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# Creation of wind speed maps of Kirklareli City

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**ABSTRACT**

Wind energy has been an important element in our country's energy policy. According to the report of Turkish Wind Energy Association (TUREB), while the share of wind power plants in electricity production in Turkey in 2018 is 6.78%, with newly established wind power plants, it was 7.42% in 2019. The most important problem for the newly established wind power plants is that the wind energy estimation of the place where the plant will be established is unknown. In this study, a study was carried out to create wind maps of Kırklareli province. Wind maps of Kırklareli province were created for estimation of new plant locations. The average wind speed data obtained from the 10 meter height wind stations were obtained from the General Directorate of Meteorology and then the wind speed data were moved to 80 and 100 meters height, and wind speed maps were created at 80 and 100 meters height.

## 1. INTRODUCTION

One of basic needs in the development of countries is energy production but systems used for energy production cause soil, air and water pollution. The most important means of reducing this pollution are renewable and sustainable energy systems (Dünvar et al. 2002). While developed countries come ahead in the development of renewable energy sources , in developing countries with limited reserves of fossil fuels such as Turkey is seen that investment in renewable energy sources(Şenol 2017). Wind energy is a low cost, commercially viable and clean energy source that can be found all over the world (Köse et al. 2004). Therefore, there is growing interest in wind energy in Turkey and in the world. (Bayraç 2004). In order to benefit from the wind efficiently and economically ,the location of wind power plant facilities is very important. The most important problem for newly established wind power plants is that the wind energy estimation of the place where the plant will be established is not known (Şimşek and Doğru 2019). For the power plant, the energy potential of the area where the plant will be installed is an important parameter. Different meteorological parameters are measured at the observation stations which are belong to the General Directorate of Meteorology (MGM).

Wind speed is one of these parameters. Wind speed maps are created with the appropriate interpolation method using Geographical Information Systems (GIS) from MGM data. The maps created are used as a base for location selection. While creating the wind speed map, the data is the number of stations used and the parameter is the wind speed. The aim of this study is to produce a highly accurate wind velocity map that will be used as a base for the location selection of wind power plants.

### 1.1. Study Area and Data

Kırklareli province was chosen as the study area. The study area in the Marmara region is between 41 - 42 north latitude and 26 - 28 degrees east longitude. Its surface area is 6650 $km^2$ and the city center is 203 meters above sea level. In this study, 12 sensors belonging to the General Directorate of Meteorology in Kırklareli province and daily average speed data of these sensors between 2014 and 2019 were used. The height of sensors are 10m and their geographical location is shown in Figure 1.

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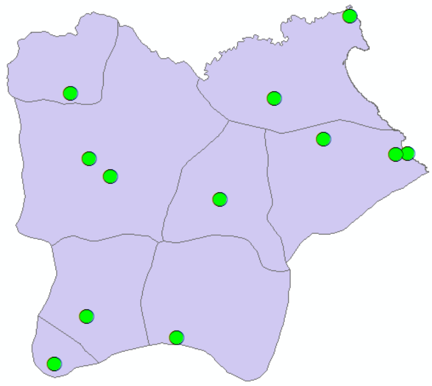

**Figure 1.** Locations of MGM stations used in the study

In order to find the friction coefficients of the stations used in the study, the CORINE land cover map and Copernicus Services inventory was used. For the purpose of the study, Hellmann equation was used to obtain wind speed at 80 and 100 meters height. In the Hellmann equation, calculations are made depending on the surface roughness of the area where the stations are located and the height to which the speed will be carried (Tar 2008).

### 1.2. Application

The locations of the stations were obtained from the MGM web page. Table 1 shows the station points and their locations used in the application.

**Table 1.** Location of station points

| Station No | Station | Lat. | Long. |
|---|---|---|---|
| 18407 | Pehlivanköy | 41,3556 | 26,9394 |
| 17631 | Lüleburgaz TIGEM | 41,3513 | 27,3108 |
| 18405 | Babaeski | 41,4433 | 27,0622 |
| 17052 | Kırklareli | 41,7382 | 27,2178 |
| 18406 | Kofçaz | 41,9411 | 27,1539 |
| 18398 | Pınarhisar | 41,6311 | 27,5236 |
| 18408 | Vize Yumurtatepe | 41,7084 | 27,8655 |
| 19900 | Kırklareli Üniversitesi | 41,7884 | 27,1683 |
| 17447 | Midye Kıyıköy Batı Mendire Fener (Ana) | 41,6317 | 28,1019 |
| 18102 | Demirköy | 41,8228 | 27,7489 |
| 18103 | Vize Kıyıköy | 41,6378 | 28,0661 |
| 18795 | Demirköy Beğendik Köyü | 41,9639 | 28,0233 |

Average daily wind speed between 2014-2019 of 12 meteorology stations in the study area were taken from MGM. Wind speeds at the stations are measured by sensors located on poles 10 meters high. With the Hellmann equation given in Equation 1, The wind speed at 80m height and 100 m height was estimated by using data of wind speed at 10m height.

$$\frac{V}{V_0} = \left(\frac{H}{H_0}\right)^{\alpha} \qquad (1)$$

In Equation 1, $V_0$ is the wind speed at a height of 10 m, H is the wind height to be carried, α is the friction coefficient and V is the wind speed at the height to be carried. In this study, $H_0$ was taken as 10 m. The CORINE land cover map Copernicus Services inventory (EEA 2019) was used to determine the friction coefficient. Table 2 shows the land type classes and the corresponding friction coefficients (Masters 2004).

**Table 2.** Friction coefficients according to land characteristics (Masters, 2004)

| Terrain Characteristics | Friction coefficient (α) |
|---|---|
| Smooth hard ground, still water | 0.10 |
| Tall grass at ground level | 0.15 |
| High crop and shrubs | 0.20 |
| Rural forest area, many trees | 0.25 |
| Small town with trees and bushes | 0.30 |
| Cities with tall buildings | 0.40 |

For each station point, the land class of the area where the station is located was determined with the help of the CORINE land cover map and satellite images, and the friction coefficient corresponding to the terrain characteristics was determined accordingly. The wind speed of 12 stations at 80 and 100 meters height were calculated using Equation 1. Data for maps to be created using Geographic Information Systems software has been converted into an appropriate format. Since the interpolation method to be used will affect the accuracy of the result, the appropriate interpolation method has been determined. Wind speed maps were created by inverse distance weighting (IDW), krigging and natural neighbor interpolation methods. When the real MGM wind speed data and interpolation methods were compared, it was determined that the most suitable method was IDW. The distribution of the sampled points in the work area greatly affects the result. Both 80m and 100 m height wind speed maps were created in grids of 200 x 200 m as raster.

## 2. RESULTS AND CONCLUSION

The 80m high wind speed map created for Kırklareli province is shown in Figure 2. When wind speeds are examined for a height of 80 meters in the study area, it is seen that the speed varies between 2.79 m / s and 7.12 m / s.

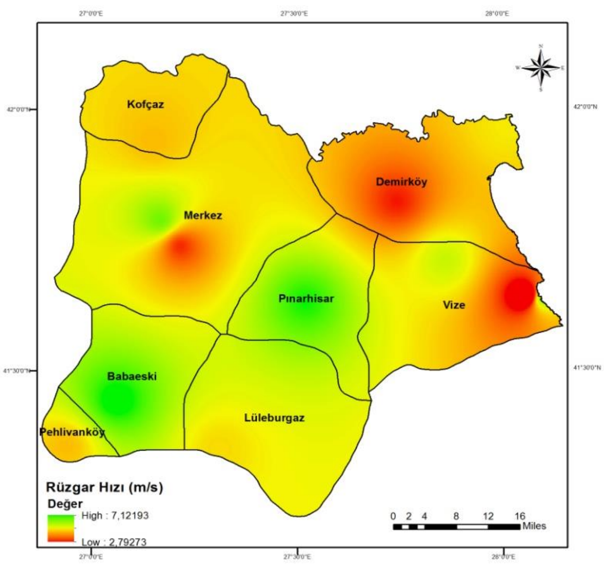


**Figure 2.** Wind Speed Map of Kırklareli Province (at 80 m height)

The wind speed map created for a height of 100 m is shown in Figure 3. When the wind speeds are examined for height of 100 meters in the study area, it is seen that the speed varies between 2.95 m / s and 7.79 m / s.

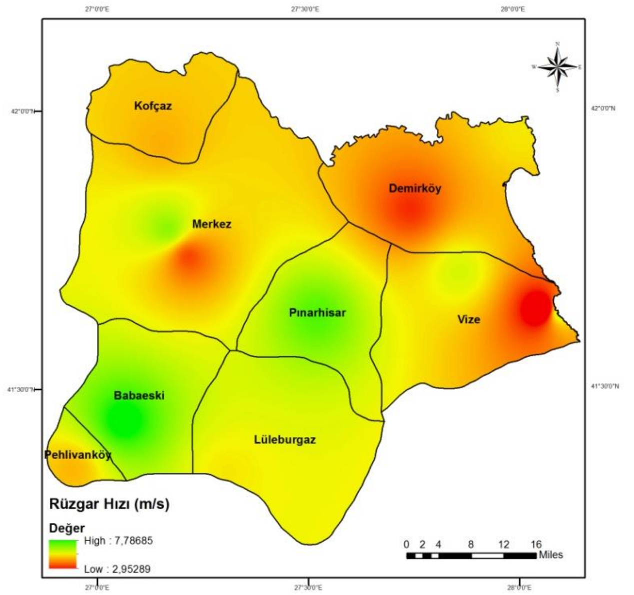


**Figure 3.** Wind Speed Map of Kırklareli Province (at 100 m height)

When the speed distributions are evaluated positionally, the wind speed around Demirköy and Vize is low ; In Pınarhisar, Lüleburgaz and Babaeski regions, wind speed is higher at both 80 and 100 meters height.

When creating wind maps, the distribution of reference points is of great importance so that the result is the closest to the expected accurate. When creating wind maps, the distribution of reference points is of great importance so that the result is the closest to the expected precision. In order to reach the most accurate result, the appropriate interpolation method should be determined and maps should be created using this interpolation method. In this study, when the maps created with the inverse distance weight (IDW) interpolation method were examined, it was determined that the wind speed was higher in the south of Kırklareli compared to other regions and it was more suitable for wind power plant location selection.

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