REMOTE SENSING URBAN HEAT-ISLAND DETECTED BY MODIS/TERRA AND MODIS/AQUA TEMPERATURE PRODUCT IN THE TEXAS CITY OF EL PASO REPORT

December 7, 2008

University of Texas San Antonio
REMOTE SENSING URBAN HEAT-ISLAND DETECTED BY MODIS/TERRA AND MODIS/AQUA TEMPERATURE PRODUCT IN THE TEXAS CITY OF EL PASO

Mario Flores, Graduate Student
Department of Applied Mathematics, UTSA

Miguel Balderas, E.I.T., Graduate Student
Department of Civil/Environmental Engineering, UTSA

ABSTRACT

This paper shows the application of MODIS/Terra and MODIS/Aqua temperature products (every 8 days with a 1 km spatial resolution and with day @ 1:30 pm EST and night data @ 1:30am EST) of time period July 2002 to December 2003 to study the urban heat island phenomenon of the city of El Paso, Texas.

INTRODUCTION

The temperature of an urban area is often higher than the surrounding rural areas. It looks like a hot island standing out in a sea of relative cool areas. This phenomenon is called urban heat island (UHI) effect, an anthropogenically induced climate feature associated with the contrast surface characteristics between urban and rural areas [Sturman and Tapper, 2006]. This phenomenon is due to the increase of local surface and atmospheric temperatures in urban areas when compare to those temperatures in rural areas. This increase in temperature results mainly from the concentration of population and the type of land use in cities like buildings, parking lots, roads which reduce the tree, grass and water surface which otherwise reduce the temperature by evapotranspiration, and the materials used retain the heat from the sun.

STUDY AREA

The study area is the city of El Paso, Texas and its surrounding area. El Paso is located at 31°47′25″N 106°25′24″W / 31.79028, -106.42333 (31.790208, -106.423242).[1] It lies at the intersection of the states of Texas, New Mexico and Chihuahua and the countries of USA and Mexico. The city's elevation is 3,800 feet (1140 m) above mean sea level. According to the United States Census Bureau, the city has a total area of 250.5 square miles (648.9 km²). El Paso has an arid, warm climate (Koppen climate classification BWh) with very hot summers (with little or no humidity) and mild, dry winters. Temperatures range from an average high of 55 F (13 °C) and an average low of 28 °F (−2 °C) in January to an average high of 97 °F (36 °C ) in June and an average low of
68 °F (20 °C) in August. The city's record high is 114 °F (45.5 °C), and its record low is −8 °F (−22 °C). (2) Temperature differences between the built-up city and the scarce populated Chihuahuan Desert shows the urban heat island effect. The image 1 is a MODIS image of the city of El Paso and image number 1a better definition image. We can see the white area to the left that represents higher temperatures. Image 3 shows a zoom with a vector layer of the city of El Paso.

Image 1

Image 2. The complete data set. The city of El Paso, Texas is at the lower right in green.
METHODOLOGY

Data

The data was obtained from NASA’s two MODIS sensors on board of Terra Earth Observing Satellites (EOS) launched in December 1999 and Aqua Earth Observing Satellites (EOS) launched in February 2002. The MODIS instrumentation provides radiometric sensitivity of 12 bits in 36 spectral bands in the range of wavelengths of 0.4 micro meters to 14.4 micrometers. One of the products that MODIS provides is the surface temperature product MOD11A1 of Aqua and Terra which is a 8 day 1 km spatial resolution of land surface temperature with accuracy of 1 degree Kelvin (Wan et al. 2002a, 2004a) with day time (1:30 pm EST) and night time (1:30 AM EST) data. This project uses the MODIS Terra MOD11A1 and MODIS Aqua MOD11A1 products to study temperature in the city of El Paso and surrounding areas (Figure 1). Data was gathered from June 2002 to November 2008, but the period under investigation is from to June 2002 to December 2003. The series were ordered at https://wist.echo.nasa.gov/api/. Image 4 shows the Internet interface that allows the order of this data.
Method

The tool for re-projection MODIS Re-projection tool (MRT) was used to process the data. It is a free software program provided by NASA for the proper map projection and datum. Below are the steps used to obtain the desired data.

(a) Select only night time LST (land surface temperature) and day time LST images
(b) Clip the images to study area
(c) Project to UTM zone 13 with WGS84 datum
(d) Using ENVI the series of images were stacked into two images: daytime image and nighttime image (i.e. all day time LST image time series into the daytime image, all night time LST image series into the nighttime image).
(e) These two stacked images were then converted to real temperature (Kelvin) by multiply the scale factor of 0.02.
(f) Then the images were classified using the density slice showed in image 5.
Image 5 Density Slice for the stacked images

(g) Every LST image was individually checked visually to find if it was affected by clouds. If the image had too many “no value” data due to cloud coverage then the image could not be used for the analysis. Image 5 shows the heat island phenomenon. The white area is at higher temperatures. As we can see in Image 6 the phenomenon is greater at the city of Ciudad Juarez, Mexico.

Image 7 shows the frequencies in the values of temperature for image 3.
Image 8 shows the statistics for JUL 12 2002 in red and DEC 19 2002 in white. We can see the differences in temperature for these dates.

(h) Using the shapefile from ArcGIS the roads vector layer of the city of El Paso was obtain from the Texas roads shapefile and added to the stacked images. Also ARC Info version 9.2 was used to format some of the images (scale, orientation, text).

RESULTS AND DISCUSSION

Dr. Xie and his proceeding classes will continue working with this project the rest of this semester and into the next coming year (2009).

As up to today this work shows a Heat island characterization map in the city of El Paso for the period of June 2002 to December 2003.

Image 9 shows an example of characterization of heat island of the city of El Paso. We can see that the area of downtown El Paso show clearly the phenomenon.

Image 10 shows the phenomenon on day 353 almost at the end of the year. We can see in this image that there are more dark areas which show less temperature. However still we can see the heat island phenomenon.


Image 11 and 12 shows the density slices for July 12, 2002 at day and night. We can see almost no difference at the heat island in the downtown area during the winter season. However there area some black spots in the night image that do not represent bad measurements. We observed during the day during the summer months that the heat island effect is not visible during the day. Due to the dessert climate in El Paso, Texas the surface temperature/emissivity is greater in the area outside the cities (El
Paso, Cuidad Juarres) or urban areas because the urban areas are absorbing most of the heat while the light colored sand areas in the desert reflect it back causing the surface temperature to be greater in those areas. At night during the summer months the heat island is visible because the heat absorbed by the urban area is being released while the surrounding desert areas lose their heat almost instantly causing the effect (Image 13).

Another reason for the night heat island effect can be attributed to the fact that these two cities (El Paso and Ciudad Juarez) are industrial cities. Many major companies and corporations (i.e. Sony) operate on a 24-hour production cycle thus intensifying the heat island effect.

![City of El Paso (Modis Terra image) 2002 Day 193 Day](Image 11)
Approximately 80 good MODIS images (both daytime and nighttime) for the study periods (July to December) of 2002-2003 have been analyzed. The existence of a heat island (HI) of the El Paso downtown area was clearly shown in ~ 80% of the available cloud-free (or near free) data. It is especially prevalent in the night-time imagery than in the daytime imagery. Overall, during nighttime (daytime), the HI is about 4 - 5 °K (6 - 8 °K) higher than the average T of the area and 5 - 6 °K (8 - 11 °K) higher than the rural area. We can assume that the rest of the data collected and analyzed to November of 2008 would yield fairly the same results. If anomalies or abnormal results are shown for a period of time, one would then have to look into the weather conditions during that time frame. A rain event lasting several days may taint some of the abnormal data. With further time and analysis one can absolutely show the heat island effect on El Paso, Texas and its sister city Ciudad Juarez, Mexico.

2 http://en.wikipedia.org/wiki/El_Paso,_Texas

3 HEAT ISLAND OF SAN ANTONIO, TEXAS DETECTED BY MODIS/AQUA TEMPERATURE PRODUCT Hongjie Xie, Huade Guan, and Sandra Ytuarte. Laboratory for Remote Sensing and Geoinformatics. Department of Earth and Environment Science University of Texas at San Antonio. San Antonio, TX 78249.