Coupled Hydrologic and Biochemical Modeling of Lake Regions

[1,2]Kathryn Levitan, [2]Stuart Jones, Ph.D., [2]Jake Zwart
[1]University of Kentucky, College of Agriculture, Food, and Environment, Lexington, KY
[2]University of Notre Dame, Department of Biology, South Bend, IN

ABSTRACT

A test bed of 163 lakes in Wisconsin was examined using publically sourced satellite temperature data from 2002 to 2016. Our objective was to examine the accuracy of the satellite data and fit the data to a more accurate model in order to predict lake volumes. For the Earth Observing System Terra and Aqua satellite, the Moderate Resolution Imaging Spectroadiometer (MODIS) was used to extract Land Surface temperature (LST) values. The MODIS satellite produced both day and night temperature values; we solely utilized the data collected at night. Using a masking geospatial tool in ArcGIS, the LST pixel values were united with each lake polygon. The programming language R was used to perform several statistical analyses in order to properly examine the large data set. The curve of the plotted data was used to extract multiple coefficient values. Using the AICc package in R Studio, the most accurate model was determined. Lake area was the most significant parameter. To validate the generated models, the predicted volumes created from the AICc test were plotted against actual volumes. The model we generated provided a more accurate and efficient way to predict lake volumes using land surface temperatures.

METHODS

AQUISTION OF LAND SURFACE TEMPERATURE FILES

↓

EXTRACTION OF DATA BY LAKE

↓

FIT QUADRATIC MODEL TO ANNUAL LAKE SURFACE TEMPERATURE DATA

↓

COMPILE QUADRATIC VARIABLES WITH KNOWN VOLUMES AND AREAS

↓

MODEL COMPARISON USING AICc

RESULTS

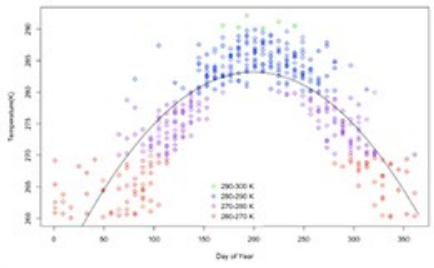

Figure 1: All land surface temperatures from 2002 to 2016 for Clear lake (Permanent ID:70335891)

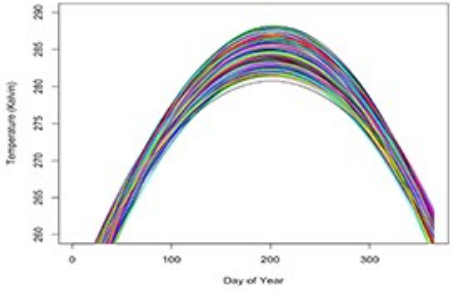

Figure 2: Temperature Best Fit line (Quadratic) for every lake in Wisconsin region

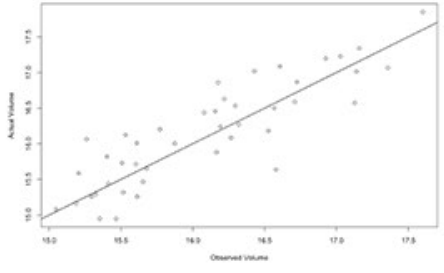

Figure 3: Validation Plot for Lake Volumes with 1:1 Ratio Linear Fit Line

	(Intercept)	log(training$Area)	training$a	training$b	training$deltaT	training$MaxTemp	df	logLik	AICc	delta	weight
2	-9.6458111	1.426745	NA	NA	NA	NA	3	-16.44699	39.56065	0.0000000	1.605729e-01
18	-0.5665241	1.494548	NA	NA	NA	-0.01320274	4	-15.47263	40.08812	0.5274666	1.236559e-01
6	-9.0612623	1.481960	NA	1563.3541	NA	NA	4	-15.55788	40.25862	0.6979702	1.135509e-01
10	-9.1324358	1.485869	NA	NA	0.09225094	NA	4	-15.57670	40.29625	0.7355978	1.114345e-01
4	-9.1324330	1.485869	-3.690053	NA	NA	NA	4	-15.57670	40.29625	0.7355989	1.114345e-01

Figure 4: The Top Five Best Model Parameters Using AICc Test

CONCLUSION

By using land surface temperature , a new model was created. Though the model did not solve the entire problem, the accuracy was increased. The model used both lake area and change in temperatures. The results lead to two main ideas. Lake area is still the most important variable in predicting lake volume and lake volume predictions still require more analysis for depth description and lake size differentiation.

FURTHER STUDIES

Questions to consider following this study :

1. What other variables can be used that are correlated with land surface temperatures?
2. Would an energy budget provide more insight and could it be used on a mass scale model?
3. Does lake size play a larger role in analyzing lake volume models?

ACKNOWLEDGMENTS

This research was supported by the National Science Foundation, the Center for Research Computing, and the Biological Science Department at the University of Notre Dame . Support also included Dr. Stuart Jones, Jacob Zwart, Kallie O'Connell, and Dr. Douglas Thain.