**Weeks Bay Water Resources**

*Using NASA Earth Observations to Evaluate Changes in Water Quality in the Weeks Bay Watershed*

**VPS Title:** What in the Weeks Bay? How Earth Observations Can Increase Understanding of Estuary Systems

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:*** Partnering with the Weeks Bay National Estuarine Research Reserve (NERR), the team modeled and analyzed sub-watershed impacts on water quality in Weeks Bay, focusing on surface run-off of nitrogen, phosphorous, and sediment. The team then determined parameters in which NASA Earth observations (EO) can be utilized to complement the partner’s current data collection methods. The data were modeled using ArcSWAT, calibrated with SWAT-CUP, and rendered into visualizations through VizSWAT to create an easily replicable workflow to be utilized by the project partner.

***Abstract:***

Weeks Bay is an estuarine system located along the southeastern shore of Mobile Bay in Baldwin County, Alabama. Its watershed encompasses approximately 149,000 acres of mixed-use land around the Fish and Magnolia Rivers. Weeks Bay and the surrounding coastal lands are currently protected as a National Estuarine Research Reserve (NERR) by the Alabama Department of Conservation and Natural Resources (ADCNR) and the National Oceanic and Atmospheric Administration (NOAA), but its watershed has been transformed from native forests and riparian land cover types to urban and agricultural areas over the last decade. These changes have resulted in increased stormwater runoff, flooding, soil erosion, and nutrient loading from the watershed into Weeks Bay. This project used NASA Earth observations from the Shuttle Radar Topography Mission (SRTM), Global Precipitation Measurement (GPM) Integrated Multi-satellite Retrievals for GPM (IMERG), and Landsat 7 Enhanced Thematic Mapper Plus (ETM+) along with ancillary data as inputs into the Soil and Water Assessment Tool (SWAT), which modeled the impacts of land use and land cover on water quality in Weeks Bay from January 2014 to January 2018 and forecasted possible future implications given continued land cover change. The SWAT model was also used to highlight sub-watersheds that impact water quality the most in order to prioritize them for conservation efforts. The outputs were then compared to a previous model created by an independent engineering firm that did not incorporate NASA precipitation data. The Weeks Bay NERR will use the findings of this project to support its watershed management and use of NASA Earth observations in future studies.

**Keywords:**

Soil and Water Assessment Tool (SWAT), Mobile Bay, estuary, Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Global Precipitation Measurement (GPM) Integrated Multi-satellite Retrievals for GPM (IMERG), Shuttle Radar Topography Mission (SRTM)

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

***Study Location:*** Weeks Bay Watershed, Baldwin County, AL

***Study Period:*** January 2014 to January 2018

***Community Concerns:***

* The conversion of forest and riparian habitats into land for agricultural use has caused soil erosion and fertilizer runoff, thus increasing sedimentation, turbidity, and eutrophication in Weeks Bay.
* The transformation of vegetated land cover to non-porous, urban land cover has increased stormwater runoff and flooding in Weeks Bay, while a growing human population has caused greater water pollution through processes such as fecal coliform contamination.
* Reduced water quality in Weeks Bay is detrimental to estuarine flora and fauna and other regional values, such as fishing, recreation, and ecosystem services provided by healthy coastal ecosystems.
* Due to the lack of extensive monitoring of the entire watershed, the Weeks Bay NERR has little capacity to observe changes in water quality parameters.

***Project Objectives:***

* Identify sub-watersheds of special concern for prioritizing conservation efforts aimed at improving water quality in Weeks Bay
* Demonstrate how to collect data from NASA EO to contribute to the knowledge base of the Weeks Bay NERR
* Conduct a comparative analysis of a previous SWAT model derived from *in situ* data to a SWAT model informed primarily by NASA EO

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC** | **Partner Type** | **Boundary Org?** |
| **Alabama Department of Conservation and Natural Resources, Weeks Bay National Estuarine Research Reserve** | Sarah Johnston, GIS Specialist | End User | Yes |

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

The Weeks Bay NERR is part of the ADCNR, State Land Division, Coastal section and a component of the National Oceanic and Atmospheric Administration NERR system. Designation as a NERR requires long-term research, monitoring, education, and coastal stewardship of Weeks Bay and the surrounding land. The Weeks Bay NERR relies on a collection of *in situ* sensors to obtain biotic and abiotic measurements of the estuary and utilizes volunteers and staff to monitor other parameters. It owns and manages land in the immediate vicinity of the Weeks Bay and serves as a center for estuary education for coastal visitors and inhabitants but have little reach into the broader Weeks Bay watershed. Currently, Weeks Bay NERR does not utilize NASA Earth observations.

***Project Benefit to End User:***

The project methods and analyses will contribute to the current conservation efforts of Weeks Bay NERR and fill in knowledge gaps, especially in how precipitation and water quantity vary across the watershed. The end products will justify the organization’s conservation efforts and highlight the usefulness of remotely sensed data in monitoring the estuary and surrounding areas. In particular, the products can assist resource managers in their evaluations of change in the Weeks Bay watershed and also provide justification for future conservation initiatives.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **SRTM** | Elevation | SRTM provided elevation data needed for the SWAT model at 30 m 1 arc-second resolution. |
| **GPM IMERG** | Precipitation | GPM IMERG data were used as the precipitation input for the SWAT model. |
| **Landsat 7 ETM+** | Surface reflectance | Landsat 7 imagery was used to create the National Land Cover Database (NLCD) 2011 land cover classification map input for the SWAT model. |

***Ancillary Datasets:***

* National Land Cover Database 2011 land cover classification map – Input as multi-resolution land cover characteristics data into the SWAT model
* STATSGO Soil Data – Input as state soil geographic data, contained in ArcSWAT database, into the SWAT model
* United States Geological Survey (USGS) National Water Information System water flow and water quality parameters – Calibrate NASA-EO-derived SWAT model
* National Estuarine Research Reserve, Centralized Data Management Office *in situ* water quality measurements – Validate, calibrate, and compare to the new EO-based model
* ADCNR Alabama Water Watch additional watershed data – Validate and calibrate NASA-EO-derived SWT model
* Thompson Engineering Model Dataset (inputs for the original SWAT model) – Compare to the NASA-EO-derived SWAT model outputs

***Modeling:***

* ArcSWAT 2012 10.3.19 (POC: Kathrene Garcia, NASA DEVELOP) – Create soil and water assessment model
* SWAT Calibration and Uncertainty Procedures (SWAT-CUP) (POC: Kathrene Garcia, NASA DEVELOP) – Calibrate the model using *in situ* data
* VIZSWAT (POC: Kathrene Garcia, NASA DEVELOP) – Create data visualizations of SWAT model outputs

***Software & Scripting:***

* Esri ArcMap 10.3.1 – Raster manipulation and analysis, imagery processing, and map creation
* R Studio – Download and preprocess precipitation data using the NASAaccess package script

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Sub-Watershed Endangerment Zone Map** | Landsat 7 ETM+  GPM IMERG  SRTM | This product derived from the SWAT analysis output highlights the contribution of sediment and nutrient inputs from sub-basins into Weeks Bay, which may need special conservation attention from partners at the NERR. | I |
| **Comparative Analysis of NASA EO-Derived SWAT Model to Existing SWAT Model** | Landsat 7 ETM+  GPM IMERG  SRTM | This analysis identifies differences between the partner’s existing SWAT model and the SWAT model derived from NASA EO. The product demonstrates to partners how NASA EO can complement their current data collection methods. | I |
| **NASA EO-Derived SWAT Output Results** | Landsat 7 ETM+  GPM IMERG  SRTM | This product serves as the basis for the comparison between NASA-EO outputs and previous SWAT model outputs that demonstrates to partners how NASA EO can complement their current data collection methods. | I |
| **NASA EO and SWAT Tutorial** | N/A | This product demonstrates to partners how to acquire and incorporate NASA EO data into future SWAT model assessments. | N/A |

**Project Handoff Package**

*Transition Plan:* All end products and deliverables were provided to the project partners through a USB drive following the project’s completion. An in-person handoff was conducted at the end of the term. During this meeting, the team presented the project results to the partners and answered any questions the Weeks Bay NERR team had.

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**Handoff Package:**

* Sub-Watershed Endangerment Zone Map
* Comparative Analysis of NASA EO-Derived SWAT Model to Existing SWAT Model
* NASA EO-Derived SWAT Output Results
* NASA EO and SWAT Tutorial
* Study Area Shapefile
* Technical Paper
* Project Video
* Poster
* Presentation

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