**Chesapeake Bay Water Resources**

*Characterization of Sediment Dynamics for Enhanced Water Quality Monitoring in* *the Chesapeake Bay*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:***

The Summer 2022 Chesapeake Bay Water Resources team analyzed turbidity and suspended sediments in the York River watershed of the Chesapeake Bay to observe water quality patterns from 2009 to 2019. The project focused on monitoring Total Suspended Sediment (TSS) concentrations and sediment dynamics using the Soil and Water Assessment Tool (SWAT), Earth observations, and imaging tools. Through collaboration with local and international community partners, the team’s research provided an improved picture of how TSS concentrations affect water quality, thereby guiding efforts to make the Chesapeake Bay’s waters healthier and more capable of supporting life.

***Abstract:***

An increase in Total Suspended Sediment (TSS) concentrations and turbidity have contributed to poor water quality in the Chesapeake Bay since the 1970s. Although turbidity and TSS have been moderately improving over the past few decades, poor water quality is detrimental to the Chesapeake Bay’s ecosystems and the surrounding watersheds. The Summer 2022 Chesapeake Bay Water Resources project observed sediment dynamics and turbidity in the York River watershed using remote sensing tools, models, and Earth observations including NASA and United States Geological Survey’s (USGS) Landsat satellite series, NASA DEVELOP’s Optical Reef Coastal Area Assessment Tool 2.0 (ORCAA), and Soil and Water Assessment Tool (SWAT). The collaborators on this project were the Chesapeake Bay National Estuarine Research Reserve (CBNERR), Group on Earth Observations (GEO) AquaWatch, the Committee on Earth Observation Satellites Coastal Observations, Applications, Services and Tools (CEOS COAST), and the Virginia Department of Environmental Quality (VA DEQ). The team concluded that the upstream sections of the York River watershed increased in TSS from 2009–2019. However, the seasonal TSS patterns often correlated with higher precipitation levels, although not necessarily major storm events. This may be due to factors like wind and waves contributing to the sedimentation trends observed. Although projects have been conducted to improve water quality, additional efforts like planting riparian buffers along areas with high TSS are needed to reduce the intensity of runoff. The team’s results will allow the end user, the VA DEQ, to inform their policymaking regarding future Bay conservation efforts.

***Key Terms:***

Chesapeake Bay, erosion, remote sensing, suspended sediment, SWAT, turbidity, water quality

***National Application Area Addressed:*** Water Resources

***Study Location:*** Chesapeake Bay, VA

***Study Period:*** 2009–2019

***Community Concerns:***

* Water quality in the York River watershed is largely impacted by sedimentation and erosion which can be caused by agricultural and urban land use.
* The Chesapeake Bay has faced historic declines in its water quality in part due to the increasing concentrations of suspended sediment. Reducing pollution would increase the value of the Bay by $22.5 billion annually, but Virginia is only partially on track to meet the goals by 2025 according to the Chesapeake Bay Foundation.
* Aquatic ecosystems, including some of the keystone species they support, are extremely vulnerable to sedimentation changes and deterioration of the overall water quality of the watershed. The Chesapeake Bay is valued at $100 billion USD annually due to ecosystem services (e.g., water filtration by oysters, filtration and habitat created by seagrasses), recreation, and fishing industries (particularly blue crabs, oysters, and striped bass). Declines in water quality are therefore economically detrimental to local communities.
* The York River region was recently designated a Habitat Focus Area by the National Oceanic and Atmospheric Administration (NOAA), which will prioritize collaboration between the local communities and partners to improve habitat conservation.

***Project Objectives:***

* Analyze suspended sediment concentrations in the Chesapeake Bay
* Compare *in situ* water quality measurements to satellite water quality data
* Examine TSS and turbidity using the SWAT and ORCAA models
* Identify changes in water quality from 2009 to 2019

**Partner Overview**

***Partner Organizations:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Virginia Department of Environmental Quality**  | Amanda Shaver, Water Quality Assessment Coordinator | End User |
| **Chesapeake Bay National Estuarine Research Reserve**  | Carl Friedrichs, Associate Director | Collaborator |
| **Group on Earth Observations, AquaWatch** | Steve Greb, Director | Collaborator |
| **Committee on Earth Observations Satellites Coastal Observations, Applications, Services and Tools** | Merrie Beth Neely, Coordinator and Networker | Collaborator |

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

The VA DEQ primarily uses *in situ* monitoring methods like point grab samples, buoys, and transects to collect turbidity and TSS data in the Chesapeake Bay. Across the state, teams from various government and scientific agencies collect water samples and perform in-field tests, which are compiled in a national database and reported to the U.S. Environmental Protection Agency. For the Virginia Chesapeake Bay region, all monitoring is conducted using consistent methodologies that match those of other states bordering the Bay. The results are publicly available as part of the Virginia Water Quality Monitoring, Information, and Restoration Act and are used to inform watershed management decisions. Additionally, the DEQ is authorized to implement laws and regulations under the State Water Control Law to preserve aquatic systems in Virginia.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 5 TM** | Surface reflectance | Surface reflectance was used to examine ocean color, specifically to calculate the Normalized Difference Turbidity Index (NDTI) |
| **Landsat 7 ETM+** | Surface reflectance | Surface reflectance was used to examine ocean color, specifically to calculate the Normalized Difference Turbidity Index (NDTI). |
| **Landsat 8 OLI**  | Surface reflectance | Surface reflectance was used to examine ocean color, specifically to calculate the Normalized Difference Turbidity Index (NDTI). |
| **GPM IMERG** | Precipitation | Precipitation was examined in correlation with sedimentation trends. |

***Ancillary Datasets:***

* United States Geological Survey (USGS) National Land Cover Database (NCLD) – SWAT model input, 30 m resolution dataset with 15 land cover classes
* Food and Agriculture Organization (FAO) Digital Soil Map of the World (DSMW) – SWAT model input, vector of global soil types at 1:5,000,000 scale
* Shuttle Radar Topography Mission (SRTM) digital elevation model – SWAT model input, 30 m resolution elevation dataset
* NASA Prediction of Worldwide Energy Resources (POWER) – SWAT model input, global precipitation and temperature values
* USGS TSS, discharge *in situ* data – validation of the SWAT model and results, monthly values

***Modeling:***

* Texas A&M University Soil & Water Assessment Tool (SWAT) – identify TSS loading/flux using QSWAT v3\_9
* Point of Contact: Duc Tran and Prakrut Kansara (University of Virginia)
* NASA DEVELOP ORCAA 2.0 tool – examine turbidity and other water quality parameters
* Point of Contact: Adam Weingram, Tasos Tentoglou, Eleda Fernald, and David Carrasco

***Software & Scripting:***

* Google Earth Engine (GEE) JavaScript API – Collect and pre-process data from multiple satellite sensors
* QGIS 3.152 – Run SWAT and generate study area visuals
* ArcGIS Pro 3.0.0 – Generate maps for visualizing study area and results

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Sediment Loading & Turbidity Analysis** | Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI  | Observing sediment dynamics and turbidity in the York watershed will allow the partners to understand which specific areas are declining in water quality. | N/A |
| **Suspended Sediment Time Series Analysis and Spatial Maps** | GPM IMERG  | Comparing suspended sediment and turbidity between 2009 and 2019 will benefit partner understanding of recent water quality trends in the Chesapeake Bay. | N/A |
| **CEOS COAST Chesapeake Bay Pilot End Product** | Landsat 8 OLI, GPM IMERG | Analyzing turbidity and suspended sediments observations will support CEOS COAST Chesapeake Bay water quality monitoring initiatives. The final products were added to the GEO AquaWatch Knowledge Hub. | N/A |

***Product Benefit to End User:***

The project will provide the end user with Earth observation-based analyses which will inform their Chesapeake Bay water quality management. The data will supplement the *in situ* monitoring efforts currently in place and provide a new perspective to the turbidity and TSS tracking that currently occurs. Furthermore, the end user may be able to continue using the SWAT model and potentially ORCAA 1.0 or 2.0 following the methodologies produced for future management decisions. Lastly, the time-series produced will also improve understanding of long-term trends in Chesapeake Bay suspended sediment dynamics.

**References**

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