**NASA DEVELOP National Program**

****NASA Langley Research Center

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**Great Lakes Climate II**

*Monitoring the Impacts of Climate Change and Decreasing Water Levels on Wetlands in the Great Lakes Region of North America*

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Fall 2014 DEVELOP Great Lakes Climate I Team

**Partner Organizations**

Great Lakes and St. Lawrence Cities Initiative (David Ullrich)

Georgian Bay Forever (David Sweetnam)

Ontario Ministry of Natural Resources and Forestry (Mike Robertson)

**Applied Sciences National Applications Addressed:**

Climate & Ecological Forecasting

**Study Area:** This study focused on two areas within the Great Lakes Basin: the Georgian Bay in Ontario, Canada and the southern portion of Lake Ontario, including Rochester, NY

**Study Period:** May 1987 – June 2013

**Earth Observations & Parameters**

* Landsat 8 OLI/TIR: Land Cover
* Landsat 7 ETM+: Land Cover
* Landsat 5 TM: Land Cover
* AQUA MODIS: NDVI
* Terra MODIS: NDVI
* Terra ASTER: Digital Elevation Model (DEM)
* TOPEX/Poseidon Jason-1: Lake Water Levels
* OSTM/Jason-2: Lake Water Levels

**Objectives Overview**

Wetlands in the Great Lakes basin are at risk of degradation due to decreases in water levels and changes in land use. Climate change models predict further declines in lake levels. A clear understanding of how wetlands have responded to lake level fluctuations in the past will help policy-makers prepare for future changes. Land cover maps highlighting the changes in coastal wetlands extent were developed, using historic Landsat and Aqua/Terra MODIS data, to satisfy this need. TOPEX/Poseidon Jason-1 and OSTM/Jason-2 lake water level data was also used to graph water level fluctuations for comparison to wetland extent changes.

**Abstract**

Wetlands are considered to be some of the most productive and diverse ecosystems on Earth. The Laurentian Great Lakes region of North America includes several types of coastal wetlands (e.g., swamps and marshes) that support a high diversity of biota. The health of these ecosystems are very important for ecological communities and economic industries, which benefit from fisheries and tourism. Great Lakes wetlands have been estimated to provide over 10,000 dollars per acre in economic and ecosystem services. The effects of climate change, including variations in temperature, precipitation, and evapotranspiration, could impact the water level of the Great Lakes directly, and therefore, the development and survival of coastal wetlands. Increasing environmental pressures from rising populations, invasive species, and pollution will also negatively affect wetlands if they are not managed appropriately. An updated land cover classification was developed, using a Random Forest classification method, to evaluate and monitor changes in the wetlands around Georgian Bay and the Southern portion of Lake Ontario. NASA Earth Observations System (EOS) data from Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper (ETM+), and Landsat 8 Operational Land Imager (OLI) provided historical images and current images to classify land cover. Resultant land cover classifications were validated with ground truth data. Additionally, TOPEX/Poseidon Jason-1 and Ocean Surface Topography Mission (OSTM)/Jason-2 radar altimeters and *in-situ* water gauge data served as a resource for tracking water levels over time. This methodology offers a more cost-effective approach to monitoring wetlands in the region.

**Community Concerns**

* Wetlands are a vital ecosystem in the Great Lakes region supporting diverse biota, eco-tourism and other economic enterprises
* Great Lakes water levels were at historic lows in 2013; continued low water levels may adversely impact the surrounding wetlands
* Pressures on wetland areas from increasing urbanization, invasive species, lower water levels and climate change may damage this important resource

**Current Management Practices & Policies**

This project reaches across different Canadian federal, provincial, and local government jurisdictions that have taken individual and combined efforts to address the status of wetlands in the Great Lakes basin.  In Canada, and specifically Ontario, where the Georgian Bay is located, there is no specific legislation protecting wetlands; although there is some indirect coverage through conservation acts. Also, some Canadian wetlands are protected through policies and agreements, but these accords are not acknowledged as law. A number of natural heritage protection measures and planned upcoming legislation may provide wetlands with future protection, but currently, detrimental policies remain in effect, including allowing the drainage of wetlands for agricultural use. The wetlands along the southern coast of Lake Ontario fall under both United States and New York state laws and regulations. These wetlands are protected under section 404 of the Clean Water Act and regulated by the United States Army Corps of Engineers. Additionally these wetlands, encompassed in the New York state (NYS) Lake Plain Ecozone, are protected under various articles of NYS’s Environmental Conservation Law (ECL). Articles 24 and 25 of the ECL, enacted in the 1970’s, specifically protect fresh water wetlands and tidal wetlands, respectively. These wetland regulations are enforced by the NYS Department of Environment Conservation’s Environmental Conservation Police Officers (ECOs) and NYS Forest Rangers. Both ECO’s and rangers are sworn state police officers able to enforce all state laws but focus their efforts on enforcing the ECL articles.

**Decision Support Tools**

* Time Series Wetland Extent Maps
* Land Cover Classified Maps
* Updated and inexpensive methodology for land cover classification of the wetland areas

**Benefit to End-User:**

* Influence conservation policy formulation by providing wetlands health and extent trends over a twenty year period
* Time-series maps provide a powerful visual aid to educate the public on the importance of wetland conservation
* A land classification methodology using Landsat and other publicly available NASA satellite data provides an inexpensive and timely method for local conservation groups to track wetland changes

**Models Utilized**

* Random Forest Classification Model

**Ancillary Datasets Utilized**

* Environment Canada (Water Office) – Parry Sound *in situ* water levels
* Google Earth Imagery - land cover
* Great Lakes Coastal Wetland Consortium – wetland shape file
* Ontario Ministry of Natural Resources and Forestry – Land Cover Database
* Ontario Ministry of Natural Resources, Science and Information Branch – Southern Ontario Land Resource Information System Classification Scheme
* United States Department of Agriculture – Lake Huron Height Variations
* United States Department of Agriculture’s Natural Resources Conservation Service – Soil Survey
* United States Army Corps of Engineers Historic Aerial Imagery/New York State 1986 Historic Aerial Photography
* U.S. Fish & Wildlife National Wetlands Inventory
* National Oceanic and Atmospheric Administration Coastal Change Analysis Program

**Software Utilized**

ArcGIS 10.2.2 - Raster Manipulation/Analysis, Image Enhancement, Map Creation, Spatial Analyst Classification tools

ERDAS IMAGINE – Accuracy Assessment

Microsoft EXCEL – Water level graphs

Python scripting – Imagery Digital Numbers to Reflectance conversion

R programming – Dr. Ned Horning’s and Dr. Martin Wegmann’s Random Forest Land Cover classification script for Landsat Imagery