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USING AN UNMANNED AERIAL VEHICLE EQUIPPED WITH A MULTISPECTRAL SENSOR TO VISUALLY MAP WATER QUALITY PARAMETERS IN DRINKING WATER RESERVOIRS.

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Measuring Optical Water Quality Parameters using an Unmanned Aerial Vehicle (UAV) – based Multispectral Sensor, Lake Bloomington and Evergreen Lake

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INTRODUCTION

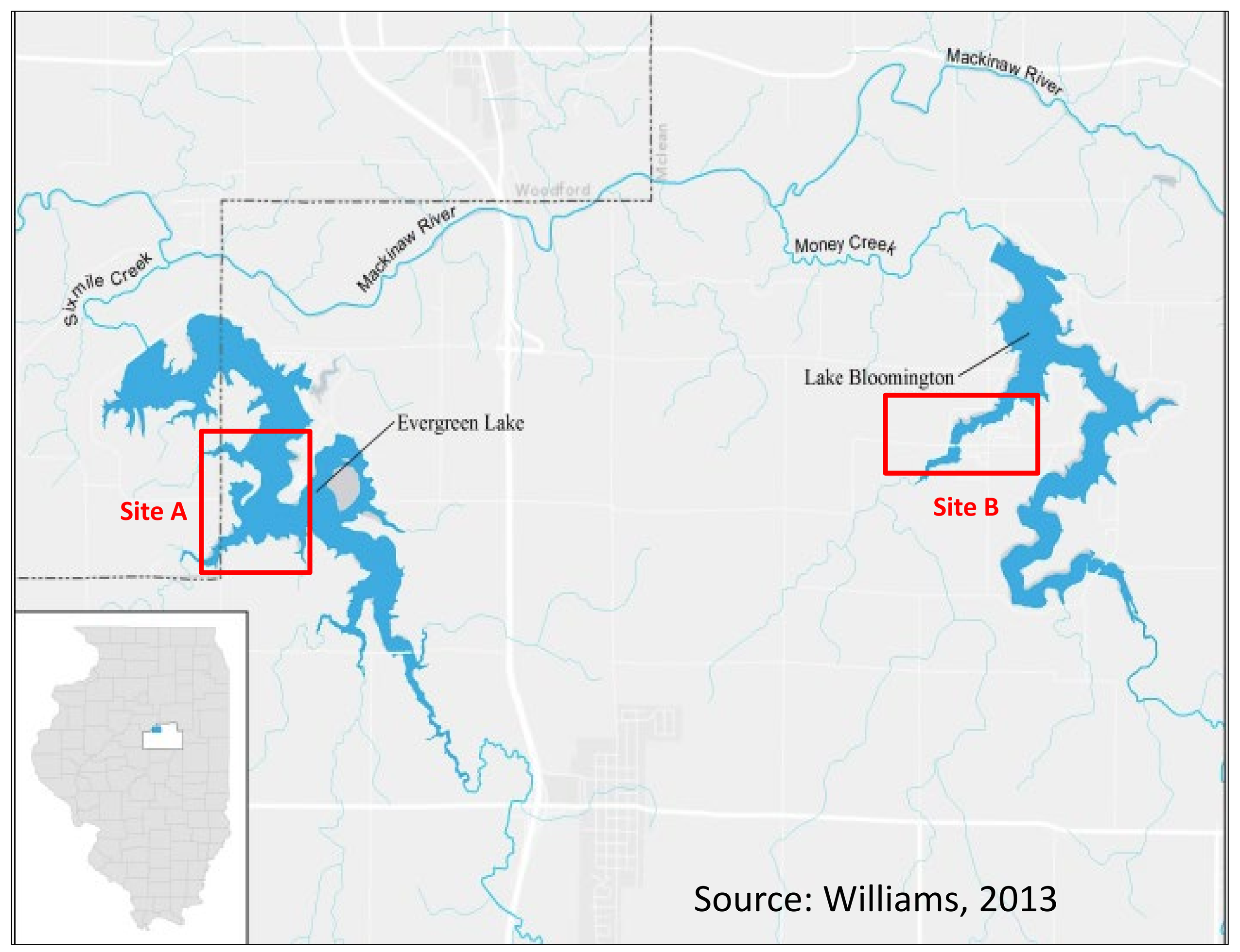
Surface drinking water infrastructure is an integral part of the development and sustainability of societies around the world. However, these surface freshwater resources have been a challenge to monitor due to the vast number of in-situ samples needed to accurately quantify constituents, expenses of equipment, coordination of personnel, and lab cost. Lake Bloomington and Evergreen Lake (Hudson, Illinois) are two vital surface water features that serve as the drinking water reservoirs for the Bloomington area. Both reservoirs are within agricultural watersheds, with watershed inputs typically being high in turbidity and nitrate.

We utilized an Unmanned Aerial Vehicle (UAV) coupled with a five-band multispectral image sensor to monitor two important drinking water parameters in the lakes; turbidity and algae. By using the UAV, along with in-situ data collected the same day as the flight, we aim to answer the following questions: 1.) What are the challenges of remotes sensing over a homogeneous setting (such as a lake) and 2.) Is it possible to detect change in the water quality at the surface of the lake using one or more spectral image combinations?

OBJECTIVES

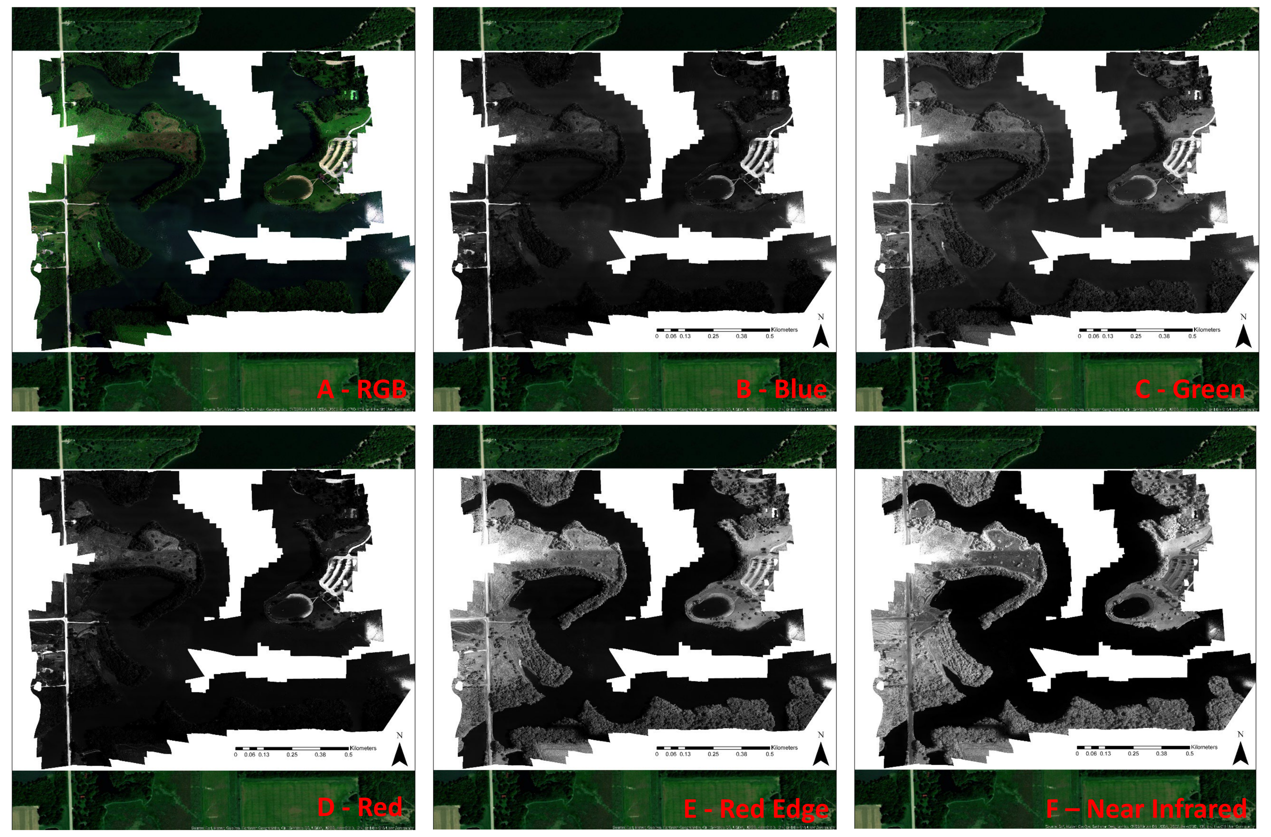
The objective of this study is two-fold. First is to evaluate if there is a quantifiable correlation with optical properties of each of the main lake water quality parameters (Chl-*a* and Turbidity). Second, we want to see what the spatial and temporal variation is in each lake over the course of the study period.

STUDY SITE



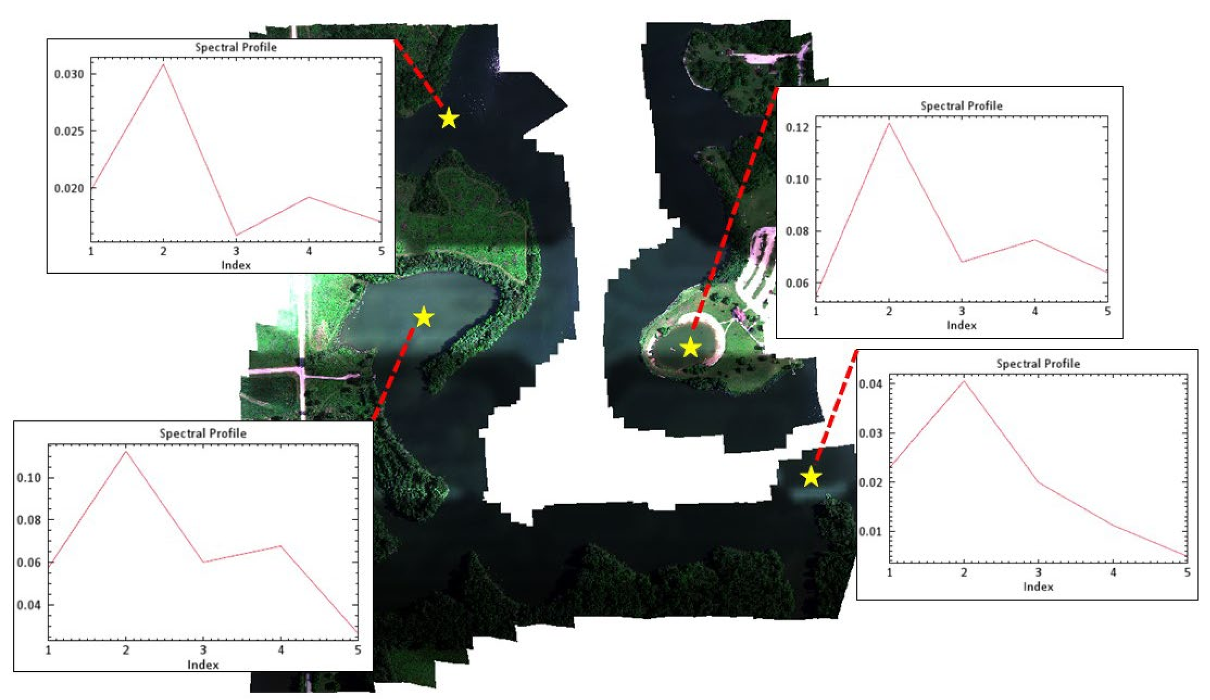
Both sites are dammed reservoirs located at the end of an agricultural watershed. Flow of these sites is to the north and stops at the dam located at the north end of each lake. Locally, agriculture consists of row crop farming (soy and corn). Both lakes have a surface area of roughly 2.7km^2. Immediate surroundings vary from each stie. Lake Bloomington is populated with private residences on over 50% of the shoreline. Evergreen Lake is surrounded by a protected forest area. Both lakes are used for sport recreation activities such as fishing and boating.

METHOD - *REMOTE SENSING*



Evergreen Lake, Site B: A. Full composite RGB image. B-F: grayscale representations of reflectance values for each band. B-Blue, C-Green, D-Red, E-Red Edge, F-Near Infrared

- DJI Matrice 200 V2 equipped with a MicaSense Red-Edge MX sensor (upper right).
- Flights were flown between 8-11am to avoid "mirror effect" from the sun directly overhead.
- The sensor was calibrated before and after each flight to insure correct reflectance values.
- Images were then processed using Agisoft Metashape, which were able to produce an image with a resolution of 6 cm and calibrated reflectance for each individual band.
- Images were then corrected for true reflectance values, creating the result you see above.



Spectral analysis in Envi (above) shows a reflectance beyond the red band at all four locations. Water's signature does not follow this after the red wavelength, making red, red-edge and NIR useful for determining chl-*a*

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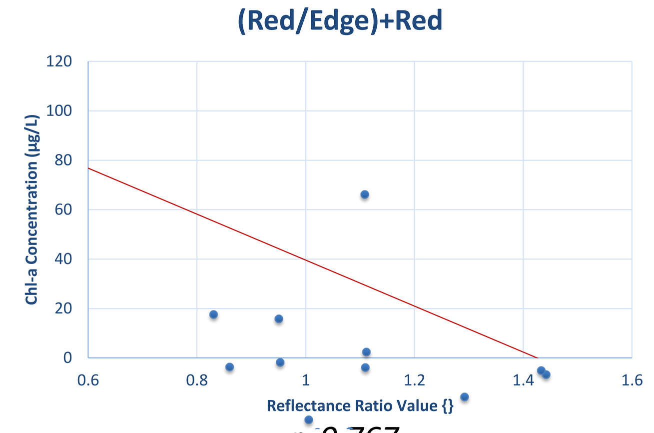
RESULTS

Correlation of UAV data and Lab Analysis for Chlorophyll-*a* and Turbidity

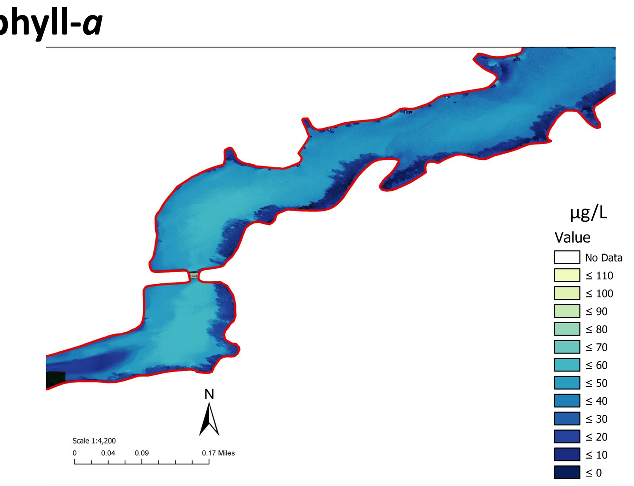
- There is a relatively strong correlation between Chlorophyll-*a*, which is used as a proxy for algae in the lakes.
- Turbidity had relatively low correlations to in comparison to in-situ data but have inverse relationship with reflectance.
- The data below highlights that there is limited variation and low concentrations, making it difficult to optically identify these constituents.
- Examples show the applicability of the algorithm on right to Site B on left

Chlorophyll-*a*

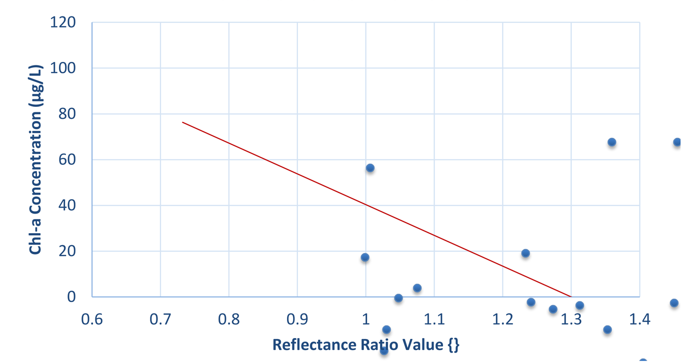
(Red/Edge)+Red



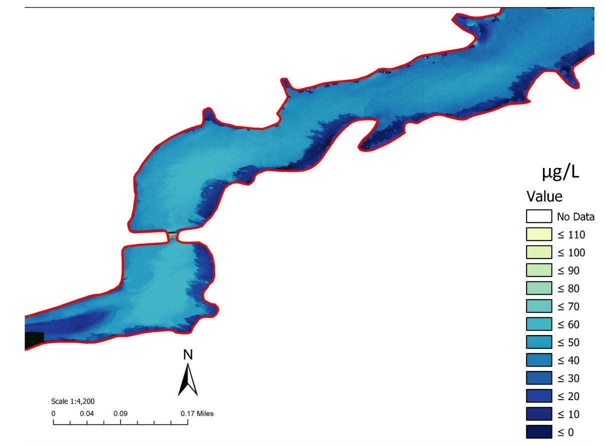
r=0.767



Multiband combination

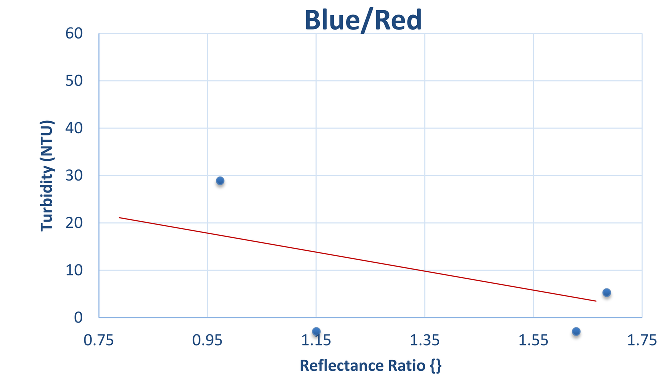


r=0.777

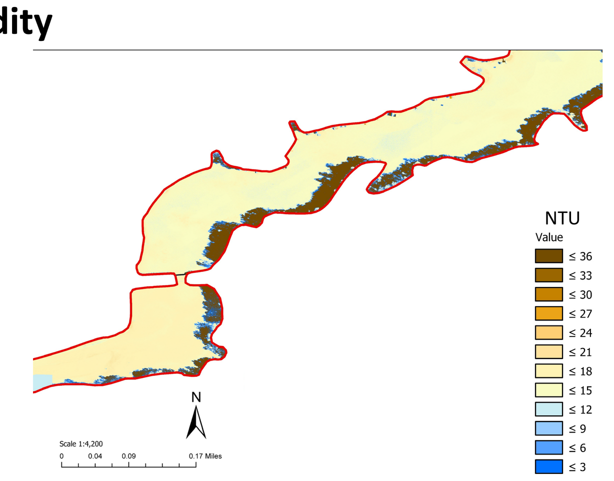


Turbidity

Blue/Red



r=0.410

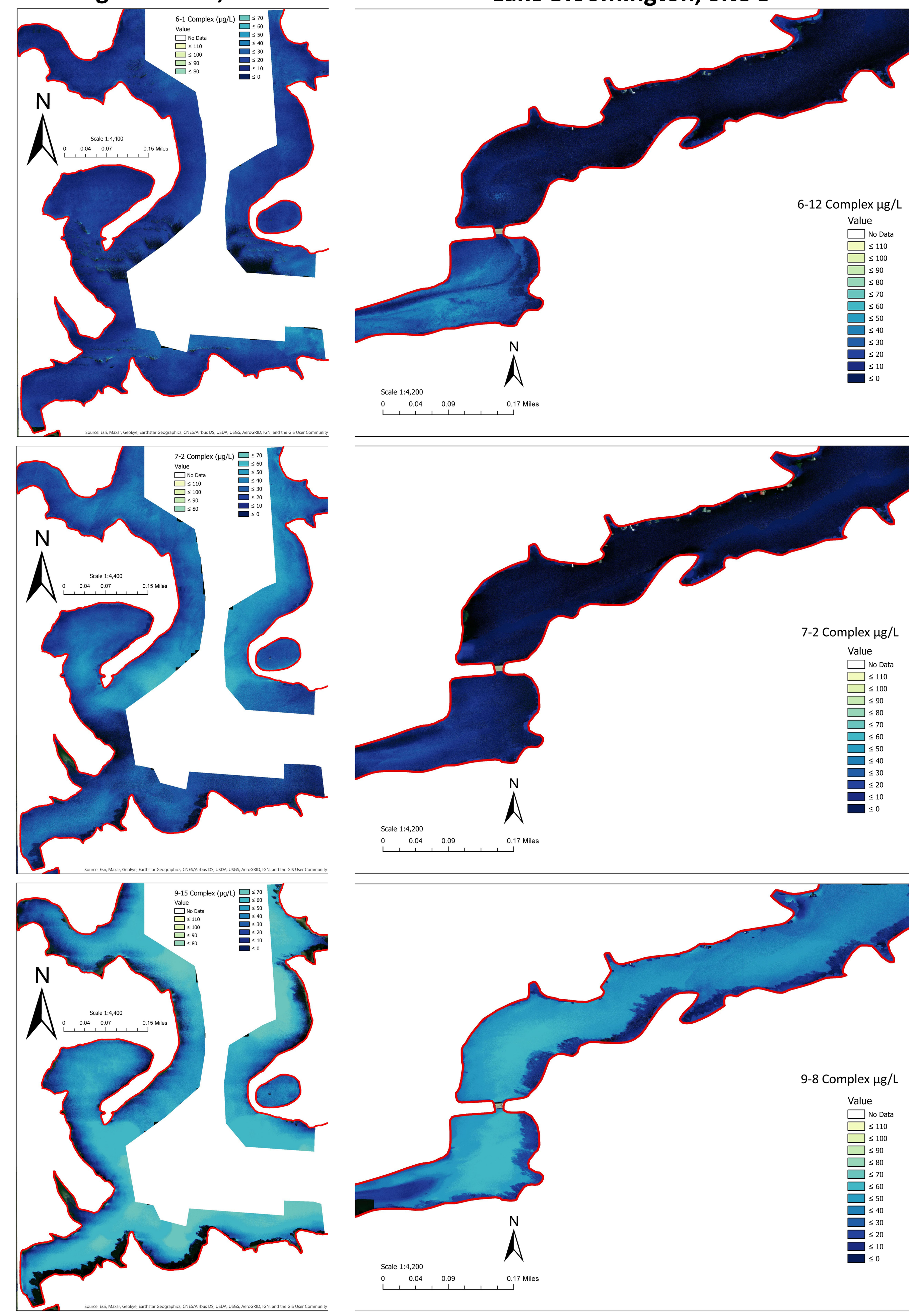


Possible Sources of error

- Aerial sampling took place in the morning as an effort to avoid sun glare that appears during the midday hours. Possible shadows on the eastern shorelines could be contributing to lower reflectance values.
- Cloud cover did contribute to overall brightness of the image, and therefore contributed to lower reflectance values across all bands.
- In-situ samples were collected up to three hours after the UAV image was taken, which could have introduced error due to near surface processes disrupting the sample. (wind, boats, wildlife)
- Image processing software has shown signs of aliasing near the edge of stitched images in prior endeavors. Although this is not readily evident in our study, the edge effects of these images could influence readings in those areas. Stitching issues also occurred in homogeneous locations (open water)

Spatiotemporal Variation of Chlorophyll-a from UAV data, chl-*a* complex

Evergreen Lake, Site A | Lake Bloomington, Site B



Conclusion

- UAV imagery can model chlorophyll-*a* throughout time with a correlation of roughly 0.7.
- Both lakes experience an increase of algae from the start of summer.
- Turbidity was very low over time in both lakes, making it difficult to optically quantify that parameters.
- Although deployment of UAV is relatively easy, reflectance factors do vary greatly based on conditions present such as clouds, sun position, and water roughness.