Identification of Satellite Indicators for Prediction Cyanobacterial HABs in Kansas

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1. Motivation

Cyanobacterial Harmful Algal Blooms (cHABs) degrade water quality by producing harmful toxins and causing significant diel changes in water column pH and dissolved oxygen concentrations, leading to degradation of water quality that disrupts food webs and has negative ecological, social, recreational, and economic impacts. The increased occurrence of cHABs in Kansas has made it a top priority for the Kansas Water Office (KWO) and the Kansas Department of Health and the Environment (KDHE). Given the ubiquity and impact of cHABs in Kansas, there is a great need for understanding and prediction of cHAB events; however, there no clear indicator or predictor for them has been established in Kansas.

2. Methods

Several datasets were collected to identify satellite data that may contain information about the formation and development of HAB events as a precursor to assimilating this information into a 1-D lake model to improve the ability to predict HAB events. The Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) from MODIS MOD13Q1 and MYD13A1 onboard the Terra and Aqua satellites are generated every 16 days at a 250 m spatial resolution. These indices were chosen as they are readily available and their ability to detect greenness fractions makes them viable candidates for predicting HAB events. MODIS MOD11A2 and MYD11A2 (Terra and Aqua) Land Surface Temperature (LST), generated as an average 8-day per pixel at a 1 km spatial resolution was collected. MODIS datasets were collected for the period July 2002 through July 2021 as MODIS onboard Aqua data began in 2002. Of the 24 lakes and reservoirs in Kansas, 22 were used for analysis after removing 2 due to an inadequate number of pixels classified as open water by MODIS. NLDAS2 data with ~12 km spatial resolution at an hourly timestep for each of the 22 locations was averaged to a monthly timestep. Sediment Core data for Marion lake collected by KBS contains information about pigments produced by cHABs over time at a coarse temporal resolution.

Table 1. Datasets for Analysis

Dataset	Spatial Resolution	Description
MODIS LST	1 km	Average 8-day per pixel land surface temperature
MODIS NDVI & EVI	250 m	16 day vegetation indices
NLDAS	~12 m	Hourly forcing datasets

3. MODIS Seasonal Trends

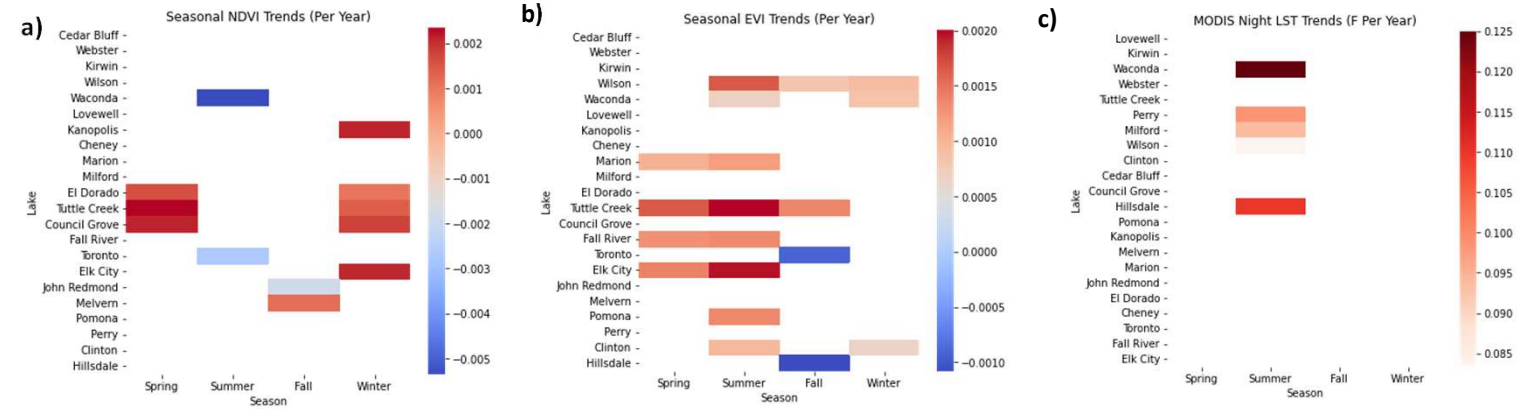


Fig 1. Seasonal Mann Kendall trends for Kansas reservoirs (listed by decreasing longitude) at p < 0.1 for the **a)** MODIS NDVI, **b)** MODIS EVI, **c)** MODIS LST at Night

4. Pearson Correlations of NDVI & EVI with NLDAS Data

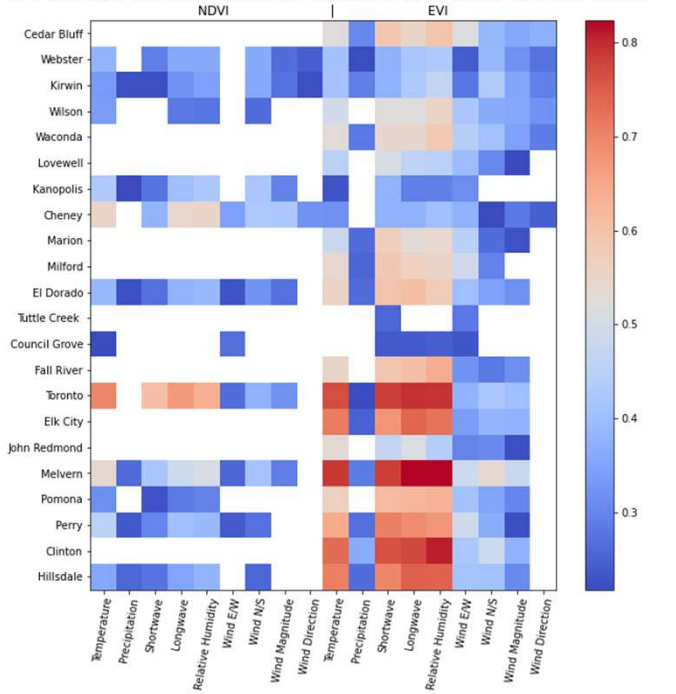
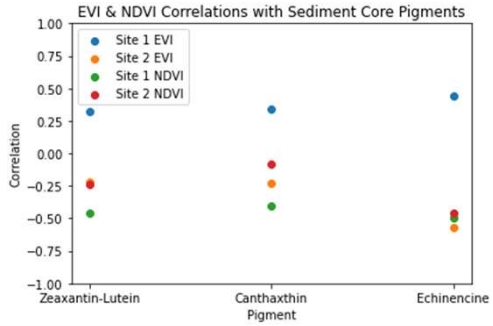


Fig 2. The Pearson Correlation of monthly average MODIS NDVI & EVI with the NLDAS dataset collected for each location (listed by decreasing longitude) at p<0.001

5. Sediment Core Data at Marion Lake



The pigments in Figure 3 indicate the presence of cyanobacteria, especially echinencine, which is unique to this algae. The coarse temporal resolution and uncertainty in sediment core data dating was not considered in this preliminary look at the correlations with the vegetation indices. Correlations only consider sediment core data between 2002 and 2021, the dates of the available MODIS dataset.

Fig 3. NDVI & EVI Correlations with Sediment Core Pigments at Marion Lake

6. Summary and Future Work

- NDVI and EVI show trends in different seasons. The seasonal trends in EVI were much stronger in the spring in summer, matching what would be expected for cHABS as they occur more frequently in warmer seasons when temperatures and nutrients available is most conducive to their growth.
- Night temperatures show increases across 5 reservoirs in Kansas. This may increase susceptibility to cHAB blooms by creating a more favorable environment for growth.
- Correlations and trends from these analyses will be used to aid in selection of candidate lakes and indictors for prediction of cHABs in Kansas reservoirs.
- Sediment cores may provide additional relevant information at reservoirs where it is available, though additional analysis must be done to confirm this.
- Future work will include establishing a prediction framework using the General Lake Model (GLM; Hipsey et al. 2019), a one-dimensional model used to simulate lake hydrodynamics and ecological dynamics via the coupled AquaticEcoDynamics (GLM-AED).

Acknowledgements

This work was funded by NASA-EPSCoR Cooperative Agreement Notice (CAN) Announcement Number NNH21ZHA002C.