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Geostatistical mapping of reference crop evapotranspiration (ETo)

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ABSTRACT

Usable natural water resources on the earth's surface are decreasing. The water mostly used in agriculture should be consumed as much as the plant needs and irrigation plans should be prepared for this. Reference Crop Evapotranspiration (ETo) can be estimated according to climatic conditions. The aim of this study is to estimate the Reference Crop Evapotranspiration of Mersin province using Penman Monteith method and produce its geostatistical map. For this, temperature, humidity, sunshine duration, wind speed and meteorological data of the month of May 2017-2020 of 28 meteorological stations provided from Mersin Provincial Directorate of Meteorology were used. The equation used in Penman Monteith method was written with buttons in MatLAB guide programming language and ETo values were calculated and estimated. Mersin province's reference crop evapotranspiration map was created as geostatistical by correlating the Eto values for the years 1 May 2017-2020 with each station and it was observed that the highest water requirement was found on May 1, 2018.

1. INTRODUCTION

Although 70% of the earth's surface is covered with water, the amount of natural spring water available is approximately 2.5%. 69.5% of this water is in glacial or frozen soil layer at the poles, approximately 30.1% is in groundwater, and the remaining 0.4% is in atmospheric and surface waters. The demand for water in the world is increasing day by day due to the increase in population, global warming, natural disasters and environmental pollution. 70% of the natural spring water is used in agriculture (Development Planı, 2014; Smedley, 2017). It is necessary to protect, manage and recycle freshwater to support human health and sustainable development (United Nations, 2017; 2018).

The reference crop evapotranspiration is the water consumption resulting from the evaporation of natural objects on the land surface and the sweating of plants (TAGEM, 2017). Reference Evapotranspiration (ETo), taken as a reference to the water consumption of grass, can be calculated with the water consumption of other plant species (Allen et al., 1998; TAGEM, 2017).

In national studies on reference crop evapotranspiration; water consumption for the selected plant (Biber & Kara, 2006; Emekli & Baştuğ, 2007; Uçar et al., 2017), forecast models (Taş & Kırnak, 2011; Şarlak & Bağçacı, 2020), seasonal impact on climate change (Bayramoğlu, 2013), geographical issues such as the use of information systems (Güler, 2014), reference crop evapotranspiration values and irrigation programs (Gürgülü & Ul, 2017), spatial and temporal distribution (Karaca et al., 2017), use of AGROS software in irrigation water management (Köksal, 2018). has been taken. In international studies; Water consumption for the selected plant (Fenech et al., 2019), crop evapotranspiration database (Tomas-Burguera et al., 2019), Bangladeş historical background of reference crop evapotranspiration due to climate (Mousumi et al., 2019) were examined. In Bosnia and Herzegovina, with the Penman-Monteith method, the annual ETo was found to be 716 mm, and it was stated that approximately 78%

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of this occurred in the vegetation period (April-September) (Čadro et al., 2019). In addition, the reference crop evapotranspiration estimates were made from satellite images (Granger, 2000).

The aim of this study is to calculate the Reference Crop Evapotranspiration (ETo) using the Penman Monteith method in the province of Mersin in MatLAB guide programming language and show the results with a geostatistical map. Equation (1) in Penman-Monteith method is coded in MatLAB guide programming language. Meteorological data of 28 Automatic Meteorological Observation Stations (OMGI) obtained from the General Directorate of Meteorology and Mersin Provincial Directorate of Meteorology were used. ETo values were calculated with 31-day meteorological data in May of 2017, 2018, 2019 and 2020. These values were matched with the station points in ArcGIS software and their map was produced with IDW (Inverse distance weighted), one of the geostatistical analysis methods.

2. METHOD

Study area is located in Mersin Province, which is in the Mediterranean region, Turkey, is between 36 ° 01' - 37° 25' north latitude 32° 47' - 35 ° 23' east longitude (Figure 2). The study area is characterized by Mediterrenean climate, which is hot and dry in summers, and warm and rainy in winters (MGM, 2020). It has fertile agricultural lands and there are four savanna within the borders of Mersin province (BKK, 2017). Especially in the dry summer months, plants need maximum water.

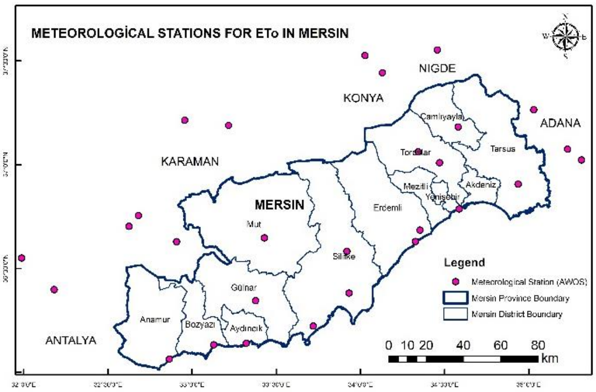

Figure 1. Meteorological stations

Automated Weather Observing System (AWOS) is a system that is sensitive to changes in meteorological parameters and consists of sensors that measure the amount of these changes and transmit data automatically (MGM, 2020). This system constitutes the whole of the meteorological stations in the field. 28 Meteorological station information and their data were obtained from Meteorology Mersin Provincial Directorate. The meteorological data, which are maximum-minimum temperature and relative humidity, wind speed and sunbathing time, belonging to a total of 28 stations, 15 in Mersin and 13 in neighboring provinces, were arranged. In addition, the height of the station and the height at which the wind was measured, the maximum possible sunshine duration and radiation reaching the outer surface of the atmosphere were collected. The raw data set of May for each station between 2017-2020 was made ready to be used in the Penman-Monteith method.

Penman-Monteith is a method adopted by the United Nations-UN, Food and Agriculture Organization-FAO in 1998. The guidelines are presented for computing crop water requirements in FAO Irrigation and Drainage Paper No. 56 (Allen et al., 1998). Since it is the closest method to real measurements made with Lysimeter, it is also accepted in the literature and is taken as a reference in model estimates (Saggi & Jain, 2019; Sanikhani et al., 2019). In addition, when calculating the evapotranspiration of a specific plant, the value found from the Penman-Monteith method is taken into account as ETo (Bruin & Trigo, 2019; Fenech et al., 2019).

$$ET_o = \frac{0{,}408\Delta(R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0{,}34 u_2)} \quad (1)$$

In Penman-Monteith Method, Equation (1) is mean following (Allen et al., 1998).
ET_o, Reference Crop Evapotranspiration (mm/gün)
Δ, slope of saturation vapour pressure curve [kPa °C-1],
R_n, net radiation [MJ m-2 day-1]
G, soil heat flux [MJ m-2 day-1],
γ, psychrometric constant [kPa °C-1],
T, average air temperature [°C]
u_2, wind speed at 2 m above ground surface [m s-1],
$(e_s - e_a)$, saturation vapour pressure deficites.

Value estimates can be found by downloading the "ETo calculator" published by FAO. The symbols seen in Penman-Monteith Equation (1) have expansions. Sub-variables of these symbols that depend on each other and the station latitude are calculated. But for this study, ETo values were estimated by using original programming.

3. RESULTS AND DISCUSSION

Reference Crop Evapotranspiration was calculated using the program written by the authors using the Penman-Monteith method. For each of the 28 meteorological stations, the days of May 1-31 were found between 2017-2020.

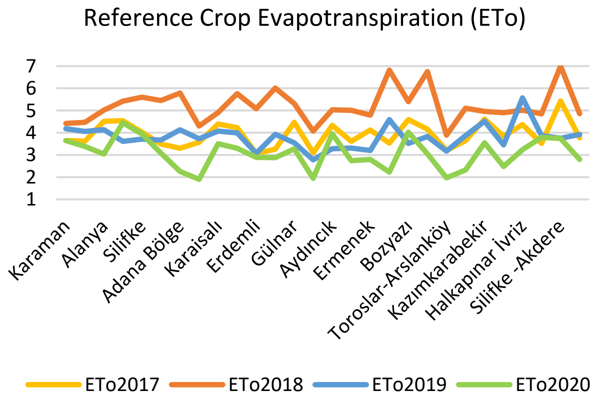

Figure 3. ETo in 2017-2020

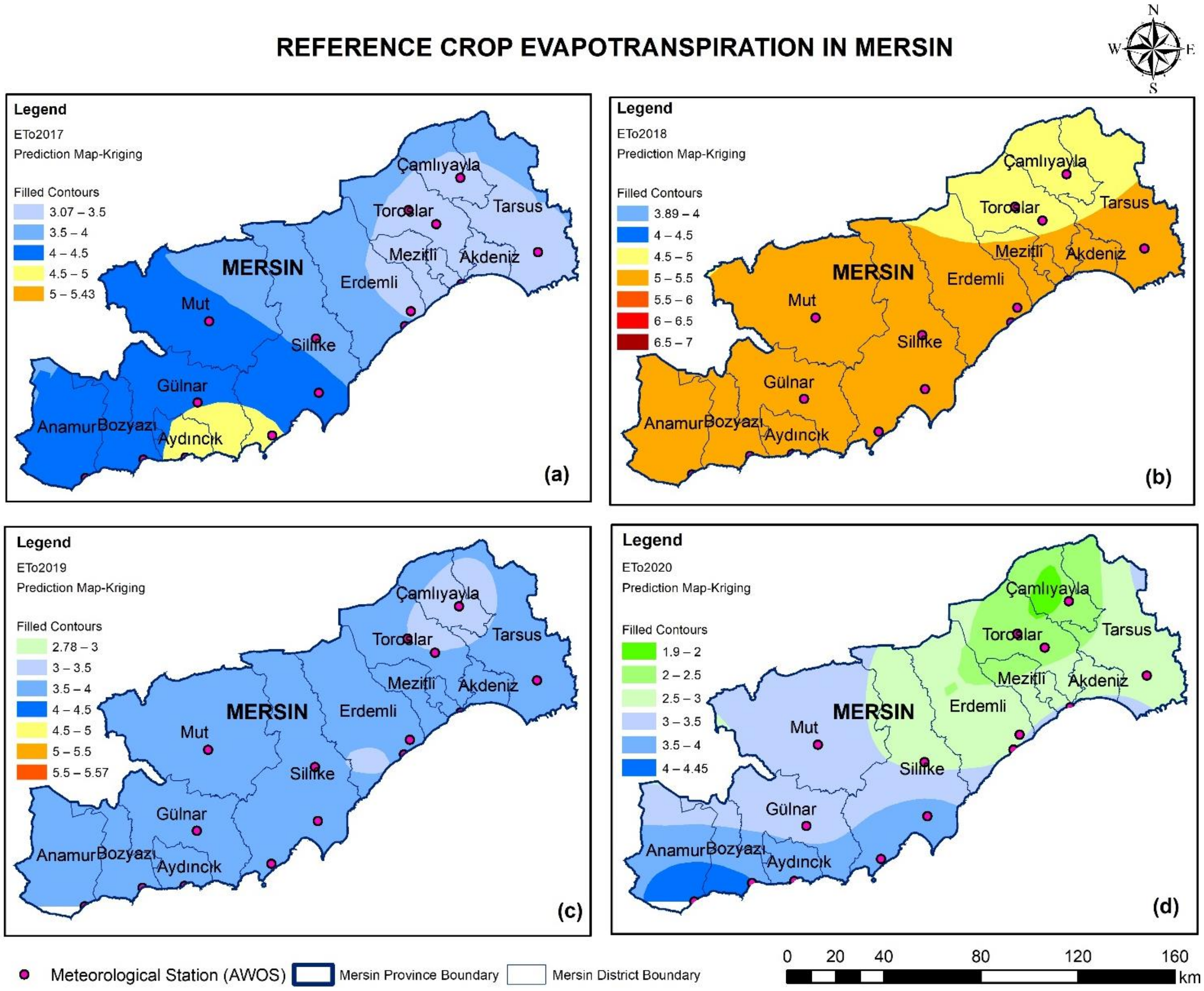

Figure 4. Maps of reference crop evapotranspiration (mm/gün)

The amount of water consumed by each plant is different, and ETo is required to find this amount. ETo shows the amount of water consumed by the grass plant, taken as a reference. Figure 3 shows that in 2018, there was a greater need for water than others. For Çamlıyayla, Toroslar and Ulukışla districts, there is a consistently low water need every year (Figure 3).

Mersin province and district borders and 28 meteorological stations were transferred to ArcGIS 10.5 geographic information system software in order to produce the statistical map of Eto. Separate map of each day of May can be created. However, in this study, maps of reference crop evapotranspiration were prepared for the years 2017-2020, taking into account only May 1. It was used kriging which is one of method of Geostatistical analyst. Not all colors in Legends appear on the maps. Because the geostatistical map is arranged according to Mersin provincial border (Figure 4).

When the maps were examined, it was observed that there was a high water requirement in Mersin on May 1, 2018. On May 1, 2017 and 2019, ETo remained especially in the range of 3-4.5 mm / day. On May 1, 2020, it was determined that the minimum water requirement was found in Çamlıyayla and its surroundings from the ETo value.

4. CONCLUSION

The basic requirements of the world's population are water and food. Agricultural areas need to be cultivated / planted for food production. It is known that most of the water consumption is used for agricultural purposes. For this reason, planning of crop evapotranspiration is of great importance. When the dam, artificial lake, pond is established, the dimensions of the irrigation canals can be determined according to the water needs of the surrounding agricultural areas. In agricultural areas, water need can be determined according to the cultivated plant type and irrigation can be done accordingly. In this case, both soil, water resources and plant will be protected.

In future studies, the ETo value estimated using the Penman-Monteith method can actually be compared with the ETo value obtained from the measurement result using the lysimeter. ETo can be predicted using modern methods.

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