Analyzing temporal variability in fDOM concentrations at the marsh-estuary interface using remote sensing

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Introduction

Environmental conservation for tidal wetlands in the U.S. is an increasingly important topic as of late. This is especially true given the fact that only 50% of original U.S. wetlands remain. This project focuses on tidal wetland carbon cycling. These wetlands contain high rates of plant growth but very low levels of oxygen in the soil (as a result of wetlands being inundated). The rate of carbon accumulation exceeds the rate of decomposition in oxygen depleted conditions . This translates to carbon storage. These wetland environments are threatened because of increasing urbanization and development, leading to wetland degradation , which in turn leads to decreases in carbon sequestration potential. However, we are also interested in understanding carbon export from tidal wetlands. Our study site is on the intersect between the Kirkpatrick Marsh and Rhode River Estuary, which are located in the northwestern shore of the Chesapeake Bay. A YSI EXO2 sensor sits at this marsh-estuary interface and continuously measures water parameters, such as turbidity, chlorophyll-a, and fDOM . We set out to compare these in-situ measurements to remote sensing observations. The specific objectives are listed in the goals section to the right.

Goals

1) To compare field data from our marsh and estuary system to NASA/USGS Landsat 8 data to determine if there are relationships between in-situ and remote sensing observations.

2) Understand how much fluorescent dissolved organic matter (fDOM) (corresponding to dissolved organic carbon) is leaving the marsh and understand the factors that affect this flux.

Methods

1

We used YSI EXO2 data taken at the Kirkpatrick Marsh-Rhode River Estuary interface in order to analyze chlorophyll-a, tidal height, turbidity, and fDOM (a fluorescence measure of dissolved organic carbon, the focus of this project). The YSI instrument reported this data in 15 minute intervals from the end of 2014, until the middle of 2016. However, the instrument was taken out of the water due to weather or routine maintenance for a few days at a time throughout the year, including the entire month of February 2015. The first step of the project was learning how to use Python in order to analyze the YSI EXO2 data. From this point forward chlorophyll-a, tidal height, turbidity, and fDOM will be referred to collectively as YSI data.

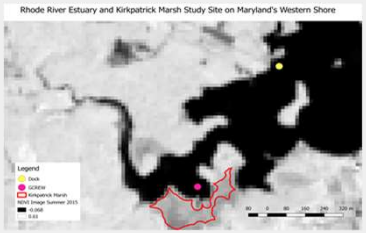
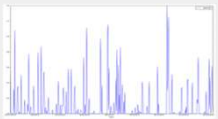


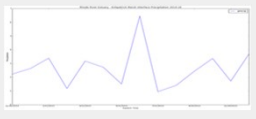
Image above: The instrument Alana Menendez used to collect data (a YSI EXO2).

Image on left: The study site at the Kirkpatrick Marsh

3

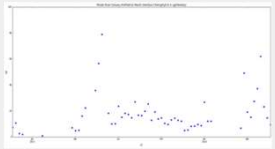
We used precipitation data from Pat Neale at the Smithsonian Environmental Research Center in order to test to see if rain (an episodic event) from the same marsh region could have affected the YSI data in any discernable way. After we resampled the precipitation data, we found that contrary to what we thought, the rain had a miniscule correlation with the YSI data (fDOM, chlorophyll-a, and turbidity) we used.



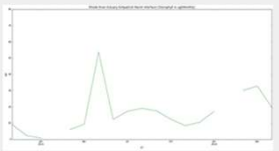


2

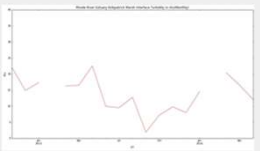
Because the YSI data was 15-minute interval data, we resampled the YSI data we received into hourly, daily, weekly, and monthly intervals using Python. The data was re-sampled by performing temporal means at the previously mentioned intervals. This resampled data was used to test for tidal, seasonal, and episodic effects in the fDOM, turbidity, and chlorophyll-a series. We found that when we resampled the data into monthly intervals, it got rid of a lot of the noise in these YSI data creating a smoother timeseries. The figures below illustrate the seasonal patterns in weekly and monthly chlorophyll-a, and monthly turbidity. These monthly series of in-situ measurements are compared to satellite observations in coming sections.



Here we resampled the chlorophyll data into weekly averages. The series shows algal blooms, increases in chlorophyll concentration, during the Springs of 2015 and 2016.



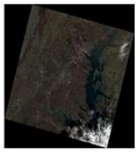
This is the monthly averaging of the weekly chlorophyll data shown to the left, which displays the algal blooms occurring in the Spring throughout the 16-month interval.



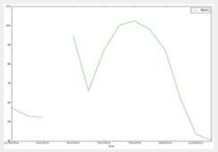
The monthly-averaged turbidity data here shows increased haziness in water quality during the Spring seasons. However, there was not a strong correlation with chlorophyll data.

4

Finally, we took the YSI EXO2 data and compared it to NASA Landsat 8 satellite data that our undergraduate mentor (Usaama Van) gathered. We compared the water-based parameters that the YSI measured to both land-based and water-based spectral indices that were derived from Landsat 8 Satellite observations. The land based remote sensing index that we tested was the normal difference vegetation index (NDVI). The water based remote sensing index that we used was the green/red ratio (GRR). We computed NDVI to investigate whether the changes in variability marsh characteristics (specifically vegetation) were related to the YSI measurements taken in the estuary. We computed the GRR to determine whether the optical properties of the estuary water measured from space by the Landsat 8 satellite were linked to the optical measurements taken by the YSI. We were particularly interested in assessing linkages between turbidity and chlorophyll-a. In order to do this, Usaama Van used ArcMap to compute spatial mean NDVI and GRR values in our regions of interest (see study site map).



These are the satellite photos for the chesapeake bay region in the Summer(left) and Winter (right) . Look at the difference in vegetation across the seasons, visible on the NDVI graph on the right.



These graphs show the close relationship between our fDOM monthly data frame (left) and our NDVI monthly data frame (right). See Conclusion goal #2.

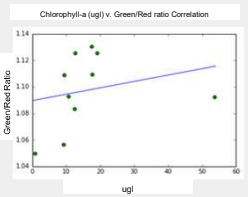
Results

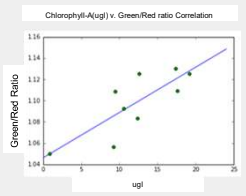
The table to the right displays the correlation values for the several YSI parameters, along with the Nasa Landsat 8 data we compared them to.

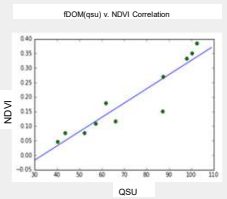
- gr_dock represents the green/red ratio at the dock site (yellow point in study site map), which isn't located at the actual marsh.
- gr_crew represents the green/red ratio at the actual site of the YSI EXO2.
- The gr_crew data was used for the graphs on the right

Correlation	fdom	chl	depth	ndvi	gr_dock	gr_gcrew
fdom	1	0.42	-0.45	0.93	0.198	0.4907
chl	0.42	1	-0.41	0.191	0.118	0.243
depth	-0.45	-0.41	1	-0.38	-0.455	-0.829
ndvi	0.93	0.191	-0.38	1	0.164	0.588
dock_point	0.198	0.118	-0.46	0.164	1	0.4899
g_crew	0.491	0.243	-0.83	0.588	0.49	1

The two graphs to the right that compare chlorophyll-a to the Green/Red ratio are an excellent example of how just removing a simple outlier in the data could change the correlation from .24 to .804







This Graph shows a .93 correlation between fDOM and NDVI (see conclusion goal #2 for explanation).

Conclusion

Goal # 1: During the project we were specifically interested in seeing how parameters such as vegetation, and red to green reflectance in water could have affected the carbon fluxes that we are striving to understand. We found that when we took the NDVI Landsat data, and resampled into a monthly database and compared it to the monthly database we created for fDOM, we found a .93 correlation (p-value < .005) between ndvi and fdom. We also found that when comparing the YSI chlorophyll-a data to the "green/red ratio" the initial correlation was .24, however when a single outlier was removed, the correlation rose to .804 (p -value = .0089)

Goal # 2: We sought to understand carbon transport processes in tidal wetlands. We found that dissolved organic carbon concentrations were highest in estuary waters during the summer time. And further that these carbon concentrations as measured through fDOM were highly correlated with NDVI which was measured on the marsh. We believe that this suggests there's a potential linkage between vegetation biomass and the amount of available organic matter that can quickly be broken down by microbes and transported in a particular growing season. It is also likely that microbial activity is simply highest when it is warmest in the summertime and during this period, multi-year organic carbon in the soil becomes most available for transport. However, it should be noted that this transport process is hydrologic and no significant correlation between fDOM and precipitation was found. In the future, tidal data will be analyzed to assess transport mechanisms.

References / Acknowledgements

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Thank you Shakila Merchant, Reza Khanbilvardi, Wayne Seemungal, and all of the other NOAA CREST Members that helped make this internship possible. Special thanks to Maria Tzortziou for welcoming us into her lab for the summer and giving us a learning experience that provided us with skills and knowledge that we will make great use of as we progress in our STEM careers.

NOAA CREST is funded by NOAA/EPP Grant # NA11SEC4810004
NOAA CREST HIRES program is a part of the SCience Research Mentoring Program and funded by Pinkerton Foundation