Big Cypress Water Resources
Using Earth Observations to assess water quality in Big Cypress Reservation, FL

Project Team

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Project Overview

Project Synopsis:
Upstream agricultural and urban development contributed to harmful algal blooms in the Seminole Tribe of Florida Big Cypress Reservation. Using Sentinel-2 MultiSpectral Instrument and water sample data, we evaluated the feasibility of monitoring algal blooms within narrow canals on the Big Cypress Reservation. While the narrowness of the canals posed several challenges, we found that Sentinel-2 indices have the potential to detect algal blooms.

Abstract:
Upstream agricultural development and runoff drove concerns of harmful algal blooms in the Big Cypress Reservation. The Seminole Tribe of Florida Environmental Resource Management Department monitors water quality in the Big Cypress Reservation, located on the north end of Big Cypress National Preserve. The Environmental Resource Management Department aimed to incorporate Earth observations into its investigative approach, which consists of Geographic Information Systems and *in situ* water sampling. We assessed the feasibility of using Earth observations to measure harmful algal blooms over time and identify vulnerable areas. We analyzed data from multiple remote sensing platforms and sensors, including Landsat 8 Thermal Infrared Spectrometer (TIRS), Landsat 9 TIRS-2, Landsat 9 Operational Land Imager 2 (OLI-2), Sentinel-2 MultiSpectral Instrument (MSI), and Sentinel-3 Ocean and Land Color Instrument (OLCI). We determined that it was challenging to use Sentinel-3, Landsat 8, and Landsat 9 imagery for monitoring the canals within the Reservation, and that Sentinel-2 MSI was the most capable platform for the study area. Using Sentinel-2, we created spectral indices for the detection of algal blooms. We used these indices to measure algal blooms at 8 stations across the Big Cypress Reservation. We then created time series and seasonal decompositions of *in situ* water sample data and indices to visualize relationships between datasets, along with correlation matrices. Our correlations were not conclusive. However, we found that the spectral

indices have the potential to detect algal blooms. Lastly, we evaluated Maxar WorldView-3 imagery and found that using data from sensors with higher spatial resolutions would improve results.

Key Terms:
remote sensing, harmful algal blooms, Sentinel, Landsat, floating algal index, chlorophyll, turbidity, canal

Application Area: Water Resources
Study Location: Big Cypress Reservation in FL
Study Period: December 2018 to July 2024

Community Concerns:
- The Seminole Tribe faced water quality issues throughout the Big Cypress Reservation, largely driven by drainage from surrounding basins.
- Canals within the Reservation struggled with high levels of nutrients due to runoff from waterbodies upstream, leading to the growth of algal blooms within the reservation.
- Runoff increased toxic conditions for fish and wildlife, which impact human health and recreation.
- The Seminole Tribe of Florida Environmental Resources Management Department wanted to incorporate Earth Observations to enhance their ability to detect and predict high nutrient loads and to develop a better understanding of harmful algal blooms.

Project Objectives:
- Develop time series of algal blooms using Earth observation indices.
- Validate indices using in-situ water quality data.
- Evaluate the feasibility of using Earth Observations for monitoring water quality in the Big Cypress Reservation

Partner Overview

Partner Organizations:

Organizations	Contact (Name, Position/Title)	Partner Type	Sector
The Seminole Tribe of Florida, Environmental Resource Management Department	Dr. Jed Redwine, Ecologist	End User	Tribal Government
Florida Gulf Coast University	Dr. Rachel Rotz, Research Scientist	Collaborator	University
NASA Langley Research Center	Dr. Kenton Ross, Research Scientist	Collaborator	Federal Government

Decision-Making Practices & Policies:
We partnered with the Seminole Tribe of Florida Environmental Resources Management Department (ERD). The Seminole Tribe spent many years building up their infrastructure and management capacity, practices, and procedures. Their management approach used Geographic Information Systems and on ground water sampling to capture information about nutrients and algal blooms. This information was used to make management decisions, such as canal operations and wetland conservation within the preserve.

Earth Observations & End Products Overview

Earth Observations:

Platform & Sensor	Parameters	Use
Landsat 8 OLI & TIRS	Land Surface Temperature (LST), Normalized	We evaluated the ability of Landsat 8 and 9 to monitor water quality in narrow canals. We found

	Difference Turbidity Index (NDTI)	that Landsat 8 and 9 were more feasible for monitoring water quality in larger bodies of water.
Landsat 9 OLI-2 & TIRS-2	Land Surface Temperature (LST), Normalized Difference Turbidity Index (NDTI)	We evaluated the ability of Landsat 8 and 9 to monitor water quality in narrow canals. We found that Landsat 8 and 9 were more feasible for monitoring water quality in larger bodies of water.
Sentinel-2 MSI	Normalized Difference Turbidity Index (NDTI), Normalized Difference Chlorophyll Index (NDCI), Floating Algal Index (FAI), Colored Dissolved Organic Matter (CDOM)	Using the high spatial resolution and red edge band of Sentinel-2, we created several indices for detecting algal blooms. We correlated these indices with water sample data throughout the Big Cypress Reservation to assess the feasibility of using Sentinel-2 to monitor algal blooms within narrow canals.
Maxar WorldView-3	Normalized Difference Chlorophyll Index (NDCI), Floating Algal Index (FAI), Colored Dissolved Organic Matter (CDOM)	Examining narrow canals with publicly available platforms resulted in some land contamination. We used Maxar WorldView-3 to evaluate if higher spatial resolution imagery could improve the ability of our indices to monitor algal blooms.

Ancillary Datasets:
- South Florida Water Management District DBHYDRO Environmental Monitoring – *in situ* water sample data from various stations for validating Earth observation indices

Software & Coding Languages:
- Esri ArcGIS Pro (3.2.0) - Defined areas for Index application, applied Maxar WorldView-3 Indices
- Python (3.12) - Downloaded and processed imagery (geemap, earthengine-api), created time series, seasonal decompositions, and correlations (pycrs, pandas, numpy, matplotlib, seaborn, statsmodels)

End Products:

End Products	Earth Observations Used	Partner Benefit & Use
Water Quality Time Series	Sentinel-2 MSI	Time series were created for 8 stations within Big Cypress Reservation, using both water sample data and Earth observation indices. Time series provide a better understanding of algal bloom trends, both spatially and over time.
Seasonal Decomposition of Indices and Water Sample Data	Sentinel-2 MSI	Seasonal decompositions will allow the ERD to visualize and validate the relationship between calculated indices and water sample data. This will inform algal bloom monitoring processes.
Correlation Matrix of Indices and Water Sample Data	Sentinel-2 MSI	The correlation matrix demonstrates one of the results of our project that requires further investigation. Our partner has interest in further refining the statistical

		methods in our methodology, and the correlations will aid them in understanding our results.
Technical Paper	Landsat 8 OLI & TIRS, Landsat 9 OLI-2 & TIRS-2, Sentinel-2 MSI, Maxar WorldView-3	The paper's detailed methodology allows the work to be reproduced, allowing Earth observations to be applied for monitoring algal blooms. Our methods for creating gauges at each station may be reused within a model that forecasts algal blooms.
One-page Flyer	Landsat 8 OLI & TIRS, Landsat 9 OLI-2 & TIRS-2, Sentinel-2 MSI, Maxar WorldView-3	This creative communication deliverable can be used by our partner to raise awareness, promoting further investigation into algal blooms and upstream causes.
Poster	Landsat 8 OLI & TIRS, Landsat 9 OLI-2 & TIRS-2, Sentinel-2 MSI, Maxar WorldView-3	The poster describes the project without requiring a presenter. It shares information on the project and efforts to monitor algal blooms within Big Cypress Reservation.
Presentation	Landsat 8 OLI & TIRS, Landsat 9 OLI-2 & TIRS-2, Sentinel-2 MSI, Maxar WorldView-3	The presentation succinctly explains the project's methods and findings. It will inform audiences on the need to further investigate algal blooms within Big Cypress Reservation and provide a scope for needed tools.

Product Benefit to End User:
Our project determined that Sentinel-2 MSI data has the potential to monitor algal blooms in the narrow canals of the Big Cypress Reservation. Earth observations will allow the ERD to survey the many waterbodies in the Reservation over a large area, which will complement the current practice of water sampling at station locations. The methodology we created for effectively capturing these waterbodies with Sentinel-2 imagery will be reproducible by the ERD, allowing them to investigate the usefulness of Earth observations for their monitoring program, informing their decision to include Earth observations moving forward. Including Earth observations could further enhance our partner's understanding of algal blooms within the Big Cypress Reservation.

References

European Space Agency. (2021). *Copernicus Sentinel-2 MSI Level-2A BOA Reflectance Product (Collection 1)* [Data set]. European Space Agency. Retrieved June 2024. https://doi.org/10.5270/S2_-znk9xsj

South Florida Water Management District (SFWMD) (2024). DBHYDRO Water Quality Data [Dataset]. Retrieved July 2024, https://my.sfwmd.gov/dbhydroplsql/show_dbkey_info.main_menu

US Geological Survey (USGS) (2021). *Landsat 8 Operational Land Imager (OLI) Level 2, Collection 2, Tier 1 Surface Temperature* [Dataset]. Earth Engine Data Catalog/USGS. Retrieved June 2024. https://doi.org/10.5066/P9OGBGM6

US Geological Survey (USGS) (2021). *Landsat 9 Operational Land Imager (OLI) Level 2, Collection 2, Tier 1 Surface Temperature* [Dataset]. Earth Engine Data Catalog/USGS. Retrieved June 2024. https://doi.org/10.5066/P9OGBGM6