Forecasting Harmful Algal Blooms Over the Coastal Water, Charlotte County, Florida

Abstract # NH13C-0710

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Abstract

Harmful algal blooms (HAB; Karenia brevis) occurrences have been reported from the coastal waters of Charlotte County in southwest Florida. We developed multivariate regression models that relate reported (January 2010 to October 2017) bloom occurrences to observations extracted from archival remote sensing data (Moderate Resolution Imaging Spectroradiometer [MODIS]) to accomplish the following: (1) identify factors controlling HAB propagation, (2) predict algal bloom distribution (same day, and 1, 2, and 3 days in advance), and (3) develop fully automated system for data distribution via a web-based GIS platform. These tasks were accomplished through three main steps: (1) automatic downloading and processing of daily MODIS products using SeaDAS software to extract relevant remote sensing variables (euphotic depth, wind direction, ocean chlorophyll three-band algorithm for MODIS [Chlorophyll a OC3M], wind speed, chlorophyll a Generalized Inherent Optical Property [GIOP], Fluorescence Line Height [Flh], diffused attenuation coefficient for downwelling irradiance at 490 nanometer [Kd_490], chlorophyll a Garver-Siegel-Maritorena [GSM], Turbidity index, Particulate backscattering coefficient at 547 nm [bbp_547_giop] and sea surface temperature [SST]), (2) development and calibration of multivariate regression models using relevant remote sensing and static variable (distance from river mouth, bathymetry) inputs for same day mapping and forecasting of HAB occurrences, and (3) automated posting of model outputs on a web-based GIS (http://www.esrs.wmich.edu/webmap/bloom/). Findings include: (1) the variables most indicative of the timing of bloom propagation are bathymetry, euphotic depth, wind direction, sea surface temperature [SST], chlorophyll a [OC3M] and distance from the river mouth, and (2) the model predictions were successful at 90% for same day mapping and 65%, 72% and 71% for the one, two and three days in advance predictions, respectively.

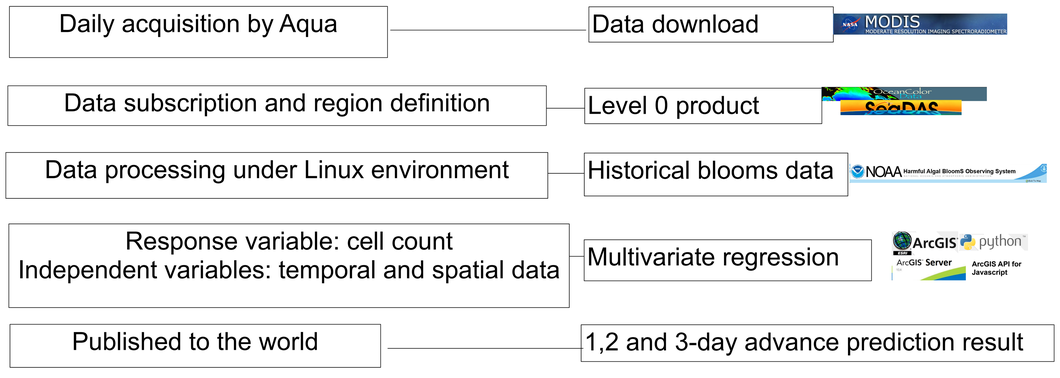
Temporal variables

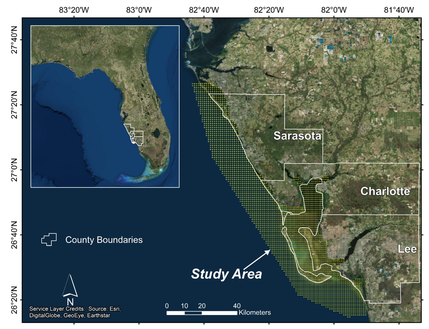
1. Euphotic Depth (m)
2. Wind direction (degrees) and wind speed (m/s)
3. Chlorophyll-a (mg/m^3) [chlorophyll-a OC3M (ocean chlorophyll three-band algorithm for MODIS), chlorophyll-a GSM (Garver-Siegel- Maritorena) and chlorophyll-a GIOP (Generalized Inherent Optical Property)]
4. Diffuse Attenuation Coefficient (Kd_490; m^{-1})
5. Turbidity Index
6. Particulate Backscattering Coefficient at 547 nm
7. Sea Surface Temperature (°C)
8. Fluorescence Line Height (FLH)

Spatial variables

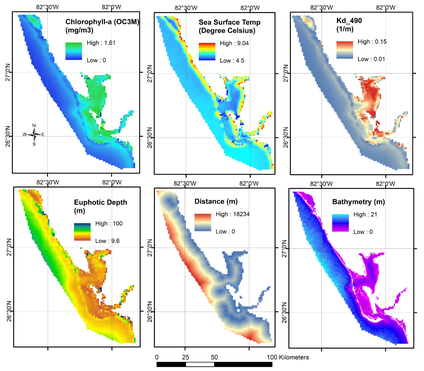
9. Bathymetry (m)
10. Distance from the river mouth (m)

Methodology



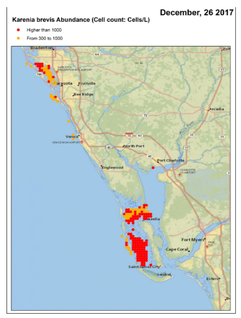


Map showing the coastal extent of the study area.

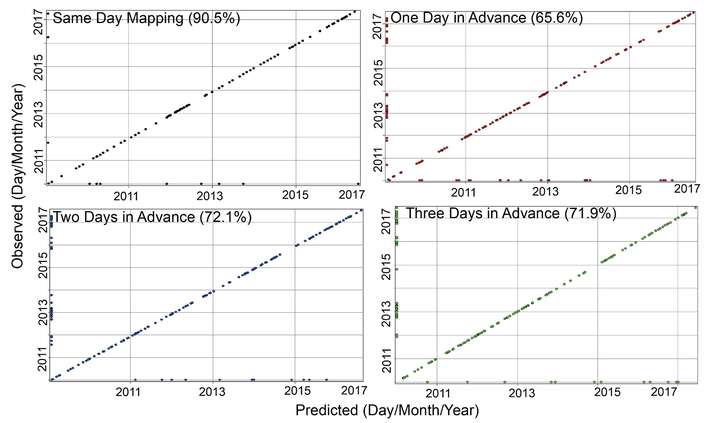


Mean values for some selected variables from 2010 to 2017. Two spatial variables (bathymetry and distance from the river mouth) are also shown.

Model Predictions



1. Three categories of the cell counts were established instead of presence and absence of the bloom
2. Locational accuracy was important for verification
3. Field collected cell count data was used for verification



The accuracy of the same day prediction was 90.5% followed by the accuracies of 65.6%, 72.1%, and 71.9% for one-day, two-day, and three-day advance prediction respectively.

Results

Relative significance of temporal and spatial variables for same-day nowcasting, and one-, two- and three-day predictions determined through the stepwise regression of the normalized variables.

	Same-day nowcasting	Forecasting		
		one day in advance	two days in advance	three days in advance
1	Bathymetry (35.9%)	Bathymetry (16.1%)	Euphotic Depth (25%)	Euphotic Depth (16.6%)
2	Euphotic depth (22.1%)	SST (15.5%)	Chlorophyll-a (OC3M) (14.2%)	Distance to river mouth (16.1%)
3	Wind direction (7.1%)	Wind direction (13.4%)	Distance to river mouth (14%)	Chlorophyll-a (OC3M) (15.1%)
4	Chlorophyll-a (OC3M) (6.7%)	Chlorophyll-a (OC3M) (10.3%)	Diffuse attenuation coefficient (Kd_490) (8.9%)	Wind direction (10%)
5	Wind speed (5.8%)	Diffuse attenuation coefficient (Kd_490) (9.9%)	SST (7.7%)	SST (9.3%)
6	Distance to river mouth (5.5%)	Distance to river mouth (9.1%)	Wind direction (6.4%)	Chlorophyll-a (GSM) (7.9%)
7	Chlorophyll-a (GIOP) (3.4%)	Wind speed (7.6%)	Fluorescence line height (5.4%)	Turbidity Index (7%)
8	Fluorescence line height (3.2%)	Turbidity index (7.1%)	Turbidity Index (5.4%)	Particulate backscattering coefficient (bbp_547_giop) (4.6%)
9	Diffuse attenuation coefficient (Kd_490) (3.1%)	Particulate backscattering coefficient (bbp_547_giop) (5.2%)	Bathymetry (4.8%)	Fluorescence line height (4.5%)
10	Chlorophyll-a (GSM) (2.4%)	Chlorophyll-a (GSM) (3.2)	Chlorophyll-a (GSM) (3.3%)	Wind speed (3%)
11	Turbidity index (2.4%)	Euphotic depth (1.9%)	Chlorophyll-a (GIOP) (2.4%)	Bathymetry (2.8%)
12	Particulate backscattering coefficient (bbp_547_giop) (1.4%)	Chlorophyll-a (GIOP) (0.5%)	Wind speed (1.5%)	Chlorophyll-a (GIOP) (1.9%)
13	SST (0.8%)	Fluorescence line height (0.2%)	Particulate backscattering coefficient (bbp_547_giop) (0.7%)	Diffuse attenuation coefficient (Kd_490) (1.3%)

Highlights

1. Used MODIS imagery to map and predict the harmful algal blooms
2. 11 temporal and 2 spatial variables were used
3. Data downloaded and processed every day
4. Same day mapping, one-, two- and three-day advance prediction
5. Same day and two-day advance prediction provided better results
6. Prediction affected by cloudy days
7. Replicable technology
8. Cost effective and global application

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Website: http://www.esrs.wmich.edu/webmap/bloom/

Article: https://www.mdpi.com/2072-4292/10/10/1656