Environmental Monitoring of the Great Lakes Using CoastWatch Data & JAVA GIS

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Environmental Monitoring and Coastal Zone Management

Many of the issues and problems that coastal and ecosystem managers address don't stop at the land's edge. Just as the land side of the coastal zone can affect near shore and off shore areas, lake-wide or localized events can impact near shore and shore areas. Examples include erosion caused by wind driven waves, ice damage to shore structures, toxic blooms that can close beaches, nutrient and sediment laden plumes that can redistribute toxic materials, and exotic species, such as the zebra mussel, that can change the ecosystem and cause great socio-economic loss. As coastal and lake management becomes a higher priority for state coastal programs and regulatory agencies, geospatial technology, such as geographic information systems (GIS), the Global Positioning System (GPS), remote sensing information (especially from satellite), and the Internet, will provide more and more data and tools that can aid in timely, integrated analysis and decision making for coastal and basin-wide management.

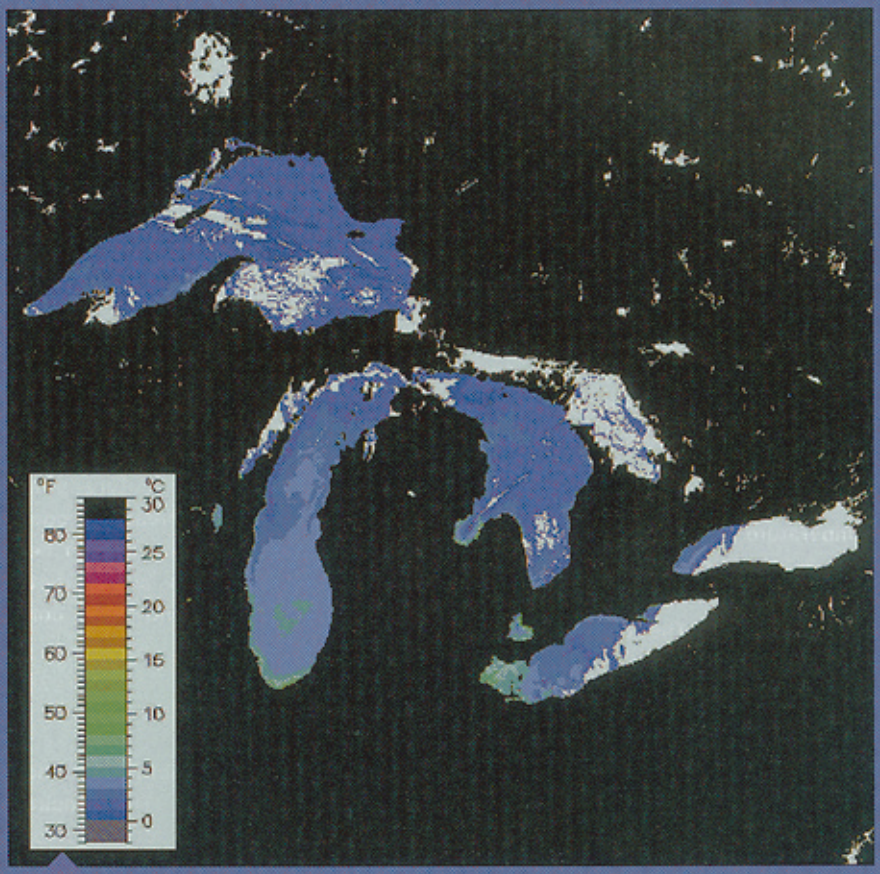

Figure 1. Sample NOAA AVHRR surface temperature image for April 11, 2003 that has been cloud masked and land masked. These 1024 x 1024 (~1.3 km resolution) images will be available for download in GeoTiff format.

CoastWatch Program

The National Oceanic and Atmospheric Administration (NOAA) CoastWatch Program got its start as the result of a "Red Tide" event off the North Carolina coast in late 1987 [1]. The National Environmental Satellite, Data, and Information Service (NESDIS) was asked to provide satellite imagery to monitor the bloom, and derived sea surface temperature (SST) imagery for use in forecasting the development of future events. Under the NOAA Coastal Ocean Program, this concept was developed and extended to other areas

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of the United States. There are currently seven CoastWatch regional sites, or nodes, throughout the coastal U.S. and Great Lakes. The goals and objectives of the program at each node are similar: (1) to receive near real-time satellite imagery and other in situ data, (2) develop regional products using the imagery, and (3) make the imagery and products available to coastal managers and researchers to support environmental science, coastal monitoring, and decision making, as well as to the general public. NOAA CoastWatch directly supports agency statuatory responsibilities in estuarine and marine science, living marine resource protection, and ecosystem monitoring and management contained in several Federal environmental statutes including the U.S.-Canadian Great Lakes Water Quality Agreement.

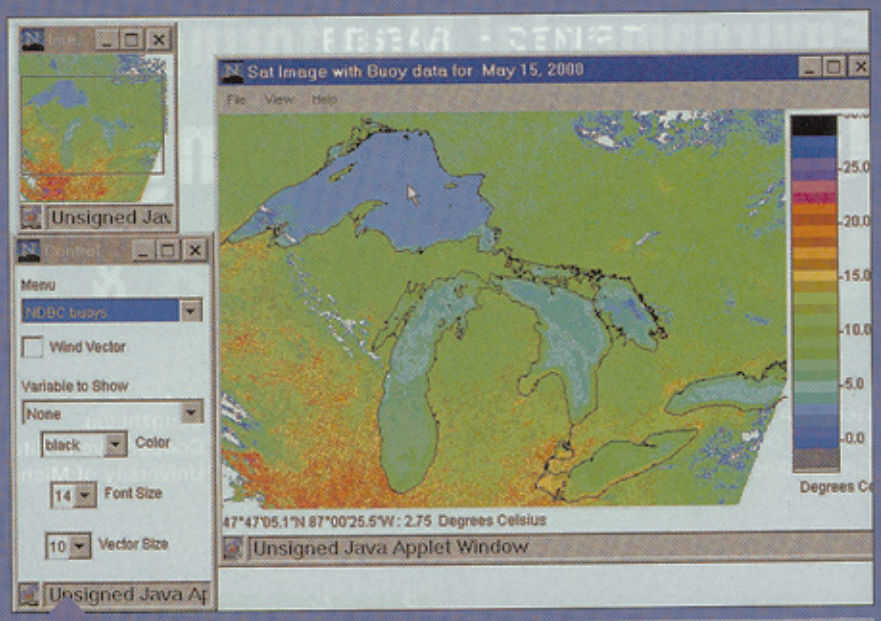

Figure 2. The JAVA applet will start two windows (panner window and image window) and a control panel. The file name, which appears in the upper left corner of the image contains the year, julian day, and hour (GMT) of the image.

Great Lakes Regional CoastWatch Site

In 1990, as part of the CoastWatch program, NOAA's Great Lakes Environmental Research Laboratory (GLERL) located in Ann Arbor, Michigan was chosen as the CoastWatch node for the Great Lakes. The initial CoastWatch product for the Great Lakes was digital imagery of lake surface temperature at resolutions of 1.3 km and 2.6 km, derived from NOAA satellite data and mapped to a Mercator projection [2]. The current product suite of 33 enhanced digital images includes satellite-derived surface temperature, visible and near-infrared reflectance, brightness temperatures, cloud masks, and satellite/solar zenith angle data from the NOAA/AVHRR (Advanced Very High Resolution Radiometer) series of satellites as well as GOES (Geostationary Operational Environmental Satellites) visible, near infrared, water vapor, and surface water temperature data. This imagery is acquired from NESDIS on a daily schedule via the Internet. In addition, in-situ and modeled data, including marine and meteorological observations, buoy observations, water level gauge measurements from NOAA's National Ocean Service, and Great Lakes Surface Environmental Analysis (GLSEA) composite charts, are routinely acquired or produced, stored, and made available to Great Lakes CoastWatch data users. Moreover, Great Lakes Forecasting System (nowcast and forecast) products are also made available. Future plans include enhancing the present product suite with products derived from new satellite sensors such as synthetic aperature radar (SAR) and ocean color sensors.

Data Availability/Use

The original data distribution method was by dial-in modem. This required the data user to have an account on our computer and was slow using the baud rates available in the early 1990's. Although compressed (~300 kb) to shorten download time, the B compression format was not readily useable without software provided to read, uncompress, display, and print the images. As the Internet was developed, data was made available via FTP. This progressed to development of an early web site.

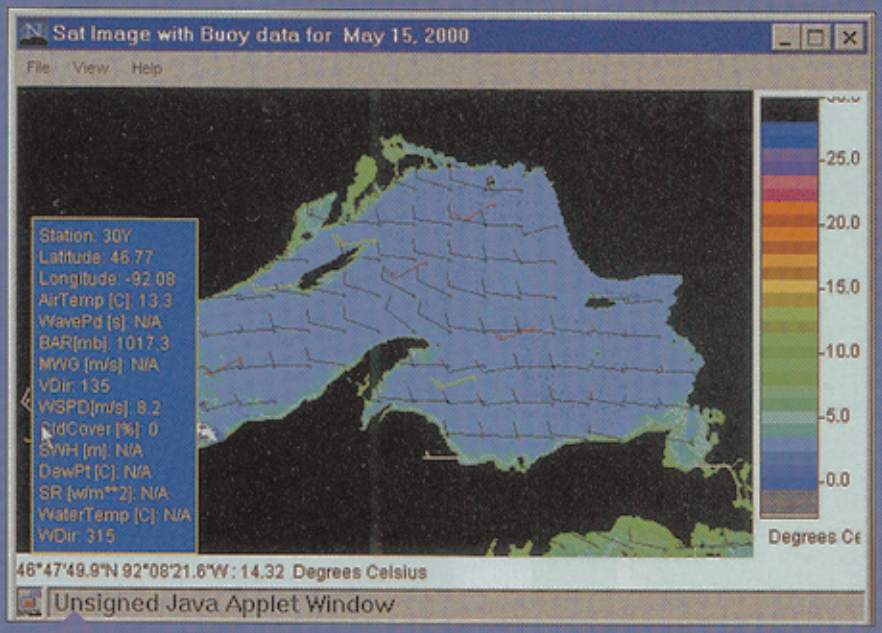

Figure 3. NOAA AVHRR surface temperature image of May 15, 2000 zoomed to show Lake Superior. In addition to the land mask, overlays shown include nowcast gridded winds (black), buoy (red), CMAN station (yellow), and U.S. Coast Guard station (white) marine observation data for the hour of the image.

However, images were not viewable in thumbnail form, so downloading a cloud covered image was a possibility. In February 1999, the current web site at: http://coastwatch.glerl.noaa.gov [3] was introduced providing image preview capability before downloading in one of three file formats (.GIF, Postscript, or CoastWatch compressed file type). Temperature/ice cover animations are available in .AVI, .FLC, and .QT formats. To facilitate the use of the near real-time AVHRR imagery and products in GIS and image processing software, future file formats will include a navigated GeoTiff file as well as .PNG and .HDF formats. The GeoTiff image will be cloud masked and land masked and available in a 1024 x 1024 synoptic scene *(Fig. 1)* and three 512 x 512 regional scenes (all at ~1.3 km resolution). The regional scenes should accommodate interest in a particular lake and the need to transfer files to research vessels underway.

CoastWatch data are used in a variety of ways including monitoring (algal blooms, plumes, ice cover, water intake temperatures at fish hatcheries, etc.), two and three dimensional modeling of Great Lakes physical parameters (wave height, currents, etc.), damage assessment modeling, research, as well as for educational and recreational activities. Great Lakes CoastWatch data and products benefit riparians as well as commercial and recreational users.

Interactive Analysis Tool

To enhance the accessibility and utility of Great Lakes CoastWatch data, a utility, based on a JAVA applet, allows interactive retrieval of physical parameters such as surface temperature, ice cover, winds, and bottom depth at a given location. The applet is initiated using the JAVA GIS button on the Great Lakes CoastWatch home page. A window will appear in which you can specify an image type and date, overlay (shapefile) data, or the URL of a user supplied shapefile to be viewed. Current image data includes near real-time NOAA AVHRR surface temperature data, Channel 1 visible reflectance data, GLSEA daily cloud-free composited surface temperature data, and bathymetry. Ice concentration data (from the National Ice Center Great Lakes Ice Analysis) is available during the winter season. Shapefiles currently include shoreline, bathymetry, and land mask overlays. Once the image type and date are chosen, desired shapefiles can be selected and loaded. Two new windows (panner window and image window) and a control panel window will appear on your screen *(Fig. 2)*. Scroll and zoom options are available using the panner and image window. Overlays (shapefiles) are turned on and off using the control panel. Overlay colors can be changed to enhance visibility. In addition, near real-time NOAAPort marine observation data at buoy, CMAN, and Coast Guard shore station locations and/or nowcast gridded winds (at the hour of the displayed satellite image) can be displayed, and observed values obtained by moving the cursor over the station or wind vector of interest *(Fig. 3)*. Retrieval

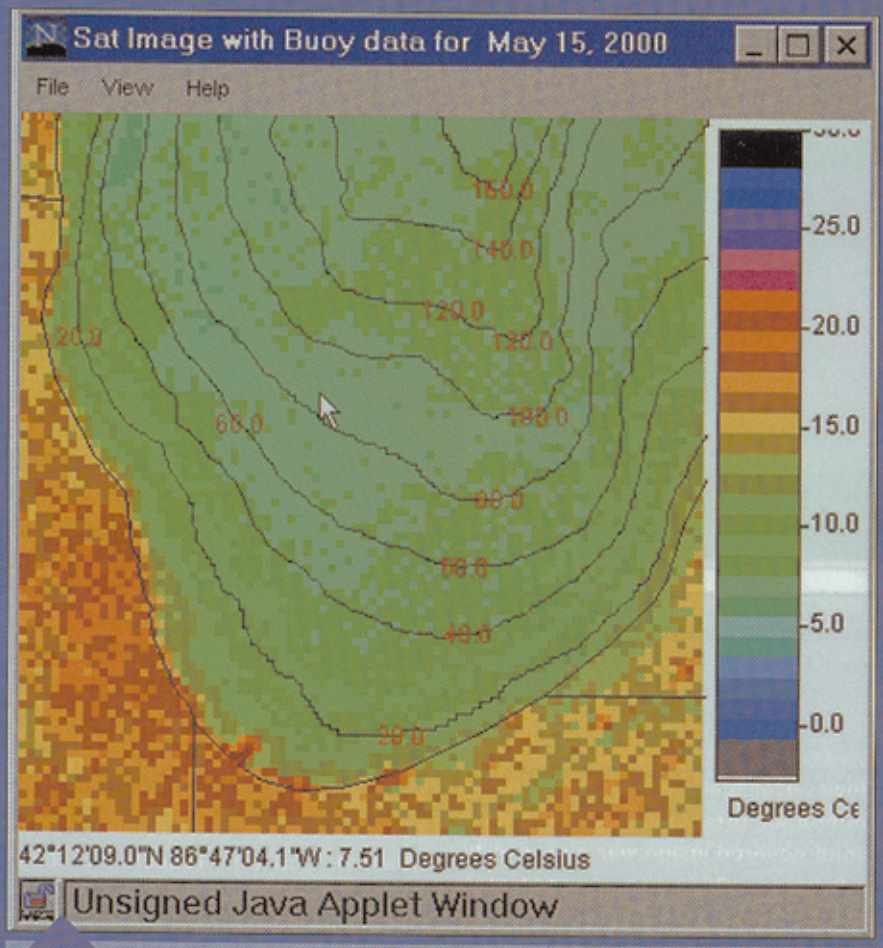

Figure 4. NOAA AVHRR surface temperature image of May 15, 2000, zoomed to show bathymetry in southern Lake Michigan (depth in meters).

of lake surface temperature, ice cover concentration, or depth and latitude/longitude at the cursor position is provided. Capturing and saving (in one of several file formats) a zoomed image with shapefile overlay *(Fig. 4)* is possible using a freeware or shareware screen capture software tool.

Although newly introduced, this applet will provide data users with a tool that will enhance the accessibility and utility of Great Lakes CoastWatch data by providing the interactive capability to examine the satellite imagery with ancillary data sets (overlays). Additional image types and shapefile overlays are planned for inclusion in the future. Moreover, the user can overlay his own data set once it is in shapefile format ■

Acknowledgements

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References

[1] Pyke, T.N., 1969. CoastWatch: New mission for NOAA weather satellites. Sea Technology 30(4):27-32.

[2] Leshkevich, G.A., Schwab, D.J., and Muhr, G.C., 1997. Satellite environmental monitoring of the Great Lakes: Great Lakes CoastWatch Program update. Marine Technology Society Journal 30(4):28-35.

[3] Leshkevich, G.A., Schwab, D.J., Muhr, G.C., and Liu, S., 1999. World Wide Web access to Great Lakes CoastWatch environmental data. In proceedings: Symposium on Water Resources and the World Wide Web. American Water Resources Association, Seattle, WA, Dec. 5-9.