

A Look into the Urban Heat Island Phenomenon of Austin, Texas

By
Ezenwanyi Onwuchekwa
Department of Earth and Environmental Science
University of Texas at San Antonio

Introduction

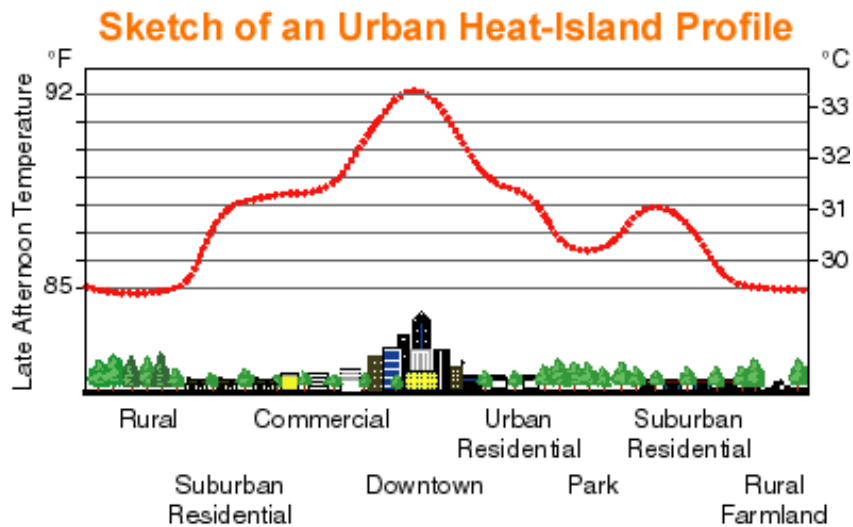
An urban heat island (UHI) is a metropolitan area which is significantly warmer than its surrounding rural areas. The temperature difference usually is larger at night than during the day and larger in winter than in summer, and is most apparent when winds are weak. The main cause of the urban heat island is modification of the land surface by urban development; waste heat generated by energy usage is a secondary contributor. Industrial activities, concrete, buildings and humans have contributed tremendously to the creation of higher temperatures in metropolitan cities than their surrounding urban areas. This increase in heat and temperature is called Urban Heat Island. The air in the urban heat can raise the average temperature by 2°F to 9°F more than the surrounding rural areas.

Many factors contribute to the manifestation of Urban Heat Island. Concrete and asphalt that is mainly used in urban areas have different bulk properties like nonevaporative and nonporous properties. Air-conditioners and refrigeration introduce a high amount of heat energy into the urban areas, mostly during the summer season which results in reduced evapotranspiration, and an increase in urban landscape temperature (Jensen, 2007). It is therefore important to incorporate Urban Heat Island effects during any urban future development.

With obvious effect on temperature, UHIs can produce secondary effects on local meteorology, including the altering of local wind patterns, the development of clouds and fog, the humidity, and the rates of precipitation.

Using satellite images, researchers discovered that city climates have a noticeable influence on plant growing seasons up to 10 kilometers (6 miles) away from a city's edges. Growing seasons in 70 cities in eastern North America were about 15 days longer in urban areas compared to rural areas outside of a city's influence.

Urban heat islands also impair water quality. Hot pavement and rooftop surfaces transfer their excess heat to stormwater, which then drains into storm sewers and raises water temperatures as it is released into streams, rivers, ponds, and lakes. Rapid temperature changes can be stressful to aquatic ecosystems.



UHIs have the potential to directly influence the health and welfare of urban residents. Within the United States alone, an average of 1000 people die each year due to extreme heat (Changnon et al., 1996). Existing health conditions, are at particular risk from these events. Excessive heat events, or abrupt and dramatic temperature increases, are particularly dangerous and can result in above-average rates of mortality. The Centers for Disease Control and Prevention estimates that from 1979–2003, excessive heat exposure contributed to more than 8,000 premature deaths in the United States. This figure exceeds the number of mortalities resulting from hurricanes, lightning, tornadoes, floods, and earthquakes combined.

Urban Heat Island (UHI) can be categorized into three distinct types as follows: Canopy Layer Heat Island (CLHI) and Boundary Layer Heat Island (BLHI) refer to the warming of the urban atmosphere while the last type, Surface Heat Island (SHI) refers to the relative warmth of urban surfaces. The urban canopy layer (UCL) is the layer of air closest to the surface in cities and extends upwards to approximately the mean building height. Above the urban canopy layer lies the urban boundary layer, which may be 1 kilometer (km) or more in thickness by daytime and shrinking to hundreds of meters or less at nighttime. It is the BLHI that forms a dome of warmer air, which extends downwind of the city. Wind often changes the dome to a plume shape (Voogt et.al, 2004).

Methodology:

Remote sensing data was used for this project. Data was retrieved from the Texas View website www.texasview.org via Landsat 7 satellite. Nine images with dates ranging from 1999-2003 was used from pass - 27 in row- 39. ENVI software was also used to check surface temperatures and analyze land coverage. In 1999, 2 Landsat images were used, 1 image from year 2000, 2 images from 2001 and 2 images from years 2002 and 2003. Images were acquired at 4:55 GMT. To check for temperature using ENVI IDL

IDL code:

```
*****  
,
```

```
PRO temper ; calculate temperature of Landsat image
```

```
; Step 1: select a thermal band image from ENVI
```

```
envi_select, title='Choose multispectral image', fid=fid, dims=dims, pos=pos
```

```
if (fid EQ -1) THEN BEGIN
```

```
    PRINT, 'cancelled'
```

```
    RETURN
```

```
ENDIF
```

```
; Step 2: Get necessary information from the image: projection, columns, rows, etc.
```

```
map_info = envi_get_map_info(fid=fid)
```

```
image=envi_get_data(fid=fid, dims=dims, pos=pos[0]) ;pos[0] is the first band,  
pos[1] the second band, ...
```

```
num_cols=dims[2]-dims[1]+1 ; get the number of columns (x)
```

```
num_rows=dims[4]-dims[3]+1 ; get the number of rows (y)
```

```
;num_bands=n_elements(pos)
```

```
;num_pixels=num_cols*num_rows
```

```
; Step 3: calculate the temperature
```

```
L=temporary(0.0370588*image+3.2); calculate radiance of high gain image
```

```
;L=temporary(0.066823*image) ;calculate radiance of low gain image
```

```
TB=temporary(1282.71/(alog((666.09/L)+1))) ;calculate brightness temperature
```

```
RT=temporary(TB/(1+(0.0007991666*TB)*alog(0.988)))
```

```
 ;supposing the same emissivity of 0.98
```

```

; Step 4: output the default C driver: c:\UserData_ENVI
fname='tmperHG.img'
;fname='temperLG.img'
openw, unit, fname, /get_lun
writeu, unit, RT
free_lun, unit

```

```

; Step 5: output to the ENVI Available Band List window
ENVI_SETUP_HEAD, fname=fname, ns=num_cols, nl=num_rows, nb=1,
interleave=0, data_type=4, offset=0, map_info=map_info,/write, /open

```

END.

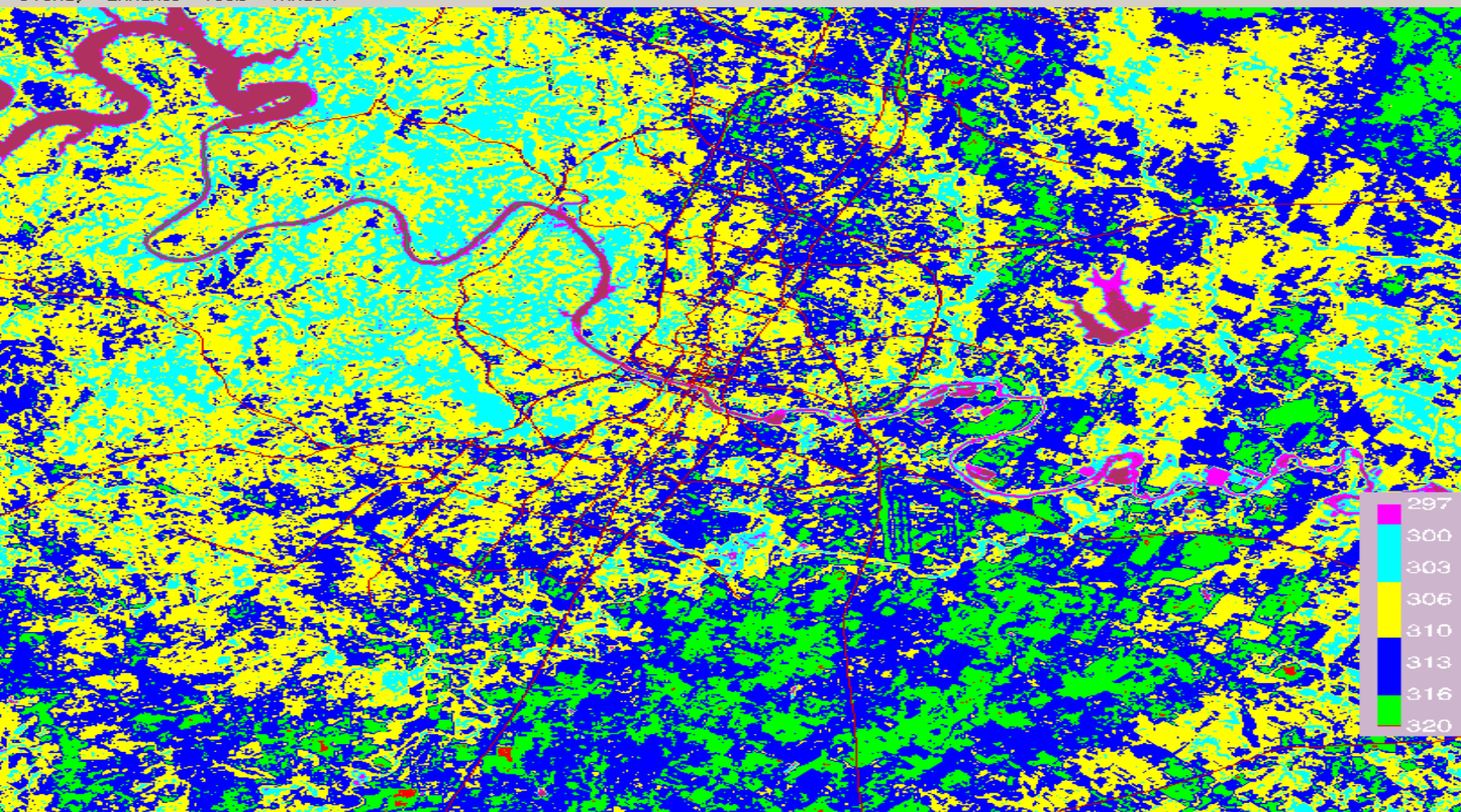
ENVI'S density slice was used to proportionate or differentiate high increase in temperature from low temperatures. Results for temperature was taken from ENVI's density slice range screen. ArcGis was used to create a vector of the downtown area.

Results:

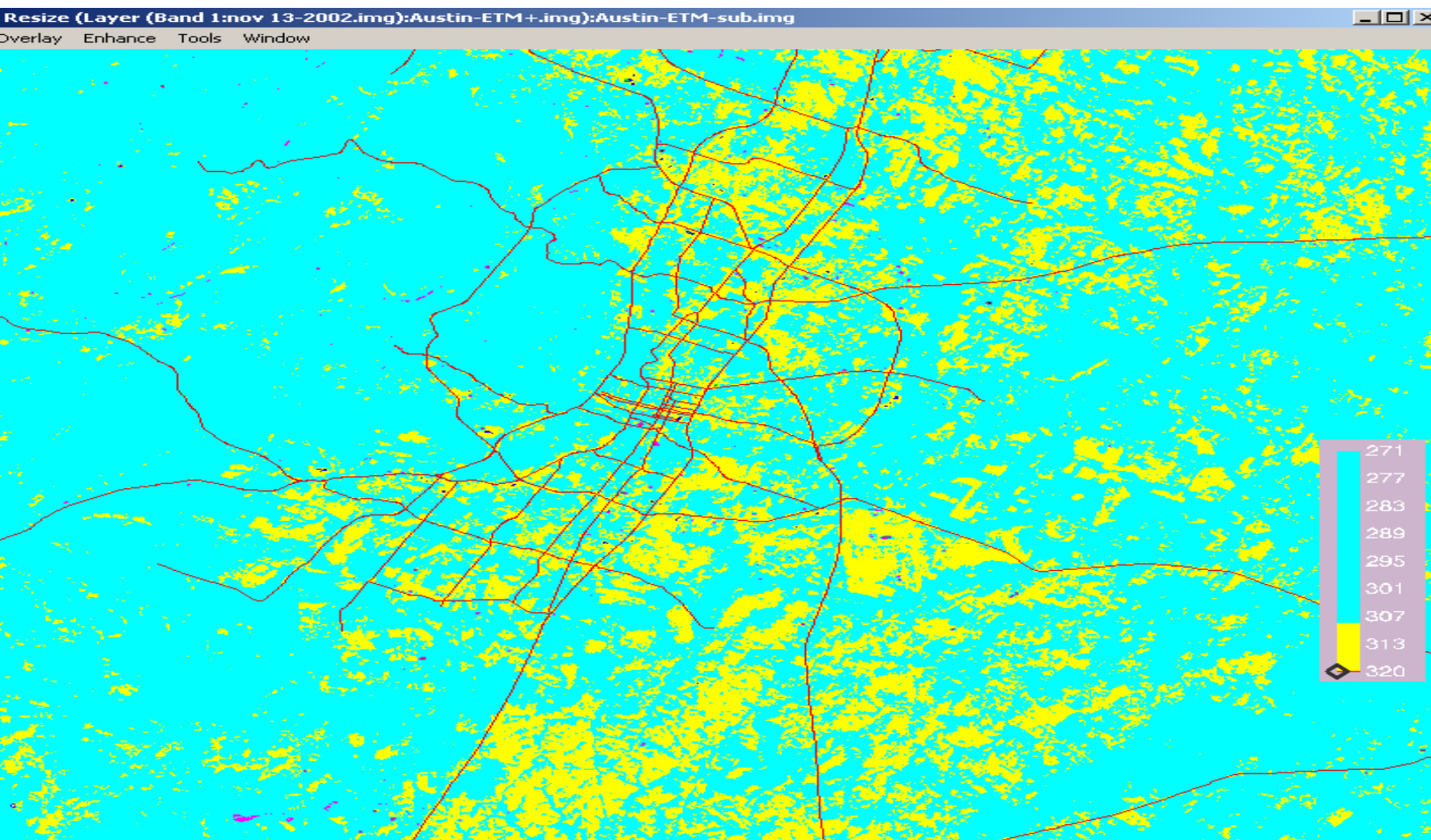
After viewing the 9 Landsat images, I observed that the images retrieved had no images from nighttime. All the images were aqisited in the afternoon. This research would have been more conclusive if night imagery was retrieved and viewed. Below is a table of maximum and minimum temperatures observed during the course of this research.

DAYS	MINIMUM TEMPERATURES	MAXIMUM TEMPERATURES
09/18/1999	289K	319K
10/20/1999	272K	316K
09/04/2000	293K	323K
03/15/2001	265K	309K
07/21/2001	289K	319K
07/08/2002	269K	312K
11/13/2002	261K	323K
01/16/2003	253K	294K
03/21/2003	271K	314K

Below are two Landsat imagery with the highest temperatures.

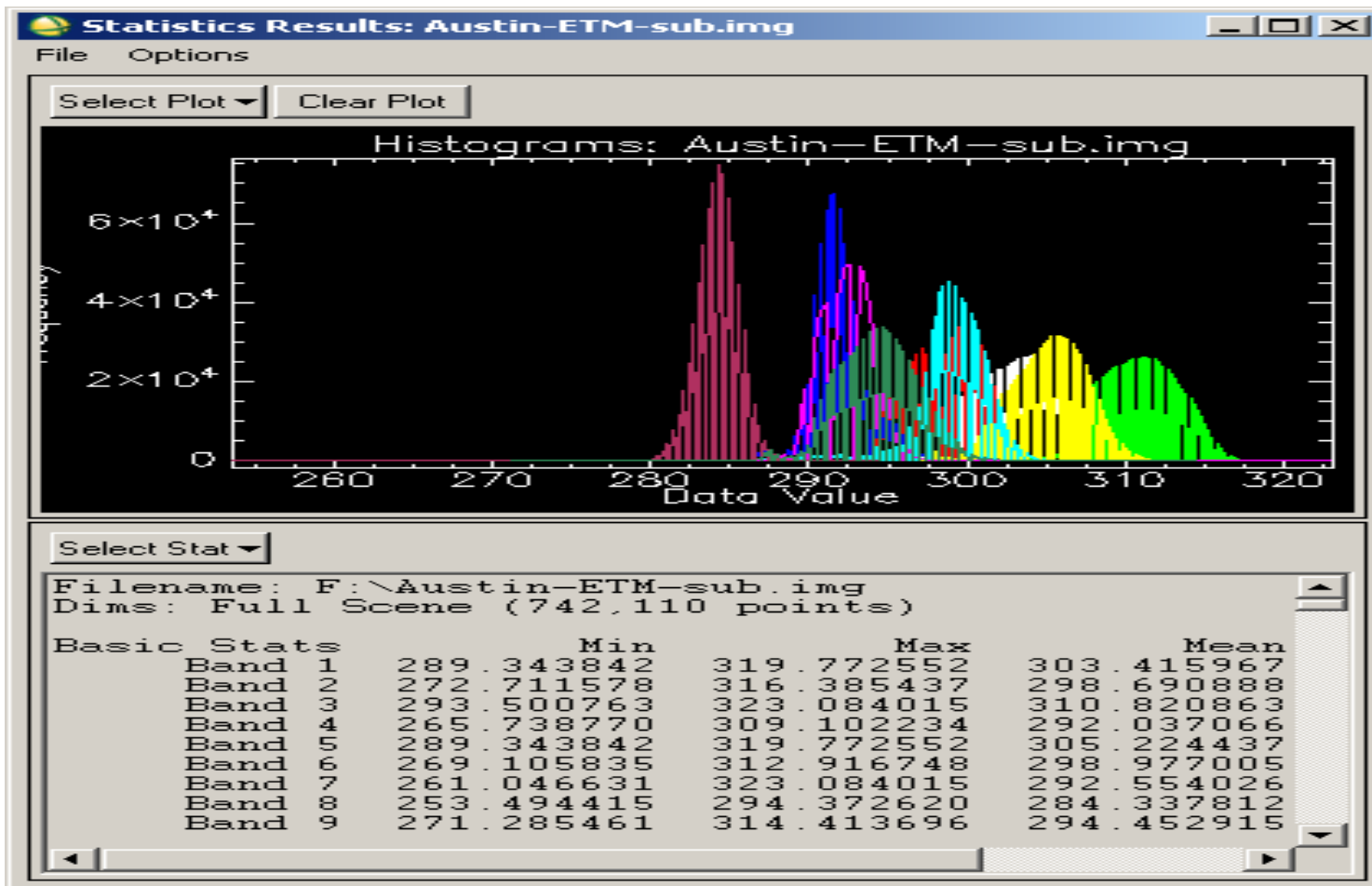


Imagery from September 4,2000 with minimum temperature of 261K and maximum temperature of 323K.Higher temperatures were more observed in surrounding areas.



Imagery from November 13,2002 with minimum temperature of 293K and maximum temperature of 323K.Higher temperatures were more observed in surrounding areas.

Below is a statistics result of the above table.



Conclusion:

In this paper, I examined nine Landsat images and no night images were observed. This does not show there is no urban heat Island in Austin since no night imagery was retrieved and accessed. More data needs to be available and future research should be conducted to see when and know when exactly urban heat island manifests.

Acknowledgement:

I would like to thank Dr. Honjie Xie for his leadership and direction in working on this project and the University of Texas at San Antonio for use of facility and equipment.

References:

Changnon, S.A Jr, K.E Kunkel and B.C Reinke (1996). "Impacts and responses to the 1995 heat wave: A call to action". Bulletin of the American Meteorological Society 77:1497-1506.

Jensen, J.R (2007). Remote Sensing of the Environment.286-288

Voogt, J.A and T.R Oke (2003). Thermal remote sensing of urban areas. Remote sensing of Environment 86:370-384.

Voogt, J.A (2004.) Urban Heat Islands: Hotter cities
www.actionbioscience.org/environment/voogt/html.

