**NASA DEVELOP National Program**



NASA Langley Research Center

*Summer 2015*

North Carolina Ecological Forecasting

Evaluating the Application of NASA Earth Observations to Rapidly Detect Change in Wetland Types at a Regional Scale

 **Technical Report**

Rough Draft – June 25, 2015

Zand Bakhtiari, (Project Lead)

Stephen Zimmerman

Kayla Patel

Brad Gregory

Dr. Kenton Ross NASA DEVELOP National Program (Science Advisor)

Michael Bender, NASA DEVELOP National Program (Technical Lead)

# I. Abstract

[Placeholder - do not put anything here until the final draft submission. The abstract in the project summary is where the working draft of the abstract should “live”]

**Keywords**

Wetlands, Outer Banks, Albemarle Sound, Pamlico Sound, Landcover, Landcover change, Ecological Forecasting

# II. Introduction

**Background:** Coastal regions, such as the Albemarle-Pamlico estuary system, are heavily dependent on extensive healthy wetlands to provide a transitional buffer between terrestrial and aquatic ecosystems. Commonly misunderstood as smelly, muddy, and aesthetically unappealing, wetlands are responsible for peat deposition and sediment trapping, and filtering toxic heavy metals and nutrient overloads from urban or agricultural runoff (Howarth et al. 1996, Lytle et al. 1998, Stevenson et al. 1985). Wetlands also offer predation refuge for juvenile fish species (Jude and Pappas, 1992) which consequently supports local fishing industry by ensuring steady and healthy fish populations. These transitional ecosystems have very high primary production and effectively sequester carbon by fixing carbon dioxide (CO2) in the form of biomass (Whiting and Chanton, 2001). Coastlines frequently subjected to hurricanes and heavy storms such as the eastern United States benefit greatly from wetlands’ ability to mitigate damage and flood conditions (Gedan et al. 2011). Ecotourism also benefits from extensive wetland ecosystems by offering economic opportunities in recreational water activities such as fishing, kayak/canoeing, and for some just an escape from reality.

**Project Objectives:** This project looked at wetland extent in the Albemarle-Pamlico estuary over time. Using a dense time-stacking of Landsat Imagery, wetland extent were mapped throughout Albemarle Pamlico watershed between the years 2000 – 2015. NASA Earth Observing Systems (EOS), in particular Landsat-5, 7, and 8, were used to collect imagery. Two indices were used, one that measured change in water extent over the years and one that measured the relative health of the wetlands themselves. This two pronged approach sought to capture both natural and anthropogenic effects on the Albemarle Pamlico estuary system.

**Study Area:** The Albemarle-Pamlico watershed encompasses a large geographic area, approximately 30,000 square miles.  This includes 25 counties in Northeastern, North Carolina and 10 counties in Southeastern, Virginia.  The watershed is made of six major river basins and two major sounds. This project’s study area focused on the Albemarle and Pamlico estuary system, the second largest estuary system in the United States.

**Study Period:** 2000 – 2015

**National Application:** This project contributes to NASA Ecological Forecasting by focusing on mapping wetland extent and creating a method to determine wetland health using remote sensing applications.

**Project Partners:** Albemarle-Pamlico National Estuary Partnership (APNEP)Partnership with APNEP has been growing since the fall 2014 term.  Jim Hawhee proposed this project with the intention of applying the methodology to all land cover types in the Albemarle-Pamlico region. The methodologies can also be applied to all National Estuary Programs (28 total) across the United States, who would like to more rapidly and accurately evaluate wetland extent trends within watersheds. APNEP staff is well-positioned to disseminate the results of this project to other programs and consult with them regarding the utility of the effort for environmental management purposes.

# III. Methodology

This analysis used Landsat 5, 7, and 8 scenes to examine changes in wetland health and shoreline extent from 2000-2015, with 2013-2015 images from Landsat-8 and 2000-2013 images from Landsat-5 and 7. In an effort to account for changes associated with seasonality, a summer, fall, winter and spring image for each year was collected from Earth Explorer and pre-processed. The summer scenes were all captured between late July and early August, the fall scenes are from late October to early November, the winter scenes were captured in late January and early February, and the spring scenes are from late April and early May. Each scene was then run through an automated script that extracted the necessary bands, converted the images to top-of-atmosphere reflectance, and performed the change analysis.

The change analysis was two-fold, with an examination of coastline change and of overall wetland health throughout the time period. Data processing involved calculating two band indices, Normalized Difference Water Index (NDWI) and a wetland band health ratio *((NIR\*SWIR)/(NIR+SWIR))* to assess each of these characteristics. NDWI leverages the green and NIR bands to highlight and measure surface water extent (McFeeters 2013). A threshold of 0 is frequently applied to the index with values > 0 classified as water and values <= 0 classified as non-water (McFeeters 2013). Using this threshold, coastline changes along the Albemarle-Pamlico watershed throughout the time series were determined, illustrating how coastal wetland locations have moved and shifted throughout the time period. The wetland health band ratio is known for separating water from urban and wetland (Ozesmi and Bauer 2002). The ratio uses the NIR band and SWIR bands to identify and highlight wetlands, allowing them to be easily visually identified. The NIR band highlights vegetation and shorelines (USGS), and is often considered the most important band in wetland determination (Ozesmi and Bauer 2002). The SWIR band discriminates soil moisture content and vegetation (USGS), helping to determine areas of frequently wet and inundated soils. Leveraging these bands highlights wetland health and extent, and when the index is calculated for each scene, these characteristics can be viewed across the time series. Using the binary NDWI images, a map showing the derived shoreline in each step in the time series was produced to illustrate the temporal change in coastline extent. The wetland health index images were compiled into a short video that runs through each image and shows how the wetlands changed over time.

# IV. Results & Discussion

Insert images, graphs, maps, charts, etc. here. Choose the most important results to highlight here. No word cap, but two to six pages is a good range.

Things to discuss:

* Analysis of Results: What can you tell from your graphs, images, etc.? What does this mean for your project?
* Errors & Uncertainty: What factors could you not account for, what things didn’t work out like you expected they would, etc.
* Future Work: If this project was to be selected for another term, what would be the focus? What other areas would be of interest?

# V. Conclusions

Final conclusions. Word count: 200-600 (~a page).

# VI. Acknowledgments

Insert here. Keep to a concise paragraph or bullets of names. End with the following sentence.

This material is based upon work supported by NASA through contract NNL11AA00B and cooperative agreement NNX14AB60A.

# VII. References

Insert references here. Only include articles/content cited in the body of text above. It’s great if you read many other articles, but they should not all be listed here unless they are being cited in this report.

Use whatever style you want - here are some options:

<http://www.dovepress.com/author_guidelines.php?folder_id=208>

<http://en.wikipedia.org/wiki/Citation>

<http://www.agu.org/pubs/pdf/AuthorRefSheet.pdf>

<http://linguistics.byu.edu/faculty/henrichsenl/apa/apa01.html>

# VIII. Content Innovation

In preparation for DEVELOP’s coming microjournal, please select two content innovation features to support your paper. For each item, please list the name of the feature, and include the tool itself if possible (eg. glossary terms and definitions). If the tool does not work in Microsoft Word (eg. Interactive MATLAB Figure Viewer), please list the file name and upload the related file to the microjournal folder on the DEVELOP Exchange. If you choose to use Inline Supplementary Material, please also include where the material should appear in the text.

**Some options include:**

AudioSlides

Database Linking Tool

Data Profile

Executable Papers

Featured Author Videos

Featured Multimedia for this Article (video and podcast options)

Glossary Viewer

Inline Supplementary Material (figures, tables, computer code)

Interactive Map Viewer

Interactive MATLAB Figure Viewer

Interactive Plot Viewer

Nomenclature Viewer

# IV. Appendices

Insert here

Equation example (from Colorado Water Resources’ Tech Paper)

“This runoff is calculated using the following equation:

Equation 2: Spatial distribution of runoff equation

where *pn* is the spatially distributed monthly precipitation data and *p* is the average climatic precipitation for the region.“