Examining relationships between meteorological and algal bloom data on Lake Champlain

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Introduction

Overall air temperature in the Lake Champlain basin, fertilizer use, and non-point phosphorous loading have all risen from 1976-2005 in the Lake Champlain basin (Smeltzer et al., 2012). Cyanobacteria (blue-green algae) are a normal part of aquatic ecosystems in Lake Champlain, yet a combination of the right conditions including excess nutrients and warm, calm water can highly increase the density of cyanobacteria (LCBP 2012).

From 2008 to 2011 several public beaches at Missisquoi Bay and other locations on the main lake were closed due to cyanobacteria (LCBP, 2012). Blue-green algae blooms pose a threat to ecosystem and human health; therefore it is imperative to develop a better understanding of the blooms develop in the lake. Weather conditions have been shown to be important determinants of surface scums on Lake Mendota. Weather may account for a large part of observed natural variability in phytoplankton, especially in the absence of nutrient limitation (Sorrano, 1997).

Objectives

To examine how different climatic conditions may contribute to the occurrence of algae blooms, we compare the occurrence of algae blooms to water temperature, lake level, precipitation, and wind data, among other meteorological variables.

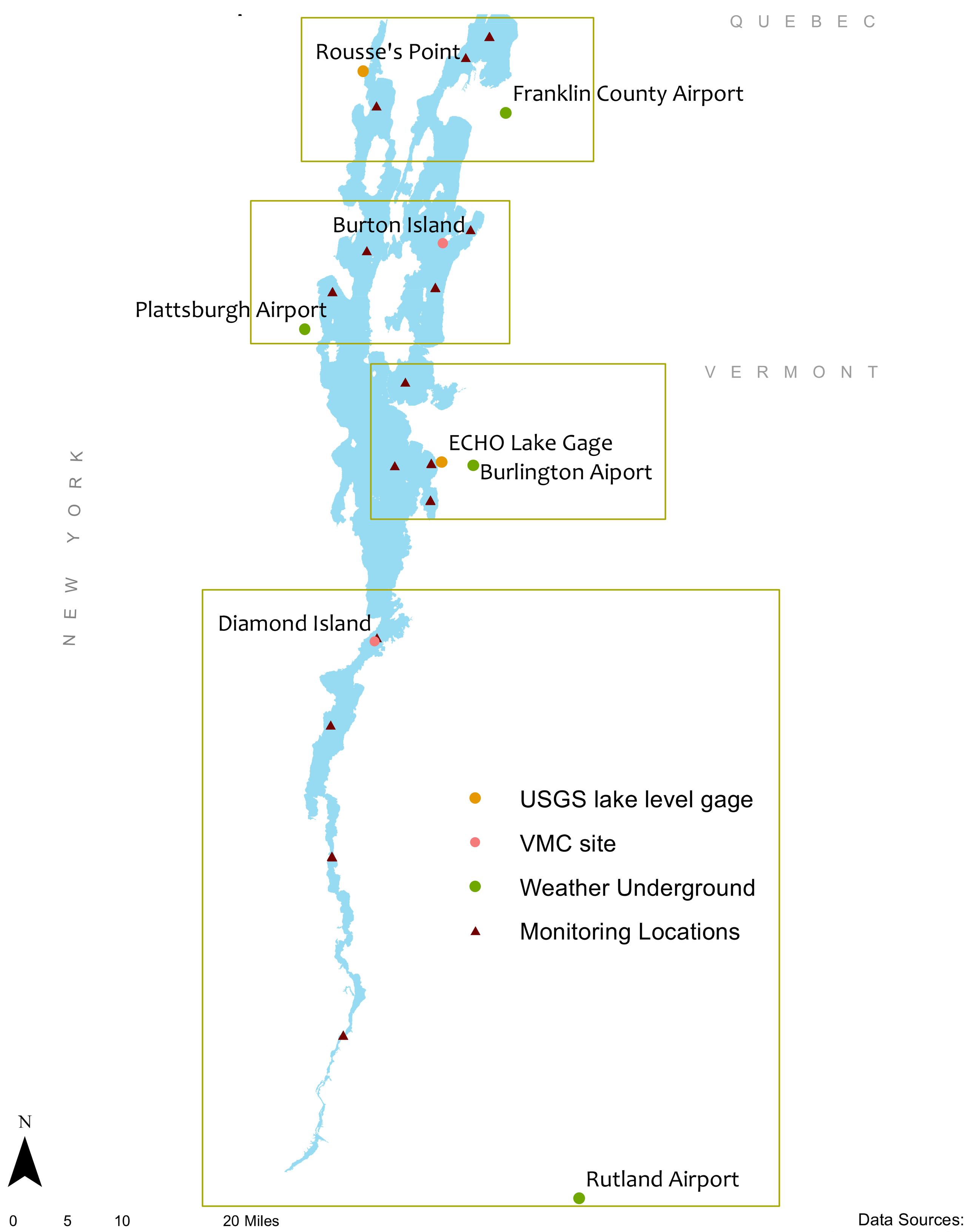

Figure 1. Chlorophyll-a and cyanobacteria monitoring sites and meteorological station locations on Lake Champlain; boxes indicate how regions were grouped for analysis. The lake level gage for Whitehall, NY is not included on this map.

Methods

- Compile data for chlorophyll-a and cyanobacteria from Lake Champlain long term monitoring sites from 2012, 2013, 2014 (http:/ / www.watershedmanagement.vt.gov/ lakes/ htm/ lp_longterm.htm)
- Determine closest airports to sites that have long term hourly or sub-hourly weather monitoring and collect data from Weather Underground historic records for airports (https:/ / www.wunderground.com/)
- Collect lake level data from USGS from stations (04925000,04279085, 4294500) on the lake and download data from the Vermont Monitoring Cooperative stations on the lake
- Develop scripts (R, https:/ / www.r-project.org) for precipitation intensity and magnitude as well as percent of the day windy and average wind speed when windy
- Remove variables due to multicollinearity (max wind speed, max pyranometer, max relative humidity, avg. air temp)
- Run multiple linear regression regular and 1-day offset
- Run LOESS regular and 1-day offset model for variable pairs (880 tests)

<u>Modeled variables</u>

- Precipitation intensity
- Precipitation magnitude
- Percent of the day windy
- Average windspeed when windy
- Average pyranometer reading
- Average relative humidity
- Average water temperature
- Mode air temperature
- Average barometric pressure
- Lake level change
- Average daily stream flow

Photo: Chris Killian, Blue-green algae in Lake Champlain (2011)

Results

There were no significant patterns in an ANOVA analysis for NSE values based on regular/ offset for chlorophyll-a or cyanobacteria overall or by site. Table 1 shows the variables that were used in over 3 variable pair models with an NSE > 0.5.

Table 1. Lists the different variables that were part of pair models with an NSE >0.5 for each type of LOESS modeled.

Site	CHLA Regular	CHLA Offset	BGA Regular	BGA Offset
Burlington		• Mode Air temp		• Average barometric pressure • Lake level change
Plattsburgh				• Average water temp
Rutland			• Average pyranometer	• Mode Air temp • Percent wind • Average barometric pressure
Swanton		• Lake level change • Average water temp • Average relative humidity	• Average wind speed • Stream flow • Mode Air temp • Average pyranometer	• Average wind speed • Stream flow • Lake level change

Results

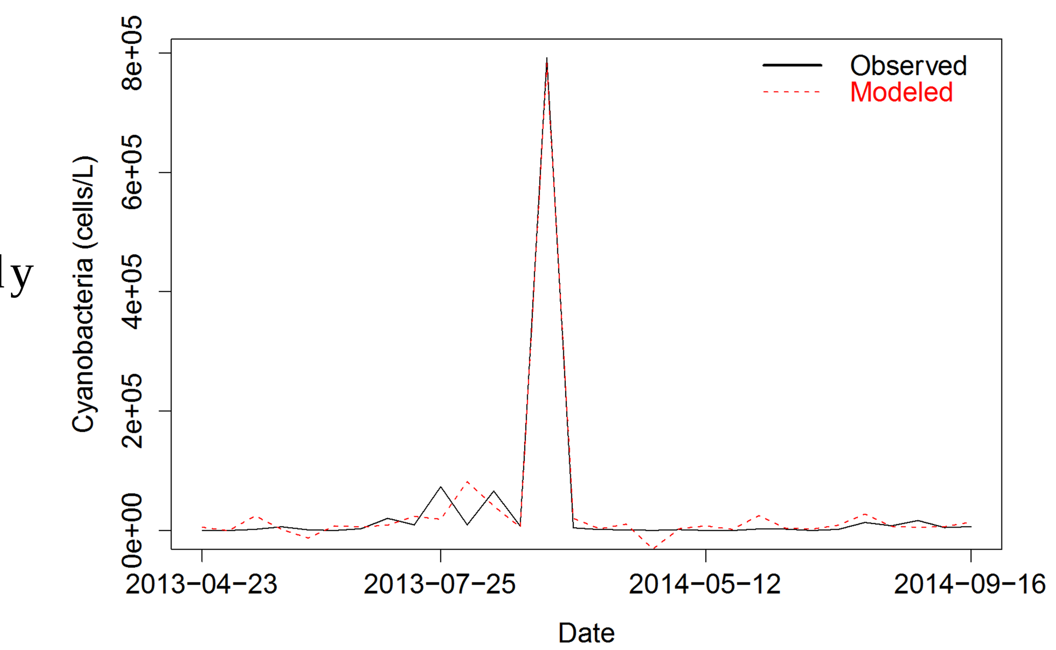

Figure 2. The best LOESS model with an NSE of 0.97 for mean air temperature and percent wind measured for cyanobacteria in Rutland

Based number counts, there were more higher (>0.5) NSE values for LOESS models that were run for the offset models than regular models. The Plattsburgh group had the fewest number of pair models with an NSE > 0.5 and the Swanton group had the most number of models with an NSE >0.5.

There are significant differences (p<0.001) between the cell counts and the web status (Generally Safe, Low and High) of BGA alerts. By determining statistical differences in qualitative measurements, it may be possible to expand the pool of data used.

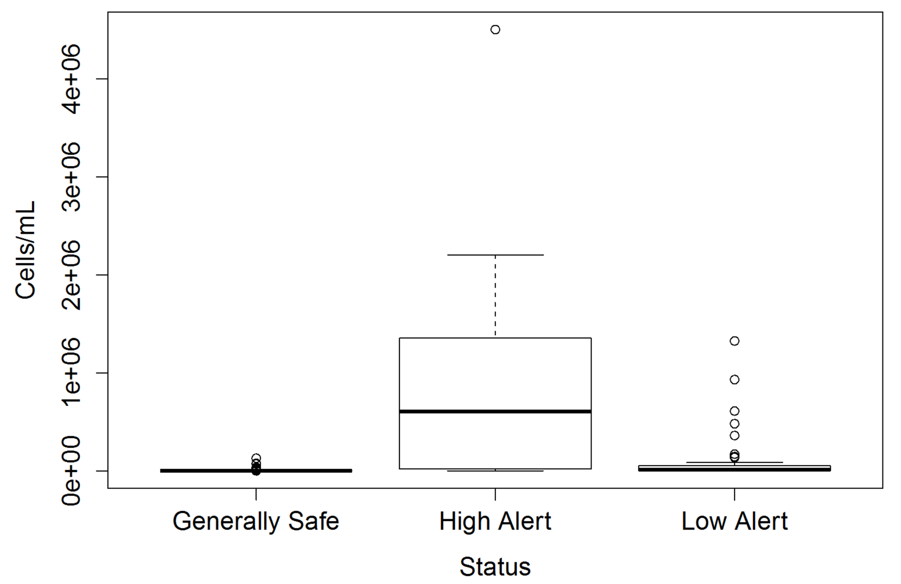

Figure 3. Box plot of different web status and the cell counts (n=885)

Summary

Modeling the behavior of a living organism is challenging and complex; therefore it is not surprising that there are a variety of important variables associated with algal blooms as well as overall inconclusive results for regular and offset models.

Future work could include running the same analysis using data when the long term monitoring started on Lake Champlain in 1992, provided that weather data is also available. Modeling over a longer time period would increase modeling capabilities to capture the amount of variability in the presence of algal blooms.

Acknowledgements

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Literature cited

LCBP (2012) State of the Lake and Ecosystems Indicators Report

Smeltzer, E., Shambaugh, A.D. and Stangel, P. (2012) Environmental change in Lake Champlain revealed by long-term monitoring Journal of Great Lakes Research 38, 6-18.

Soranno, P. (1997) Factors affecting the timing of surface scums and epilimnetic blooms of blue-green algae in a eutrophic lake. Canadian Journal of Fisheries and Aquatic Sciences 54(9), 1965-1975.