Environment Canada Environnement Canada

www.ec.gc.ca

Developing New Tools to Monitor Canadian Inland Water Quality

The Problem

Sustaining the quality of inland waters is vital to human and environmental health, and critical to the strength of Canada's resource-based economy. Environment Canada has maintained a ground-based network of monitoring stations since the early 1970s to keep informed on water quality status in Canada, but the picture provided by this monitoring approach is often incomplete.

Weather, climatic cycles, and other stressors of natural origin affect water quality, as do human-induced stressors such as non-point and point-source contaminant and nutrient loadings. Resulting water quality issues often manifest as poor water clarity, eutrophication, and harmful algal blooms.

Photo: Tim Pascoe, Environment Canada

Images capturing the intensity of a cyanobacteria bloom in Lake of the Woods in September 2009; surface accumulations of algal biomass produced thick mats clearly visible from space.

Environment Canada's ground-based network provides a wealth of data to enable scientists and resource managers to establish baseline water quality conditions, determine spatial and temporal trends, ensure compliance with established water quality guidelines, detect emerging water quality issues and measure response to remedial measures and regulatory decisions. But, due to the scale of coverage required, inaccessibility of reaches of terrain, and budgetary and logistical restraints, this kind of monitoring cannot provide all the information needed for fully informed decision making.

Canada

Seeking Solutions through S&T

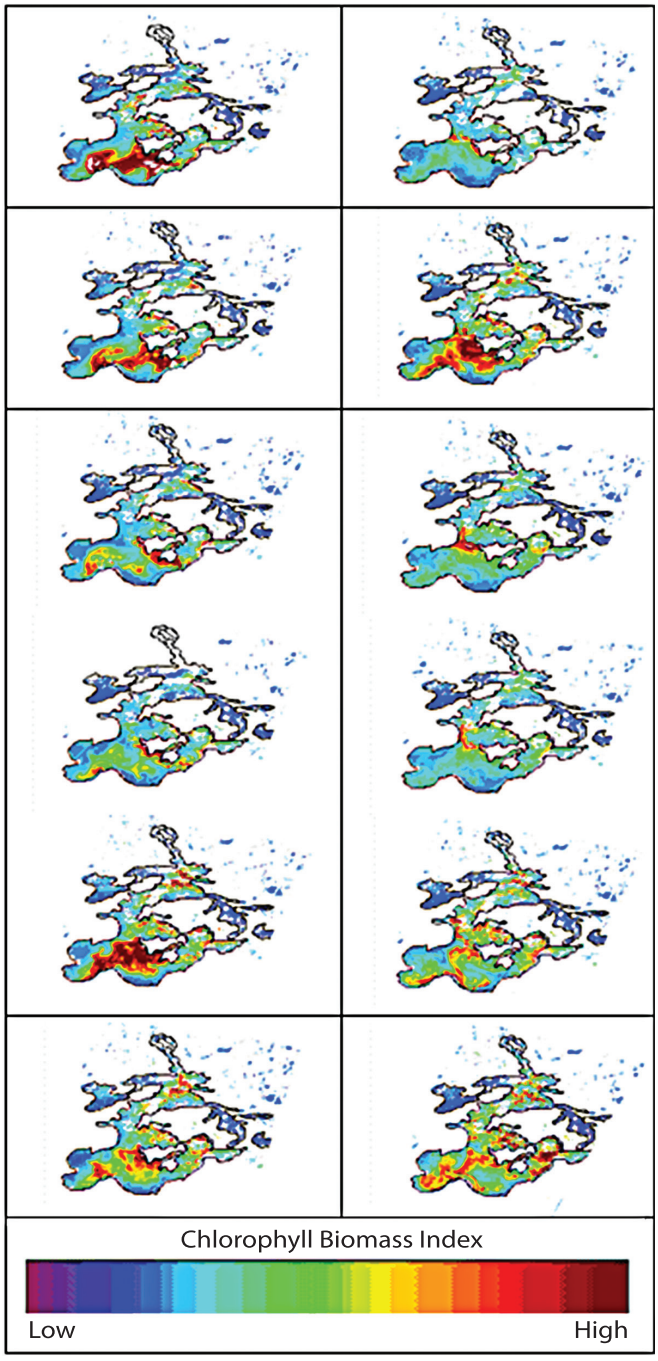

Figure 1: Evolution of a surface cyanobacteria bloom in Lake of the Woods observed by the MERIS aquatic colour sensor, September 2009.

Earth observation satellites are a logical addition to a ground-based network of water quality monitoring stations because they give regular, high-resolution coverage that provides more robust evidence of current status and trends than can be ascertained from intermittent point-sampling alone. With the support of the Canadian Space Agency, researchers in the Aquatic Optics and Remote Sensing Group are working to develop this capacity within Environment Canada.

Extracting inland water quality information from remote sensing of inland water requires detailed knowledge of the optical properties of the waters under consideration, accurate solutions to aquatic radiative transfer theory, and a capacity to differentiate the contribution to the remote sensing signal from the intervening atmosphere.

Researchers have used data from multispectral satellite sensors such as the Moderate Resolution Imaging Spectroradiometer (MODIS), Sea-viewing Wide Field-of-view Sensor (SeaWiFS), Coastal Zone Color Scanner (CZCS), and Medium Resolution Imaging Spectrometer (MERIS) in extensive studies of the Laurentian Great Lakes, Lake Winnipeg and Lake of the Woods, and, recently, the St. Lawrence River. Maps of water clarity, suspended particulates and algal blooms are generated through a combination of empirical, inverse modelling and multivariate statistical methods. These products are used in conjunction with conventional water quality monitoring activities to provide insight into areas of environmental research on scales unobtainable through ground-based approaches. The technology and methodologies are now in place at Environment Canada to acquire and process aquatic colour remote sensing data over some Canadian inland waters in near-real-time, producing daily snapshots of inland water conditions on a routine, fully automated basis. Ongoing development of this facility aims to make these products readily available to users via the website www.ec.gc.ca/inre-nwri/Default.asp?lang=En&n=37A22BD5-1.

Current research is improving the capacity to monitor the onset and progress of harmful algal blooms, and relate algal bloom evolution to bio-optical and physical processes occurring within the water body or its surroundings. Synoptic time-series analyses of such inland water algal blooms as seen from space have been instrumental in describing algal bloom dynamics in Lake of the Woods, to give only one example (Figure 1).

How does it work?

The quality of water is dictated by its physical, chemical and biological properties, some components of which interact with the surrounding light field to cause discernible changes in the colour of the water. The spectral variation of visible radiation leaving a water body, as seen from a remote platform such as an aircraft or satellite sensor, provides information suitable for detecting colour-producing water quality parameters such as phytoplankton pigments, mineral suspended particulates, and dissolved organic matter. Consequently, satellite observations of aquatic colour such as those in Figure 2 can be interpreted in terms of changes in water quality, illustrating seasonal and inter-annual variability of bright-water episodes such as intense phytoplankton blooms and the re-suspension of bottom sediments.

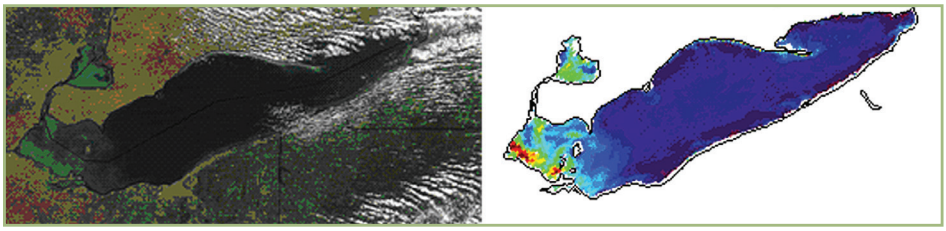

Figure 2: MODIS True Colour composite and derived total suspended particulate matter in Lake Erie.

Transforming Knowledge into Action

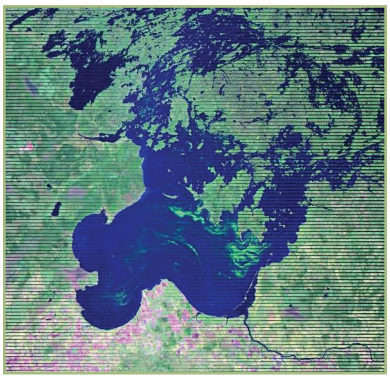

Photo: Caren Binding, Environment Canada

True-colour composite image from the Landsat satellite sensor capturing the fine detail in a surface cyanobacteria bloom in Lake of the Woods on September 22, 2007.

Who can use these results?

Research at Environment Canada's National Water Research Institute provides clear evidence that remote sensing technologies can generate useful tools for environmental scientists and for science users working in environmental stewardship, policy making, resource management, education, and the private sector. The satellite-derived water quality products produced by the Aquatic Optics and Remote Sensing Group make possible increased scale and cost-effectiveness of monitoring activities, enhancing the potential for early warning of adverse ecosystem effects. This has enormous implications for providing effective and consistent widespread monitoring of both event-driven and recurring water quality issues.

Photo: Caren Binding, Environment Canada

True colour image from NASA's MODIS aquatic colour satellite sensor capturing the optical variability of the Great Lakes on September 10, 2004, with the turbid waters of Lake Erie, an offshore algal bloom on Lake Ontario and a Whiting event on Lake Michigan.

Benefits to Canadians

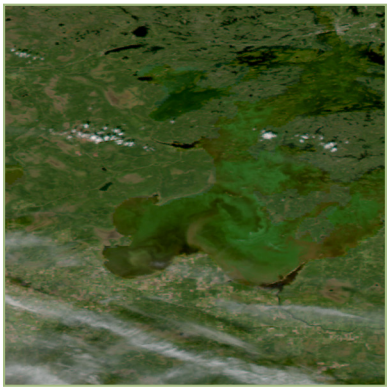

Photo: Caren Binding, Environment Canada

True colour image from NASA's MODIS aquatic colour satellite sensor, capturing the lake-wide cyanobacteria bloom on Lake of the Woods on September 5, 2010. Brown: suspended sediments/high DOC, Green: land vegetation and surface algal bloom, Dark Blue/Black: clear water, White: cloud.

Safe drinking water, protection of beaches and recreational waters, good management of domestic, industrial and agricultural water usage, and conservation of ecosystem health are all of considerable value to Canadians. Synoptic, near-real-time views of inland water quality are of significant value to organizations that play a role in delivering these to Canadians: for example, agencies responsible for drinking water standards, tourism and recreation, and industrial water use, including federal and provincial departments, conservation authorities, and municipal water treatment facilities.

Canadians benefit also from effective legislation and regulation to protect water resources. Remote sensing tools contribute to the fulfilment of several federal and international obligations, including the *Canada Water Act* and the Canada–U.S. Great Lakes Water Quality Agreement.

For more information:

Inland Water Remote Sensing Products (www.ec.gc.ca/inre-nwri/Default.asp?lang=En&n=37A22BD5-1)

Binding, C.E., T.A. Greenberg, J.H. Jerome, R.P. Bukata and G. Letourneau. 2010. An assessment of MERIS algal products during an intense bloom in Lake of the Woods. *Journal of Plankton Research*, doi: 10.1093/plankt/fbq133

Binding, C.E., J.H. Jerome, R.P. Bukata and W.G. Booty. 2010. Suspended particulate matter in Lake Erie derived from MODIS aquatic colour imagery. *International Journal of Remote Sensing* 31(9), doi:10.1080/01431160903302973.

Binding, C.E., J.H. Jerome, W.G. Booty and R.P. Bukata. 2008. Spectral absorption properties of dissolved and particulate matter in Lake Erie. *Remote Sensing of Environment* 112: 1702–1711.

Binding, C.E., J.H. Jerome, R.P. Bukata and W.G. Booty. 2007. Trends in water clarity of the Great Lakes from SeaWiFS and CZCS aquatic colour. *Journal of Great Lakes Research* 33(4): 828–841.

Catalogue No.: En39-1/2011E; ISBN 978-1-100-17659-8