A National Science Foundation Supported Project

Digitalization of Coastal Management and Decision Making

Supported by Multi-Dimensional Geospatial Information and Analysis

Principal Investigator Rongxing (Ron) Li[1]

Co-PIs Keith W. Bedford[1], C. K. Shum[1], J. Raul Ramirez[2], and Aidong Zhang[3]

with the assistance of

Dr. K. Di[1], Dr. A. Elaksher[1], R. Al-Ruzouq[1], T. Ali[2], K.-C. Cheng[1], C.-Y. Kuo[1], R. Ma[1], S. O'Neil[1], and X. Xu[3]

[1]*Department of Civil and Environmental Engineering and Geodetic Science, The Ohio State University*

[2]*Center for Mapping, The Ohio State University*

[3]*Department of Computer Science and Engineering, State University of New York at Buffalo*

Government agencies face an urgent challenge in their management of coastal resources. For example, economic losses from coastal zone erosion in Ohio alone exceed tens of millions of dollars per year. Researchers at The Ohio State University and the State University of New York at Buffalo are addressing these problems in a National Science Foundation Digital Government project aimed at developing new and more efficient technologies for government decision making.

The goal of this interdisciplinary research project (2001-2004) is to develop technologies to enhance the operational capabilities of governmental agencies responsible for coastal management and policy making. For the first time, agencies will be able to account for the changing nature of coastal zones. Detailed information and forecasting models combined with an Internet-based information system will enable a high degree of coordination between coastal management and policy making.

This project will:

a) significantly enhance the capacity for handling spatio-temporal coastal databases,

b) build a basis for coastal geospatial information sharing for interagency operations, and

c) provide innovative tools for data analysis to increase efficiency and reduce operating costs.

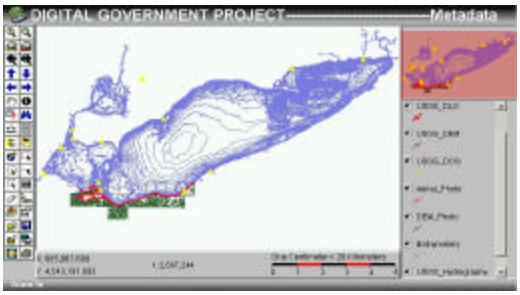
First Year Accomplishments

The research team has created a coastal terrain model (CTM) containing both topography and bathymetry and generated Lake Erie shorelines using 1-meter (stereo) and 4-meter resolution IKONOS satellite images and aerial photographs. In addition, high-quality water level data for Lake Erie has been generated using the Great Lakes Forecasting System along with tide gauge, buoy and spaceborne satellite altimeter data. Studies have been conducted on the uncertainties within traditional and digital shorelines, visualization of coastal features, and the interoperability of distributed data. System design for two decision support subsystems (ODNR permit approval system, and pilot erosion warning system) is complete, including conceptual model, logical model, and database design.

The project is now entering its second year. Research results from the Lake Erie pilot site will be published. In addition to conducting further research based on Lake Erie data, results will be modified and tested at a Tampa Bay test site.

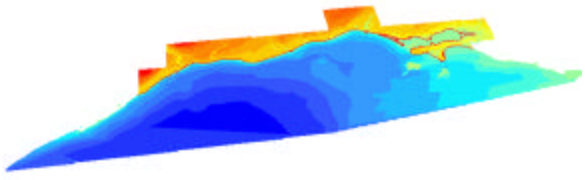
Spatio-temporal Databases

A Snapshot of the Spatial Data Inventory Model



A web-based data inventory system has been developed using ESRI's ArcIMS software. The system allows government agencies to search for scientific data provided by multiple sources in a project area. Shoreline, DLG, bathymetry and hydrography data are displayed directly in the system as different layers. DEM and DOQ data are associated with the shoreline using dynamic segmentation techniques. Available data and metadata information can be retrieved easily by clicking on different segments on the shoreline. This unified system also supports searching for land parcel and water level data, allowing agencies to efficiently and equitably assess areas of concern for coastal policy making.

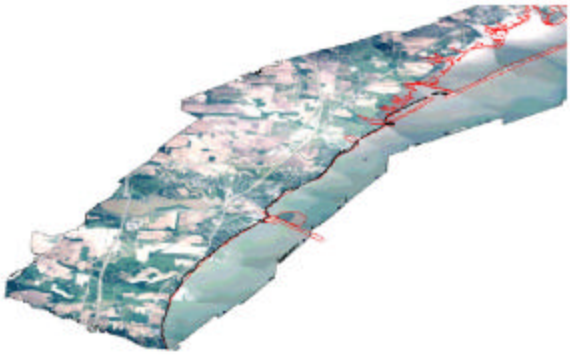
Coastal Terrain Modeling



In this research area, advanced modeling techniques have been used to join the land topography and the lake bathymetry into one unified three-dimensional coastal terrain model (CTM) containing both topography and bathymetry. A 30-meter resolution CTM was produced using USGS DEM and NOAA bathymetry data by horizontal and vertical datum conversion, projection transformation, resampling and mosaicking.

For further information, please contact Dr. Rongxing (Ron) Li via e-mail at li.282@osu.edu
The Ohio State University Department of Civil & Environmental Engineering & Geodetic Science
470 Hitchcock Hall, 2070 Neil Avenue, Columbus, OH 43210-1275

Shoreline Mapping



DEM and orthoimage for the Lake Erie test site have been generated from IKONOS images acquired in 2001 as well as 1997 NOAA aerial images. A shoreline was digitized directly from the 4-meter resolution IKONOS georeferenced multispectral imagery. For the 1-meter resolution stereo images, the vendor-provided Rational Function (RF) model was refined using ground control points (GCPs). Afterwards, semi-automatic shoreline extraction from IKONOS stereo images was conducted by image matching. A 3-D shoreline was then calculated through space intersection using the refined RF. The ground position RMS errors of the shoreline and the orthoimage were found to be 1 to 2 meters.

Water Surface Modeling

Annual and 19-year average mean high water (MHW) and mean lower-low water (MLLW) were initially calculated for 17 tide-gauge stations in Lake Erie. Water levels in the lake were also calculated using satellite altimetry points. In addition, a GPS buoy survey was conducted at Marblehead.

Using the Great Lakes Forecasting System, a numerical model has been developed for Lake Erie that simulates the water level variation on 2 km and 0.5 km grid intervals for the lake surface.

The objective of this research is to develop a protocol for determining a 19-year average lake water surface that can be used with the CTM and various instantaneous shorelines to produce tide-coordinated shorelines for mapping purposes and/or instantaneous shorelines for use in erosion prediction systems.

Coastal Management and Decision Making

Geospatial Information-based Construction Permit Model

The ODNR construction permit approval system simulates the decision-making process for the granting of building permits on coastline properties in a GIS environment. The system incorporates a complete set of relevant geospatial data including USGS DOQ, DLG, and DEM; instantaneous and tide-coordinated shorelines; a CTM; and a water surface model (WSM) as well as cadastral data (parcel maps) and construction design maps. This information can be combined in the agency application process to provide a complete analysis tool for ODNR managers.

Internet-based Shoreline Erosion Awareness Model

An Internet-based shoreline erosion awareness system has been designed to forecast the retreating Lake Erie shoreline in the Painesville, OH area. This system can provide support for coastal property management and land-use decision making and also provide information for the examination of environmental changes. In particular, the system can

- Identify coastal areas at high risk of erosion,
- Precisely identify areas in need of protection, and
- Identify efficient and/or inefficient shoreline protection measures.

Acknowledgements

We would like to acknowledge significant collaborative contributions in the first year by CDR Jon Bailey, Dr. Bruce Parker, and Dr. Kurt Hess (NOAA); Dr. Grady Tuell (University of Florida); and John Watkins, Justin Reinhart and Don Guy (ODNR). Based on tasks of the second and third year, we expect to work with additional collaborators.

Collaborating research agencies include NOAA National Geodetic Survey, NOAA Office of Coastal Survey, NOAA National Geophysical Data Center, NIMA, USGS Coastal and Marine Geology Program, Office of Naval Research Laboratory, Ohio Supercomputing Center, Ohio Department of Natural Resources, Ohio Department of Environmental Protection, and the Lake County Commission of Ohio.