

Remote sensing models using Landsat satellite data to monitor algal blooms in Lake Champlain

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Lake Champlain, with a surface area of 1,127 km², is a drinking water source to about 200,000 people living in Vermont and New York (LCBP, 2006). Like many New England lakes, Lake Champlain regularly experiences eutrophic conditions and degraded water quality from seasonal nutrient loadings associated with agricultural and urban runoff in the surrounding watersheds. Non-point sources are the largest contributor of pollution to the lake. These conditions often result in algal blooms, which have become an increasing problem over the past two decades. Frequent lake-wide monitoring is required to understand the dynamics of algal blooms in Lake Champlain. Satellite imagery can provide regular, synoptic coverage of algal production over large areas with better spatial and temporal resolution than in situ monitoring. This study employs Landsat satellite images to monitor the spatial and temporal distributions of algal blooms in Lake Champlain

A three-year composite of *in situ* algal and water quality monitoring data obtained from the University of Vermont's Rubenstein Ecosystem Science Laboratory and the Vermont Department of Environmental Conservation's Long Term Monitoring Program were used to develop satellite algal production models using multi-linear regression. The model is based on the unique spectral signatures of chlorophyll-a, present in all algae (Sellner, et al. 2003).

Landsat Enhanced Thematic Mapper Plus (ETM⁺) satellite images were obtained for the same time period as the in situ water measurement data between 2006 and 2008. A multi-linear regression model was developed using single-band and band-ratio algorithms based on the coincident pairs of satellite reflectance and in situ measurements. The final chlorophyll-a model was then applied to entire satellite scenes to obtain model estimates for all of Lake Champlain.

Model results (Figure 1) show that Landsat satellite data provide a promising monitoring tool to predict lake-wide algal bloom concentrations and propagation. The regression model (Figure 2) showed good performance when compared with in situ data. Our approach can be used to develop a continuous monitoring system for spatial and temporal distribution of algae and has the potential to delineate toxic algal blooms from other species.

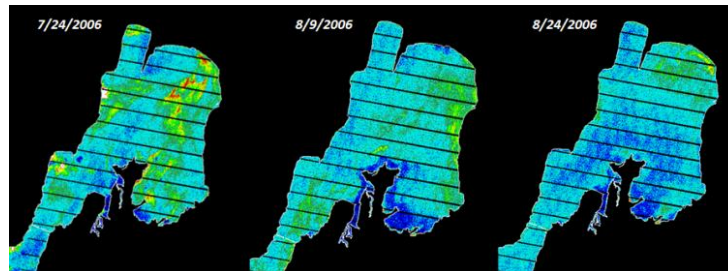
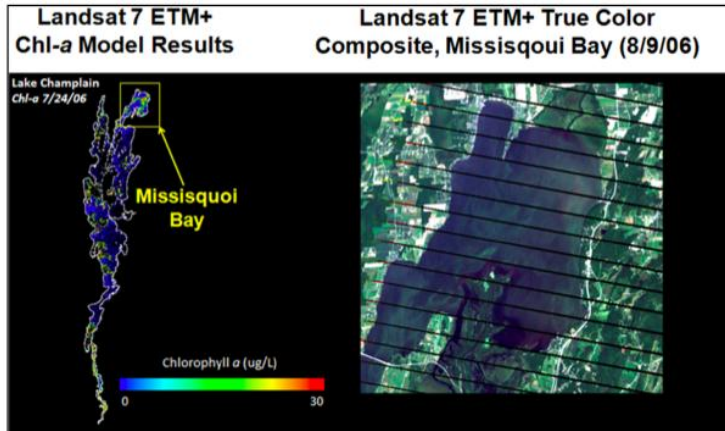


Figure 1 Lake Champlain Landsat ETM+ algal prediction model results shown as chlorophyll-a concentrations in Missisquoi Bay (a 'true color' composite image of Missisquoi Bay from August 9, 2006 is shown in the top right corner for reference).

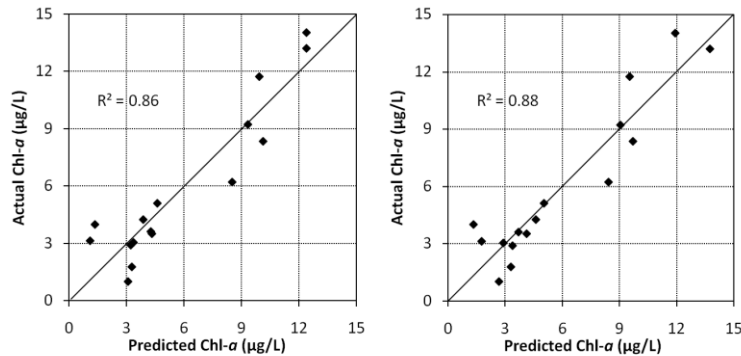


Figure 2 A linear regression model between A) actual and predicted chlorophyll a concentrations (the line represents 1 to 1); B) in situ chlorophyll a and total phytoplankton density (in cells/mL).

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