**NASA DEVELOP National Program**

Wise, VA and Langley Research Center

**Fall 2015**

**Short Title: Virginia Water Resources II**

**Subtitle:** Utilizing NASA Earth Observations to Identify Algal Hotspots in the Chesapeake Bay

**VPS Title:**

**Project Team & Partners**

**Project Team:**

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**Partner Organizations:**

Virginia Institute of Marine Science (VIMS), End-User, POC: Dr. Kim Reece

Virginia Department of Environmental Quality (DEQ), End-User, POC: Anne Schlegal, Dr. Tish Robertson

Old Dominion University (ODU) Department of Biological Sciences, Collaborator, POC: Dr. Todd Egerton)

Virginia Governor’s Office Deputy Secretary of Natural Resources for the Chesapeake Bay, Collaborator,

POC: Russ Baxter)

**Project Details**

**Applied Sciences National Applications Addressed:**

Water Resources

**Study Area:** Virginia (VA) - Lower James River, Lower York River, Elizabeth River, Mobjack Bay,

Chesapeake Bay

**Study Period:** May 2011 - October 2015

**Earth Observations & Parameters:**

Aqua, MODIS - Multispectral reflectance

Landsat 8, OLI - Multispectral reflectance

Landsat 7, ETM+ - Multispectral reflectance

**Ancillary Datasets Utilized:**

* Virginia Institute of Marine Science - in situ water sample data
* Old Dominion University - in situ water sample data
* National Oceanic and Atmospheric Administration – CoastWatch MODIS Chlorophyll-a product

**Models Utilized:**

* Lim, J & Choi, M (2015) - Multiple regression models of spectral reflectance and water quality parameters
* Song et. al. (2011) Retrieval of total suspended matter (TSM) and chlorophyll-a (Chl-a) concentration from remote-sensing data for drinking water resources

**Software Utilized:**

ArcGIS - Raster manipulation/analysis, image enhancement & mapping of Landsat data

R - Statistical analysis, calculation and testing of chlorophyll estimation formula

**Project Overview**

**80-100 Word Objectives Overview:**

The purpose of this project was to create a python tool that allows its users to determine potential locations of harmful algal blooms (HABs) in the Chesapeake Bay and its estuaries. The tool integrates Landsat8 and Aqua MODIS data and applies an algorithm calibrated using historical in-situ data collected by the Virginia Institute of Marine Science (VIMS), Old Dominion University, and Landsat8 satellites to create maps highlighting hotspots of algal blooms. This tool allows our partners to monitor the timing, magnitude, duration and frequency of specific HAB locations on the Chesapeake Bay and to predict future vulnerable areas.

The purpose of this project was to create a python tool that allows its users to determine potential locations of harmful algal blooms (HABs) in the Chesapeake Bay and its estuaries. The tool uses an algorithm to integrate Landsat 8 data, Aqua MODIS data, and historical in-situ data collected by Virginia Institute of Marine Science and Old Dominion University to create maps highlighting hotspots of algal blooms. This tool allows our partners to monitor the timing, magnitude, duration and frequency of specific HAB locations on the Chesapeake Bay and to predict future vulnerable areas.

**Abstract:**

Harmful Algal Blooms (HABs) in the Chesapeake Bay Watershed have an increasingly negative effect on the ecosystems in which they grow; they deprive their ecosystem of oxygen, produce harmful toxins, and mechanically damage other organisms, thereby disrupting the natural water chemistry, causing large-scale fish mortality events and causing human illness. Scientists from the Virginia Institute of Marine Science (VIMS) and Old Dominion University (ODU) monitor HABs and their effect on the water quality. However, the Chesapeake and its estuaries are geographically too large for the groups to continuously monitor the HABs. This limits the group’s ability to monitor up-to-date locations of HABs and the water quality associated with them. To remedy this, data from Landsat8 Surface Reflectance obtained from the USGS Earth Explorer, data from the Aqua MODIS Chlorophyll imagery collected from NOAA CoastWatch, and in-situ data from VIMS and ODU were combined and correlated to create an algorithm which produces a map of algal hotspots in the Chesapeake Bay area. Data was collected from May 2011 through October 2015. This algorithm will allow scientists at VIMS and ODU to identify the location of algal hotspots using current Landsat8 and MODIS data, as well as give them the ability to assess the timing, magnitude, duration, and frequency of HABs in the Chesapeake Bay Watershed.

**Community Concerns:**

* Harmful Algal Blooms (HABs) are growing more common in Virginia Rivers. HABs degrade water quality by reducing oxygen, blocking sunlight, and producing toxins dangerous to fish and human health.
* HABs negatively impact the ecological and economic health of fisheries and pose threats to human health and the tourism industry.

**Current Management Practices & Policies**:

Currently, a Harmful Algal Blooms (HAB) task force (comprised of the Virginia Institute of Marine Science, the Marine Resources Commission, the Department of Environmental Quality, Old Dominion University, the Virginia Department of Health, and several auxiliary agencies) is responsible for the detection, research, and response to HABs in the Chesapeake Bay area. This task force has 20 fixed testing stations throughout the Chesapeake Bay. Water quality parameters, genetic molecular analysis, and HAB/phytoplankton identification tests are conducted monthly from May through November. Additionally, a 24 hour HAB Hotline has been established, and community members are asked to report suspicious colors, smells, or fish kills in their areas. When a HAB is detected or reported, the response team collects samples that are analyzed at different institutions depending on the nature of the report. The VA Health Department then determines future actions based on guidelines set by the Clean Water Act and State of Virginia Water Quality Standards. This current method requires many resources, relies heavily on community engagement, and requires ample time to identify, collect, and process samples.

**Decision Support Tools & Benefits:**

|  |  |  |
| --- | --- | --- |
| **End-Product** | **Earth Observations Used** | **Benefit & Impact** |
| Chlorophyll Hotspot Detector Algorithm | Landsat8 OLI/TIRS | Will allow partners to identify areas with high chlorophyll content, allowing them to determine potential sampling sites. Imagery will be available every 8 days at 30 meter resolution, available within a day of acquisition |

**Project Imagery**

**[Insert image here]**

**Caption:** [Insert Caption Here. Max of 25 words.] Image Credit: [Insert project short title] Team.

**Image:** File Name (Please submit your image as a separate .jpeg as well as inserting it in this document)

**Software Release Requirements**

Category IV

**Software Title:** Pending (Chesapeake Bay Chlorophyll Hotspot Identifier)

**Software Abbreviation:** CBCHI

**Technical Point of Contact:** Arika Egan, arikaegan@gmail.com. Wise County, VA.

**Brief Description of the Software:**

The CBCHI (pending name) allows users to identify chlorophyll concentrations in the Chesapeake Bay area using Landsat8 And AquaMODIS data as input. It will output a map whose legend identifies chlorophyll concentrations in the Landsat8 data.

Insert here (ex. The dnppy package will be used to functionalize common programming tasks in the geospatial community, specifically for working with NASA data products. It will include functions for processing satellite data and assist in structuring analysis to reduce the startup time for DEVELOP teams to learn programming and create tools for end users.)

**Type of Code:** *Executable Code* and/or *Source Code* (Select one or both)

**Will the software include any embedded computer databases?** *Yes* or *No* (Select one)

**Does the software use or call any open software or libraries?** *Open Source* and/or *Proprietary/Commercial* (Select one or both)

**List the software or libraries used, under what license they were obtained, and the URL for the license in the table below:**

|  |  |  |
| --- | --- | --- |
| **Name** | **License** | **License URL** |
| Not yet available, as of 9-29-2015 |  |  |

**Full Software Description and Plan**

**Introduction/Objective:**

The Chesapeake Bay Area is host to excessive blooms of algae that damage the ecosystem. The Virginia Institute of Marine Science conducts surveys to identify these blooms in order to mitigate their effect on the environment. However, the geographic size of the Chesapeake Bay Area is too large to conduct continuous data surveys. We created a tool that uses satellite data to provide a map of the Chesapeake Bay Area, highlighting harmful algal blooms. This will allow scientists at VIMS to quickly identify the locations of the harmful algae blooms so they know where they should conduct surveys to understand the causes of the blooms.

**Applications and Scope:**

This program will can be used with new and incoming data from the Landsat8 satellite to determine algal hotspots in the Chesapeake Bay area. The results it produces will provide areas of high sampling necessity and/or priority.

**Capabilities:**

Every ecosystem is different, so a program or algorithm that identifies HABs in one region will not work for another. There does not currently exist an algorithm that works specifically for the Chesapeake Bay Area. This algorithm identifies hotspots of chlorophyll in the Chesapeake Bay Area. Since Chlorophyll is present in algae, this algorithm identifies hotspots of algae. This algorithm is the first of its kind for the Chesapeake Bay area. It will provide a map of algae concentrations, which will alert researchers of locations with higher study priority.

**Interfaces:**

This is a tool that will take in satellite images and output a map. It will be used in ArcGIS. Probably a little command line and a little GUI. It’s not yet built (as of the rough draft on October 1st, 2015).

**Assumptions, limitations, & Errors:**

Ideally, this tool should be able to provide predictions of chlorophyll concentrations in the Chesapeake Bay Area. We are limited by our availability of data. The literature review revealed a multitude of methods for predicting chlorophyll concentrations using bottom reflectance, atmospheric correction, and much more good satellite data than was available to us. Once this program is given to VIMS, they may be able to further calibrate the algorithm to provide predicted values of chlorophyll concentration.

**Testing:**

Our python tool will have been created and modified using an artificial neural network, which learns over time when it’s initialized with a general pattern, given raw data as an input upon which to impose that pattern, and also fed known results. This allows the neural network to modify its initial conditions according to the input and the desired output. Once the neural network has an acceptable algorithm, it will output accurate results when raw data is given as an input. This neural network will be verified with in-situ data collected from VIMS and ODU.