Spatio-Temporal Variations of Aquatic Vegetation in Lakes. A remote sensing and machine learning approach based on Google Earth Engine. The Maracaibo lake case.

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Theme 1: Emerging pollutants in aquatic ecosystems.

Karen Escalona [*,1], Rodrigo Abarca-del-Rio [2], Maria Pedreros [2], Ignacio García [2]

ABSTRACT

This study seeks to identify and monitor long-term aquatic vegetation encroachment. We are using Maracaibo lake (Venezuela), which is highly anthropogenic, as a test of a robust and fast remote sensing methodology. The strategy was created and implemented in Google Earth Engine (GEE) using Landsat 7 and 8 satellite images and combining cloud masking, spectral indices, and machine learning classification techniques. Thus, monthly coverages were routinely calculated from 2013 to 2021. Subsequently, annual, seasonal and climatological frequency products were derived and analyzed. The results indicate that the average yearly coverage has been increasing significantly (slope from 2013 to 2021).

Also, it was identified that the slope is dependent on the season of the year (dry and/or rainy), being more important during the latter. The climatological distribution shows that proliferations predominate between October and January, weaken from February to May, and then have a secondary maximum between June and August. From a spatial perspective, the areas of most significant accumulation and concern are on the northwest shores and the lake strait to the north. Our routine use of freely available imagery and a fast cloud computing environment could be used as a complement to monitor the performance of eradication and control plans by local governments in Maracaibo or in other regions of the world beset by similar invasions, especially when climate change threatens water resources.

OBJECTIVES

METHODS AND MATERIALS

Previous studies on the detection of aquatic vegetation in the lake have mainly focused on monitoring and analysis of invasions using short-term datasets. Due to the challenge of "Big Data", which requires huge computing infrastructure and larger storage space. However, the recent emergence of the Google Earth Engine (GEE) platform, allowed us to create a methodology combining different remote sensing techniques on Landsat 7 and 8 satellite images, and thus obtain more detailed information on the Spatio-temporal distribution of aquatic vegetation.

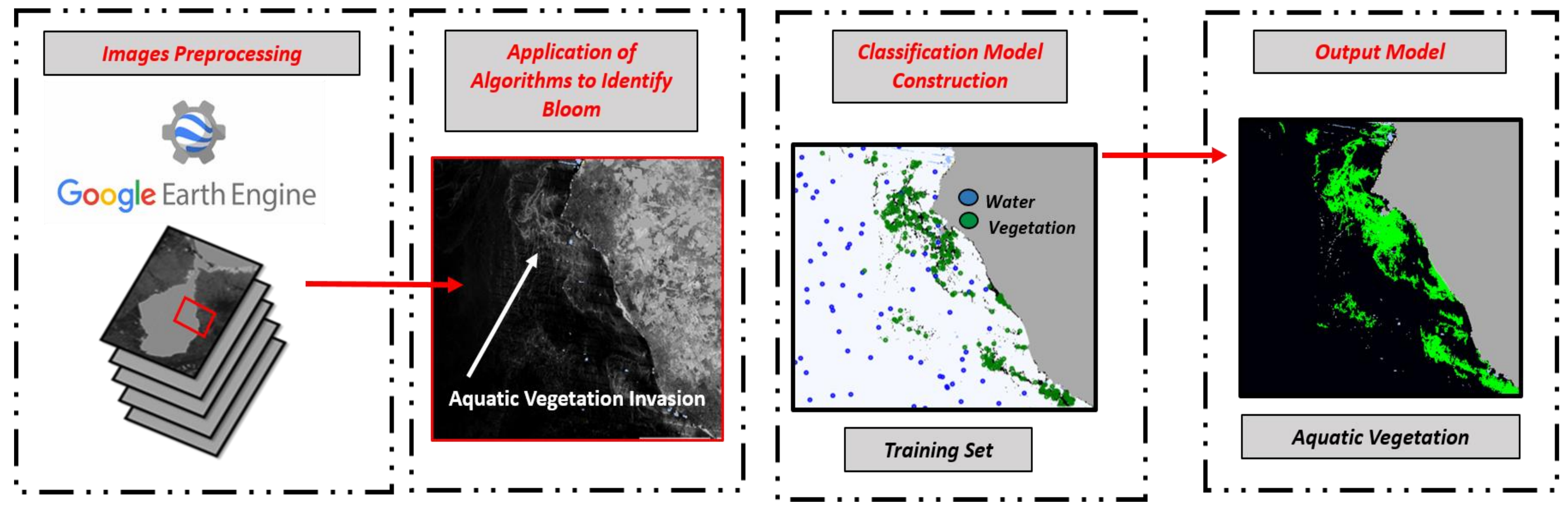


Figure 1. Model construction for estimation Monthly vegetation

CASE STUDY

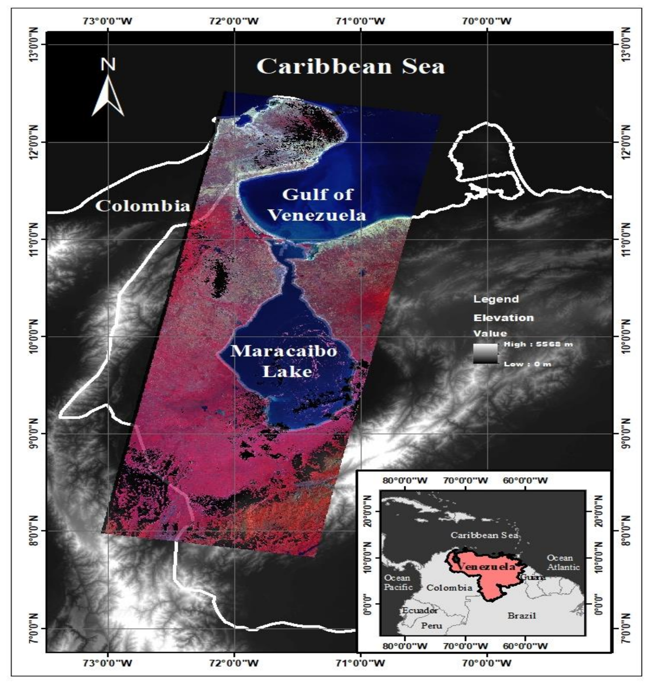


Figure 2. Study Area.

The Lake Maracaibo basin is located in the Northwest of Venezuela, between 7° and 12° North latitude, and 69° and 74° West longitude.

The waters of the Lake have undergone a change in their chemical composition since 1938 when greater human intervention began due to oil exploration activities, agriculture, and population growth, producing a large amount of waste that is discharged into the lake and its tributaries, drastically altering the ecological balance maintained in the ecosystem for thousands of years (Morillo et. Al 2008).

CLOUDS CLASSIFICATION

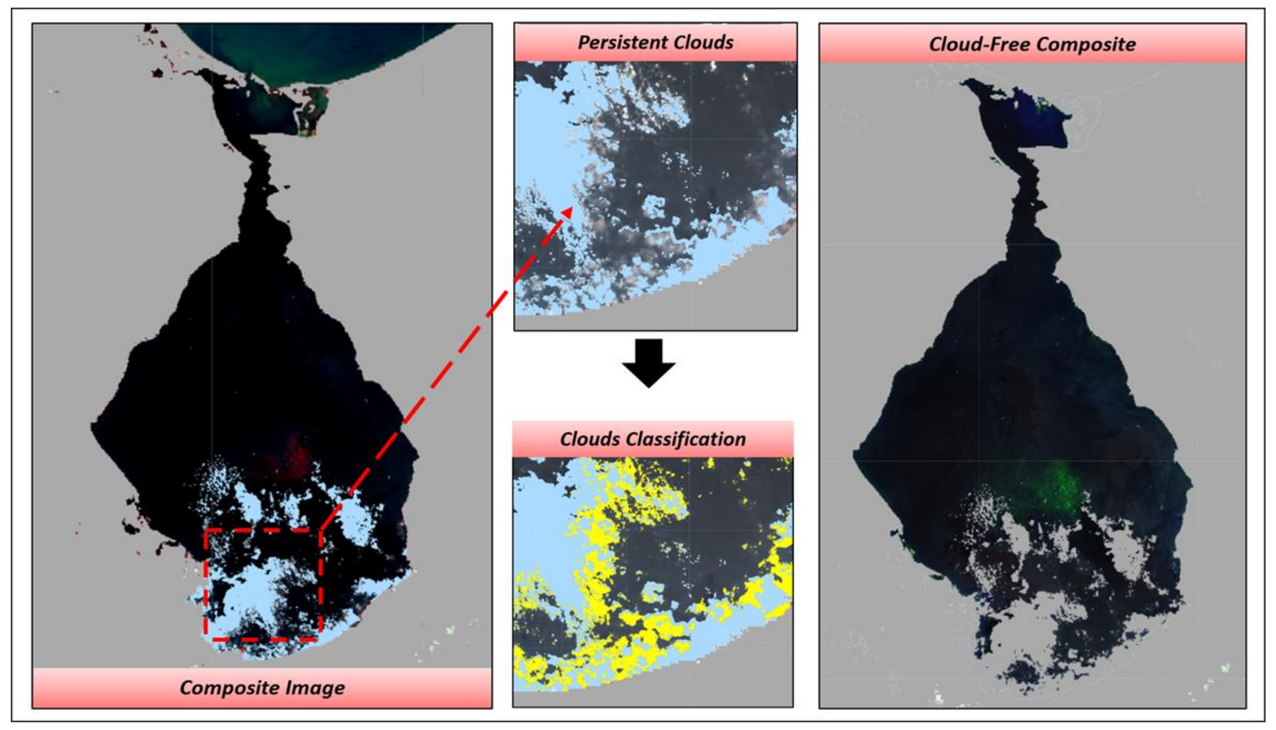
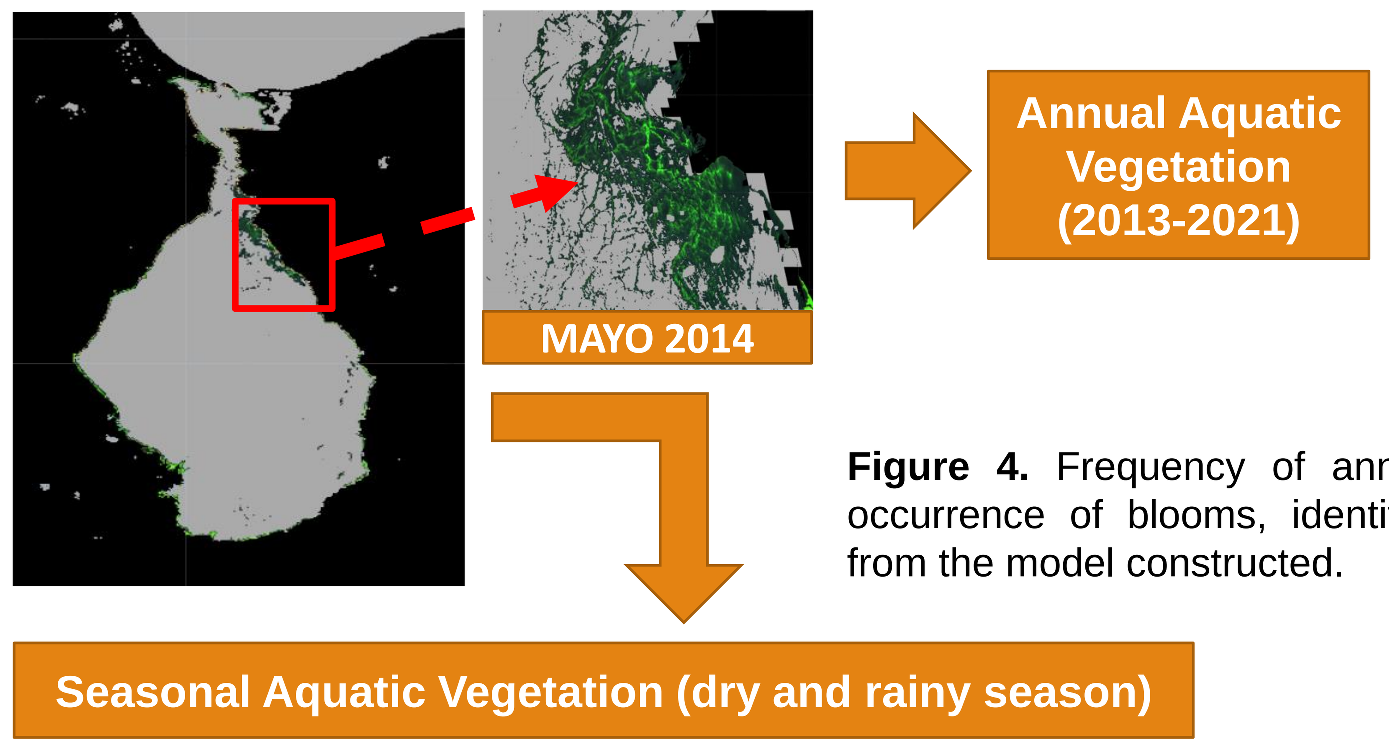


Figure 3. Cloud Algorithm.

Given the difficulty of clouds in Maracaibo, due to its tropical location. Our study proposes a new approach for cloud removal, by combining two methods (Indexes + classification). Reducing the misclassification of aquatic vegetation in cloud pixels, thus increasing the accuracy of the final model for long-term monitoring.

PRELIMINARY RESULTS



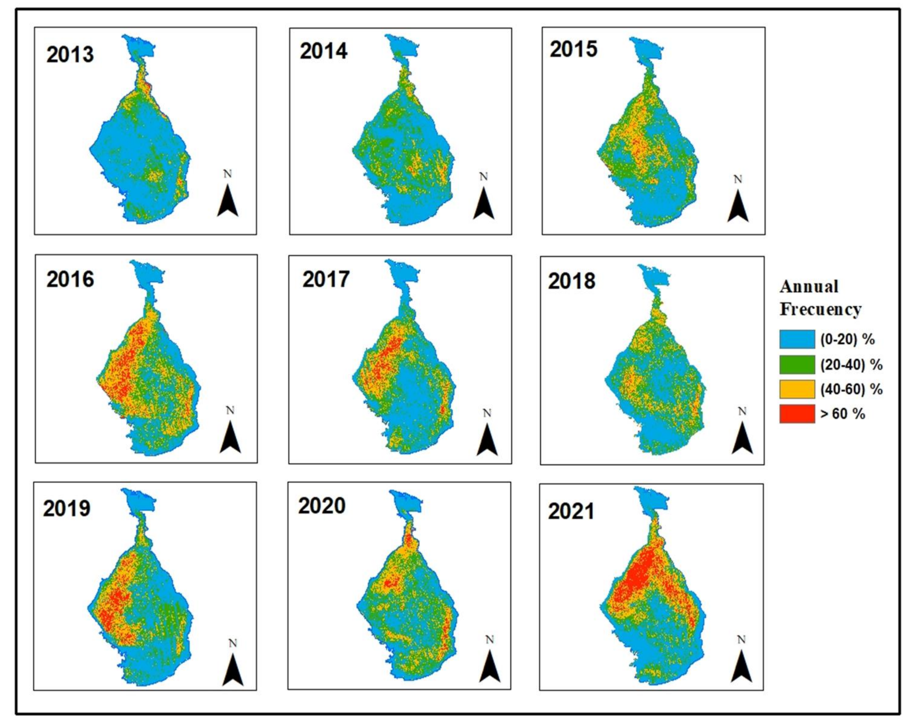
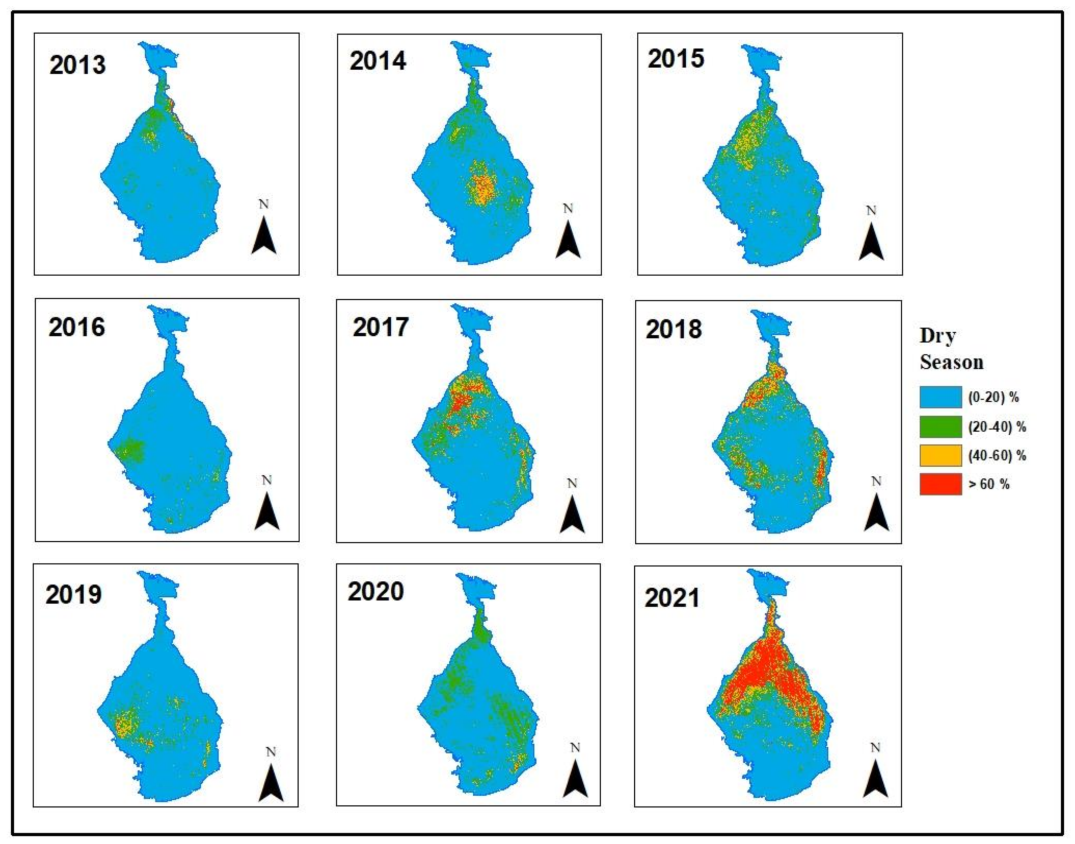


Figure 4. Frequency of annual occurrence of blooms, identified from the model constructed.



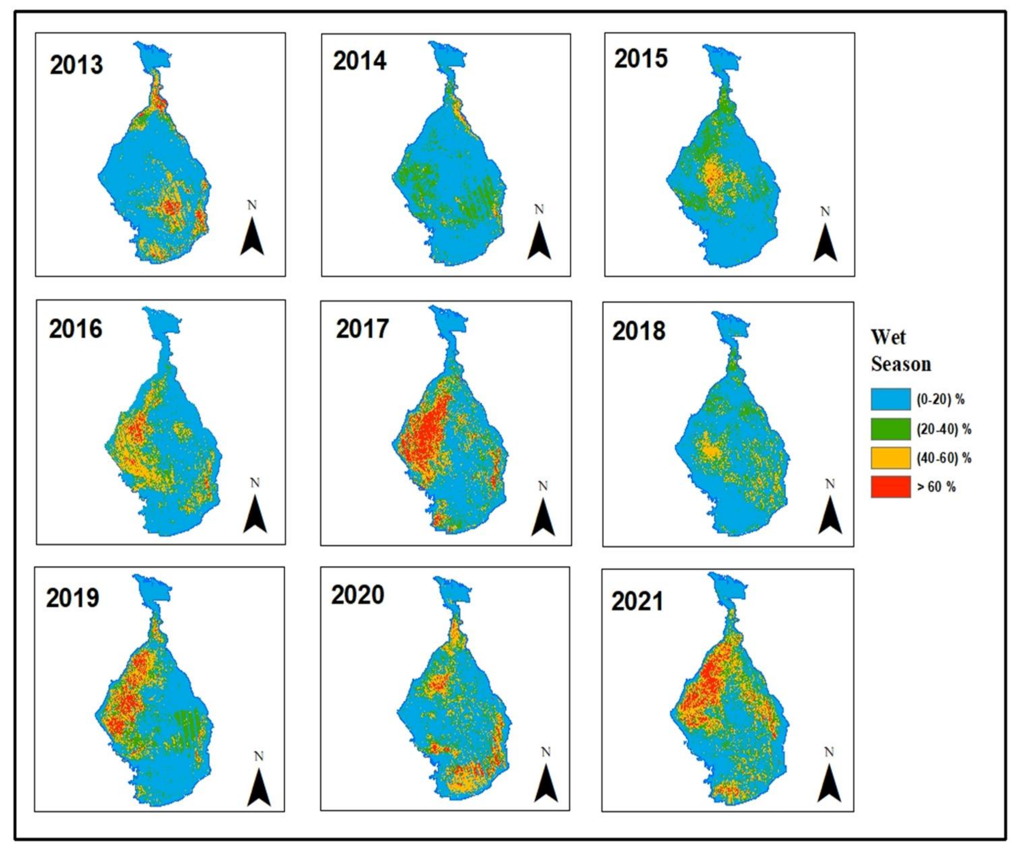


Figure 5. Frequency of seasonal occurrence of blooms, identified from the model constructed.

PRELIMINARY CONCLUSION

- The annual and seasonal spatial distribution of aquatic vegetation occurrence reveals that the northwestern shore of the lake had a high frequency of occurrence; therefore, these areas are documented as vulnerable and of greatest concern. The bay area, on the other hand, lacks favorable conditions for permanent vegetation accumulation.
- The distribution of aquatic vegetation varies seasonally (dry and rainy periods). The potential increase in growth during the rainy season is comparable to Badell et al. 2008.
- This proposed methodological workflow provides an automated approach solution for frequent and accurate long-term remote sensing monitoring of invasive aquatic vegetation. It can be implemented in other comparable eutrophic inland waters.

REFERENCES

- Morillo G. et al. 2018 "Estimación de clorofila a en el Lago de Maracaibo, Venezuela utilizando imágenes LANDSAT 8".
- Badell, G.; Flores, J.; Rincón, J.; Rubio, M. "Computational simulation of duckweed population growth rate in Lake Maracaibo".
- Lawrence M. Kiage y Nan D. Walker. 2008 "Using NDVI from MODIS to Monitor Duckweed Bloom in Lake Maracaibo, Venezuela".

[1]Doctoral Program in Physical Sciences, Faculty of Physical Sciences and Mathematics, University of Concepción, Chile.
[2] Department of Geophysics, Faculty of Physical Sciences and Mathematics, University of Concepción, Chile.

Contact: Karen Escalona. Email: kescalona@udec.cl