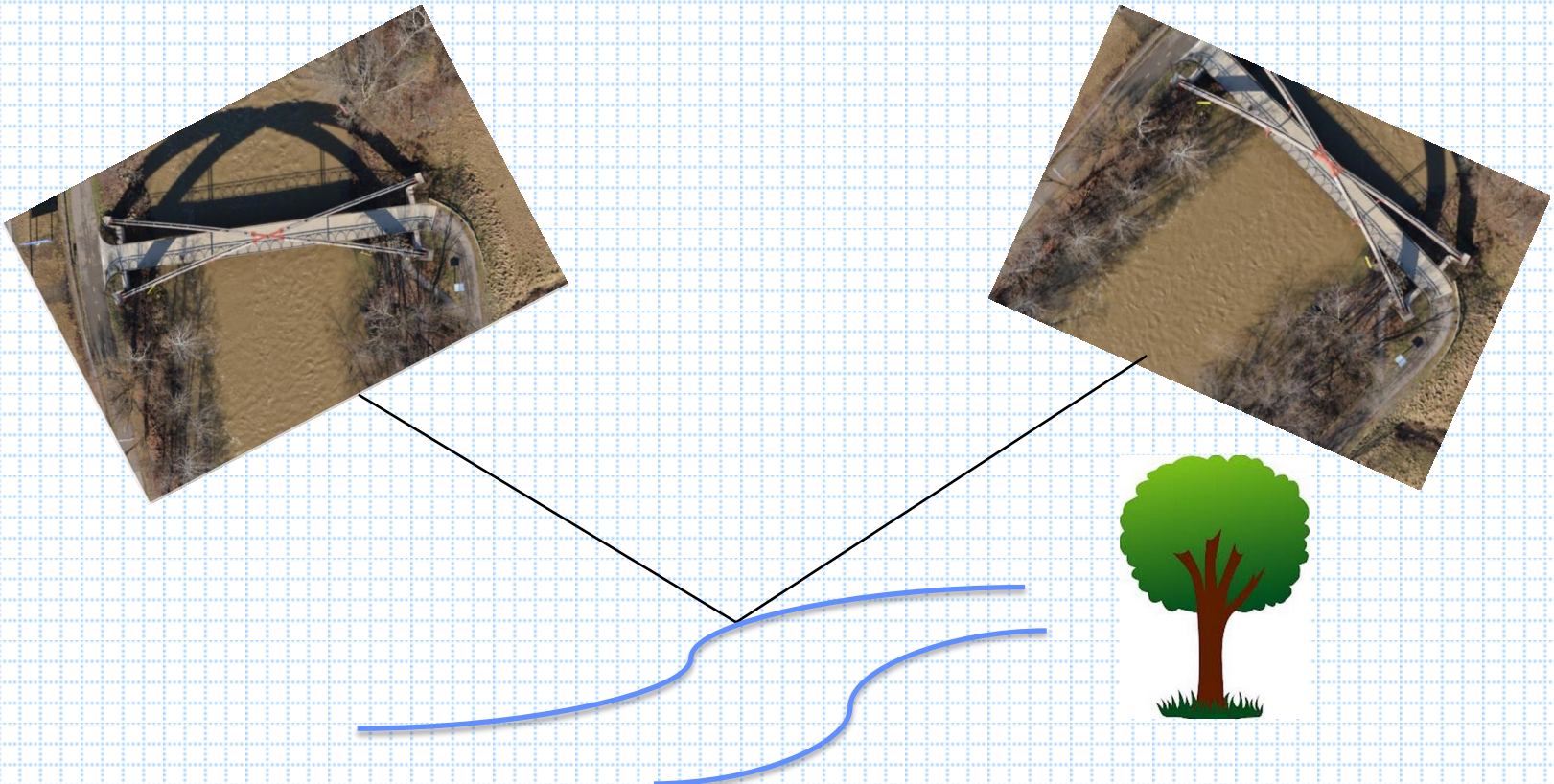
- Small UAVs are fast replacing traditional platforms in applications including mapping, tracking, and emergency response.
- Benefits vs traditional platforms
  - Decreased upfront and operating costs
  - High resolution and high accuracy data
  - DDD – Dull, Dirty, Dangerous
- Current Research Applications
  - Landslide monitoring, Forestry, Geophysical Exploration, Water Resources, Change Detection
  - Water Quality?

Platform, Sensors, and Integration

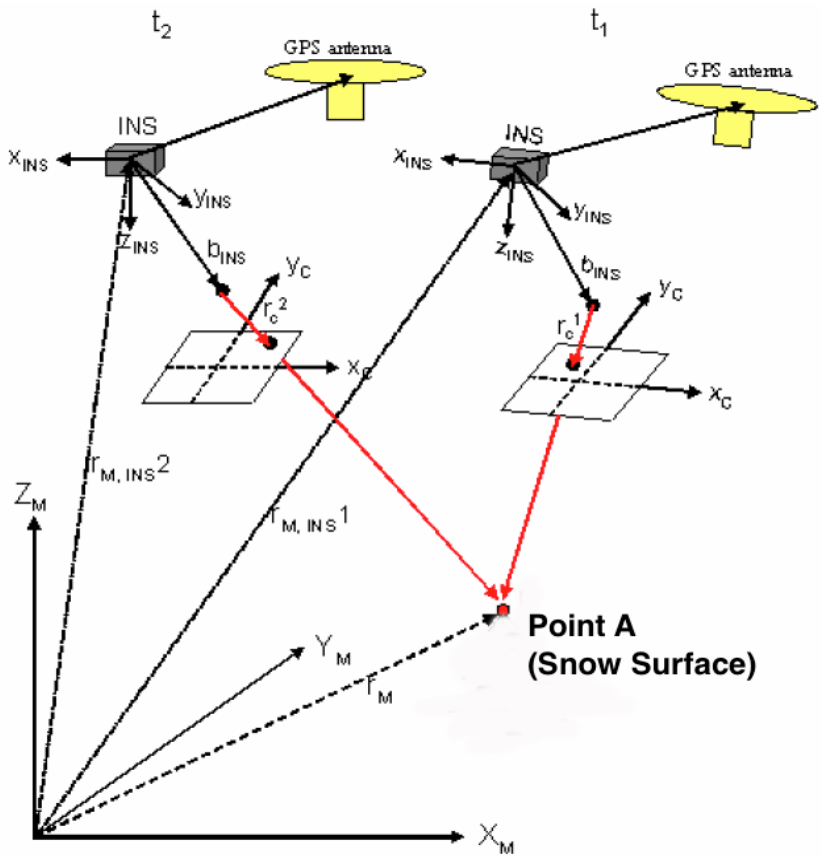
- ✓ Octocopter made by small “boutique” manufacturer in Michigan
- ✓ Sensors include the followiong
  - ❖ Novatel OEM 615 Dual Frequency GNSS receiver (RTK)
  - ❖ Antcom GNSS antenna
  - ❖ Microstrain 3DGM Inertial Measurement Unit (IMU)
  - ❖ Nikon D800 camera
  - ❖ Autopilot and control software
  - ❖ Velodyne Lidar (in the works)
- ✓ Onboard computer to log/process the data (FitPC)

Concept: Measure River Width

- Images are typically taken at regular intervals as platforms move through the object space, based on matching relative changes in orientation and 3D object space information can be derived.
  - Using the collinearity equations and the 2D SIFT features, the object space can be reconstructed and the metric 3D measurements can be made.



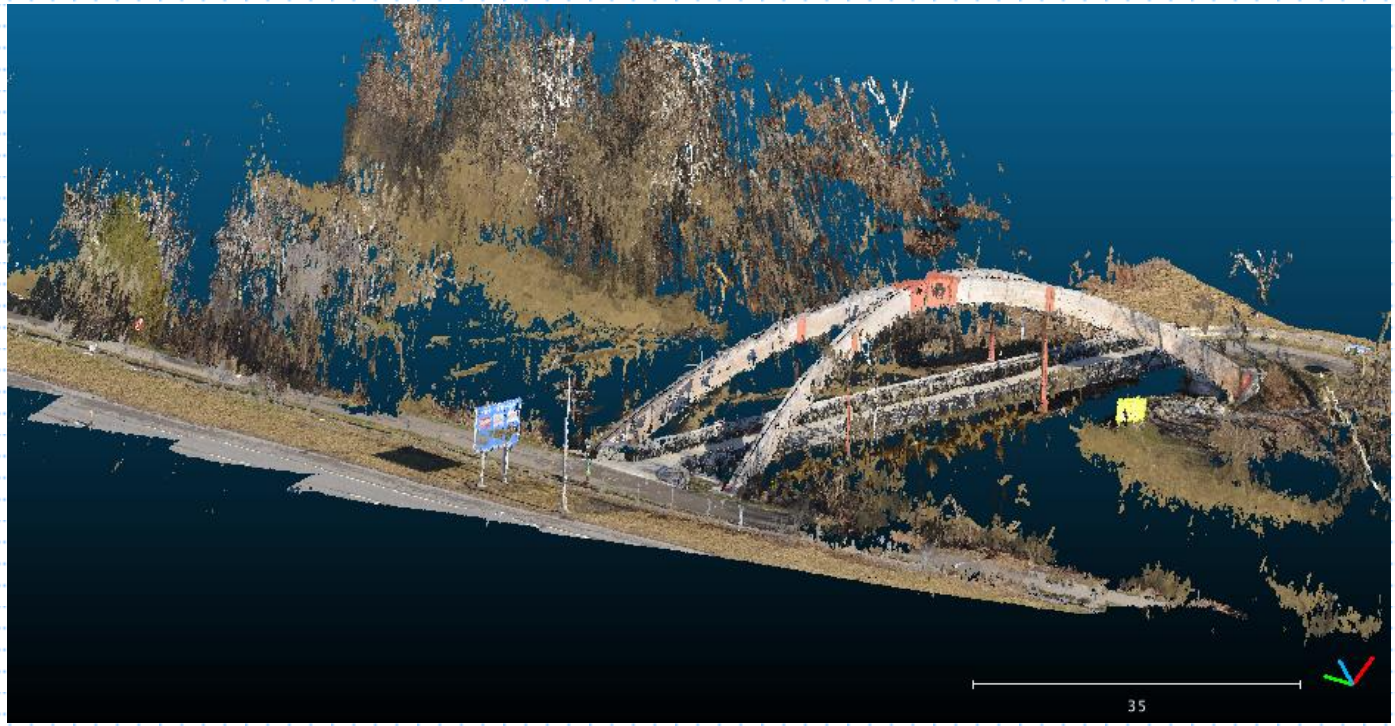
Concepts – Collinearity Equations



- ✓ Relates projective image space to 3D object space
- ✓ Can be linearized and integrated into bundle adjustment
  - ❖ optimal

$$\begin{pmatrix} x_{im} \\ y_{im} \end{pmatrix} = \begin{pmatrix} x_o + f\dfrac{r_{11}(X_A - X_0) + r_{21}(Y_A - Y_0) + r_{31}(Z - Z_0)}{r_{13}(X_A - X_0) + r_{23}(Y_A - Y_0) + r_{33}(Z - Z_0)} \\ y_o + f\dfrac{r_{12}(X_A - X_0) + r_{22}(Y_A - Y_0) + r_{32}(Z - Z_0)}{r_{13}(X_A - X_0) + r_{23}(Y_A - Y_0) + r_{33}(Z - Z_0)} \end{pmatrix}$$

3D Rendering of Scene

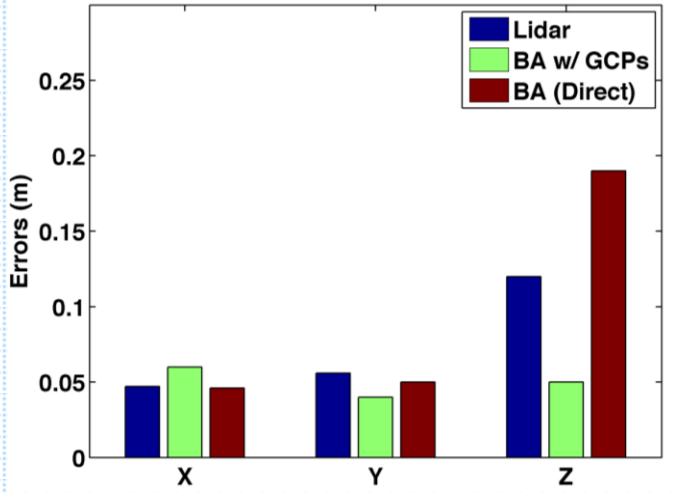


- ✓ We assume scene to be static, UAS generates the stereo disparity.
  - ❖ Problem: River is moving ☺
  - ❖ Solution: Look at rivers edge
  - ❖ Problem: Lots of vegetation at rivers edge
  - ❖ Solution: Use Lidar

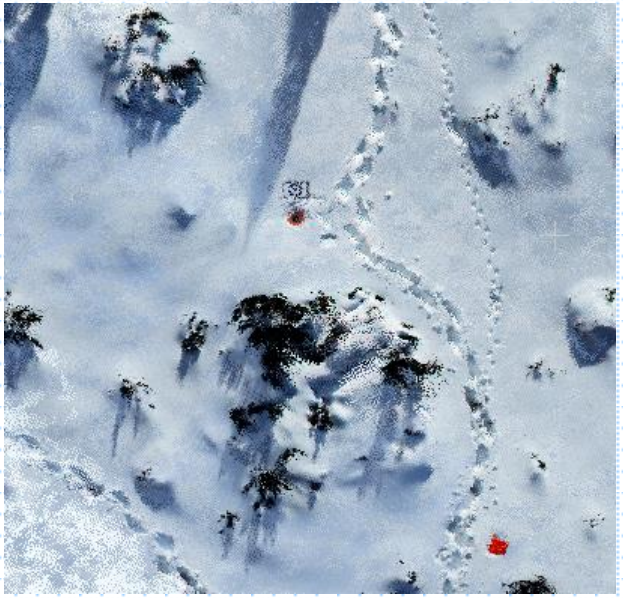
Accuracy (not precison!)

- ✓ Objective: How accurately can you resolve 3D information obtained from UAVs?
- ✓ Oftentimes, accuracy is what matters, as opposed to pretty pictures.

Lidar	Indirect BA (truth)	Direct BA
0.047 m	0.05 m	~0.05 m
0.056 m	0.041 m	~0.05 m
0.123 m	0.052 m	0.19 m



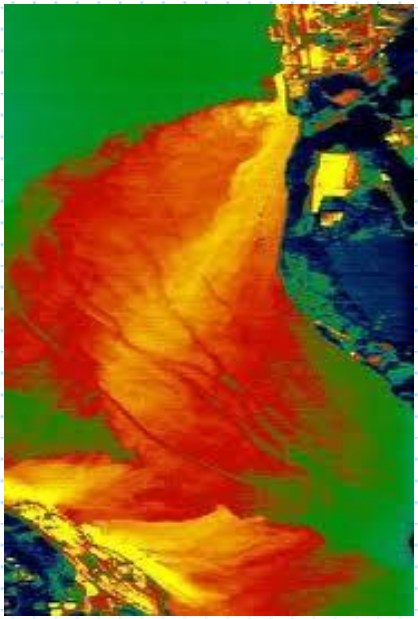
Snow Study



- ✓ Can we measure snow depth?.
  - ❖ Problem: Snow is homogeneous in the visible spectrum (its white)
  - ❖ Solution: Lower altitudes and high res imagery provide more texture
- ✓ Other remote sensing techniques fail in deeper snow
  - ❖ accuracy remains the same regardless of depth

Great Lakes Applications

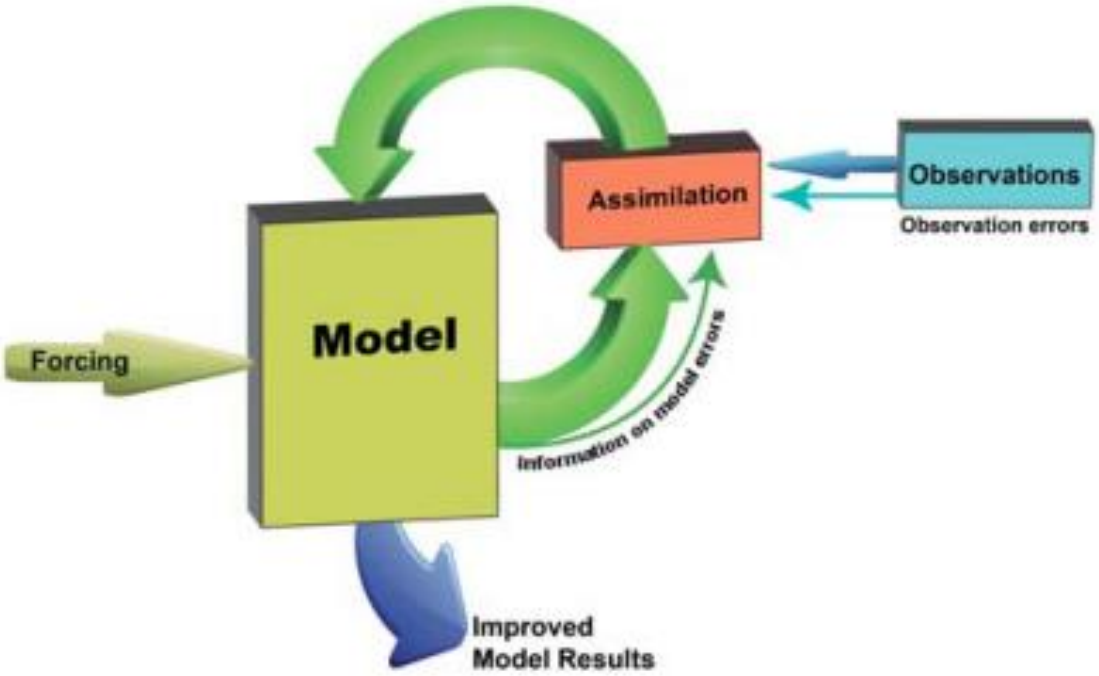
- ✓ Thermal Discharge
  - ❖ High resolution data provides much better assessment on the magnitude of discharge by utility corporations.
- ✓ Ag/Sediment Discharge
  - ❖ Lake Erie algae blooms
    - Cyanobacteria
  - ❖ Individualized watershed sources
  - ❖ Inland lake blooms
    - Buckeye Lake
    - Grand Lake St. Marys
    - Etc.
- ✓ Currents/Lake Circulation
- ✓ Sediment Plumes
- ✓ Data Assimilation
- ✓ Whatever needs high resolution data will work well!



Credit: MERIS/NASA; processed by NOAA (probably George)

Data Assimilation

- More information is always better!



- Great Lakes DA
  - Model
    - NOAA GLCF
  - Observations
    - satellite
    - airborne
    - low altitude UAS
  - States/Outcome
    - predicted thermal plume

Current Limitations

- With small, electric platforms, battery life is an issue.
  - great for smaller scale work, not Great Lakes (yet)
    - e.g. a river outlet plume
  - payload weight has inverse relationship with flight times
- Sensor integration can be a problem (often requires custom payload solutions)
- FAA has yet to implement regulations pertaining to UAV operations
  - As of now, research/industrial users need a certificate of authorization to UAV research.
  - Takes ~6-8 months to obtain (if successful)

Current and Future Solutions

Hardware

- ✓ Solar Powered
  - ❖ No refueling required
  - ❖ Facebook/Titan Aerospace
- ✓ Increased Battery Life
- ✓ Decreased sensor cost

Software

- ✓ Cloud computing
  - ❖ don't bog down your work machine processing data
  - ❖ One integrated software solution
    - GPS
    - Mapping
    - Navigation, etc

Any Questions?

Lets make this obsolete!