

A Comparison Study Between Ground- Truth Temperature Data of Mitchell Lake and the Temperature Data Obtained Using MODIS Satellite Images.

Amber Patrick and Erin Manitou
Department of Earth and Environmental Sciences
The University of Texas at San Antonio

Introduction & Background

Study Area

Mitchell Lake is one of only two natural lakes in the state of Texas. The 600-acre body of water is centered on 1300 acres of wetlands and is located 12 miles south of San Antonio at 29° 32' N latitude and -98° 28' W longitude. It has an average water depth of less than 8 feet.

During the turn of the 20th century, Mitchell Lake was dammed and converted into a sludge disposal lagoon for the city of San Antonio's raw sewage. Raw sewage was dumped into the lake until 1930's. At this time various water treatment facilities came on line, all of which, dumped the now treated effluent into the lake. This practice continues even now, the Leon Creek Recycling Water Center's effluent is discharged into the lake. It is said this practice is to maintain water level and there by safeguard surrounding wetland habitat. During the mid 1970's, 87 acres of the upper portion of the lake were diked to form a polder complex that accepted waste activated sludge from the Rilling Road wastewater treatment plant

In 1973, the city of San Antonio attempted reclaim the lake and designated it a Wildlife Refuge The lake is now owned by the San Antonio Water System (SAWS), but is being overseen by the San Antonio Chapter of the National Audubon Society which is acting as caretaker of the lake and the visiting center. They have made the made Mitchell Lake and the surrounding wetlands one of their core conservation initiatives in this area. In the 1990's there was an engineering analysis done of the dam and water quality, they concluded that there was no hazardous material found in the lake and that the water quality levels were within the Texas Natural Resource Conservation Committee standards. (The TNRCC is now known as the Texas Commission for Environmental Quality).

As far back as there is documentation about the lake, it has been known to attract much bird life. In fact, back in the 1700's the original name of the lake was Laguna de los Patos, which is Spanish for Lagoon of the Ducks. Even now, after decades of hosting raw city effluent, this lake is a highly populated bird sanctuary. There have been a reported 307 bird species sited at the lake and surrounding refuge area. Mitchell Lake has become a pivotal migratory stopping point in the central migratory flightway for over several hundred species of birds. The incorporation of Mitchell Lake by SAWS has produced a great concern from Environmentalists, wildlife ecologists, and local

residents to both improve the quality of the lake for avian species, as well as create an educational and wetlands research field site.

Due to the interesting and regrettable history of the lake and its recent ascent to recovery, we believe Mitchell Lake to be an interesting and important site for our remote sensing project. The imagery and analysis will focus on the lake itself.

Satellite Imagery

Moderate-resolution Imaging Spectroradiometer (MODIS) sensor can be found on both the Terra and the Aqua satellites, launched in 1999 and 2002 respectively. Both of these satellites are sun-synchronous (or polar orbiting) with global coverage and repeat sampling. The difference is the direction in which they travel. The Terra satellite travels north to south so that it crosses the equator in the morning. The Aqua satellite travels south to north such that it crosses the equator in the afternoon. The instruments capture images with spatial resolutions of 250 meters, 500 meters, and 1 kilometer in 36 spectral bands ranging in wavelengths from 0.4 μm to 14.4 μm . The MODIS instrument has a viewing swath of 2330 km and views the entire surface of the Earth every 1 to 2 days. The MODIS sensor also has a radiometric sensitivity of 12 bits.

The MODIS sensor was created so that it could provide continuity from the AVHRR sensor. The MODIS sensor has higher radiometric sensitivity and higher spatial resolution than the AVHRR. Another advantage of using MODIS imagery is that the images are free on the internet whereas the AVHRR can be close to \$100 per scene.

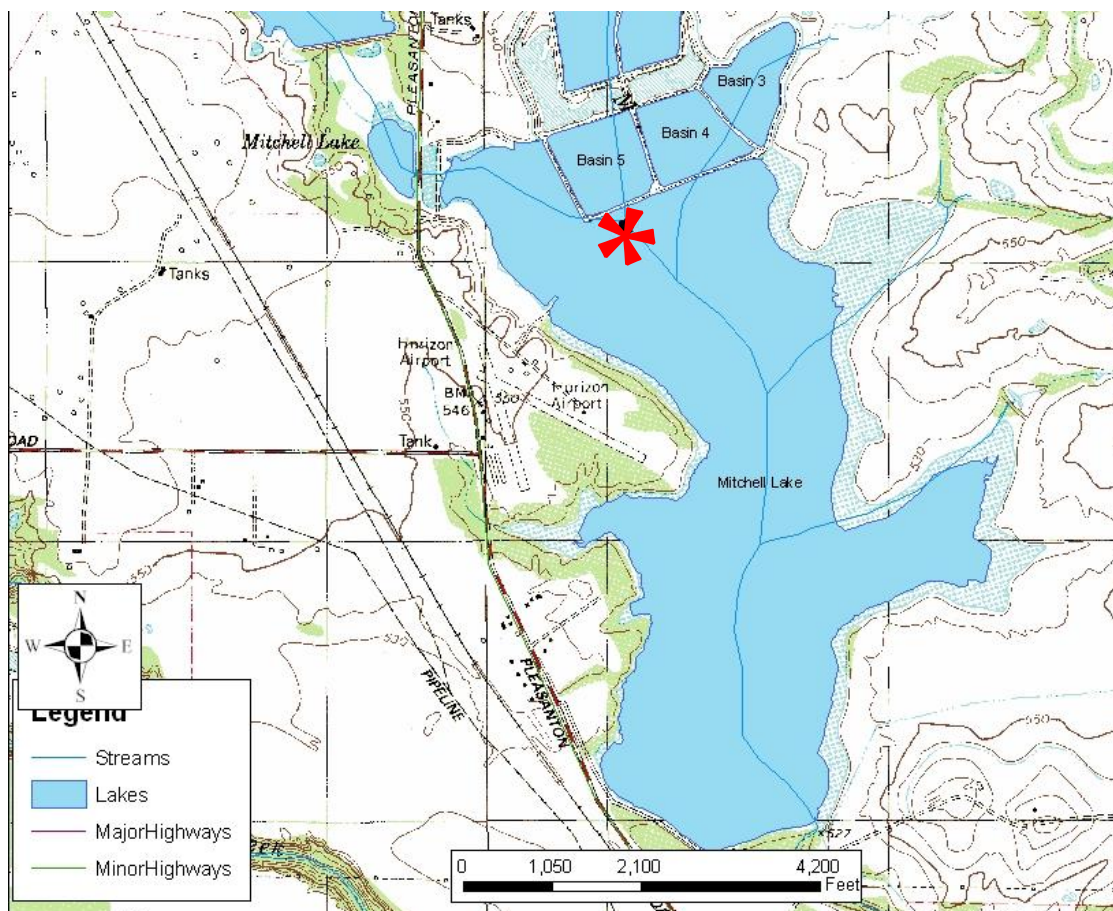
The satellites carrying the MODIS sensors pass over the Mitchell Lake area 4 times a day, starting at 02:00, 10:00, 14:00, and 23:00 Zulu time. The project was originally intending to use the data from both satellites and there by give 4 images of our site a day. For reasons explained later, we did not find the Aqua data of any use for this project. So the data used for the project will be the band representing the temperature images from MODIS on the Terra satellite. The data was that obtained from the EOS Data Gateway has a spatial resolution of 1KM.

Ground truth data

Acquisition of the ground truth data has been run by Dr. Murray, Dr. Bodour and undergraduate students. The start date of the data collection is August 10, 2006. The data has been collected from the south rim of basin #5 (see image below) using a Troll 9000 Pro XP probe (serial number 33444) which was placed approximately 5 feet under the water surface. In addition to the temperature data, the probe has also collected other valuable data from the lake such as pressure in PSI, barometric pressure, pH, dissolved oxygen levels, chloride levels, and conductivity.

The water temperature is recorded every hour of the day starting at 00:33 military time. Temperature was recorded in degrees C°. The data was given to be used for our

project for the purpose of comparing them with the temperatures we calculated from the remotely sensed images.



Objectives

1. To perform a comparison study of the differences and similarities between the ground-truth temperatures that have been recorded directly from the lake to the temperature reading obtained using the MODIS satellite imagery.
2. To verify that remotely sensed images, such as MODIS, can indeed be used to accurately record the lakes temperature and possibly lake depth.

Methods

MODIS images of the study area were obtained electronically from the Earth Observing System (EOS) Gateway. Data from both the MODIS/Terra and MODIS/Aqua satellites were obtained for a 20-day period from 10 August 2006 to 30 August 2006. Both satellites offer two images per day, a daytime image, and an evening image. These images were taken at 1:30am and 1:30pm. After the images are downloaded, the MODIS reproject tool was used to convert the .hdr files to .tif files. Of the various bands available, only the daytime and nighttime temperature bands were

selected. The coordinate system selected was NAD 83, zone 14N. The ENVI 4.1 software was used to open each image and analyze the image for digital numbers (DN). The DN of each pixel was converted to degrees Kelvin by using the band math tool and multiplying the DN by 0.02. The new, converted images were saved and analyzed. The images were analyzed visually through ENVI, and it was observed that the majority of the Aqua images were too contaminated with clouds to be used in this project. The remaining Terra images were also analyzed, and those that had minimal or no cloud contamination were used. The following days were used: August 10, 11, 13, 16, 17, 18, 20, 25, 27.

Density slice was created based on the temperature values of the pixels. 25 categories were chosen with each category representing 3 degrees Kelvin. The cooler temperatures were represented by purples and blues. The scale followed a rainbow pattern with the hottest temperature values being in the orange and red colors. For simplicity purposes, the range eliminated temperature values from 0-285, starting with 286 and ending at 232 degrees Kelvin. Figure 1 shows what the images looked like with the addition of the density slice.

Region of Interest (ROI) was created to represent Mitchell Lake. A polygon of the lake was created to observe the pixels that covered the lake area. The ROI was saved and applied to each of the 8 images used. Once the ROI was applied, it was observed that 9 separate pixels covered the lake with varying percentages of lake coverage per pixel. Figure 2 shows the breakdown of pixels and how they were labeled for comparison with the temperature data.

Diurnal temperature information from the ground-truth data was available for comparison with the August 25th and 27th image data. The temperature readings were obtained using the probe mentioned in the background. The temperature data was collected every hour at 15 minutes past the hour. The two temperature readings used in this project were the 1:15 am and 13:15 pm times.

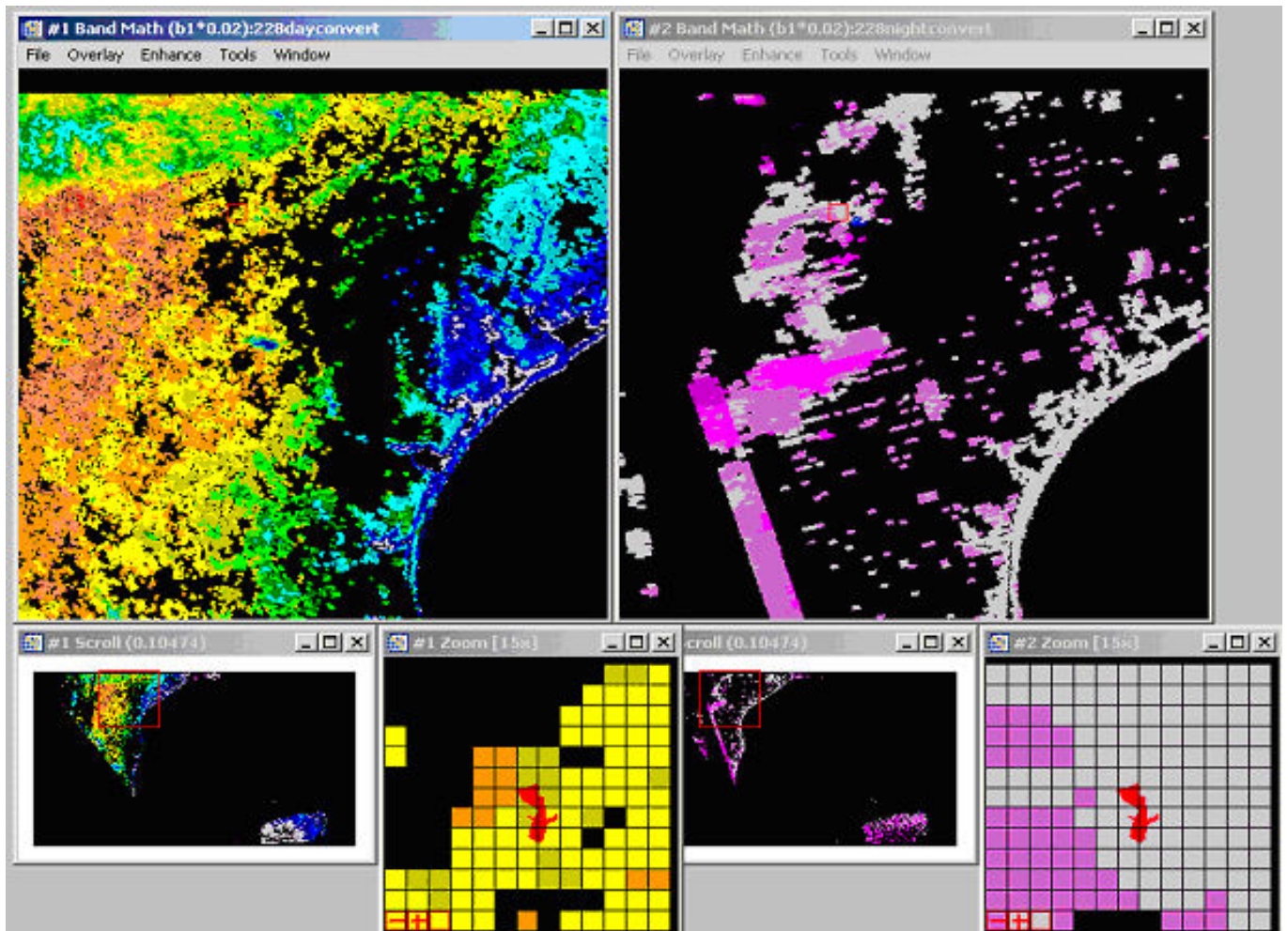


Figure 1.

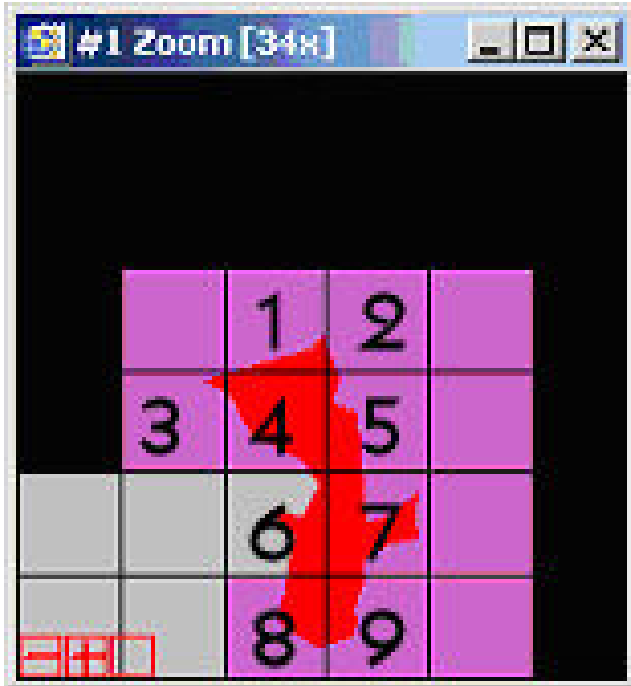


Figure 2. ROI of Mitchell Lake with Pixel breakdown

Results

As researching did not overturn any published articles dealing with remotely sensed temperature imagery of sludge lakes and whether or not they were accurate, results from this experiment will not be compared to anything but themselves and the ground truth data. Despite lacking comparison results, it was expected that there not be a significant difference between the ground-truth data recorded directly from the lake itself and the remotely sensed images. This was not found to be the case. The remotely sensed images gave temperature readings that were much higher than expected for the daytime. Temperature data for all pixel values for all 8 days ranges from 85.352° F to 112.676° F for the daytime, and 72.968° F to 82.472° F for the nighttime. The higher daytime temperatures were contributed to possible contamination of the pixel DN values by surrounding objects such as land, cement, parking lots, etc. These objects combined with the water could create a temperature higher than the water itself, especially in those pixels that were largely land with only small amounts of water, such as pixels 2 and 3.

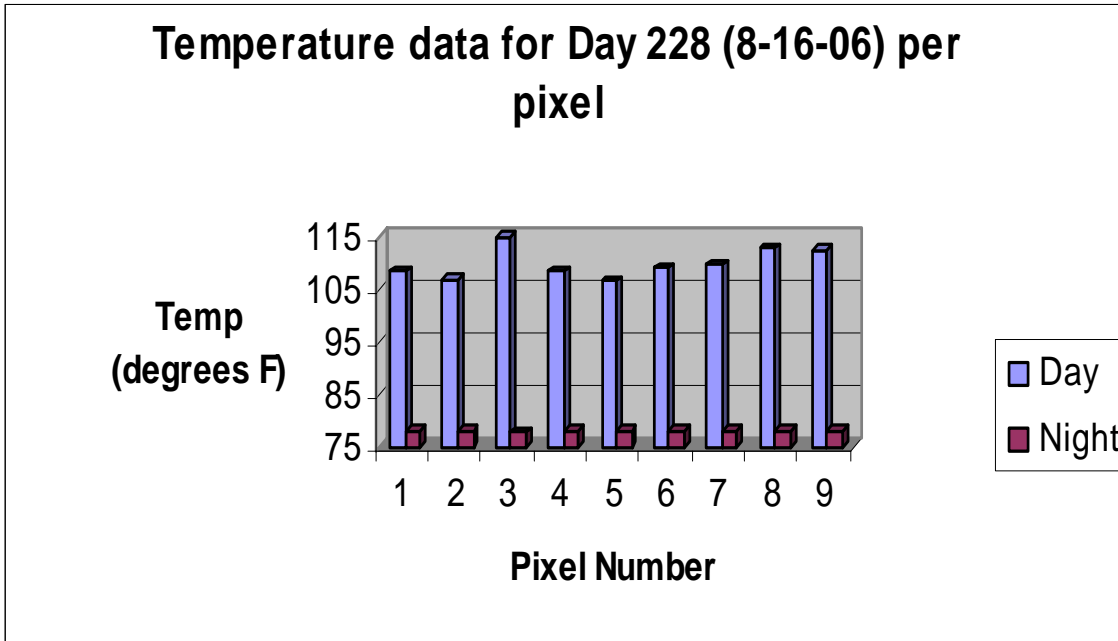


Figure 3. Temp (F) data for Aug 16th, remotely sensed image

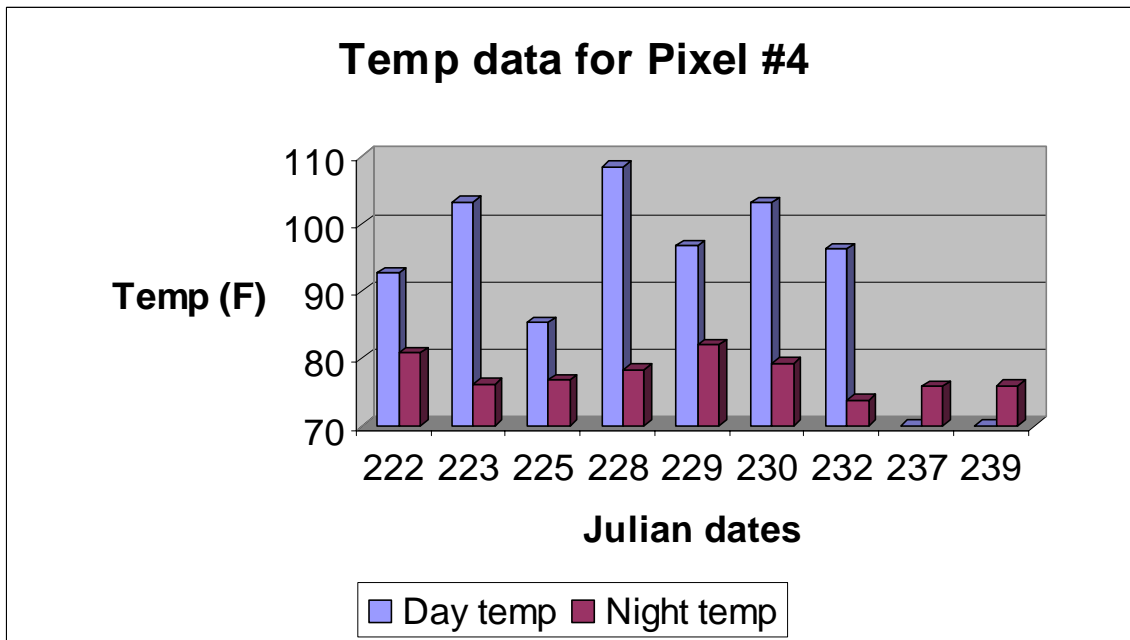


Figure 4. Temp (F) data for pixel 4, all 8 days.

Conclusions

Lack of consistent data in both the remotely sensed images and the ground-truth data proved to be problematic for an accurate comparison of the two data. The location of the probe to collect the ground truth data was inconsistent with the collection of the remotely sensed images. The probe location was 5 ft below the water's surface, while the remotely sensed images DN were represented by water surface values. In addition, the cloud contamination proved to be a great obstacle in obtaining consistent data over a period of time. The data from the Aqua Satellite was extremely contaminated with cloud cover such that only a handful had data from our site. Moreover, MODIS images have a rather large spatial resolution, allowing for only a few pixels values to represent a small body of water such as Mitchell Lake. Another issue caused by the spatial resolution was that all of our pixels were a mix of land and lake, which threw off the surface temperatures greatly. (Land heats up much more than does water.) The land surrounding the lake may have had asphalt roads, buildings, cement, or buildings and if they were included in the pixel it would have greatly increased temperature readings. The reason for this is due to the fact that the value for each pixel is an averaged value of all of the area within that pixel. It is for this reason, that to do this type of project it is recommended to use a satellite, such as Landsat 7 with a much smaller spatial resolution (15 m) which could be used to delineate temperature values from remotely sensed images. Although more costly, Landsat 7 and other sensors with a better spatial resolution may provide more accurate and usable data.

Higher Goals

Our ultimate goal in choosing this project was to provide any useful information to the Mitchell lake project itself. After decades of having raw city sewage pumped into the lake, this now diversely populated bird sanctuary is in a time of recovery. Research must be continued in this area to bolster remediation efforts. It is our hope that through our project we might uncover other ways that remote sensing might be able to work hand-in-hand with remediation of the lake.

Other Research Ideas Involving Remote Sensing and Mitchell Lake

1. Using reflectance to infer about water quality.
2. Using MODIS and Normalized Difference Vegetation Index (NDVI) to examine algal blooms on the lake surface due to over abundance of nutrients such as phosphorus and nitrogen.

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