Binghamton University

The Open Repository @ Binghamton (The ORB)

Research Days Posters Spring 2020

Division of Research

2020

The Use of Spectral Remote Sensing to Detect, Monitor, and Predict Harmful Algal Bloom Location and Intensity

Kelly Young
Binghamton University--SUNY

Follow this and additional works at: https://orb.binghamton.edu/research_days_posters_spring2020

Hyperspectral Drone Detection of Harmful Algal Blooms: Ground truthing new approaches for water quality assessment

Kelly Young[1], Hudson Hyams[2], Jason Provanzano[2], Keeley Nguyen[2], Kely Amejecor[3], Alex Nikulin[2], Kenneth Chiu[2], Lisa Cleckner[4], Kiyoko Yokota[5], Courtney Wigdahl-Perry[6] and Timothy S. de Smet[7]

(1)Binghamton University, Geography and Environmental Studies, Binghamton, NY, United States, (2)Binghamton University, Binghamton, NY, United States, (3)Hobart and William Smith Colleges, Geoscience, Geneva, NY, United States, (4)Hobart & William Smith Colleges, Finger Lakes Institute, Geneva, NY, United States, (5)SUNY College at Oneonta, Oneonta, NY, United States, (6)SUNY at Fredonia, Fredonia, United States, (7)Binghamton University, Geological Sciences and Environmental Studies, Binghamton, NY, United States

Research Objective

Use satellite remote sensing from NASA's Landsat 8 Satellite to monitor and predict the location and intensity of Harmful Algal Blooms (HABs) in Lake Chautauqua and Lake Seneca. The ultimate goal is to use hyperspectral remote sensing data create a predictive model that can be applied to all lakes.

Introduction

- Harmful algal blooms are becoming an increasingly prevalent worldwide threat as eutrophic waters are formed from **agricultural runoff and the overuse of fertilizers**.
- Eutrophication increases harmful algal blooms and leads to a condition known as **hypoxia which cause fish kill offs.**
- They cause an estimated **>$50 million in damages annually** from decreased tourism, filtration costs, and the death of shellfish.
- **Current detection methods** are inefficient and **fail to give an accurate depiction of the entire water body**.
- Hyperspectral and satellite sensing has been used in the detection of environmental conditions such as algal blooms based on **chlorophyll levels, cyanobacterial pigments, and phycocyanin.**

The Progression of a Harmful Algal Bloom
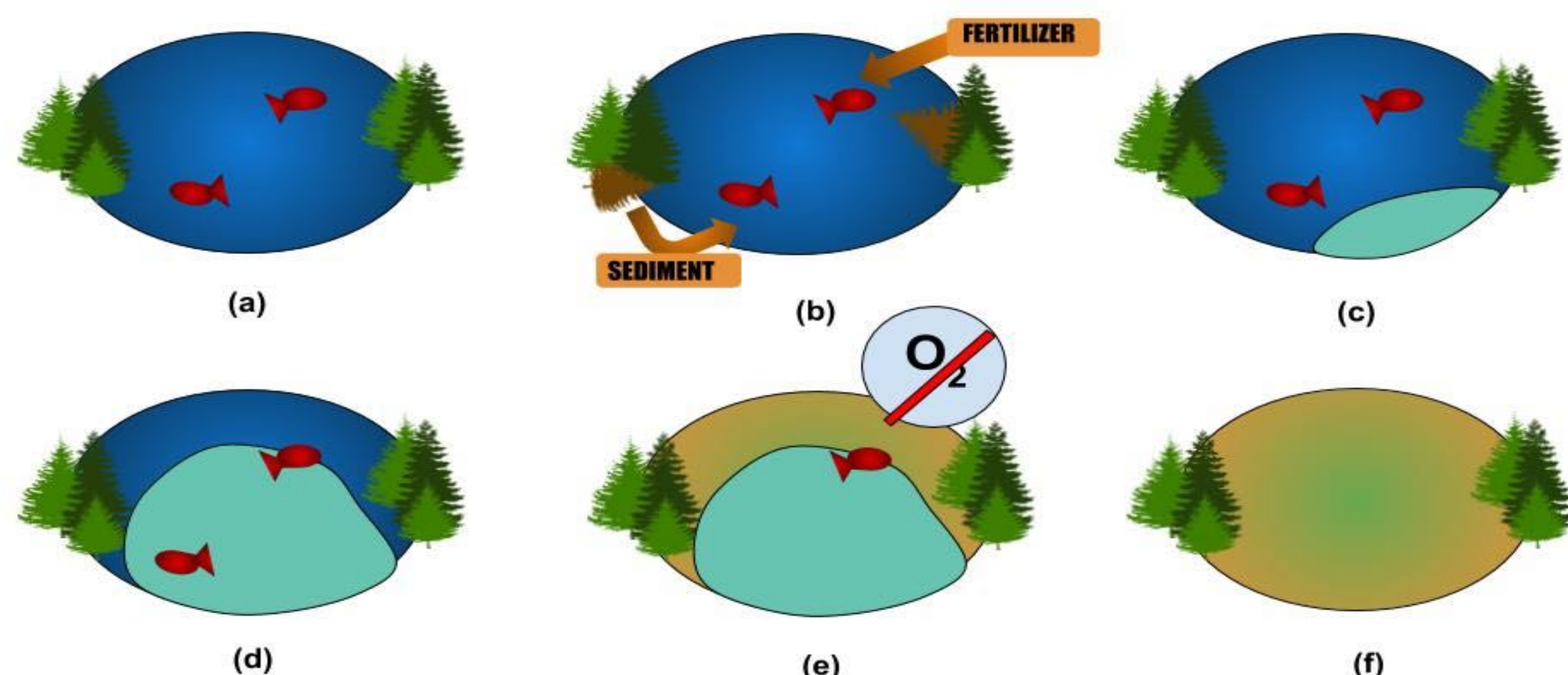
Figure 1: Showing the development of an algal blooms. A) Healthy lake in early spring; B) sedimentation and agricultural runoff leads to nutrient pollution; C) Accelerated algal growth begins in late spring due to eutrophic conditions; D) Algal bloom formation begins; E) Algae depletes oxygen from the water, causing oxygen loss and hypoxia; F) Lake is unable to support life, dead zones replace algae blooms by mid-Fall (Figure made by Keeley Nguyen, Hudson Hyams, Jason Provanzano and Kelly Young)

Methods
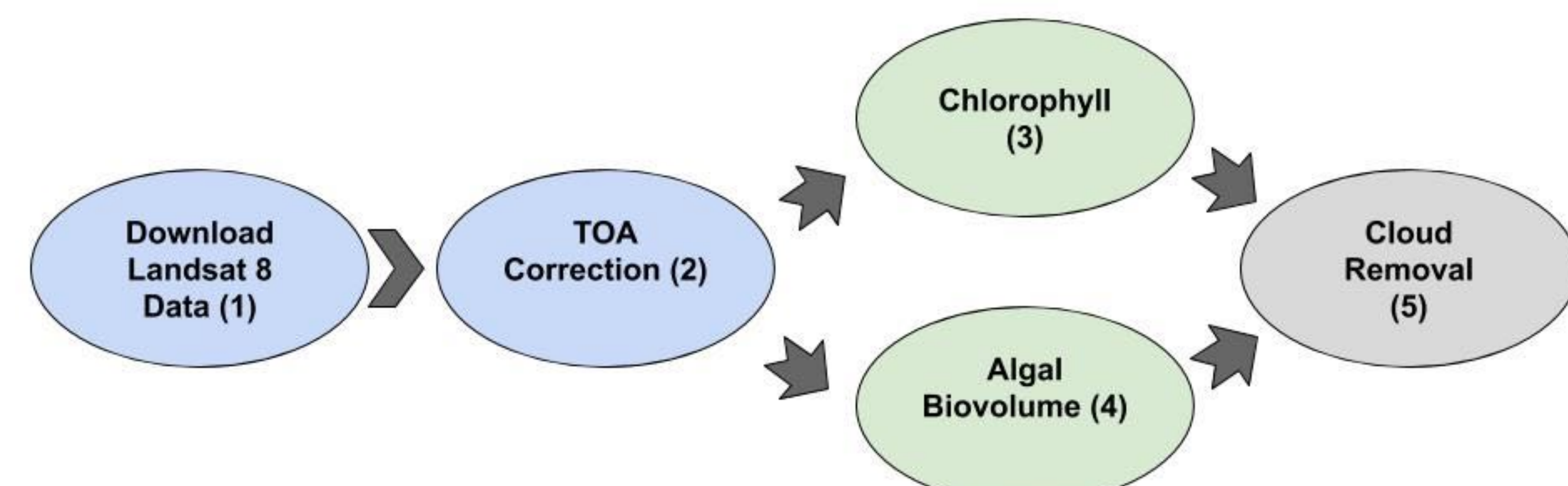
Figure 2: Showing flowchart of methods used for Landsat 8 Satellite Processing. 2018 Data was obtained from EarthExplorer and processed for chlorophyll and algal biovolume levels.
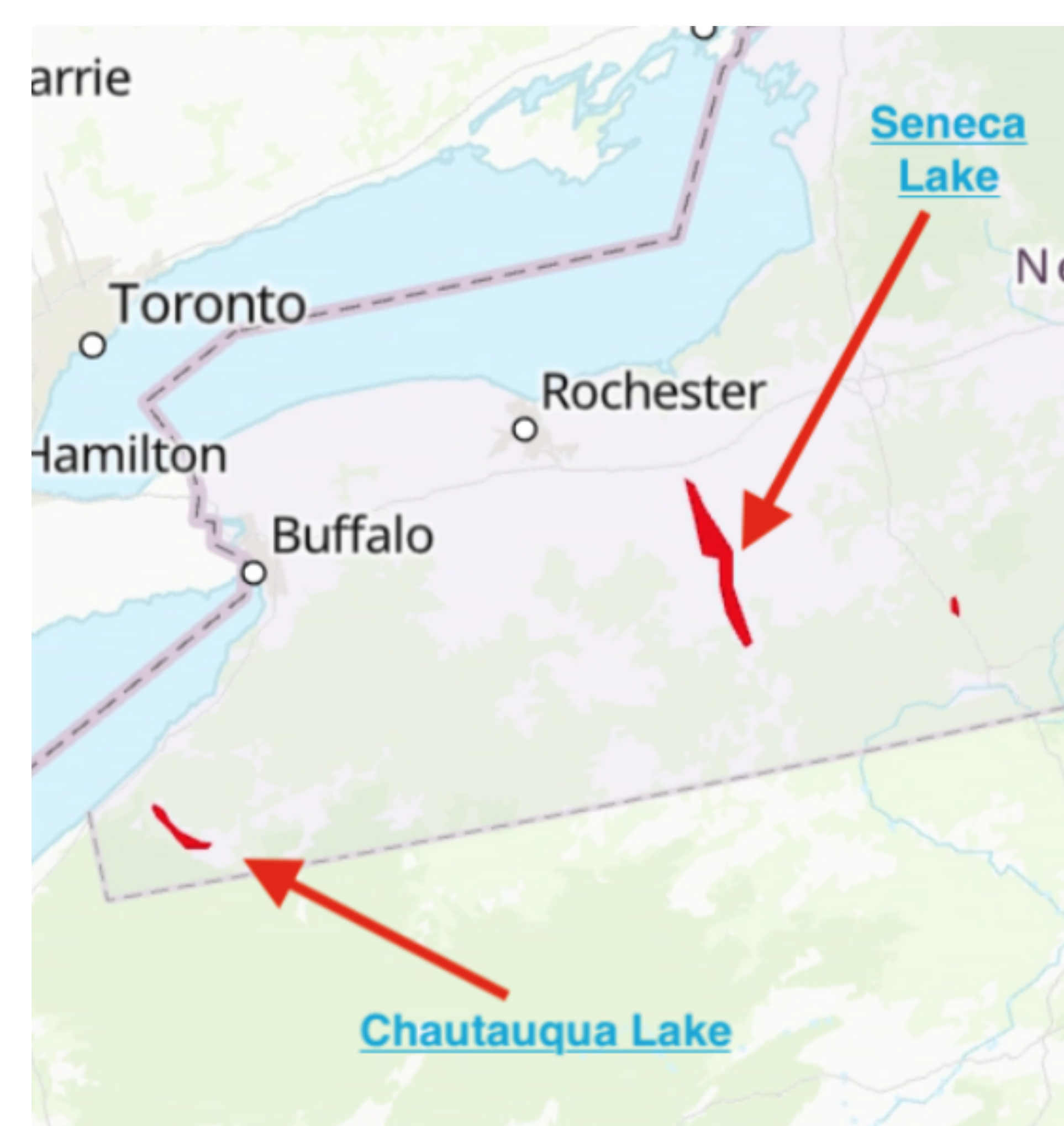
Figure 3: Showing the lakes of interest, Lake Chautauqua and Lake Seneca, on a map of New York State.

- 2018 Landsat 8 Data was downloaded from EarthExplorer and corrected for Top of the Atmosphere (TOA) interference
- Bands 2, 3, and 4 were used to determine chlorophyll concentrations and algal biovolume in ArcMap
- After processing the data, clouds were removed via the BQA band and a 100m buffer was added around the lake to reduce spectral mixing.

TOA Correction:
$$0.00002*``BAND''+(-0.1)$$

Chlorophyll:
$$-46.51-105.3*(B3/B2)-40.39*(B4/B2)$$

Algal Biovolume:
$$-0.6858+1.616*(B3/B2)-0.8025*(B4/B2)$$

Cloud Removal:
$$con*(BQA>=2800,0,1)$$

Data from satellites can be used to detect, monitor, and predict Harmful Algal Blooms (HABs)

Chlorophyll Concentrations Lake Chautauqua 2018

June 11 July 13 August 23
September 15 October 10 November 11

Chlorophyll (ug/L) 40.00 Low : 0
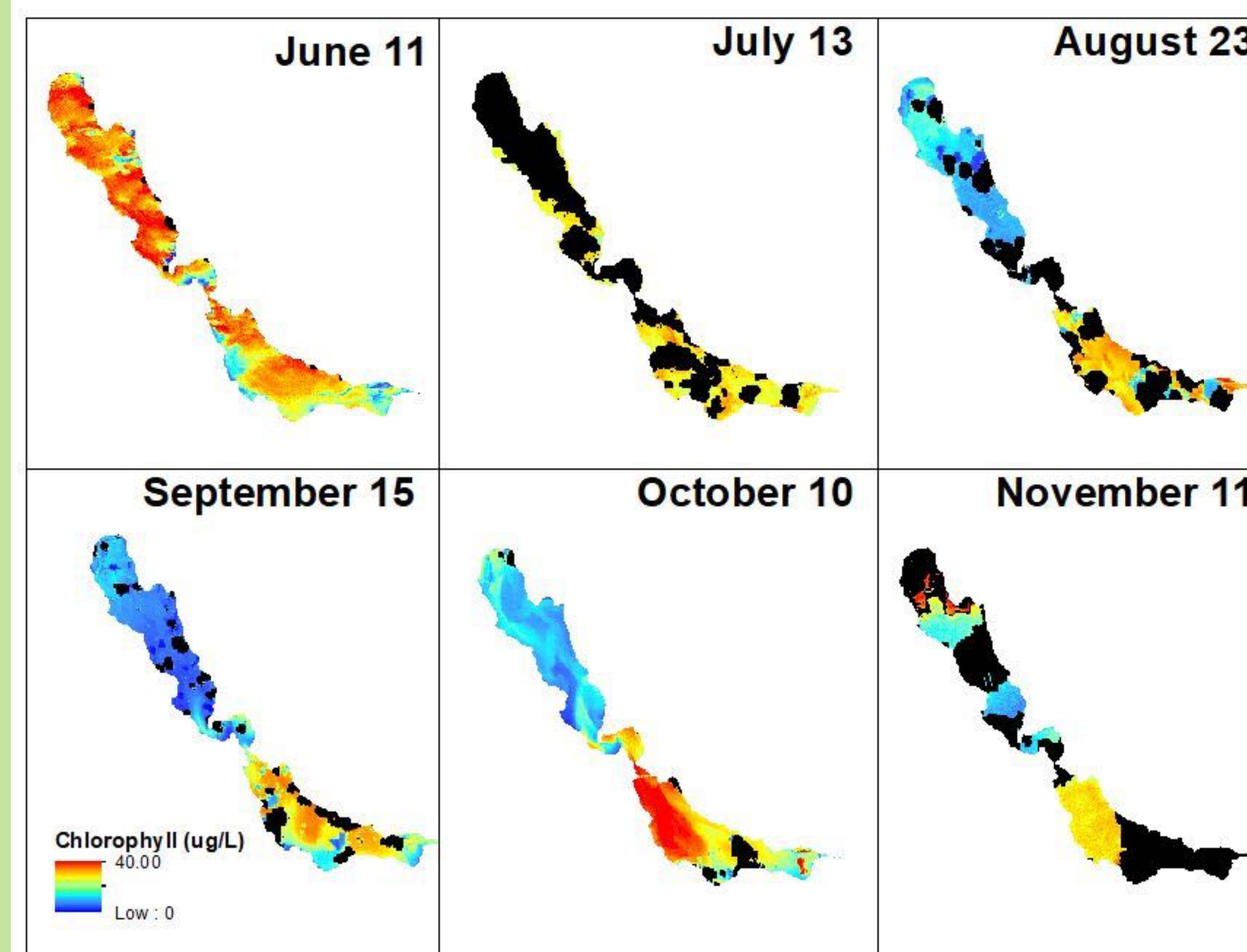
Figure 4: Showing chlorophyll levels in Lake Chautauqua during algae growing seasons. Cloud cover in December-May prevented data from being processed and were removed from analysis. Concentrations are highest in southern lake basin.

Chlorophyll Concentrations Lake Seneca 2018

June 29 July 15 August 16
September 01 October 19 November 04

Chlorophyll (ug/L) Value 40.00 Low : 0
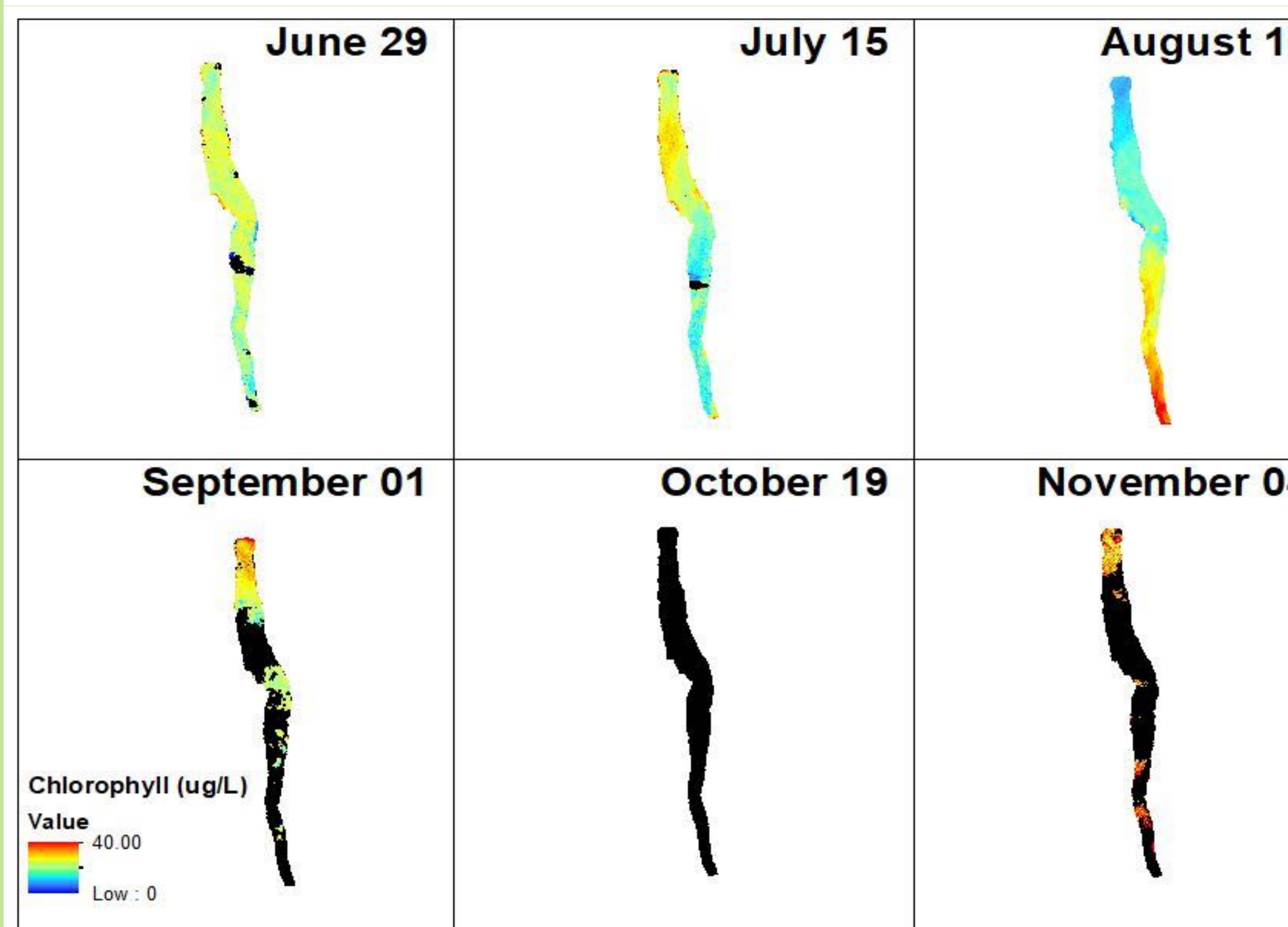
Figure 4: Showing chlorophyll levels in Lake Seneca throughout 2018. Chlorophyll levels were highest in June-August although cloud cover prevents accurate analysis of entire year. Concentrations are highest at Southern tip of the lake.

Results & Conclusion

- Landsat 8 imagery was successful in determining trends in algal intensity and location in Lake Chautauqua and Lake Seneca.
- In both Lake Chautauqua and Lake Seneca, blooms are located in the southern basin of lake and are most dense between May and August.
  - This is likely due to higher temperatures that cause algae to bloom.
  - Water movement in the lake pushes bloom formation into the southern stagnant water, thus creating build up in the southern basin/tip of the lake.
- Biovolume and chlorophyll had a correlation coefficient ranging from **0.95-0.99** indicating that high chlorophyll concentrations direct result in higher biovolume
- Cloud cover limited data analysis which explains unseasonably low biovolume levels in Lake Seneca and indicates the potential for improvements via hyperspectral data collection

Algal Biovolume Lake Chautauqua, 2018
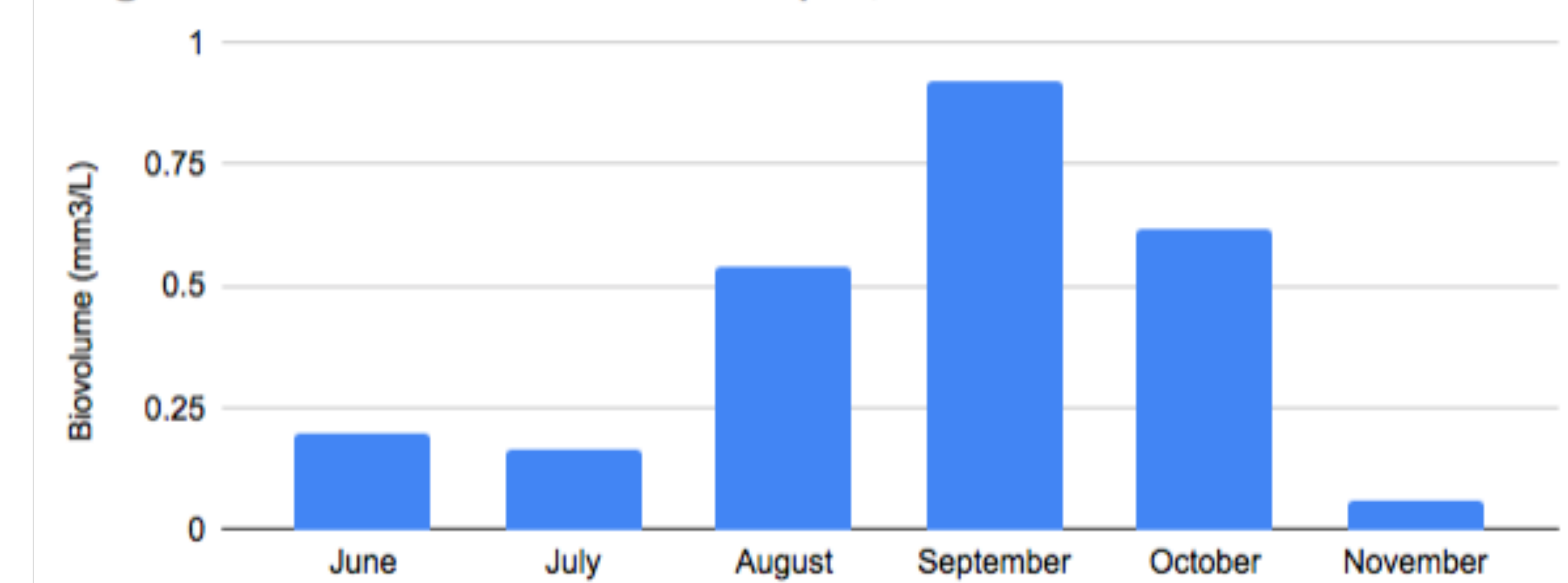
Figure 5: Algal biovolume in Lake Chautauqua peaked in September and October with a general increase during the summer months which indicates algal blooms were most intense during this time period.

Algal Biovolume Lake Seneca, 2018
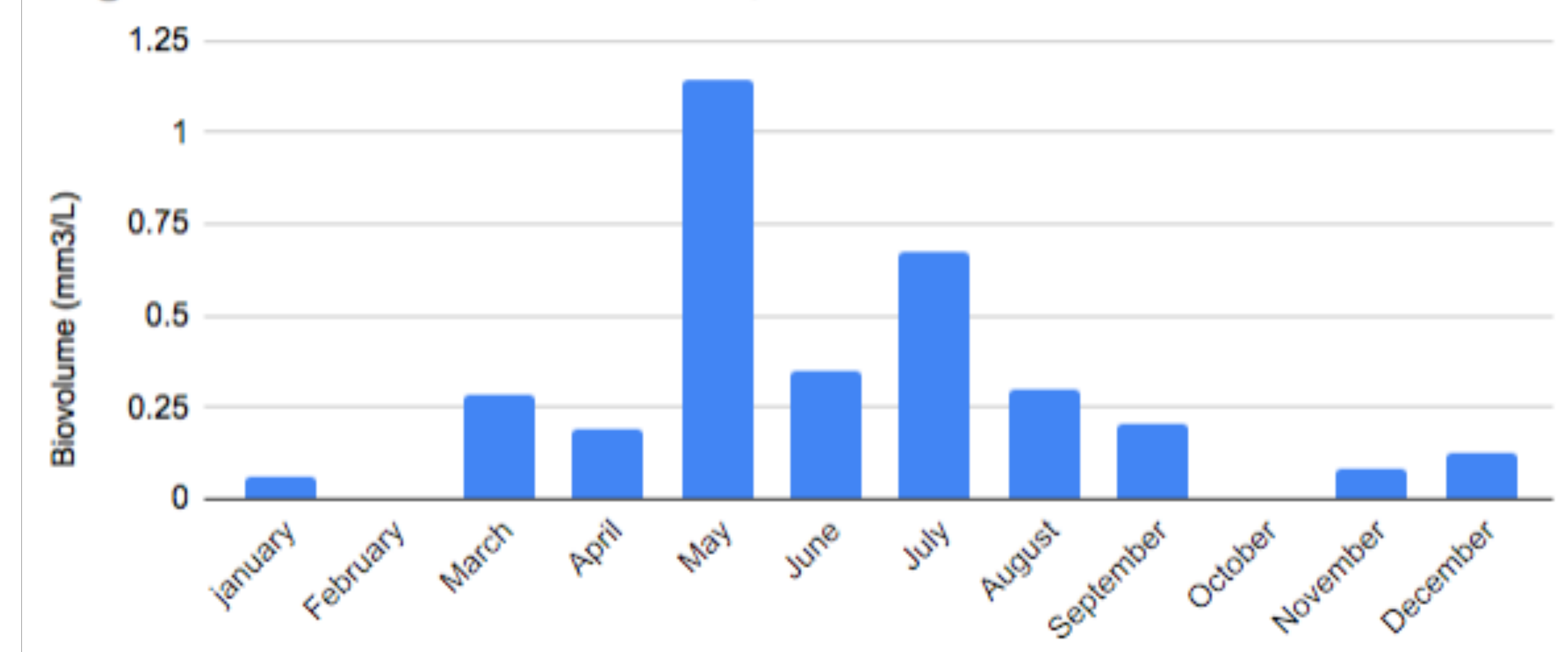
Figure 6: Lake Seneca's Algal biovolume peaked in May and July. The months of May-August had higher overall values, indicating heightened intensity. February and October contained complete cloud cover, and thus the values are represented as 0.

Future Research

Figure 7: DJI Matrice 600 Drone that will be used to collect hyperspectral data in the future

- Landsat 8 Data will be used to determine nitrogen and phosphorous concentrations for 2018
- Hyperspectral sensors will be used to obtain time series data in accordance with Landsat 8 starting in the 2020 growing season
- Data obtained in this preliminary study will help determine sampling locations
- Correlations and time series data will be obtained and used to create a predictive model for algal blooms
- Preliminary hyperspectral HSI data was collected at Binghamton University in November, 2019 and is currently undergoing processing

References

Environmental Protection Agency (EPA). Cyanobacteria/Cyanotoxins. Environmental Protection Agency. 2019. Available: https://www.epa.gov/nutrient-policy-data/cyanobacteriacyanotoxins#what2 (Accessed 5 February 2019).

National Oceanic and Atmospheric Association (NOAA). Hypoxia. United States Department of Commerce. 2014. Available: https://oceanservice.noaa.gov/hazards/hypoxia/ (Accessed 5 February 2019).

United Nations Environment Programme Division of Technology, Industry and Economics (UNEP). How Bad Is Eutrophication at Present? Water Quality: The Impact of Eutrophication. UNEP. 2016. Available from: http://www.unep.or.jp/ietc/publications/short_series/lakereservoirs-3/2.asp (Accessed 6 February 2019).

Beauvais, Joel. Renewed Call to Action to Reduce Nutrient Pollution and Support for Incremental Actions to Protect Water Quality and Public Health. Environmental Protection Agency. 2016. Available from: https://www.epa.gov/sites/production/files/2016-09/documents/renewed-call-nutrient-memo-2016.pdf (Accessed 7 May 2019).

World Resources Institute. About Eutrophication. 2011. Available from: http://www.wri.org/our-work/project/eutrophication-and-hypoxia/about-eutrophication (Accessed 4 February 2019).

Dodds, Walter K. Bouska, Wes. Eitzmann, Jeffrey. Pilger, Tyler. Pitts, Kristen. Riley, Alyssa. Schloesser, Joshua. Thornbrugh, Darren. Eutrophication of U.S. Freshwaters: Analysis of Potential Economic Damages. American Chemical Society. 2009. Volume 43, 12–19. Available from: https://pubs.acs.org/doi/10.1021/es801217q (Accessed 7 May 2019).

Minasyan, Arevik. Christophides, Christophoros. Wilson, Alan. Zervou, Sevasti- Kiriaki.Kaloudis, Triantafyllos. Hiskia, Anastasia. Diversity of cyanobacteria and the presence of cyanotoxins in the epilimnion of Lake Yerevan (Armenia). Toxicon. 2018, Volume 150, 28–38. Available from: https://www.sciencedirect.com/science/article/pii/S0041010118301648. (Accessed 7 May 2019).

Watson, Sue. Higgins, Scott. Whitton, Brian. Paerl, Hans. Harmful Algal Blooms (HABs). Freshwater Algae of North America. 2015. 2nd Edition. Available from: https://www.researchgate.net/publication/280578045_Harmful_Algal_Blooms. (Accessed 7 May 2019).

NYSDEC. Harmful Algal Blooms (HABS) Notifications Page. New York State Department of Environmental Conservation. 2016. Available from: http://www.dec.ny.gov/chemical/83310.html. (Accessed 29 January 2019).

NYSDEC. 2018 Archived HABs Notices. New York State Department of Environmental Conservation. 2018. Available from: http://www.dec.ny.gov/docs/water_pdf/habsarchive2018.pdf. (Accessed 29 January 2019).