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To cite this article: Riyad H AL-Anbari *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **518** 022033

IOP Conf. Series: Materials Science and Engineering **518** (2019) 022033 doi:10.1088/1757-899X/518/2/022033

Estimation High Resolution Air Temperature Based on landsat8 images and Climate Datasets

Riyad H AL-Anbari[1], Oday Z Jasim[2] and Zainab T Mohammed[2]
[1]Dijlah University Collage, Baghdad, Iraq
[1]Department of Civil Engineering, University of Technology, Baghdad, Iraq

Abstract. Near surface air temperature (Ta) is one of the critical variables in environmental health, hydrology, climatology and epidemiology. In this study, we suggested a model to estimate high resolution air temperature for different region based on climate datasets estimation by Iraqi Agrometeorological network daily air temperature and the land surface temperature derived from thermal bands of landsat8 images. The new air temperature estimation was tested over part of Babylon governorate as a case study. Observations from four weather stations at Babylon governorate for four months from June to September for the year 2017 were used for modelling and accuracy assessment air temperature estimation.

1. Introduction

The air temperature (Ta) effect is a widely studied phenomenon. There are several facts effected either by air temperature such as infrastructural, urban areas grow, roads, buildings, vegetation or open land. Several studies have indicated that urban expansion has caused localized increases in the air temperature (Ta). The traditional method for air temperature study relies on meteorology data derived from rural and urban weather stations. It is very difficult and need to monitor air temperatures because it required a dense network of air temperature so can use land surface temperature that derived from the thermal infrared satellite images to estimate air temperature.

There are many satellite images using to derive land surface temperature such as MODIS satellite image, Sentinel3 satellite images and Landsat satellite images. In this study, it is decided to use Landsat8 satellite images to estimate air temperature because of has two high resolution thermal bands and availability download from US Geological Survey (USGS) website.

2. Study Area

Babylon governorate is located in the middle of Iraq approximately 100 km to the south of Baghdad. Study area is a region located in Babylon Governorate that containing four weather stations with in area around 1880 km² as a study area as shown in figure 1, Its geographical coordinates are 44°35'16.691''longitude and 32°34'3.143''N latitude and an average elevation about 20.356335 meters.

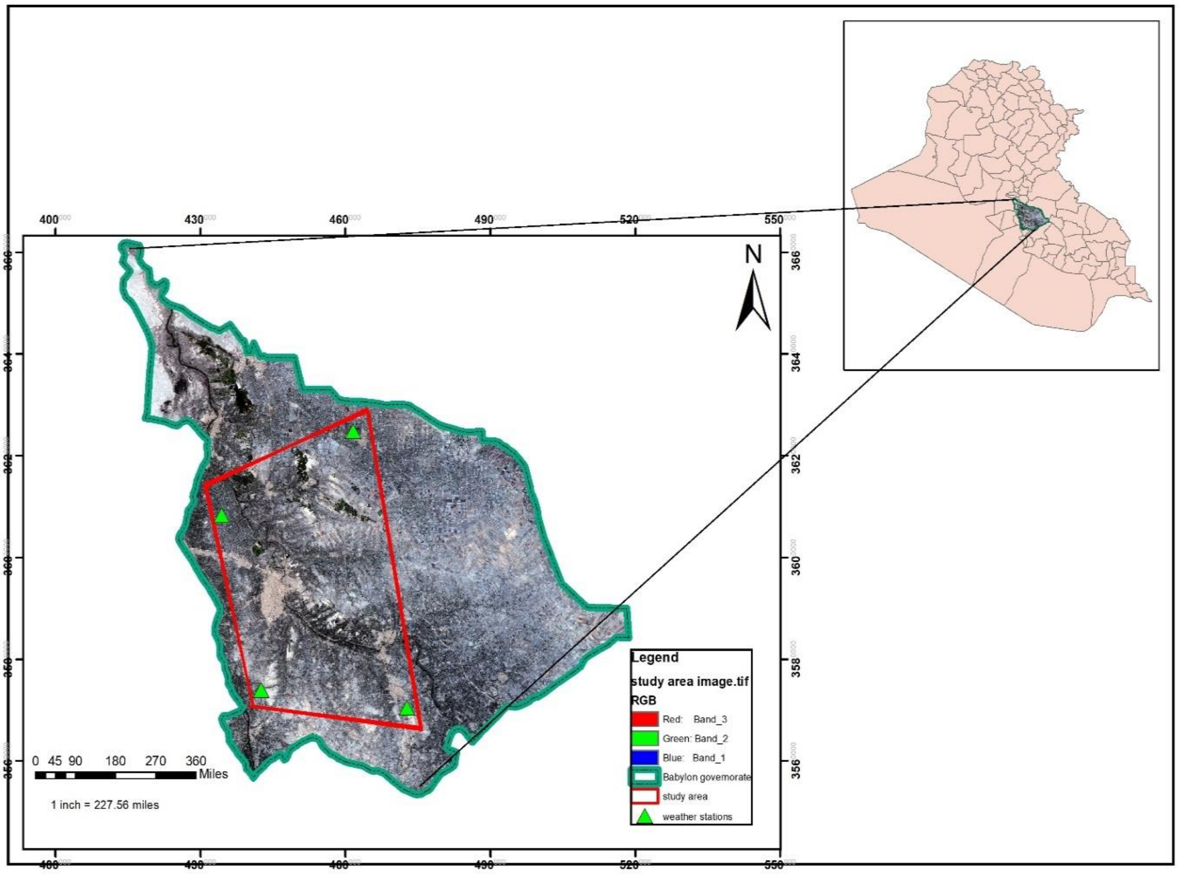

Figure 1. Study Area

3. Research Methodology

In this search air temperature was estimated using land surface temperature produced by thermal bands of Landsat images, Digital Elevation Model (DEM) and Duration Day Length (DDL) represent as a model parameters. The variation of air temperature represented by (DDL), the effected of elevation on air temperature represented by (DEM), while the reflected of spatial distribution of air temperature represented by land surface temperature as shown in figure 2.

$$Ta = a*LST + b*DEM + c*DDL + d \quad (1)$$

Where LST is (Land Surface Temperature), DEM is (Digital Elevation Model), DDL is (Duration Day Length).

To build numerical model a linear regression model was used for training maximum daily air temperature (Ta) and up-scaled model parameters:

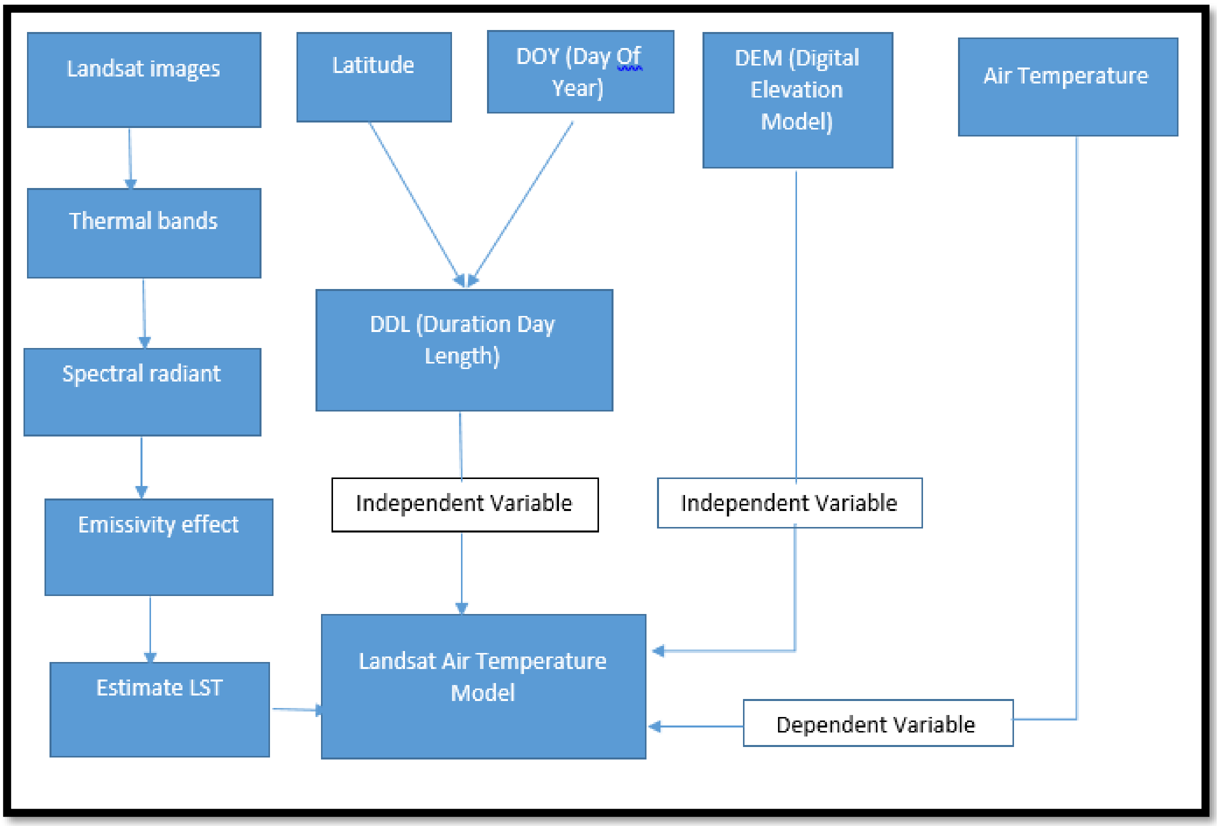

Figure 2. Research Methodology

3.1. Estimate Landsat LST (Land Surface Temperature)

To estimate land surface temperature for landsat8 images using steps as shown in figure 3. In this research land surface temperature has been estimated for four weather stations on Landsat images for every 16 days from date 1-june to 30-September 2017 at 7:30 AM as shown in table (1) and using ARCGIS modelbuilder as shown in figure 4.

Table 1. Study area covered by two following LandSat satellite images

Satellite	Sesnsor ID	Pixel Size (m)	Date
Landsat8	OLI and TIRS	100	3-Jun-17 19-Jun-17 5-Jul-17 21-Jul-17 6-Aug-17 22-Aug-17 7-Sep-17 23-Sep-17

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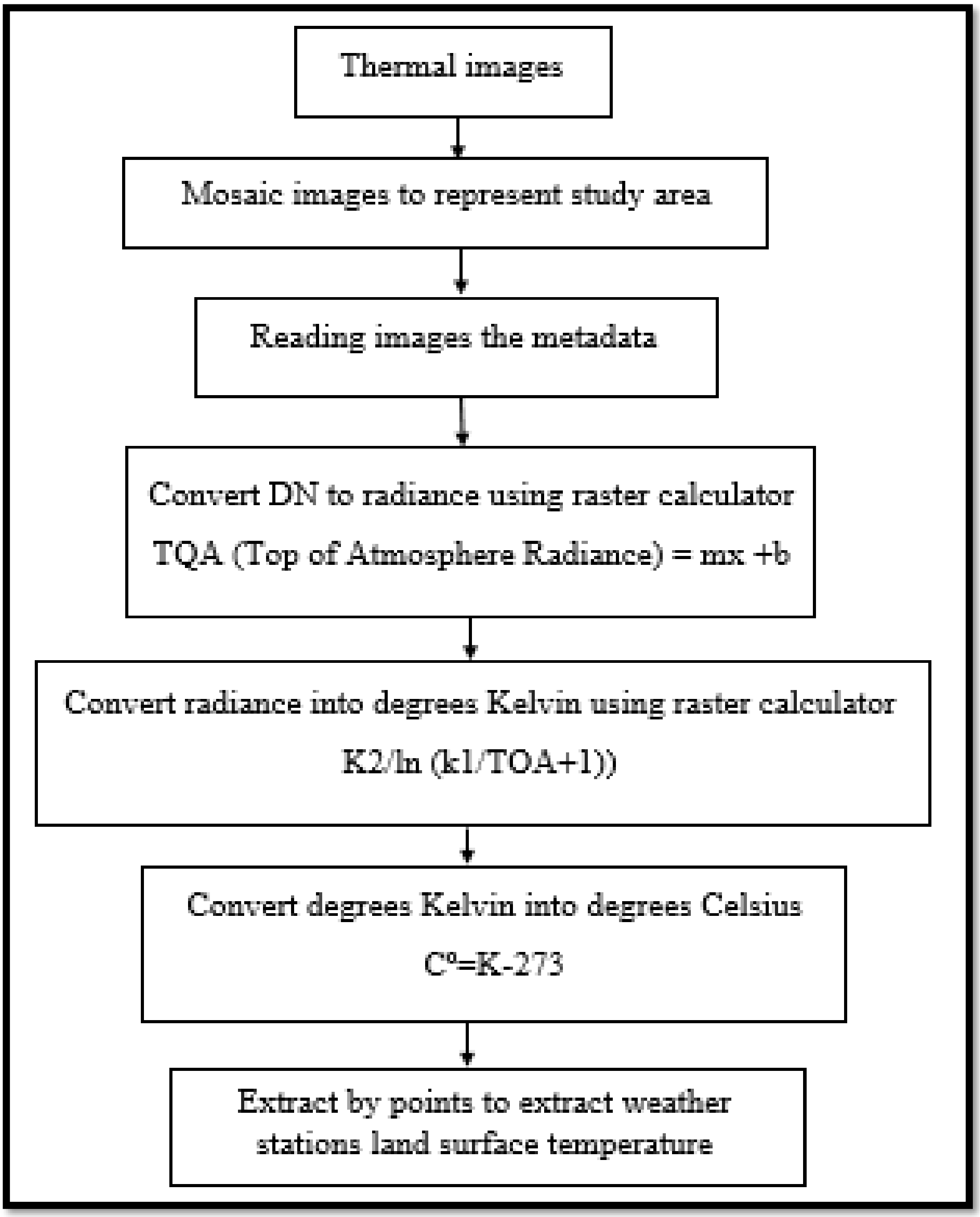

Figure 3. Steps for Estimation Land Surface Temperature

Where m is the Radiance Multiplier, x is the raw band, b is the Radiance Add The landsat satellite images metadata that using to estimate land surface temperature shown in table

Table 2. Metadata of landsat satellite image thermal bands

Band	M_i	k1 (W m^{2} sr^{1} m^{1})	k2 (K)
Band10	0.0003	774.8853	1321.1
Band11	0.1	480.8883	1201.1

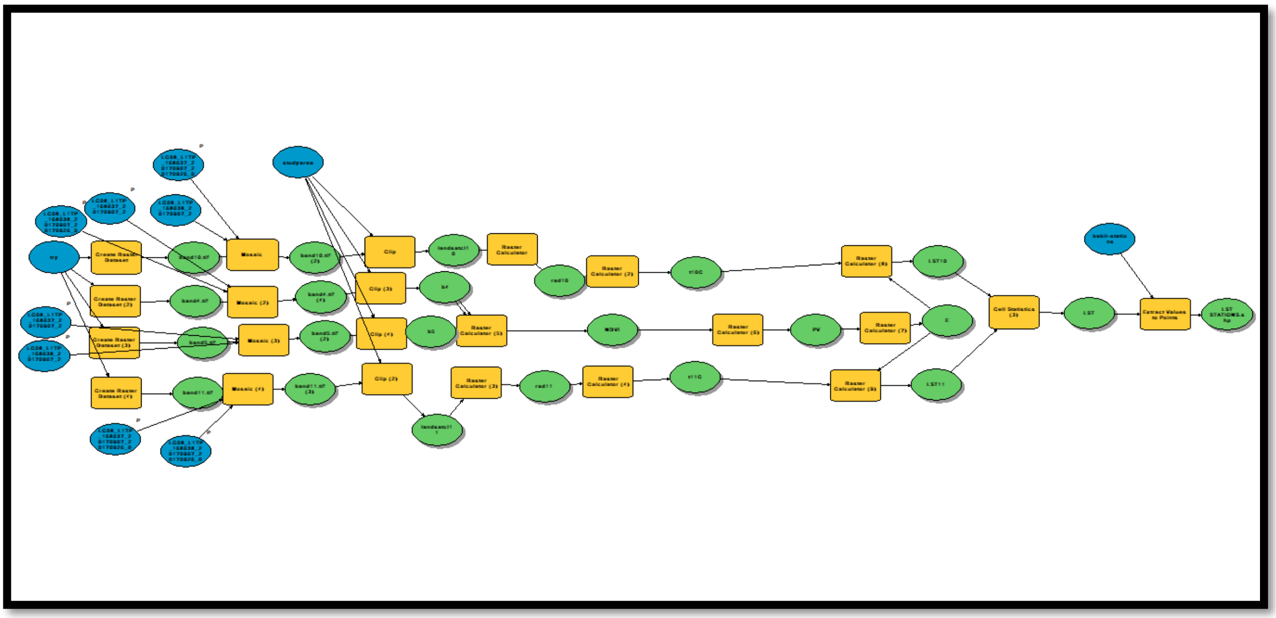

Figure 4. Model to Estimation Land Surface Temperature Landsat 8 Images

The sample of run modelbuilder of landsat images land surface temperature as shown in figure 5.

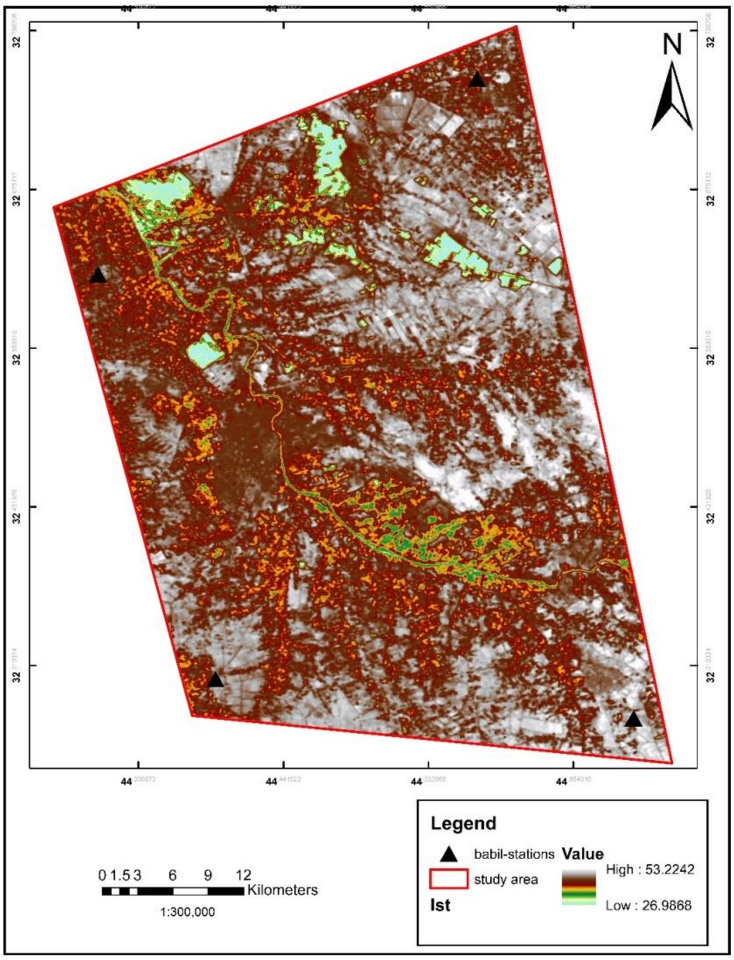

Figure 5. Land surface temperature for landsat8 image at date 21-7-2017

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3.2. Extract DEM from ASTER satellite image
Extract DEM for weather stations using two steps

a- Build raster attribute table: using to create a table with information about the digital elevation model
b- Extract value to point using to extract value weather stations' DEM as showin in figure 6.

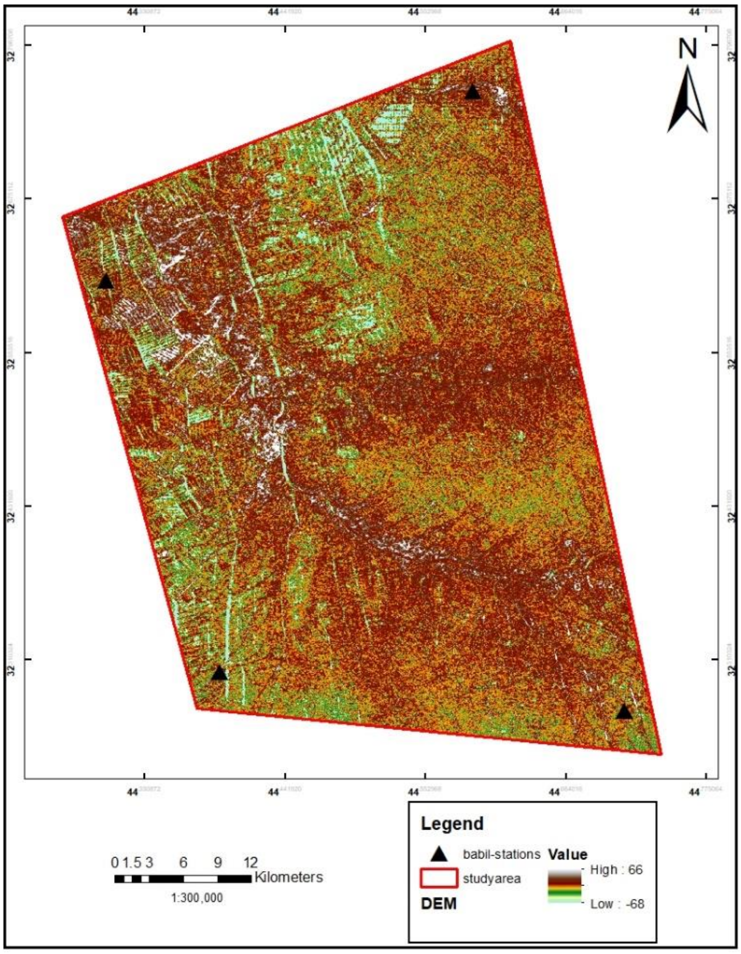

Figure 6. DEM of study area

3.3. Estimation of Duration Day Length (DDL)
The duration day length is calculated from declination angle (δ) and local latitude (Φ)

$$DDL=\frac{24}{\pi} \arccos \left(\tan \frac{\Phi}{180}\pi\right) \tan \left(\frac{23.45\pi}{180} \sin (\delta)\right),$$

Where (δ) is declination angle represent the angle between a line extending from the center of the earth to the center of the sun and the projection of this line upon the earth's equatorial plane and (Φ) is local latitude. Declination angle can calculate by following equation

$$\delta = \frac{2\pi(284+DOY)}{365}$$, where DOY is (Day of Year)

4. Model coefficients
To estimate model coefficients (a, b, c and d) for model parameters (LST, ddl, DEM) that minimize squared error on training data using linear regression model in weka program, for as sown in table (3).

$X=W_o+W1\ a1+ W2\ a2+ W3a3+\ldots+W\square a\square$

Table 3. Model Parameters

Date	Station name	LST	DEM	DOY	phi	ddl	ta
3/6/2017	Mosayab	34.34	25	154	32.76	14.04	38.55
	Kafal	40.82	25	154	32.30	14.01	38.01
	Mahanawya	34.15	27	154	32.61	14.03	36.99
	Kasim	39.45	23	154	32.27	14.00	37.68
19/6/2017	Mosayab	38.69	25	170	32.76	14.16	42.67
	Kafal	44.85	25	170	32.30	14.12	43.89
	Mahanawya	38.67	27	170	32.61	14.15	43.01
	Kasim	43.61	23	170	32.27	14.12	43.36
5/7/2017	Mosayab	31.64	25	186	32.76	14.10	48.49
	Kafal	22.93	25	186	32.30	14.06	48.43
	Mahanawya	-11.88	27	186	32.61	14.09	47.32
	Kasim	31.31	23	186	32.27	14.06	47.87
21/7/2017	Mosayab	39.61	25	202	32.76	13.86	47.51
	Kafal	43.37	25	202	32.30	13.83	47.92
	Mahanawya	39.99	27	202	32.61	13.85	46.98
	Kasim	44.58	23	202	32.27	13.82	46.98
6/8/2017	Mosayab	40.66	25	218	32.76	13.48	48.69
	Kafal	45.86	25	218	32.30	13.46	49.17
	Mahanawya	40.74	27	218	32.61	13.47	47.21
	Kasim	45.81	23	218	32.27	13.45	48.12
22/8/2017	Mosayab	36.23	25	234	32.76	13.01	45.94
	Kafal	39.97	25	234	32.30	12.99	45.73
	Mahanawya	36.07	27	234	32.61	13.00	43.83
	Kasim	40.29	23	234	32.27	12.99	45.59
7/9/2017	Mosayab	33.21	25	250	32.76	12.48	42.98
	Kafal	28.03	25	250	32.30	12.47	43.81
	Mahanawya	31.64	27	250	32.61	12.48	40.81
	Kasim	22.04	23	250	32.27	12.47	43.93
23/9/2017	Mosayab	33.08	25	266	32.76	11.93	39.64
	Kafal	36.69	25	266	32.30	11.93	40.32
	Mahanawya	32.59	27	266	32.61	11.93	38.07
	Kasim	36.60	23	266	32.27	11.93	39.41

The weights of linear regression model are:

a=35.533, b=0.163, c=-0.327, d=0.773

5. Accuracy Assessment

Root mean square error (RMSE) is used to assess the deviation between the estimators (x) and observed values (y).

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(x_i - y_i)^2}{n}}$$

In this search RMSE=3.7375

6. Air Temperature Estimation

To estimate air temperature using ARCGIS raster calculator as shown in Figure (7) through following equation

ta = 35.533+0.163*lst+ -0.327* DEM + 0.773* ddl

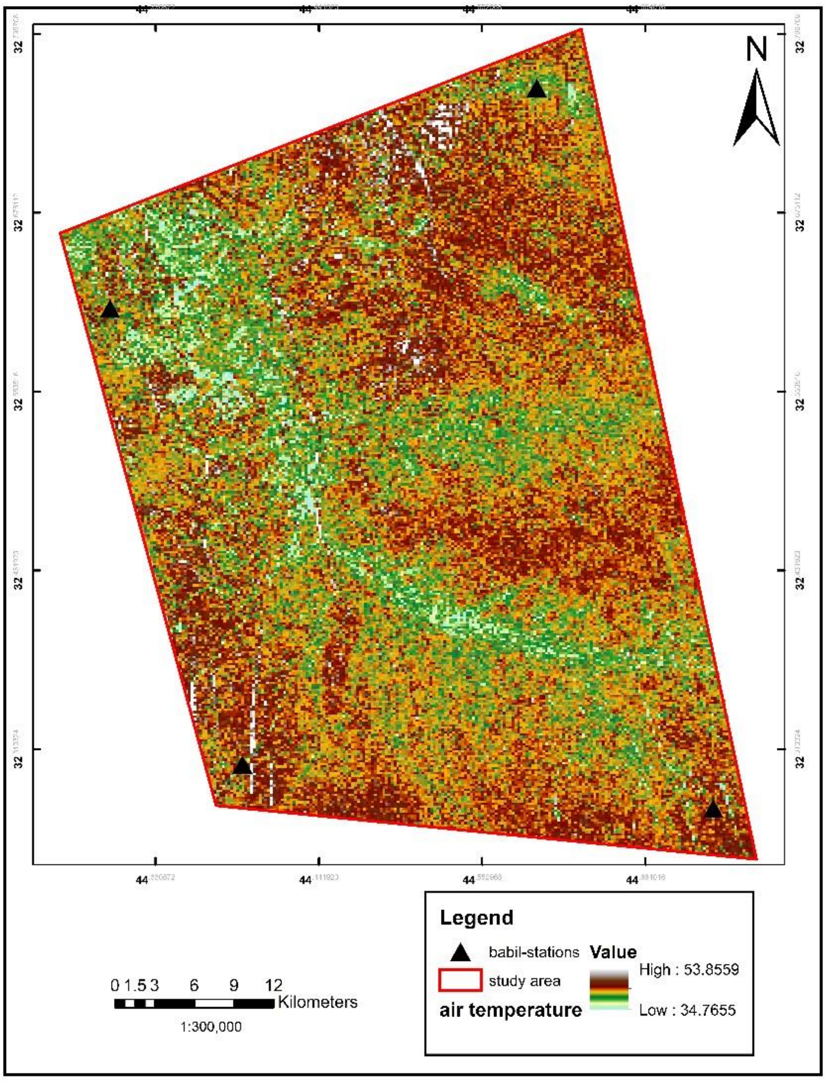

Figure 7. Air Temperature at date 21/7/2017

7. Conclusion

This study discussed a method to estimate high resolution maximum air temperature depended on air temperature datasets, landsat8 land surface temperature, Digital Elevation Model (DEM) and the Day of Year (DOY). The method trained for four months period, landsat8 images captured every 16 days over 1800 km² in Babylon. Validation shows overall RMSE equal 3.7375. In previous study using daily modis products to estimate air temperature shows RMSE equal 1.9766. So the Modis land surface temperature better than landsat8 images to estimate high resolution air temperature because it products four images captures every day.

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