**NASA DEVELOP National Program**

NASA Langley Research Center

*Summer 2017*

**Short Title: Chesapeake Bay Water Resources II**

**Subtitle:** Assessing and Assisting Monitoring Efforts of Water Clarity to Identify Potential Areas of Submerged Aquatic Vegetation (SAV) in the Chesapeake Bay

**VPS Title:** Smooth Satellite: An Efficient Alternative to Monitoring the Chesapeake Bay’s Water Resources

**Project Team**

**Project Team:**

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**Project Overview**

**80-100 Word Objectives Overview:**

Measurements of water quality, including dissolved oxygen, pH, salinity, and turbidity, help determine the health of a body of water. The size of the Chesapeake Bay makes it difficult to provide timely and cost efficient bay-wide water quality and Submerged Aquatic Vegetation (SAV) measurements. This project correlates NASA’s Landsat and the European Space Agency’s (ESA) Sentinel data with *in situ* water quality data collected by the Virginia Institute of Marine Science (VIMS) to determine the feasibility of using remote sensing data to help aid the measurement of turbidity and its effect on SAV growth within the Chesapeake bay.

**Abstract:**

Submerged Aquatic Vegetation (SAV) is vitally important to the Chesapeake Bay, serving as one of the primary food sources for the organisms that inhabit its ecosystems. This project evaluated the efficacy of remote sensing applications to monitor water quality parameters, specifically turbidity, to indicate areas that can potentially support healthy populations of SAV in the Chesapeake Bay. The resources and methods included visual analysis of the Chesapeake Bay by utilizing Landsat 8 Operational Land Imager (OLI) and Sentinel-2 MultiSpectral Instrument (MSI). The algorithms incorporated in ACOLITE software allow for atmospheric correction of spatial and temporal surface reflectance satellite imagery. By correlating Landsat- and Sentinel-derived output turbidity products to the Virginia Institute of Marine Sciences’ *in situ* monitoring data, different model was created that provided estimates of water clarity throughout the entire bay and its associated tributaries. Dogliotti turbidity products provided the best correlations between satellite remote sensing and *in situ* turbidity data throughout the open waters of the Chesapeake Bay, while Nechad turbidity products provided stronger correlations throughout the bay’s tributaries. The models can be used as additional resources for the Virginia Department of Environmental Quality to aid the monitoring of turbidity variations within the Chesapeake Bay. These monitoring techniques will also assist in determining Total Maximum Daily Load calculations and the resulting effects on SAV growth.

**Keywords:**

Submerged Aquatic Vegetation (SAV), turbidity, water quality, Landsat, Sentinel, remote sensing, atmospheric correction

**Partner Organizations:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Virginia Department of Environmental Quality | Tish Robertson, Office of Ecology, Water Quality Monitoring and Assessment Coordinator | End User | No |
| US Geological Survey, Water Science Center | Peter Tango, Chesapeake Bay Monitoring Coordinator | Collaborator | No |

**Community Concerns:**

* Submerged Aquatic Vegetation (SAV) provides food resources and habitat to many important species. Water clarity conditions affect SAV and need monitoring in order to ensure the survival of these species.
* The Virginia Department of Environmental Quality (DEQ) does not have the resources to monitor the entire Chesapeake Bay annually and so other methods of data collection, like remotely sensing water clarity, could prove to be highly useful.

**Current Decision-Making Practices & Policies**:

Virginia DEQ’s current method of monitoring water clarity and SAV habitable areas within the Chesapeake Bay relies upon two methods: continuous data from monitoring stations throughout the bay and its tributaries, and small boats that provide dataflow generating a surface map of water quality. The continuous data monitoring stations collect data every fifteen minutes at a depth of approximately one meter, measuring various parameters like turbidity, salinity, chlorophyll, etc. Although this *in situ* monitoring is important and essential for understanding SAV growth and its effect on the bay, current methods limit their ability to collect data from localized and stationary areas. The DEQ works alongside the Environmental Protection Agency (EPA) Chesapeake Bay Program to evaluate the health of the Chesapeake Bay and its tributaries using Total Maximum Daily Load (TMDL) calculations to estimate the maximum amount of pollutants that can occur within the bay.

**Decision Support Tools & Benefits:**

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software**  **Release** |
| Annual Water Clarity Maps (Chesapeake Bay) | Landsat 8 OLI  Sentinel-2 MSI | Clarity maps will be used to identify areas suitable for SAV by assessing water clarity annually throughout the Chesapeake Bay. Water clarity maps will be utilized to assess how accurate data gathered from remote sensing is to *in situ* monitoring data. | I |
| Annual Water Clarity Maps (Tributaries) | Landsat 8 OLI  Sentinel-2 MSI | Tributary maps will be used to identify areas suitable for SAV by assessing water clarity annually within Virginia tributaries. Water clarity maps will be utilized to assess how accurate data gathered from remote sensing is to *in situ* monitoring data. | I |
| Water Clarity Maps Workflow | N/A | Documentation detailing how to gather water quality data and the subsequent creation of water clarity maps can be used by the end user to aid with future assessment of water clarity and SAV health within the bay. | I |
| ACOLITE Processing Automation | Landsat 8 OLI  Sentinel-2 MSI | A Python script automating the methodology of processing Landsat 8 and Sentinel-2 imagery through ACOLITE software will be provided for the end user. | III |

**Project Benefit to End User**:

The results of this term will benefit the Virginia DEQ by providing updated mapping products with greater spatial and temporal assessments of water quality with the Chesapeake Bay as compared to the *in situ* and aerial-based data currently used by the department. The NASA DEVELOP team will update the maps produced in term one by improving the regressions previously developed through application of atmospheric correction. A documented workflow detailing the creation of water clarity maps and associated python scripts will also be provided to the Virginia DEQ so they can continue to monitor changes in water clarity more efficiently and accurately in the future.

**Project Details**

**Applied Sciences National Application Addressed:** Water Resources

**Study Area:** Chesapeake Bay, VA

**Study Period:** March 2013 – May 2017 (March – October)

**Earth Observations & Parameters:**

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| Landsat 8 OLI | ACOLITE Output Turbidity Products | Landsat 8 was utilized to create maps identifying areas of high and low water clarity and where suitable SAV habitat can be found in the Chesapeake Bay and its Virginia tributaries. |
| Sentinel-2 MultiSpectral Instrument (MSI) | ACOLITE Output Turbidity Products | Sentinel-2 was utilized to compare with Landsat imagery metadata and results. |

**Ancillary Datasets Utilized:**

* Virginia Institute of Marine Science (VIMS) Virginia Estuarine and Coastal Observing System (VECOS) *in situ* water clarity measurements – used to validate mapping products for end users

**Software Utilized:**

* ACOLITE – Landsat and Sentinel-2 analysis
* Esri ArcGIS – map creation
* Python – used for ACOLITE image processing and automation

**Project Handoff Package**

**Transition Plan:**

Annual water clarity maps (for both the Chesapeake Bay and associated tributaries) will be provided to the partners via an in-person meeting (if available) or a video conference at the end of the 2017 Summer Term. Providing the maps immediately after the term is preferred so that the Virginia DEQ and USGS Water Science Center can decide if they would like to immediately integrate the provided maps and results into their decision-making process and where this research can be implemented within the organization.

*Software Release Plan*: The team has notified Tish Robertson and Peter Tango on the process of getting code to go through approval process, and how they should be prepared for delayed delivery of any code, scripts, or tools that we provide at the conclusion of the project. Python scripts and documentation detailing how to work the code (README, etc.) will be provided to the partners for ease of use.

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**Partner POC**: Tish Robertson, Tish.Robertson@deq.virginia.gov & Peter Tango, ptango@chesapeakebay.net

**Handoff Package:**

* Annual Water Clarity Maps (Chesapeake Bay-wide)
* Annual Water Clarity Maps (Tributaries)
* ACOLITE processing automation
* Documented workflow detailing the creation of water clarity maps (Potential Resource)
* Final Technical Paper
* Presentation