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Thermal Sensing Change Detection for Baghdad City, the Period (2000-2017)

Yasser F. Sabri* & Alaa S. Mahdi

* Department of Physics, College of Science, University of Baghdad, 2020

E-mail: yaser.ge.hum@uodiyala.edu.iq

Abstract

The thermal sensing change detection is consider as important application in remote sensing task especially in the areas that have thermal pollution such as Baghdad city. The thermal pollution in this city make many different problems which is caused from different human activates such as, electricity generator, and other types of thermal emission sources. In the real word, all Iraqi country severed from the high temperature increase, such as above 50C**°.** Also, the rapid urban expansion over the last four decades due to accelerated economic growth, affected the temperature distribution in this city.

In this research the Landsat series imagery thermal bands were used to monitor and detect the change in this Baghdad city, from 2000 to 2017 as temporally period. For this purpose three set of imagery were collected from the USGS downloader site, the first image in 2000, sensor Landsat 5 TM, second in 2010 is Landsat7 ETM+, and the third in 2017 Landsat 8 OLI. Many digital change detection methods are used in this project to extract the thermal change in the city, such as image differencing, image rationing, and the principal components analysis change detector. Also, traditional classification methods can be use to quantify the temperatures change values. The results were evaluated using well-known remote sensing packages and written programs.

Keywords: Thermal Sensing; Change Detection; Landsat 8 OLI; PCA; Baghdad

1. Introduction

The use of Thermal Infrared (TIR) satellite sensors is a important technique for monitoring the surface temperatures at different spatial resolutions: such as; (e.g., Meteosat Second Generation, MSG, or the Geostationary Environmental Satellite,

GOES), moderate (e.g., MODIS, AVHRR, Sentinel 3) and high (e.g., Advanced Spaceborne Thermal Emission and Reflection Radiometer, ASTER, and Landsat 8 OLI), [R1]. The development of remote sensing techniques aimed to estimation and monitor the surface temperatures of any energy sources in the ground and atmosphere, as well as the digital thermal change detection for targets and phenomenon, [1].

The Operational Land Imager (OLI), generate by the Ball Aerospace & Technologies Corporation, operate in the visible, near infrared, and short wave infrared portions of the spectrum. The images have 15-m spatial resolution for the panchromatic mode and 30-m for multi-spectral mode. The images swath width is 185 km, covering wide areas of the Earth's landscape while giving multi resolution to detect and distinguish many targets and features such as; urban centers, farms, forests and other land uses. The temporal resolution of satellite is 16 days due to Landsat 8's circular near-polar orbit, [2, and 3].

The OLI's design is a new generation in Landsat sensor technology and uses an approach demonstrated by the Advanced Land Imager sensor flown on NASA's experimental EO-1 satellite. The Instruments on earlier Landsat satellites employed scan mirrors to sweep the instrument fields of view across the surface swath width and transmit light to a few detectors. The OLI instead uses long detector arrays, with over 7,000 detectors per spectral band, aligned across its focal plane to view across the swath. This "push-broom" design results in a more sensitive instrument providing improved land surface information with fewer moving parts. With an improved signal-to-noise ratio compared to past Landsat instruments, OLI is more reliable and provides improved performance, [2, and 3].

2. Region of Interest and Available Data

The Baghdad city is the capital of Iraq, occurs nearly in the central country, the Tigris River divide the region into two parts (West and East). The Diyala River is nearly abounded the city from the South East. Within the city there are manned canals and

pounds. Baghdad is suited in a plain area of an elevation between 31-39 m above sea level. So, no natural boundaries exists that limits the aerial extension of the city, [4].

The study area is a part of Baghdad city, Upper left point Lat. 33^{o} 30′ 58.21″ E, Long. 44^{o} 13′ 32.85″ N to lower down point Lat. 33^{o} 10′ 48.23″ E, Long. 44^{o} 37′ 50.46″ N, within area of approximately 1406.25 square Km. The study area will be represented by any figures below. The data sets can represent as following;

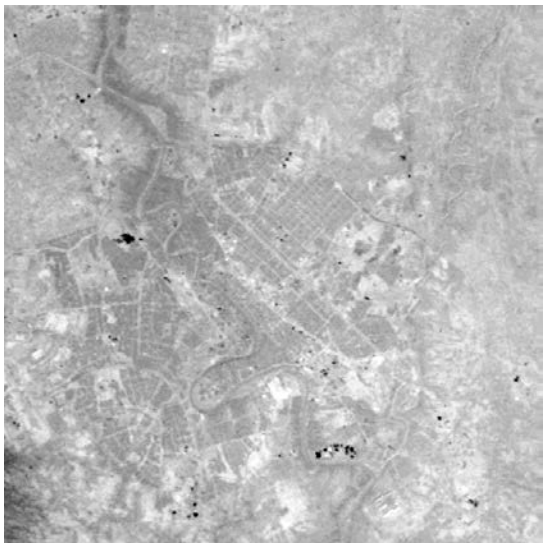

Figure 1, The Landsat 5 TM Thermal Band, Exposure date 29-12-2000

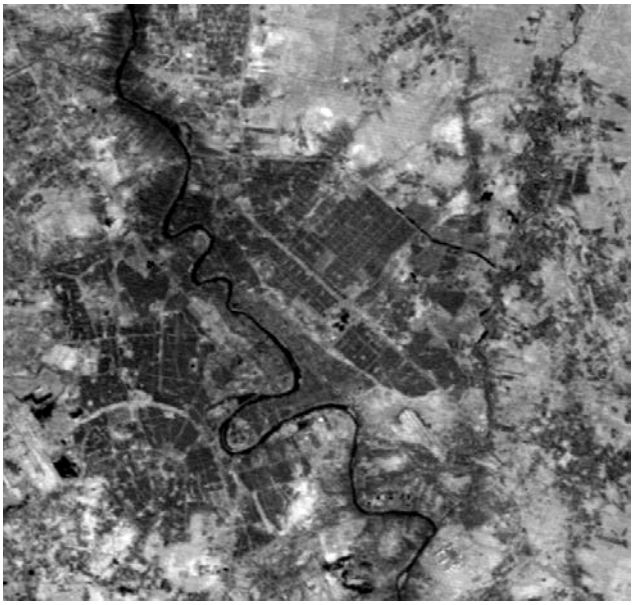

Figure 2, The Landsat 7 ETM+ Thermal Band, Exposure date 9-12-2010

Figure 3, The Landsat 8 OLI Thermal Band, Exposure date 12-12-2017

For the Landsat 8 OLI, the two thermal bands are b10 TIR1 (10.6-11.19) µm, and b11 TIR2 (11.5-12.51) µm, [5]. In order to merge the two spectral regions i.e. (10.6-12.51) a new image will be performs for above wavelength see figure 3. These bands are fusion to 30 m in spatial resolution by USGS.

3. Digital Change Detection Results

Since the satellite orbits has repeatable capability, i.e. scanning the same area after fixed period called temporal resolution, therefore, the digital change detection project can be perform, [6]. The temporal resolution of the used data set is 16 day, the satellite cover all global in this period. The condition for any digital change detection an summarize as; same images in different date, perfectly same geographical areas, same images in spatial and spectral resolutions, it can may be multi sensors types. The important factor is that the matching images is less than of the half of images spatial resolution, [7]. The three data set were matching into less than half pixel using the projection coordinates system, associated with the image files. The following figure show the results of digital change detection each as its caption.

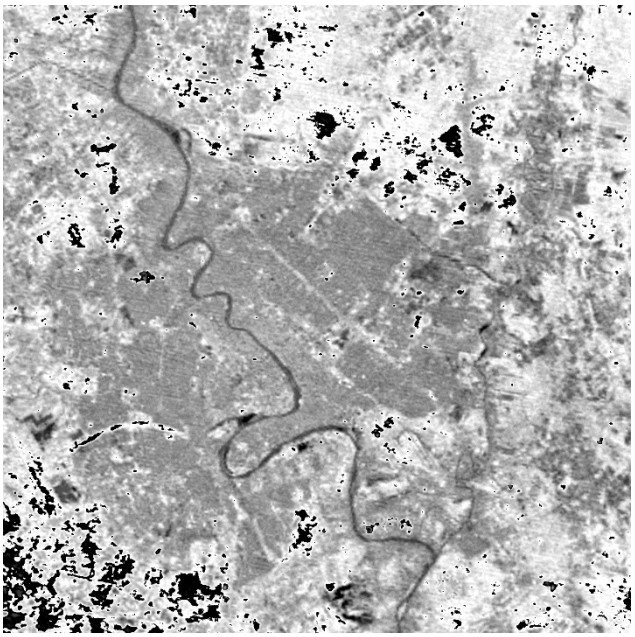

Figure 4, The Differencing Result Year 2010 -2000

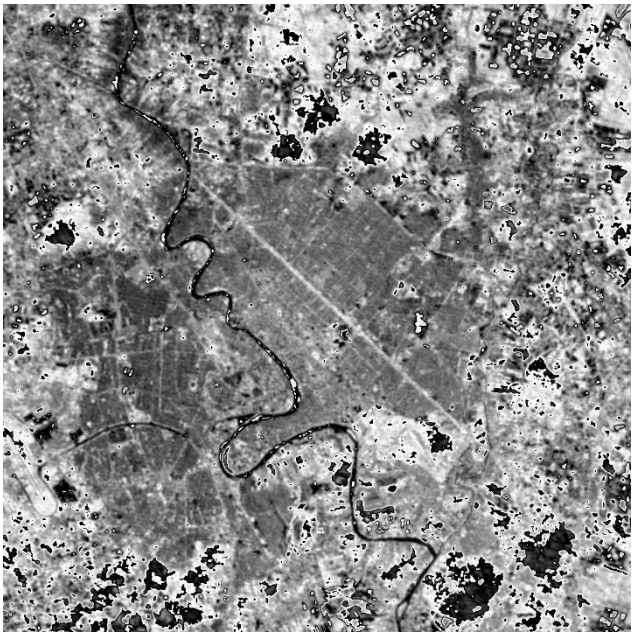

Figure 5, The Differencing Result Year 2017 -2010

Figure 6, The Differencing Result Year 2017 -2000

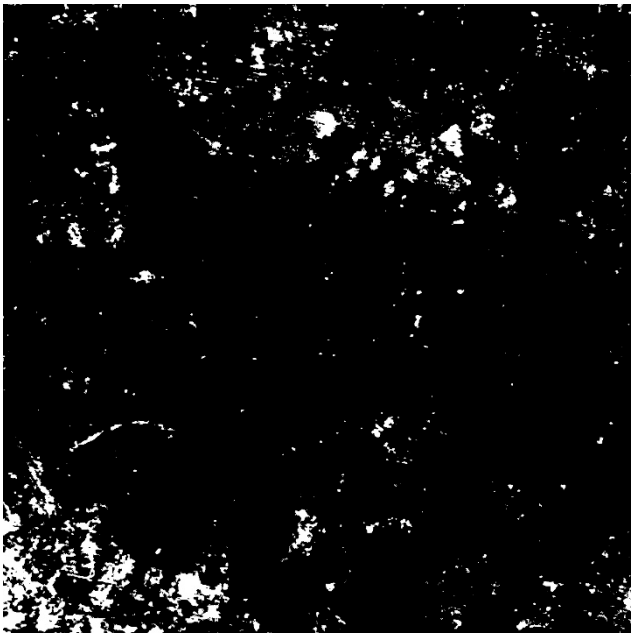

Figure 7, The Rationing Result Year 2010 over 2000

Figure 8, The Rationing Result Year 2017 over 2010

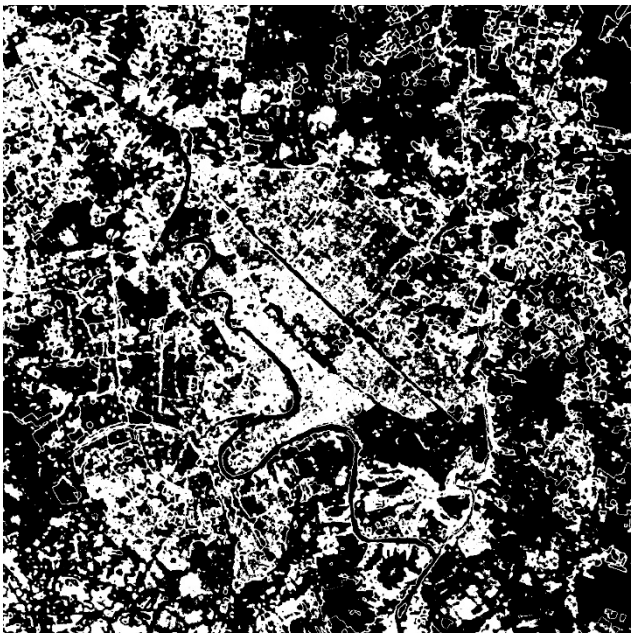

Figure 9, The Rationing Result Year 2017 over 2000

The Principal Components Analysis (PCA) change detector can be apply for the images sets such as; merge the three temporary images in one file, apply (PCA) kernel, the 1st PC is no change, the 2nd PC represent the change, and the other PCs are noise, [8]. as in following figures;

Figure 10, The PC1 Image,. No Change

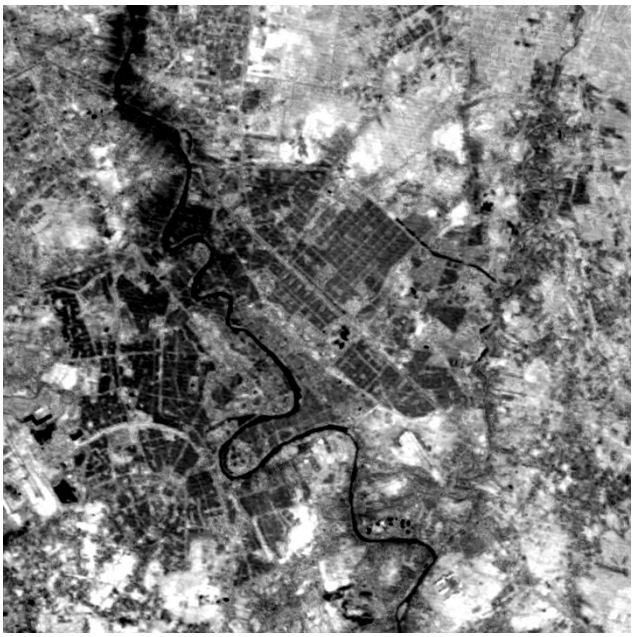

Figure 11, The PC2,. The Change Image

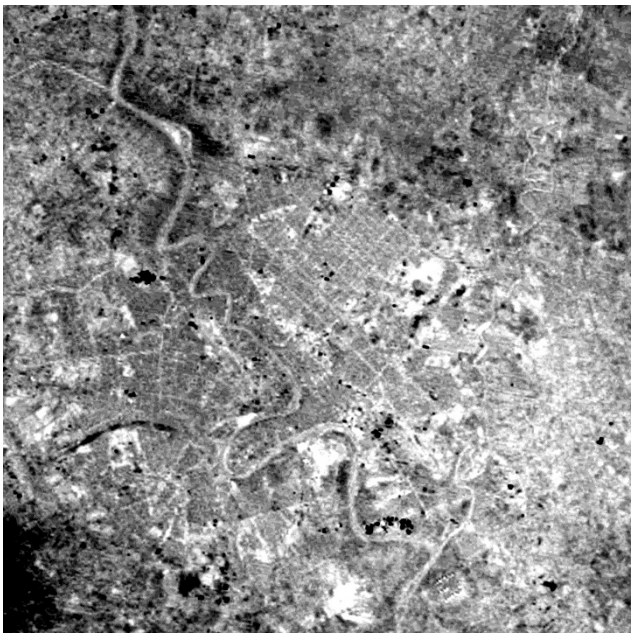

Figure 12, The PC3,. The Noise Image

The PCA Eigen values can be represent by figure 13 as following;

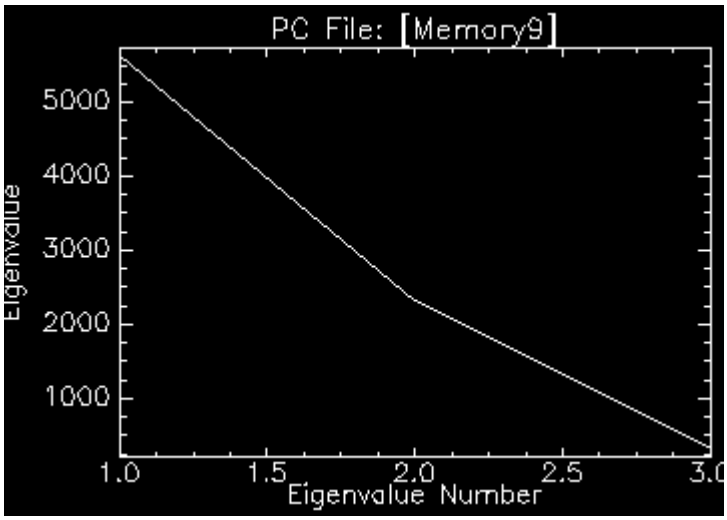

Figure 13, The PCA Transform Eigen Values

4. Discussion & Conclusion

1. The temporal resolution of the used data set is 16 day, the satellite cover all global in this period.
2. The condition for digital change detection is that the matching images is less than of the half of images spatial resolution.
3. The three data set were matching into less than half pixel using the projection coordinates system, associated with the image files.
4. ENVI software was used for image processing and performing the (Differencing, Rationing, and PCA Transform).
5. The change detection for The Differencing and Rationing Result images in figures (9 and 6) more than figures (8, 7, 5, and 4).
6. The results showed that there is a significant change in temperatures for the year 2017 from 2010 and 2000.

5. References

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