Title of pre-proposal

Water Temperature Estimation Using Landsat Satellite Imagery in Google Earth Engine.

Student Information

Ennis A. Rios

ennisrios@tamu.edu

619-618-5040

Masters of Water Management

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Committee Chair

Dr. George H. Allen, Assistant Professor- Department of Geography

geoallen@tamu.edu

979-845-7187

Abstract

River water temperature is an indicator of several freshwater properties including aquatic ecosystem health, species migration patterns, and rate of sedimentation. Water temperature also reflects the anthropogenic influence of urbanization and land use change on riparian environments. In all of these applications, water temperature can be used to study climatic trends and develop hypothesis for their cause based on the large rivers that traverse the landscape. Despite its importance, temperature measurements within large river systems is limited by sparse temperature gauging networks. Using thermal infrared (TIR) imagery captured by the Landsat satellite suite, temperatures of large rivers can be estimated over large areas and temporal scales. Satellite remote sensing has long been used to estimate sea surface temperatures and the water surface temperatures of large lakes and reservoirs, but less work has been conducted to study the thermal regimes of rivers. In this study, we seek to develop a standardized model of using Google Earth Engine to process Landsat imagery provided by the USGS in order to estimate the water temperatures in large rivers. The methods developed in this study can be integrated into the analysis workflows of organizations that influence policy related to climate change, urban planning and environmental management in Texas and beyond.

Description of Research

a. TNRIS, TCEQ, and TPWD, are just a few of the Texas state agencies that collect, analyze and distribute geospatial information, either for internal use or for use by organizations that support their missions. There is a high cost associated with data collection and processing. Purchasing access to the data, paying personnel to process it, and acquiring software licenses are several of the most notable costs. With the advent of Google Earth Engine (GEE), a central repository of imagery from multiple satellite platforms is available. Through GEE, imagery can be imported and examined using countless built in tools as they come, or modified for the specific needs of the research. Rather than executing the processes on a local computer, GEE allows for distributed processing on virtual servers. This not only alleviates the processing cost on the local computer, it prevents the agency from spending exuberant amounts of limited funding on expensive hardware previously needed.
b. The limited availability of river temperature data inhibits a holistic approach to mitigating the effects of climate change and anthropogenic influence on the thermal regime of riparian ecosystems. The ability to quantify river temperatures globally will further our understanding of human influence on the environment (Liu et al., 2020). Runoff from treated agricultural land contains chemicals whose negative effects on aquatic species are exasperated by increased

temperature (Holmstrup et al., 2010). The slowed rate of organic carbon mineralization and its subsequent storage within rivers and lakes is positively correlated with increased temperature (Gudasz et al., 2010). Upper and middle stream runoff has been found to increase with rising temperature (Wu et al., 2020). The IPCC (2014) states that a 1.5 degree Celsius increase in global mean surface temperature will have negative effects on crop production which will magnify food shortages globally. The more tools available to assess climate change, the more prepared the scientific community will be to contribute to the development of comprehensive mitigation policies. I plan to use GEE to investigate different methods available to assess river temperatures using Landsat imagery. During the investigation, GEE scripts will be developed and refined. These scripts will be publicly available for use and, it is my hope, they will be useful for individuals or groups that seek to understand the effects of climate change on riparian systems within Texas.

c. This study is a continuation of my work that looked at several river segments in the United States and estimated the water temperature with varying degrees of accuracy. In this study, GEE code developed by Ermida et al. (2020) is used to process Landsat imagery collections. Calibrated Tier-1 top-of-atmosphere (TOA) reflectance and surface reflectance (SR) datasets for Landsat 4, 5, 7, and 8 are used by the Ermida et al. code to generate land surface temperature (LST) within a Landsat scene that corresponds to user defined coordinates and specified temporal range. The code for generating LST, including examples, is available to GEE users at: https://code.earthengine.google.com/?scriptPath=users%2Fsofiaermida%2Flandsat_smw_lst%3Aexample_2.js. This study aims to estimate river water temperature from Landsat imagery which requires the selected pixels for measurement are centered between the wetted widths of large rivers. The Ermida et al. GEE code was not specifically intended for use in measuring water surface temperature which is why this study is exploring its feasibility of application. As a validation of the methodology, river segments that coincide USGS gauges will be used. Comparing the available USGS historical temperature data to the estimated temperature from simultaneous satellite images will provide the baseline of accuracy. The method in which this is accomplished has already been established during previous work. Regression statistics run in R were used to assess feasibility of the methods in future work. The mean R^2 of temperature estimation for the seven rivers included in the previous study = 0.87. A known limitation is the river's width. If the width is less than that of the spatial resolution of the thermal sensor, mixed pixels (land and water) can be included in the analysis and skew the results. I anticipate challenges within Texas given the limited flows of many west Texas river systems, yet I believe the study will be fruitful in that it will establish a process and code that can be manipulated for other Texas related environmental studies.

d. The expected results of this study are multifaceted. At the very least, it will establish a process for integrating GEE processing power into the workflow of geospatial analysis. My hope is to develop a method of using up to date imagery through GEE to show river water temperatures across Texas (scalable beyond Texas). The intended result is not only for the ease of gathering future temperature information, but to ease the cost of such data processing by state agencies. Further, where gauged temperature data already exists, this method may be used to fill in temporal ranges in which the gauge was offline or decommissioned.

Intended Career Path

Upon completion of my Masters of Water Management program, I intend to seek a career within the water sector. While that is a broad statement, I know that I want to work for an organization that seeks to improve the use and conservation of our natural resources. I would like for that to be in Texas, but I am realistic enough to know that I must go where the jobs are. As far as specific career path, I cannot answer that beyond; I will seek to influence a positive impact on our environment, whether it is at the municipal, state, national, or global scale.

References

Ermida, S. L., Soares, P., Mantas, V., Göttsche, F. M., & Trigo, I. F. (2020). Google Earth Engine Open-Source Code for Land Surface Temperature Estimation from the Landsat Series. *Remote Sensing*, *12*(9), 1471.

Gudasz, C., Bastviken, D., Steger, K., Premke, K., Sobek, S., & Tranvik, L. J. (2010). Temperature-controlled organic carbon mineralization in lake sediments. *Nature*, *466*(7305), 478-481.

Holmstrup, M., Bindesbøl, A. M., Oostingh, G. J., Duschl, A., Scheil, V., Köhler, H. R., ... & Gerhardt, A. (2010). Interactions between effects of environmental chemicals and natural stressors: a review. *Science of the Total Environment*, *408*(18), 3746-3762.

IPCC, 2014: *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.

Liu, S., Xie, Z., Liu, B., Wang, Y., Gao, J., Zeng, Y., ... & Li, R. (2020). Global river water warming due to climate change and anthropogenic heat emission. *Global and Planetary Change*, *193*, 103289.

Wu, Y., Fang, H., Huang, L., & Ouyang, W. (2020). Changing runoff due to temperature and precipitation variations in the dammed Jinsha River. *Journal of Hydrology*, *582*, 124500.

Link to GEE code:

https://code.earthengine.google.com/208a5d7221cf40436fd31caeca6c8f94