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Heating and Cooling Degree Day Maps of Turkey

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Abstract-Energy requirements are increasing for all year gradually. Calculating of heating and cooling degree day (HCDD) is the most important factor to determine the quantity of energy consumptions. The consumption is related with the factors directly for all types of buildings, such as fabrics, markets, houses etc..

In this study, using 140 station values evaluated by ArcGIS 10.1–ESRI software, HCDD for 2016 were estimated for each season and checked with long term (30 years) average value. As a result; heating necessities are increasing for Aegean, Marmara and Mediterranean regions in consequence of above average temperature. It is falling of around East of the area due to negative temperatures anomalies. Visualized maps produced with this criterion by different methods can show increasing and decreasing energy requirements. So, the maps are base and can be used to take into account for all future new measures.

Index Terms-Disaster and crisis management, energy policy and planning, risk analysis, probability maps.

1. INTRODUCTION

Information of Cooling degree day (CDD) and Heating degree day (HDD) are indispensable data to learn energy requirements for buildings. In this study the main aim is illustration of critical zones at the point of abnormal energy requirements. So some precautions will be take into agenda easily by the HDD/CDD prediction maps. Prediction maps which may be produced with monthly, annual and long term average data will show us the way for crisis management, energy policy and planning or risk analysis for the future.

In calculation of degree-day mean heating degrees are 18°C in Europe, 18.3°C in USA. Comfortable heat interval is between 15°C and 24°C. The below of 15°C heating requirement appears, above of 24°C cooling requirement appears [1].

According to [2] HDD value declare severity of coldness at inside or outside heat. Some countries uses different formulas. Eurostat (European statistic Office) proposed the formula for HDD calculation.

HDD = [18 °C – Ta] x dn, assuming Ta ≥ 15 °C limit value over HDD minimum value

CDD = [Ta – 22 °C] x dn, assuming Ta ≤ 22 °C limit value over CDD minimum value

In this formula;

Ta = Daily average temperature value,
dn= number of days.

According to [3] to determine overall HCDD are very considerable to compute heating and cooling demands for buildings. If daily average temperatures are above 15°C it isn't necessary heating. Expense of heating and annual HDD are depend on each other. So, 30 years HDD must be calculate first. HDD indicates which amount necessity of fuel for the season and future winter. However isolation and cooling expenses must be taken into account the value.

In recent years, some studies have been verified about geostatistics, kriging, inverse square distance (ISD) and splines. In Mediterranean region by [4-10] have studied about relation effects of elevation and precipitation. [11], established some advantages of geostatistics.

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2. MATERIAL AND METHOD

Turkey has been evaluated for the study area. Two different interpolation methods (ISD and Kriging) have been used to produce prediction maps and compared each other.

Study area is between 36°-42° latitude and 26° -45° longitudes. Total area is 780 576km2 and it has 9 816km2 lakes. Land border is more than 2750km, and sea line is more than 6000km. Mean elevation is 1131m., and mean temperature is between 4°C and 20°C. From Turkish Meteorological Service, the lowest temperature is recorded -46.4°C and the highest is 48.8°C up to now.

2.1. *Linear regression and inverse square distance*

[12] form a formula relationship of altitude and rainfall values. The formulation is as folows:

$$z_{LR}(s_0) = a + bz_2(s_0)$$

(1)

(z) is rate of precipitation at s_0 node.

$$z_{ISD}(s_0) = \frac{\sum_{i=1}^{n(s)} z_1(s_i) d_i^{-2}}{\sum_{i=1}^{n(s)} d_i^{-2}}$$

(2)

$z_1(s_i)$: the data points, d_i: the dimensions between stations s_i and unrecognized point s_0.

2.2. *Kriging interpolation*

In study of [13], Geostatistical analysis uses some interpolation methods; ISD, kriging, polynomial methods are used to form a solid surfaces.

[12] defined linear regression between elevation and precipitation of a certain earth location as follows;

$$z_{LR}(s_0) = a + bz_2(s_0)$$

(3)

Where; z : corresponding precipitation value, s_0: given grid node for each elevation datum.

Further calculation performed for precipitation values of the given locations can be performed by using multivariate geostatistical approach. It is aimed to calculate unrecognised falling value at the sampled station s. s_0 is specified as follows:

$$Z_{OCK}(s_0) = \sum_{i=1}^{n} \lambda_i z_i(s_i) + \sum_{j=1}^{m} \lambda_j z_2(s_j)$$

(4)

Where; z_i : vectors of observing data.

z_2 **:** Value of neighbour observations s_j,

λ_i and λ_j *:* weight between s_0 and s_i.

3. CONCLUSION

Energy consumptions is the biggest demand of any country. The energy supply of Turkey is insufficient and limited. Our country is non-depended at the side of primary energy sources. While very severe winter conditions take effect on some region, at some other region under the influence of severe summer conditions. This means that both more cooling energy demands and also residual heating energy resources are necessary. At this point the importance calculations of HDD or CDD are take effect. All energy projections must be established by the values. So, extra dissipation of energy can be prevented by observing and collecting accurate investigation monthly and annual in all year.

As a result 140 station's data have been evaluated and four different prediction maps have been produced by two different interpolation methods. To get more precious interpolated values all errors have been compared each other. Up to now a lot of precipitation maps have been generated by different interpolation procedures. Adequateness of some methods or maps cannot been confirmed by traditional methods. Geostatistics, helps its user not only different kinds of visualized maps but also statistical and mathematical results. So, all results must be proofed by geostatistical calculated consequences.

Table 1. ISD and Kriging error values

Prediction standard error (cm)	ISD (CDD)	ISD (HDD)	Kriging (CDD)	Kriging (HDD)
Mean	-5.65	26.10	-1.72	10.44
Root mean square	176.41	615.51	1.61	53.28
Average standard error			1.37	5.86
Mean standardized			1.14	0.86

Table 1 show interpolation error values by ISD and Kriging. According to Table 1 Kriging interpolation method yields more precious error values. However HDD and CDD prediction maps have been shown in Figure 1, 2, 3, 4.

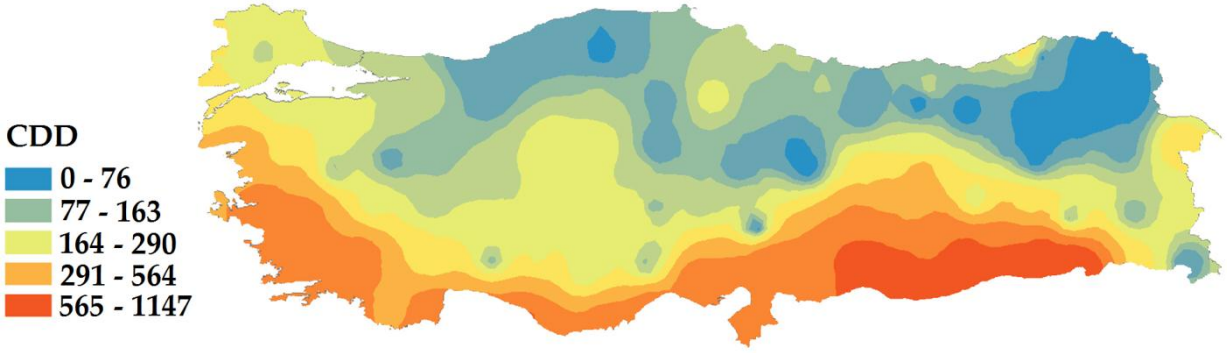

Fig. 1. CDD map by ISD.

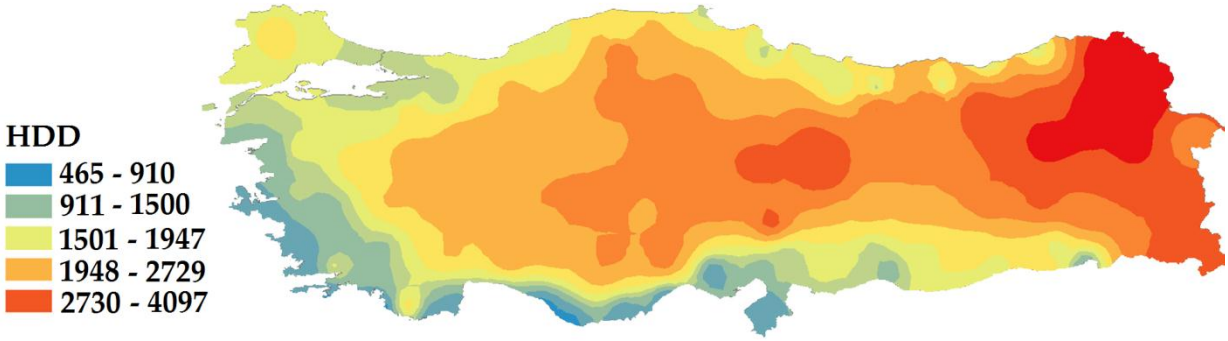

Fig. 2. HDD map by ISD.

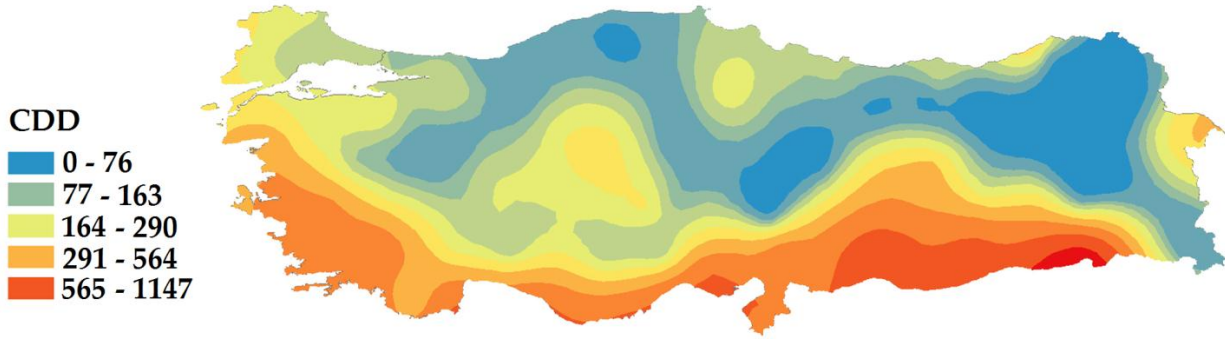

Fig. 3. CDD map by Kriging.

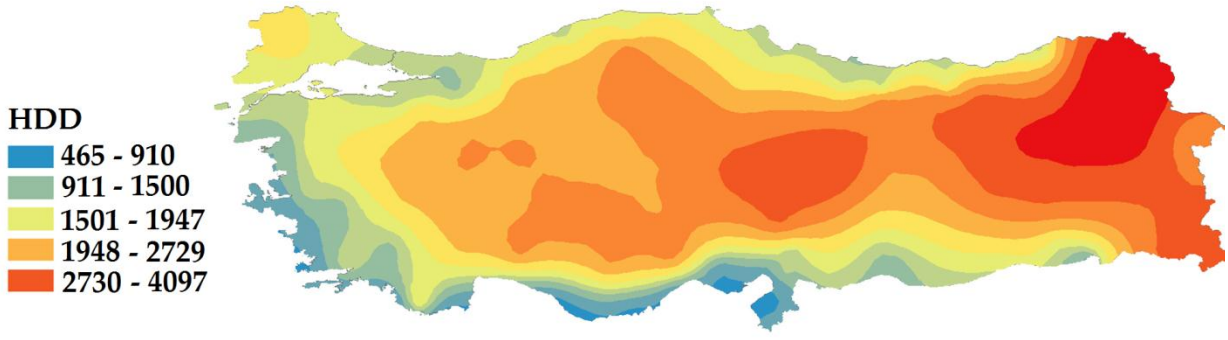

Fig. 4. HDD map by Kriging.

Erosion by Multivariate Geostatistics. Süleyman

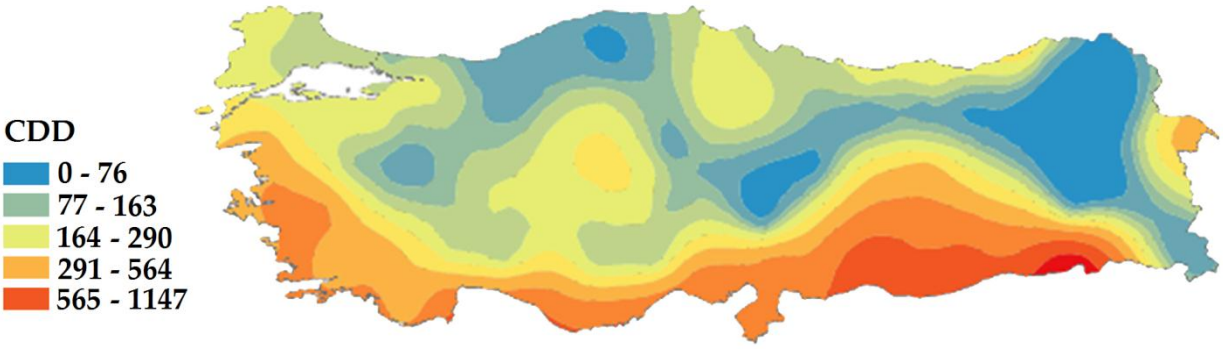

Fig. 5. CDD 2016 map by Kriging.

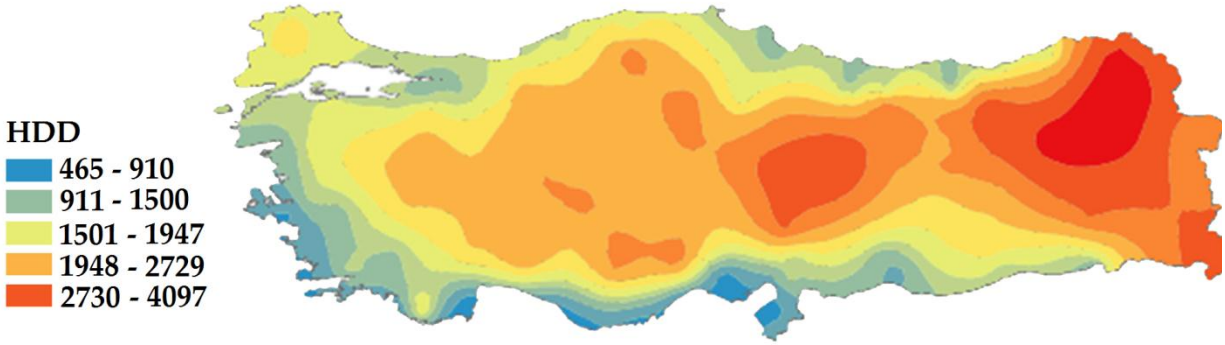

Fig. 6. HDD 2016 map by Kriging.

Requirements of cooling or heating can be calculated and illustrated on maps. These are long term average data maps. Figure 5, 6 shows 2016 HDD, CDD prediction maps by Kriging interpolation.

At this phase results must be compared Figure 3 with Figure 5 and Figure 4 with Figure 6, if cooling or heating requirements increased or reduced. However long term minimum HDD is 590 the value of HDD in 2016 reduced to 468 and maximum HDD has been reduced to 1592 from 5175. Long term maximum CDD increased to 1592 from 1248.

According to [14] heating requirements will be reduced 10% and cooling requirements will be increased 30% in the world until 2030. All hazards are effective for Turkey in the short run. The best materials are the maps which produced different visualised form by geostatiscal methods for planning precautions for nowadays and future.

REFERENCES

[1] Dombayci A., H.C.B., Ozgur A.E. (2009): Interpolation Processes For Mapping Of Climatological Precipitation To Investigate Water Demirel Ün. Fen Bilimleri Enstitüsü dergisi, **13-3**: pp. 311-314.

[2] Gikas, A. and. Keenan, R (2006): Profil climatique Degrés jours de chauffage, Statistique en bref. Environnement et énergie, **5**: pp. 2006.

[3] Ulupınar, Y., et al. (2008): Yılı Isıtma ve Sogutma Gün Derecelerinin Değerlendirmesi.

[4] Agnew, M.D. and Palutikof, J.P. (2000): GIS-based construction of baseline climatologies for the Mediterranean using terrain variables. Climate Research, **14**(2): pp. 115-127.

[5] Attorre, F., et al., (2007): Comparison of interpolation methods for mapping climatic and bioclimatic variables at regional scale. International Journal of Climatology, **27**(13): pp. 1825-1843.

[6] De Iaco, S., Palma, M. and Posa, D. (2013) :Prediction of particle pollution through spatio-temporal multivariate geostatistical analysis: spatial special issue. AStA Advances in Statistical Analysis, **97**(2): p. 133-150.

[7] Krakauer, N.Y. (2012); Estimating climate trends: application to United States plant hardiness zones. Advances in Meteorology,

[8] Laguardia, G. (2011): Representing the precipitation regime by means of Fourier series. International Journal of Climatology, **31**(9): pp. 1398-1407.

[9] Pearce, J.L., et al. (2009): Characterizing the spatiotemporal variability of PM 2.5 in Cusco, Peru

using kriging with external drift. Atmospheric Environment. **43**(12): pp. 2060-2069.
[10] Perry, M. and Hollis, D. (2005): The generation of monthly gridded datasets for a range of climatic variables over the UK. International Journal of Climatology, **25**(8): pp. 1041-1054.
[11] Goovaerts, P., (2000): Geostatistical approaches for incorporating elevation into the spatial interpolation of rainfall. Journal of hydrology, **228**(1): pp. 113-129.
[12] Diodato, N. and Ceccarelli M. (2005): Interpolation processes using multivariate geostatistics for mapping of climatological precipitation mean in the Sannio Mountains (southern Italy). Earth Surface Processes and Landforms, **30**(3): pp. 259-268.
[13] Kumar, A., S. Maroju, and Bhat, A. (2007): Application of ArcGIS geostatistical analyst for interpolating environmental data from observations. Environmental Progress, **26**(3): pp. 220-225.
[14] Valor, E., V. Meneu, and Caselles, V. (2001): Daily air temperature and electricity load in Spain. Journal of applied Meteorology, **40**(8): pp. 1413-1421.