# A Numerical computation of airflow over Iraq

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## Abstract

The best way to understand the general atmosphere system is to collect and analyze data, identify the variables that occur in the upper and lower classes, and compare them with other values in favor of comparing them to other studies and research. Studies have been conducted in this research by analyzing the wind speed and direction and comparing it with the surface roughness to reach a concept by dividing the regions of Iraq on the basis of the surface roughness that affects the wind speed near the surface. The research aims to know the effect of air flow on the nature of the earth's surface and its effect on the different regions in Iraq.

The methods used in the study depend on the hourly rates of surface roughness, wind speed and direction taken from the European-Mediterranean Weather Forecast (ECMWF) for a full year 2016 from 34 stations over Iraq. Results obtained from wind speed analysis and trend data. The highest value of wind speed (6.5 m / s) in the less rough areas (0-50 m) is concentrated in the semi-desert in the southern and western regions of the country (Anbar, Najaf and Smawa) and the lowest wind speed (1.8 m / s) for the rough areas (11- 72 m) in the mountainous regions in the northern part of the state. The importance of the results enables us to know the movement of air in this layer in terms of its weakness or strength according to the nature of the surface of the earth, as it has formed (barren lands, bodies of water, mountainous areas), which can be used in future studies to monitor the movement and speed of winds and to determine the natural properties of the air layer in contact with the surface of the earth. This requires knowledge of the impact of temperature, wind speed and direction in dividing the layers of Iraq on the basis of surface roughness.

**Keywords:** climate change, wind speed, wind direction, surface roughness, airflow.

## 1. Introduction

Surface roughness is an important factor in wind movement near the surface of the earth and in determining many physical factors such as dispersion of pollutants, values of evaporation rate, volatile energy rates, and various engineering fields in designing residential complexes and building airports, as well as selecting the best sites for installing wind power plants [1]. The roughness of the surface reduces the speed of the wind and that is why the winds in the lower atmosphere are completely stagnant. The direction of the surface winds is the result of three forces: Coriolis force and pressure that control the movement of the wind, while the third force is the frictional force that increases the speed Wind [2] Many of the previous studies dealt with the analysis of the change in the near-surface wind speed, where the researcher Zhang, R., Zhang, S., Luo, J reanalyzed and monitored the station data. Differences in the near-surface wind speed were analyzed in China [3] As for the researcher Naglaa Muhammad analyzed the differences in the wind speed near the surface by studying the aerodynamic surface roughness of the area surrounding Al-Mustansiriya University for a circle of diameter (1 km), where the length of the surface roughness is one of the main variables in micro-metering studies and studies [4] Other researchers have studied the relationship of surface roughness to air temperature and perceived heat flow [5] Researcher LI Zhikun analyzed the characteristics of changing the wind speed and direction in the earth, as the results of his study showed that the expansion of the city causes an increase in roughness, pulls the northern winds, reduces the wind speed in Leeds and changes the wind field in Beijing. [6] Several studies analyzing observations of surface wind speed have found a decrease in wind speed over the past 30 to 50 years. Sometimes suggested cause is increased surface roughness, although the evidence to date that this is the primary factor remains inconclusive. In this study, changes in surface roughness were verified for 20 stations in the Netherlands and 137 stations in 7 other European countries, and this is what the researcher Wever found [7]. An analysis of the observed ground wind velocity trends in IP is to assess whether the atmosphere is still observed above this mid-latitude area. The main objectives are those studied by the researcher LOPEZ-BUSTINS [8]. The researcher used a new method to improve wind speed predictions. The outputs show that the GPR model improves prediction accuracy over the original NWP data, and taking into account atmospheric stability reduces prediction errors [9]. Therefore, GIS provides a flexible environment for entering digital data from various sources and it is a powerful tool [10]. By providing data from this center, it has become possible to conduct many research studies, identify many weather phenomena, analyze patterns and shapes of weather, and identify the variables that occur in the climate system. Since these centers provide data for many aerial variables, this study was a major step in analyzing wind speed and direction and compared to surface roughness for a whole year over the region of Iraq. The roughness of the surface plays an important role in the wind movement near the ground surface. All data are provided by the European Center that contains reliable data and the importance of this research is due to dividing the regions of Iraq into layers according to the nature of the geographical area.

## 2. Description of study area

Iraq was chosen for this study, it is located within the geographical coordinates between latitudes (29.5-37.5 N) north of the equator, and between longitudes (39.45 - 48.45 E) of the northern hemisphere. Iraq has a subtropical climate, Continental, dry, with a hot and dry summer and cold winter with some precipitation in the center and south country and more rain in northern Iraq.[11] In this study, data on wind speed and direction as well as surface roughness were provided by the ECMWF for eight full hours (2016),more than 34 station data were collected for different areas of the country as in figure (1), the stations are shown in table (1).

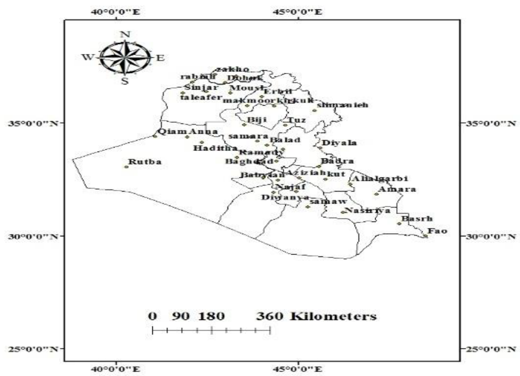



**Figure 1.** Meteorological stations in Iraq map.

**Table 1.** Meteorological stations [12]

| Station | Longitude (Degree) | Latitude (Degree) | Station | Longitude (Degree) | Latitude (Degree) |
|---|---|---|---|---|---|
| Baghdad | 44.4 | 33.3 | zakho | 42.72 | 37.13 |
| Rutb | 40.28 | 33.03 | slimanieh | 45.45 | 35.53 |
| Basra | 47.78 | 30.52 | Erbil | 44 | 36.15 |
| Mousl | 43.15 | 36.31 | talafer | 42.48 | 36.37 |
| Najaf | 44.32 | 31.92 | Tuz | 44.65 | 34.88 |
| Diwania | 44.95 | 31.95 | samara | 43.88 | 34.18 |
| Ramady | 43.32 | 33.45 | Anna | 41.95 | 34.37 |
| kerballa | 44.05 | 32.57 | Qiam | 41.07 | 34.38 |
| kirkuk | 44.35 | 35.74 | Nukheb | 24.28 | 32.03 |
| Amara | 47.17 | 31.83 | Balad | 44.15 | 34 |
| Dyala | 45.62 | 33.88 | Sinjar | 41.83 | 36.32 |
| Smaw | 45.27 | 31.27 | Alialgarbi | 46.43 | 32.28 |
| kut | 45.75 | 32.49 | Badra | 45.57 | 33.06 |

| | | | | | |
|---|---|---|---|---|---|
| Nasiriya | 46.23 | 31.02 | Aziziah | 45.04 | 32.55 |
| Babylon | 44.45 | 32.45 | Haditha | 42.35 | 34.13 |
| Tikirit | 43.7 | 34.37 | Biji | 43.53 | 34.9 |
| Dohuk | 43 | 36.78 | Fao | 48.5 | 29.98 |

## 3. Data Analysis

Data analysis was done using MATLAB software to convert Net CDF (network common data form) format file get it from European Centre for Medium-Range Weather Forecasts (ECMWF). was Hourly data of wind speed from 1/1/2016 to 31/12/2016 was collected at two height (2 meter and 10 meter ). Data for surface roughness from the Iraqi region was collected as well.

the value of the friction velocity (U*) was calculated using the following equation :[13]

$$\frac{k(U(Z_2)-U(Z_1))}{\ln\left(\frac{Z_2-d}{Z_1-d}\right)} \qquad (1)$$

Where : k is the Von Karman constant (0.41)

U(Z2):Wind speed at 10 meter ,U(Z1):Wind speed at 2 meter .

d is the zero-plane displacement (in meters) ,which is calculate from canopy height (hc) and surface surface roughness(ZO) :[14]

$$Z_o = 0.07\, h_c \qquad (2)$$

$$\frac{d}{h_c} = \frac{2}{3} \qquad (3)$$

hence

$$d = \frac{2}{3} * \frac{Z_o}{0.07} \qquad (4)$$

from eq.1 and eq.3 to calculate U(z):[15]

$$U(z) = \frac{U_*}{k}\left[\ln\left(\frac{z-d}{Z_o}\right)\right] \qquad (5)$$

## *4.* Results and Discussions

### 4.1 Analysis of wind speed and direction at 00:00 UTC over the Iraq region

Figure 2: shows an analysis of wind speed and direction at night at (00:00 UTC). The highest value of wind speed was (2.96 m / s) as the wind moved from northwest to southeast, and the lowest wind speed (0.25 m / s) was traveling in winds from northwest to east, where we notice that the movement of air in the desert areas was faster than mountainous regions, this is because winds tend to remain in open areas as a result of cooling and forming a layer of stable air. The desert causes winds to move faster than the desert (add reference that supports this statement).

### 4.2 Analysis of wind speed and direction at 03:00 UTC over the Iraq region

Figure 3: shows an analysis of the speed and direction of wind at night at (03:00UTC). The highest value of wind speed was (2.98 m / s), the wind moved from northwest to south and southeast. the lowest wind speed (0.25 m / s) was directed in wind from the eastern direction and during the day, in the daytime, the air in mountainous regions is always faster than air in desert regions .

### 4.3 Analysis of wind speed and direction at (06:00, 09:00) UTC over the Iraq region

Figure 4 and Figure 5: show an analysis of wind speed and direction at (06:00 / UTC). The highest value of the wind speed was ((2.92 m / s)) as the wind moved from north to southeast, and the lowest wind speed (0.23 m / s) was directed from the wind from the north in the western region. The movement of air in mountain regions differs from the movement of air in desert regions through the difference in speed and air currents in mountain regions, and the reason for this difference is that these areas are a rough surface that increases the friction factor with the movement of air, which leads to a decrease in its speed.

### 4.4 Analysis of wind speed and direction at (*12:00*)UTC over the Iraq region

Figure 6: shows an analysis of hourly wind speed and direction (12:00UTC). The highest value of wind speed was (3.86 m / s) as the wind blows from north to south and the lowest wind speed (0.6 m / s) The wind direction is from the northern direction from east to southwest, the day and night speed varies. In the daytime, air in mountainous areas is always faster than air In desert areas and at night, the opposite happens, as during the day the element of obstructing the peaks in the mountainous areas of wind overcomes, and thus the wind speed in the mountainous regions is less than its speed in the desert areas while at night and because the wind tends to dwell in open areas as a result of cooling and the formation of a layer of stable air, then Mountainous areas in this case are still warmer than desert regions, so the stability of air in them is less than desert areas, which leads to the movement of winds that are faster than desert areas.

### 4.5 Analysis of wind speed and direction at (*15:00*)UTC over the Iraq region

Figure 7: shows an analysis of the wind speed and direction at (15:00 / UTC). The highest value of the wind speed was the highest value of the wind speed (3.65 m / s) in which the winds go from northwest to southwest and the lowest wind speed (0.59 m / s). It heads in the wind from

north to south direction. Air stability in mountainous areas is less than desert areas, which leads to wind movement that is faster than desert areas.

### 4.6 Analysis of wind speed and direction at (*18:00*)UTC over the Iraq region

Figure 8: shows an analysis of wind speed and direction at 18:00 / UTC. The highest value of wind speed was (2.98 m / s) in which the wind went from northwest to southeast and the lowest wind speed (0.07 m / s). It winds in the direction from the north to the east, As the wind tends to remain silent during the day in the desert areas, this is why we notice that the fast wind is heading from the mountainous areas towards the desert.

### 4.7 Analysis of wind speed and direction at (*21:00*)UTC over the Iraq region

Figure 9: shows an analysis of wind speed and direction at (21:00 / UTC) and the highest value of wind speed was ((2.83 m / s)) as the wind runs from northwest to southwest, and the lowest wind speed is (0.24 m / s). From north to east, during the day the air in mountainous regions is always faster than air in desert regions.

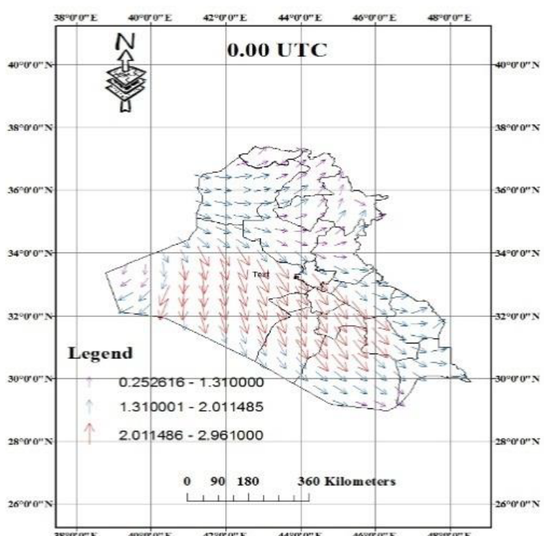



**Figure2.** The hourly average for one year (2016) of wind speed and direction at (00:00 UTC) over Iraq region.

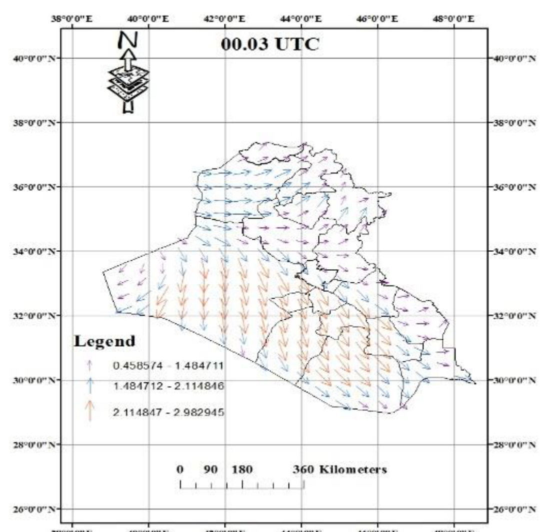



**Figure3.** The hourly average for one year (2016) of wind speed and direction at (03:00 UTC) over Iraq region.

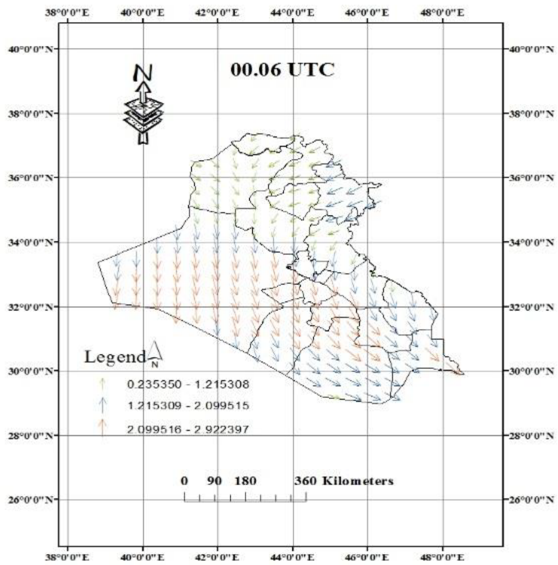



**Figure4.** The hourly average for one year (2016) of wind speed and direction at (06:00 UTC) over Iraq region

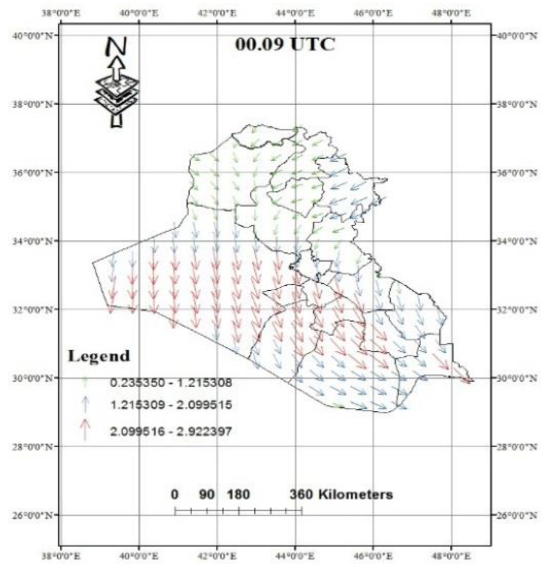



**Figure5.** The hourly average for one year (2016) of wind speed and direction at (09:00 UTC) over Iraq region

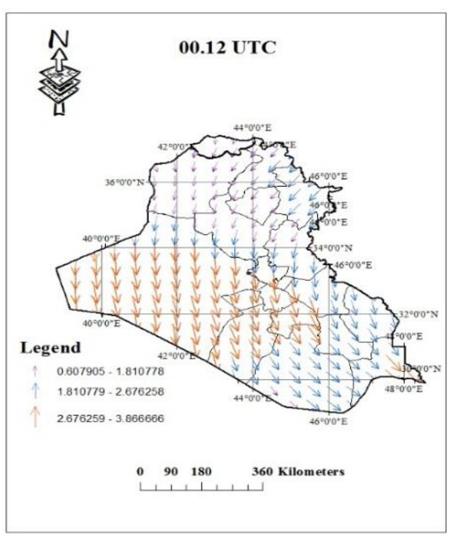



**Figure6.** The hourly average for one year (2016) of wind speed and direction at (12:00 UTC) over Iraq region

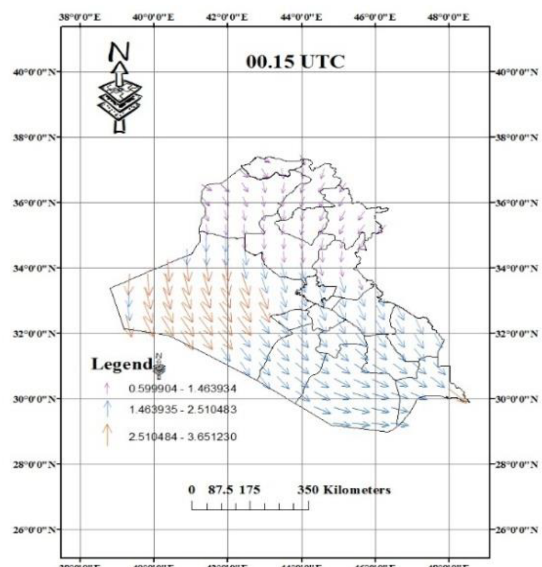



**Figure7.** The hourly average for one year (2016) of wind speed and direction at (15:00 UTC) over Iraq region

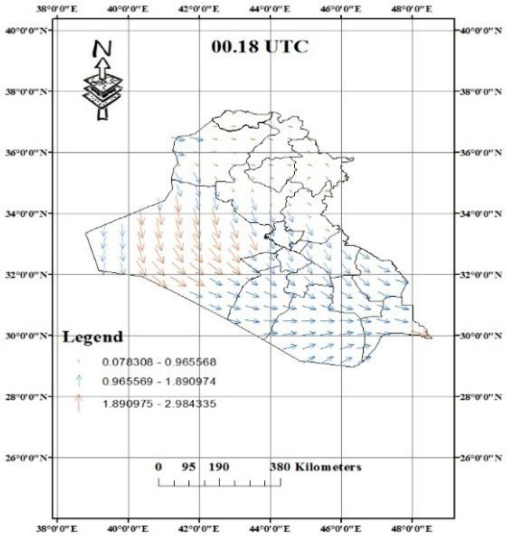



**Figure8.** The hourly average for one year (2016) of wind speed and direction at (18: 00 UTC) over Iraq region

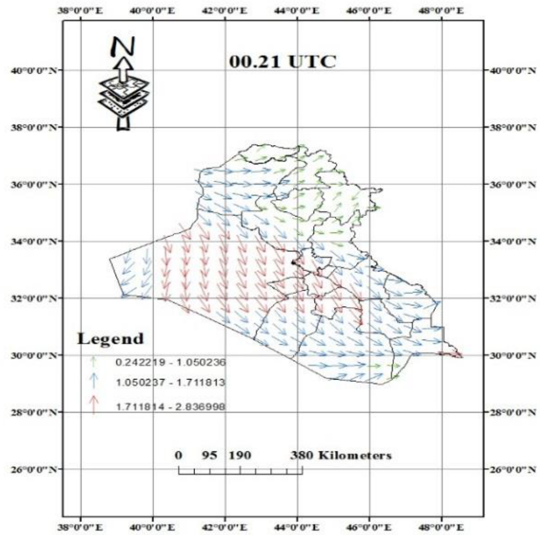



**Figure9**. The hourly average for one year (2016) of wind speed and direction at (21: 00 UTC) over Iraq region

### 4.8 Analysis of wind speed and direction data based on surface roughness over Iraq

Figures 10, and 11 and Table 2 show the analysis of wind speed data and direction during the study period for a full year (2016) for all regions of Iraq. The analysis showed that Iraq can be divided into four different rugged regions, where the highest wind speeds were found in Anbar, Najaf and Muthanna. In the less rough areas (0.50 m / s), there are surface roughness ranges (0.5-2 m) for eight governorates (Baghdad, Babil, Salah al-Din, Karbala, Qadisiyah, Dhi Qar, Maysan, Basra). The approximate topographical nature of roughness areas ranges from (2-11 m) represented in the governorates of (Mosul, Diyala and Wasit) and the lowest wind speed of 1.8 m / s in the hardest areas (11-72 m) which are the northern regions of Iraq, which are mountainous regions. Duhok, Erbil, and Sulaymaniyah).

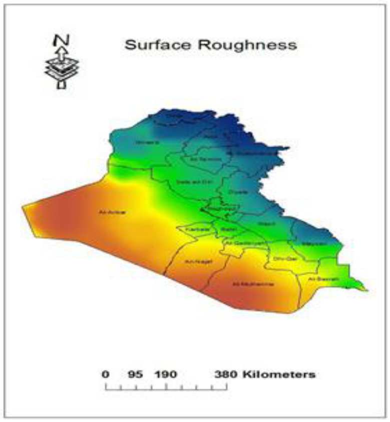



**Figure 10**. represents surface roughness for Iraq region.

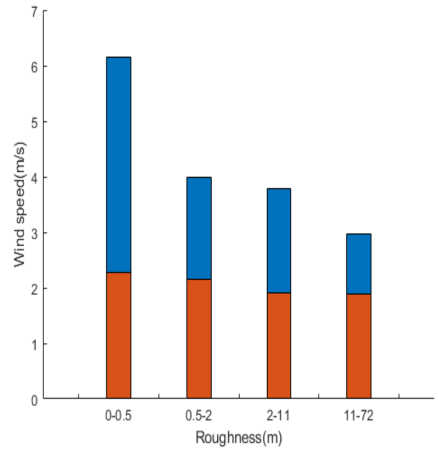



**Figure 11**. represents wind speed analysis according to surface roughness.

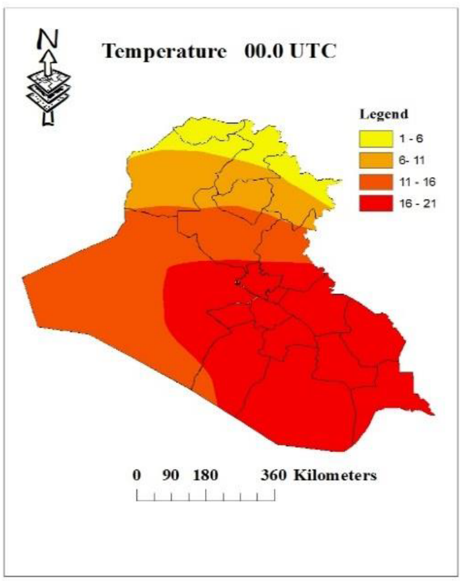
**Table 2.** The distribution of surface roughness in the different areas in Iraq

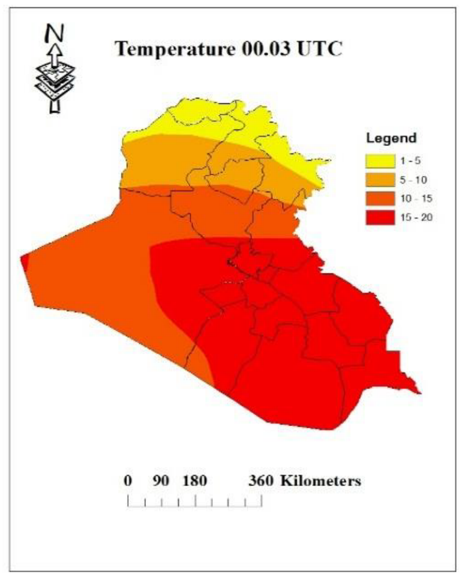
| **Roughness** (m) | **Wind speed (m/s)** | **Station** (Iraqis' provinces) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0-0.5 m | 2.72-6.15 | Al-Anbar | Al-Najaf | Al-Muthanna | | | | | |
| 0.5-2 m | 2.16-4 | Baghdad | Babylon | Sala ad-Din | Karbala | Al-Qadisiyah | Dhi-Qar | Maysan | Al-Basrah |
| 2-11 m | 1.9-3.79 | Ninawa | Al-Tamim | Diyala | Wasit | | | | |
| 11-72 m | 1.89-2.97 | Dohuk | Arbil | Sulaymaniyah | | | | | |

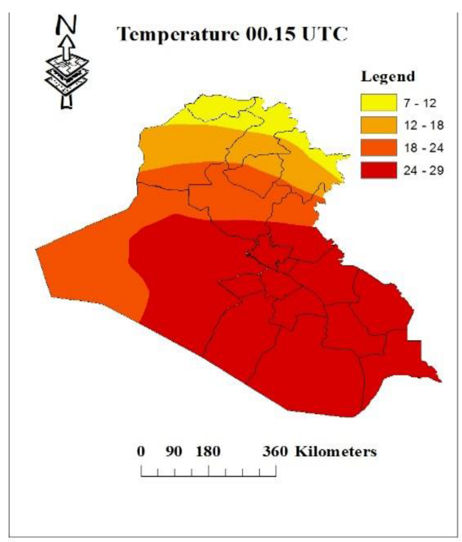
### 4.9 Analysis Average hourly for each year (2016) of temperatures over the regions of Iraq

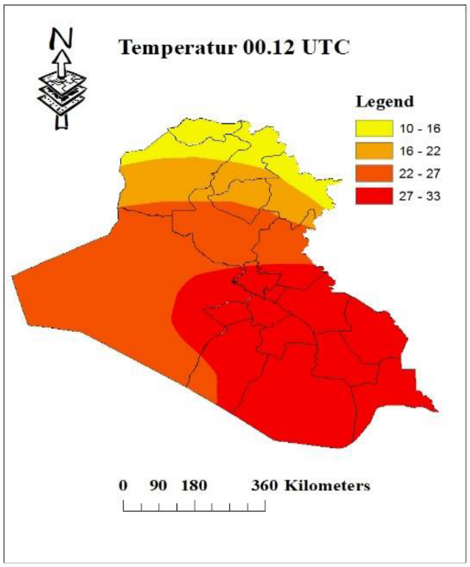
Figure 11 shows the distribution of hourly temperatures over the regions of Iraq, were it was found that the highest value of temperature was at 12:00 a.m. at 33 in the southern regions. These regions are characterized as dry desert areas due to lack of rain, high evaporation and low relative humidity in these areas. the lowest value was reached at 00:00 in mountainous areas, which are characterized by frequent rain, lack of evaporation and high relative humidity in the northern regions, where the speed and direction of the wind are associated with a decrease or increase in temperatures, and speed variation. During the day, the air of the mountainous regions is always faster than the air in the desert areas, and at night the opposite happens, as during the day the element of obstructing the peaks in the mountainous areas of wind overcomes, thus the wind speed in the mountainous regions is less than its speed in the desert areas while at night and because wind tends to remain in open areas as a result of cooling and forming a layer of stable air. In this case, mountainous areas are still warmer than desert regions, so the air stability there is less than desert areas, which leads to wind movement that is faster than desert areas. As the speed between the air in the mountainous and desert areas decreases as the air speed increases, in relation to the direction of the wind and the movement of air currents over the mountainous regions, the assumption is that the air over the mountainous regions warms more than the air in the desert areas, as it will be upward air currents that lead to a relative decrease in pressure that requires fetching air from the mountainous regions to replace the rising air, thus bringing relatively cool air from the mountainous

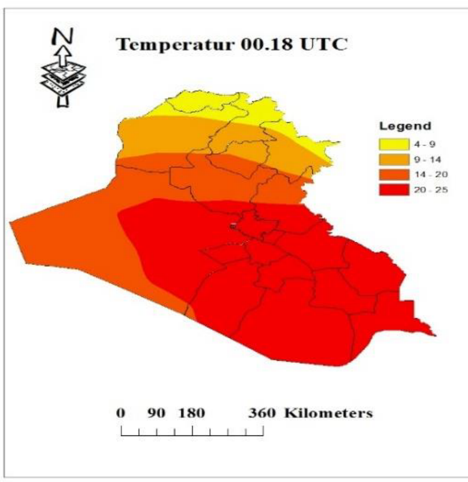
.




N
Temperatur 00.12 UTC
Legend
10 - 16
16 - 22
22 - 27
27 - 33
0 90 180 360 Kilometers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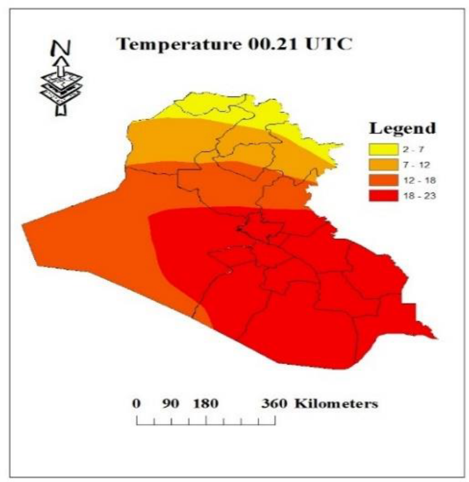
0 90 180 360 Kilometers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Temperature 00.21 UTC
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2 - 7
7 - 12
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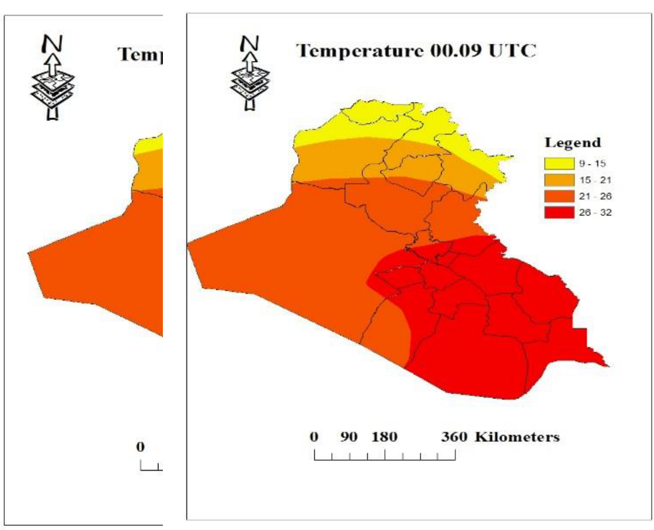
18 - 23
0 90 180 360 Kilometers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Temperature 00.09 UTC
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9 - 15
15 - 21
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26 - 32
0 90 180 360 Kilometers

**Figure 12**: The hourly average for one year (2016) Temperature over Iraq region

## 5. Conclusions

The results showed that the highest wind speed was (6.15 m / s) for the less rugged areas (0-0.5) add regions name, which are semi-desert areas, and the lowest wind speed was (1.8 m / s) in the rugged mountainous areas (add regions name). .It was also found that there is an inverse relationship between wind speed and surface roughness, as wind speed increases when the roughness values referred to by comparing wind velocity and surface roughness are reduced, and the prevailing winds are northwest and southeast to monitor wind movement and speed, as bumpers can be made to reduce air movement. finally, the highest temperature was in desert areas (add name of this areas/regions) and the lowest temperature in mountainous areas (add name of this areas/regions). In order to find out the effect of temperatures on the division according to the roughness of the surface and reduce the rise in temperature in desert areas, afforestation can be used.

## 6. Recommendations

Afforestation is one of the most important tools that must be provided for better understanding of climate conditions and accurate studies. Since the surface of the earth is covered with plants, it creates climatic conditions of its own, , especially during the night when the orchard climate is warmer than the open areas as the plants retain the long reflected rays. Mirrored from the Earth's surface, the vegetation also works to obstruct the wind and reduce its speed near the surface of the earth until it reaches its lowest speed inside the orchard or vegetation[16]

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