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Spatial variations of climate indices in Turkey

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ABSTRACT: The present study explores the spatial variability of the continentality, oceanity and aridity indices in Turkey. Climatic indices are diagnostic tools used to describe climatic conditions and the state of a climate system. In this study, four indices were calculated using the climatic data from 229 meteorological stations in Turkey. The nature of the indices expresses general climatic features such as continentality, marine influences and aridity. The climatic indices used here are the Johansson Continentality (JC) Index, the Kerner Oceanity Index (KOI), the De Martonne Aridity Index (I_{DM}) and the Pinna Combinative (PV) Index. Furthermore, aridity characteristics in Turkey have been examined using the two separate periods (1960–1990 and 1991–2006). To assess the temperature and precipitation patterns in Turkey, the climatic indices were calculated by using monthly temperature and precipitation for the period 1960–2006. According to the results of the KOI, marine climates characteristics were dominant in the Black Sea region than in its Aegean and Mediterranean region. The JC index is used for the climatic classification between continental and oceanic climates. The continental effect was found across 25% of the country. The maximum continentality with a score of 71.5 has been found in the eastern Anatolia. Furthermore, semi-dry areas were increasing in the 1991–2006 period compared to 1960–1990. A significant correlation was found between the values of the JC index and the KOI. The JC index gives reasonable results for Turkey. The continental effect was found across 25% of the country. This analysis may be of benefit for the explanation of landscape characteristics and the rational utilization of water resources, agriculture and energy scenarios for the region in many areas of Turkey.

KEY WORDS climate indices; continental and oceanic; dry and wet

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1. Introduction

Climate indices which are diagnostic tools used to define the state of a climate system and the understanding of the various climate mechanisms have been improved based mainly on several climate variables. The spatial distribution of various climatic indices is also determined by the climatic conditions of a region. Climate indices studies were extensively studied in the literature (Smith, 1982; Conway *et al*., 1996; Jones *et al*., 1997; Baltas, 2007). The studies on climate indices have been proved very useful for the forecasting of agricultural production (Dalezios and Zarpas, 1996; Dalezios *et al*., 2000). Generally, climate indices are derived from temperature and precipitation measurements.

The temperature increase in Europe and Mediterranean has been well documented in the literature (Jones *et al*., 1999; Karl *et al*., 2000; Houghton *et al*., 2001; Klein *et al*., 2002). The continued heating has been forecast with variations in extreme climate events (Folland *et al*., 1999; Groisman *et al*., 1999; Nicholls and Murray, 1999; Haylock and Nicholls, 2000). Recently, drought conditions and climatic variability in Turkey were analysed in several studies (Hulme, 1994; Jones, 1994; Peterson and Vose, 1997; Tayanç and Toros, 1997; New *et al*., 1998; Jones *et al*., 1999; Karaca *et al*., 2000; Kömüşcü, 2001; Türkeş *et al*., 2002a,b).

According to the IPCC Fourth Assessment Report, annual precipitation is very likely to decrease in the most of the Mediterranean area including Turkey. Furthermore the global mean surface temperature is rising. Europe's average temperature has risen even faster than the global mean (about 1 °C; IPCC, 2007). The southern part of the Europe has dried by as much as 20% in the last century. Climate and land use change influence the characteristics of water balance. According to IPCC scenarios, the southeastern Europe including Turkey would experience a reduction in stream flow (Gao *et al*. 2006; Onol and Semazzi, 2009).

In recent years, the Standardized Precipitation Index (SPI) has been increasingly used for assessment of drought intensity in many countries (Vicente-Serrano *et al*., 2004; Wilhite *et al*., 2005; Wu *et al*., 2006). Homogeneous climatic zones were derived using SPI in Mexico (Giddings *et al*., 2005). Moreover, the analysis of spatial characteristics in rainfall datasets and their association with large-scale climate indices can demonstrate the existence of nonstable structures that vary according to cyclic climate patterns. These analyses are of particular interest for the Euro-Mediterranean area, where regional climates are mainly the result of the interactions between the North Atlantic sector [whose variability is expressed through

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the North Atlantic Oscillation (NAO) index], continental Europe and the Mediterranean Sea (Zanchettin *et al.*, 2008, Zhang *et al.*, 2005b). According to Köppen climate classification, west and southern parts of the Turkey having moderate temperature and rainy weather in winter, and dry and hot summer Mediterranean climate are classified with Csa. Furthermore, central and east Anatolia which have continental subarctic climate and highland locations are classified with Dsc. The northerly regions of Turkey which represent the hot summer continental climates are indicated with Dwa.

The knowledge of aridity is needed to explain landscape characteristics and the rational utilization of water resources in many areas of Turkey. Aridity indices provide a simple way to express the ratio of precipitation to evaporation. In this study, to determine the climate structure of the regions in Turkey we investigated the spatial variation of several climate indices including continentality, oceanity and aridity. The climatic indices used in this study are the Johansson Continentality (JC) index, the Kerner Oceanity Index (KOI), and the DM Aridity index. These indices are calculated over Turkey by using monthly temperature and precipitation data and then were compared with the topographical effects on temperature and precipitation.

2. Data and study area

The data used in this analysis are a surface meteorological data set provided by Turkish Meteorological Service. A total of 229 stations across the country were used to determine and examine the indices during the period 1960–2006. The stations cover the whole range of climatic conditions in the country (Figure 1). Homogeneity tests have been assessed for time series of the temperature and precipitation data in each station. For this purpose, Swed-Eisenhart Run test was applied within this study (Oliver, 1981). The Swed-Eisenhart test is a nonparametric test used in determining the randomness or homogeneity of a data set (Vining and Griffiths, 1985).

The meteorological data applied in this study were used in calculating the climate indices. The indices were spatially interpolated by kriging methodology to generate relatively homogeneous areas using Surfer Program. It has been shown that using the kriging methodology for the interpolation process provides reliable results (Holawe and Dutter, 1999).

3. General climate in Turkey

Turkey (36–42°N; 26–45 °E) is located at the south-eastern part of Europe between Europe and Asia. The total land area is about 780 000 km^2, of which 97% is in Asia and 3% in Europe. The average altitude is 1130 m and gradually increases from the central part of Anatolia to the east (Figure 2). The country is surrounded by the Black Sea, Aegean Sea and Mediterranean Sea, and the total number of stations includes 35% lowlands (0–200 m), 7% hills (200–600 m), 50% highlands (600–1600 m) and 8% mountains (>1600 m). The coastal areas of the Mediterranean region in the south separates from central Anatolia by the South Anatolian Mountains (Taurus) with reach to 3000 m. Similarly, the North Anatolian Mountains which reach to 3942 m elevation in Kackar are parallel to the Black Sea coast. The central Anatolia Plateou is located between the two mountains with varied elevations from 600 to 1200 m.

Turkey is situated over a transition region between polar and tropical air masses with Mediterranean climate characteristics in a subtropical climate zone. Furthermore, topographic effects associated with the mountainous terrain in particular greatly complicate the climate variability. In addition to the topography and other geographical factors such as landscape and altitude, Turkey's climate is mainly determined by atmospheric circulation patterns.

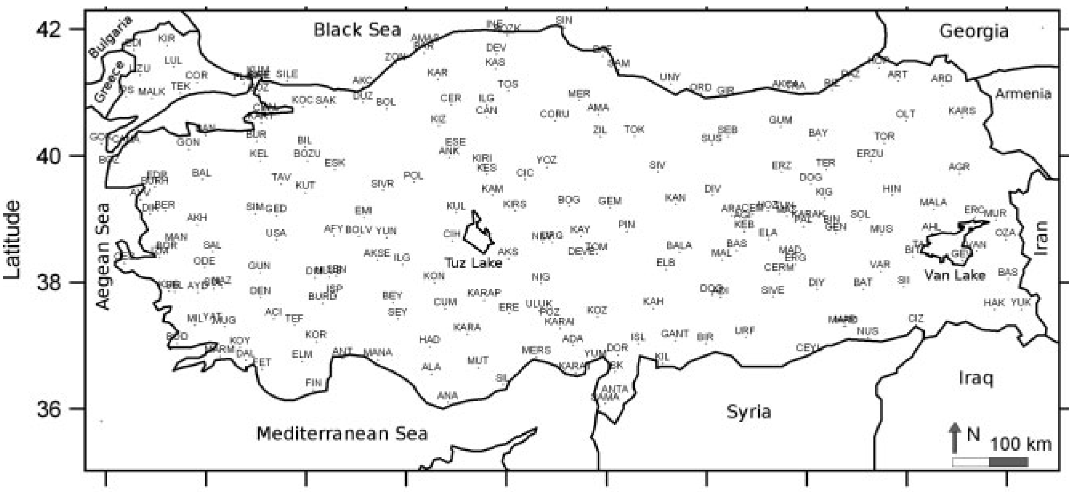

Figure 1. The locations of the meteorological stations over Turkey.

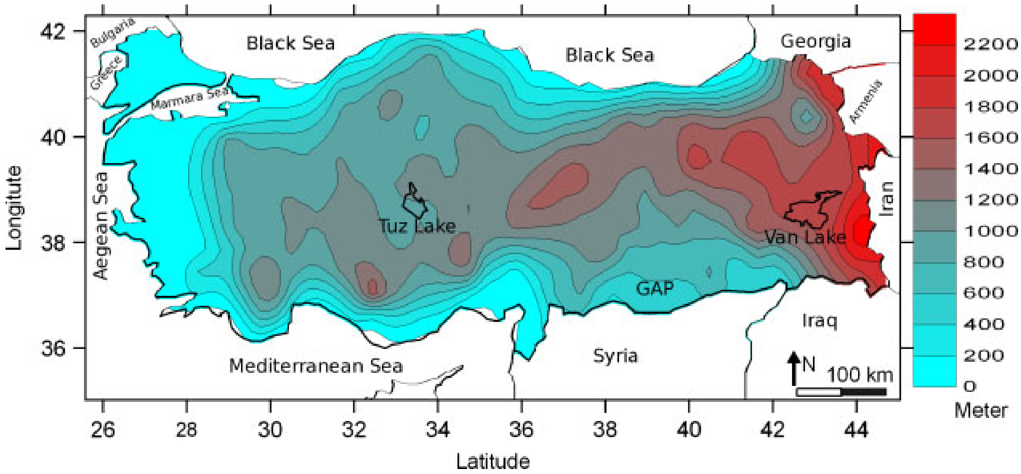

Figure 2. Topography of the study area. This figure is available in colour online at wileyonlinelibrary.com/journal/joc

In winter, it is under the influence of the polar front, cold air masses from Balkan Peninsula and the lowest pressure area centered in Mediterranean with frontal passages towards east. In summer, the polar front is shifted to more northerly latitudes, and consequently weak frontal passages and maritime effects are dominant. Furthermore, anticyclonic pressure patterns are also important for Turkey's climate such as Azores high-pressure system in summer and Siberian anticyclone during winters. Generally these patterns cause below normal precipitation over the country. According to several analyses, a large part of the Anatolia usually has dry sub-humid conditions (Türkeş, 1999; Kadıoğlu, 2000). Türkeş (1999) explained the semi-arid and dry sub-humid environmental conditions over the continental interiors and southeastern Anatolia. He showed that dry conditions could be associated generally with the persistence of drought-favouring anticyclonic weather types over the central and eastern Mediterrenean Basin. The annual mean temperature in Turkey varies from 3.6 °C to 20.1 °C, depending on location and elevation. Temperature normally reaches a maximum in July and a minimum in January.

About half of Turkey is classified as having a continental climate, with peak precipitation occurring in late spring or early summer, whereas the west and southern parts have Mediterranean climate with both winter and late spring precipitation peaks (Şensoy *et al.*, 2008). Figure 3 presents the annual average rainfall distribution. Turkey is not a rich country in terms of precipitation. The annual average rainfall in the country is around 648 mm with an annual variation ranging from 295 to 2220 mm in 229 stations. The precipitation occurs mostly during the winter months.

There is high degree of spatial variability in rainfall amounts in the country. The mean annual precipitation increases with altitude in eastern Anatolia. Mean annual rainfall is between 295 and 770 mm for the central Anatolia, 321 and 1230 mm for the East Anatolia and 331 and 821 mm for the southeastern Anatolia. The average annual minimum rainfall amounts were minimum in central Anatolia (Karapınar-kara-, 1004 m asl) with 295 mm and in southeast Anatolia (Ceylanpınar-ceyl-, 398 m asl) with 331 mm. This leads to fragile crop yield problems in these regions. However, the eastern

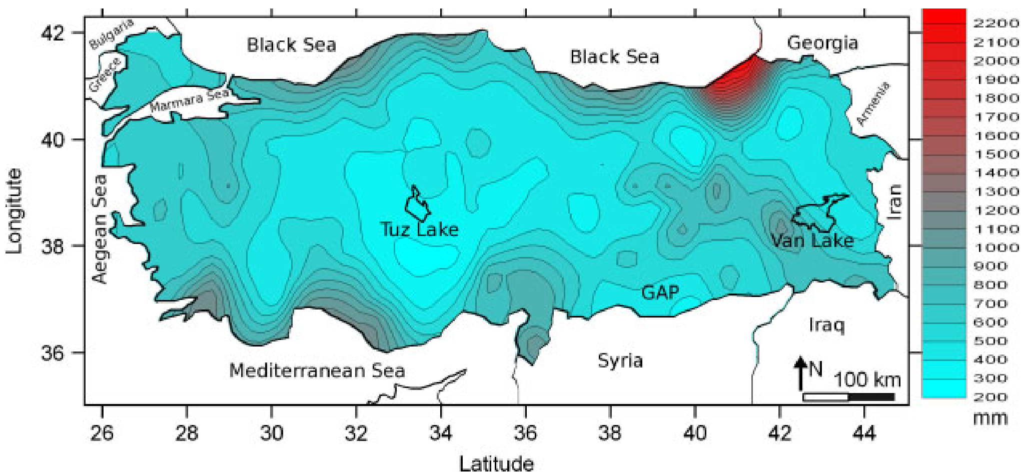

Figure 3. The mean total annual spatial precipitation (mm) of the study area. This figure is available in colour online at wileyonlinelibrary.com/journal/joc

Black Sea coastal areas in the northeast have a relatively wetter climate under influence of the North Anatolian Mountains, circulation patterns in the region, and local orography conditions. The average maximum annual rainfall amounts have been occurred over the Black Sea coasts with 1000 mm and reached to 2210 mm in Hopa (hop) region which is located at the eastern part of the coast. The eastern Black Sea Mountains reach to 3900 m and behave like lee mountains in the region. Therefore, the plateaus behind the mountains in the south receive much less rainfall than Hopa(hop) (The average ratio of the rainfall varied by 18–20%).

The understanding of atmospheric processes in Turkey and its different geographical regions is key point for research programs related to the behaviour of the temperature and precipitation regime. The average annual temperature distribution is shown in Figure 4. The average minimum temperatures appear in the plateaus of eastern Anatolia region due to the higher mountains which exceed 2500 m. The average maximum temperatures occur in the Southern parts of Anatolia and the Mediterranean coasts.

4. Application of the climate indices over Turkey

The climatic indices are used to determine the climatic classification of the regions. The simple measures can also be used to determine the climatic conditions of a region. In this study, several indices of continentality, oceanity and aridity have been calculated and exhibited for Turkey based on climatological data for the period 1960–2006.

4.1. Continentality index

The continentality is a function of location within a continent. It is mainly the result of the increased diurnal range of temperatures that occur over land. Continental air originates over land, typically remote from ocean or marine influence, and usually has drier conditions with low humidity. Continental locations typically have greater diurnal changes in winter and summer. The continentality index is a simple but efficient way to estimate the influence of the continentality on the local climate. The index is calculated from several formulas such as Gorczynski (1920), Johansson (1931). One of the widely used formulas is given below. The index is known as the Gorczynski or the JC index (Gorczynski 1920; Flocas, 1994; Chronopoulo-Sereli, 1996 and Baltas, 2007). In this study we used the JC index as follows:

$$k = \frac{1.7\ \Delta T}{\sin f} - 20.4 \qquad (1)$$

where k is the JC index, ΔT is the annual range of monthly mean air temperatures, in °C, (difference between the maximum and minimum monthly mean air temperatures) and f is the latitude of the stations. The index of k with 100 indicates the most continental and low values of continentality indicate high marine influence. Continentality using the JC equation was calculated for 229 meteorological stations in Turkey for the 1960–2006 periods. The climate is characterized as marine when k varies between 0 and 33, as continental when k varies between 34 and 66, and exceptionally continental when k varies between 67 and 100. The continentality isopleths were shown in Figure 5 as the spatial variation of the JC index in Turkey. The trend of the isopleths is nearly parallel to the coasts of the Black Sea, Aegean Sea and the Mediterranean. A high marine influence extends all along the Black Sea coasts. This illustrates the great reach of the Black Sea influence. Furthermore relatively high marine influence can be seen in Marmara region. The highest and lowest values continentality indices are given in Table I.

The eastern part of the Anatolia exhibits larger values of the continentality than the other regions of the country. The mean value of the continentality index for the 229 stations for the 47-year period is 42.6. According to JC index values, the highest and lowest continentality effects have been found in Mus (mus) region with 71.5, Bozcaada (Boz) Island with 22.1, respectively. It is

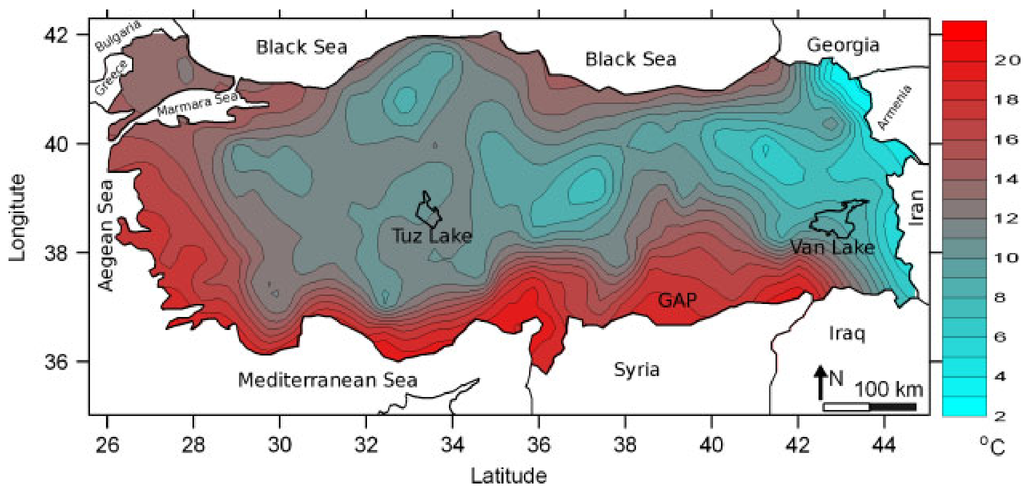

Figure 4. The average annual air temperature (°C) of the study area. This figure is available in colour online at wileyonlinelibrary.com/journal/joc

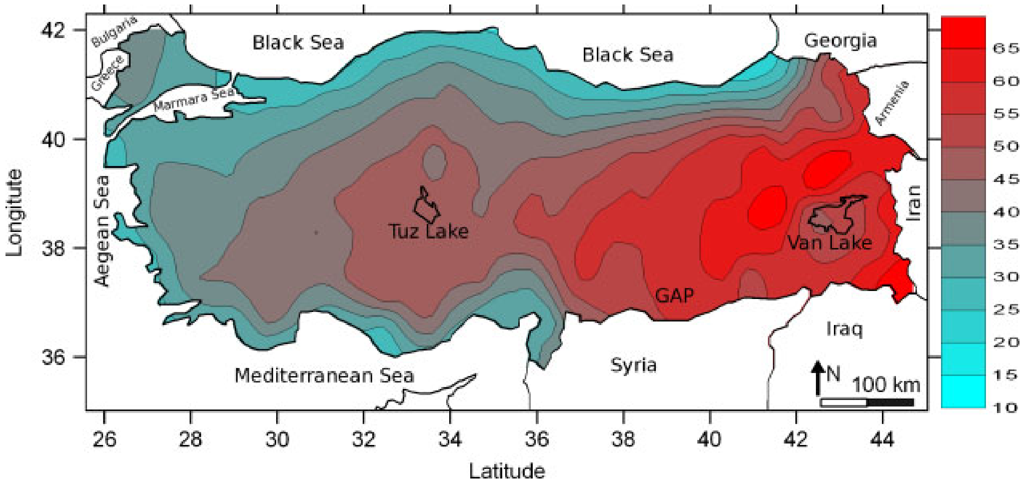

Figure 5. Isopleths of equal continentality for Turkey using JC index. This figure is available in colour online at wileyonlinelibrary.com/journal/joc

Table I. The stations having maximum and minimum continentality indices.

Max continentality					Min continentality				
Stations	Longitude	Latitude	Elevation	k	Stations	Longitude	Latitude	Elevation	k
Mus	42	39	1320	71.5	**Unye (uny)**	37.28	41.13	20	23.6
Malazgirt (mala)	43	39	1565	70.6	**Hopa (hop) Amasra**	41.40	41.30	33	22.9
Agri (agr)	43	40	1632	69.9	**(amas)**	32.38	41.75	73	22.8
Yuksekova (yuk)	44	38	1900	68.0	**Pazar(paz)**	40.88	41.18	79	22.7
Genc(gen)	41	39	1250	64.2	**Bozcaada(boz)**	26.07	39.83	28	22.1

clearly seen that the continentality effect is decreased in and around the lake areas, e.g. Tuz Lake in the central Anatolia; Van Lake in the eastern Anatolia and south-eastern Anatolia Integrated Project (GAP) region which comprises 22 dams, 19 hydroelectric power plants and irrigation schemes on the eastern part of the Anatolia. The status having the maximum continentality and maritime effect by JC index is presented in Table I.

4.2. Oceanity index

Oceanity is the climatic influence caused by the temperature retention (heat capacity) and humidity of oceans. Maritime air masses form above wide water surfaces and therefore contain a great deal of moisture. An oceanic climate represents the more humid and less extreme temperature fluctuations. Winters are usually mild and summers warm. There are several oceanity indices indicating the thermal continentality. In one of them, ocean effects have been proposed by Kerner with index of oceanity in the beginning of 20th century (Kerner, 1905). Kerner was motivated by the fact that in marine climates the spring months are colder than the autumn months, and formed the thermoisodynamic fraction (Retuerto and Carballeira, 1992; Gavilan, 2005; Baltas, 2007):

$$k_1 = \frac{100(T_o - T_a)}{\Delta T} \quad (2)$$

where T_o and T_a are the October and April mean values of air temperatures, respectively. October (April) are generally the transition months from dry (wet) to wet (dry) climates in Turkey. ΔT is the annual range of monthly mean air temperatures (in °C). Small or negative values of k_1 imply a continental climate, whereas larger ones imply an oceanic climate (Zambakas, 1992).

More specifically, in the present study, when the Kerner Oceanity is higher than 10, the climate is characterized as an oceanic. The spatial variation of the KOI values is shown in Figure 6. It shows the values of the KOI within the range of 1.9–31.1. The spatial distribution of the KOI values presents the similar behaviours to the Johansson Index. Relationships between the Kerner and JC indexes were examined. The lowest index values which correspond to the higher continent climate were found at inner regions with 99 of 229 stations.

4.3. De Martonne Aridity Index

Aridity is a lack of moisture. It is also a cumulative result of the absence of effective rainfall. An areal study of aridity needs index. Aridity index is a result of the interactions of several parameters providing a simple way to describe the ratio of precipitation to evaporation and it is useful for assessing areas sensitive to desertification processes. As evaporation is rarely observed, rainfall and temperature play an important role on the aridity index. Shortly, an aridity index is defined as the numerical indicator of the degree of dryness of the climate at a given location and it classifies the type of climate in relation to water availability. The higher the aridity indices of

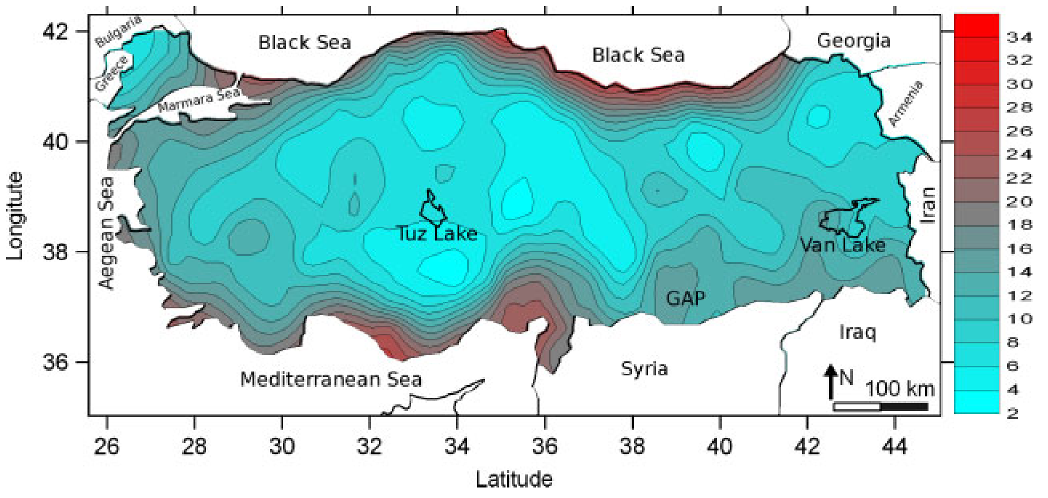

Figure 6. The Kerner Oceanity Index for Turkey. This figure is available in colour online at wileyonlinelibrary.com/journal/joc

a region, the greater water resources variability. The increasing aridity represents a higher frequency of dry years over an area.

A number of aridity indices have been used in the literature. De Martonne (DM) is one of the best known and widely used indices. De Martonne (1941) created a climatic classification based on the duration of the aridity over the period year. The De Martonne Aridity Index (I_{DM}) is defined as the ratio of the mean annual precipitation P in mm and annual mean temperature in °C +10. The I_{DM} index is given by Equation (3).

$$I_{DM} = P/(T + 10) \quad (3)$$

The DM aridity formula was determined for 229 meteorological stations in Turkey for 1960–2006 periods. The aridity isopleths are shown in Figure 7 as the spatial variation of the DM index. According to I_{DM} value, DM classified the climate into six types from dry ($I_{DM} < 10$) to very humid ($I_{DM} \geq 35$). Table II presents the I_{DM}, classification types, the corresponding number of stations and their ratios in Turkey. There exists no climatologically dry zone in Turkey. However, some parts in the central and southeastern of the country have an aridity index close to that of semi-dry–dry zones. From Table II based on the DM index, about 21% of the country was semi-dry, 19% was Mediterranean, 21% was semi-humid, 21% was humid and 19% was very humid. I_{DM} spatial distribution shows the semi-dry conditions in the central, southeastern and in some parts of continental highlands of northeastern Anatolia with a ratio of 21%.

The result of climate change associated with global warming, aridity is an increasing problem in many parts of the world, including southeastern Europe and Turkey. To understand in identifying possible signals of climate change, we computed the DM aridity index, I_{DM} for the 1960–1990 and 1991–2006 periods (Table III). In the second period, semi-dry areas are increasing from 22% to 24%. Furthermore, very humid areas are decreasing from 19 to 16%. I_{DM} values in eastern Anatolia are also decreasing having with more continentality. The only Mediterranean climate type is increasing by 2%. Spatial distribution of I_{DM} differences calculated using

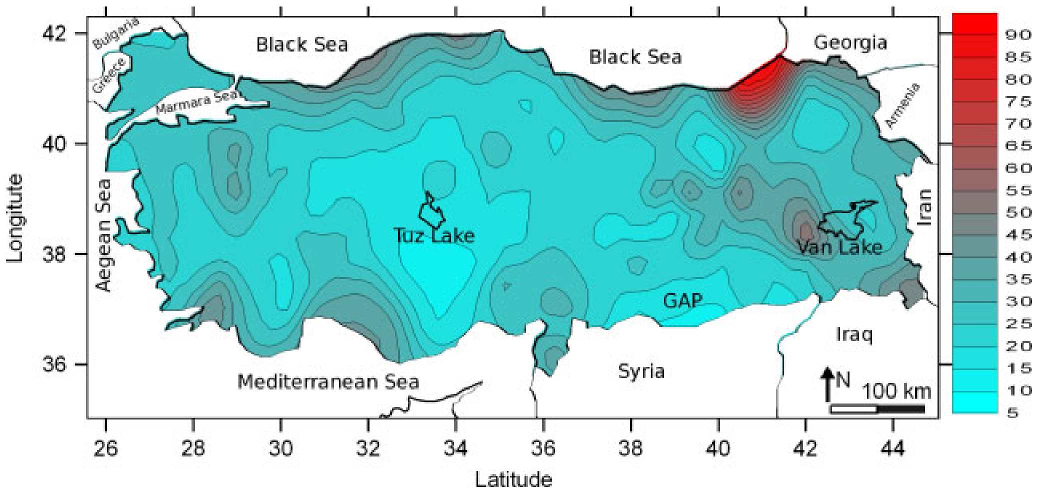

Figure 7. The isopleths of equal aridity for Turkey using De Martonne Aridity Index formula. This figure is available in colour online at wileyonlinelibrary.com/journal/joc

Table II. De **Martonne** Index climatic classification (De **Martonne**, 1941).

	Values of I_{DM}			Values of P (mm)			Both of I_{DM} and P	
Climate	I_{DM}	Freq. of I_{DM}	Ratio of I_{DM} (%)	Precipitation (mm)	Frequency of P	Ratio of P	Frequency	Ratio (%)
Dry	$I_{DM} < 10$	0	0	$P < 200$	0	0	0	00
Semi-dry	$10 \leq I_{DM} < 20$	48	21	$200 \leq P < 400$	32	14	28	12
Mediterranean	$20 \leq I_{DM} < 24$	44	19	$400 \leq P < 500$	52	23	21	09
Semi-humid	$24 \leq I_{DM} < 28$	47	21	$500 \leq P < 600$	34	15	10	04
Humid	$28 \leq I_{DM} < 35$	47	21	$600 \leq P < 700$	34	15	10	04
Very humid	$I_{DM} \geq 35$	43	19	$P \geq 700$	77	34	40	17

Table III. De Martonne Index climatic classification for 1960–1990 and 1991–2006.

		1960–1990		1991–2006	
Climate	I_{DM}	Frequency of I_{DM}	Ratio of I_{DM} (%)	**Frequency** of I_{DM}	Ratio of I_{DM} (%)
Dry	$I_{DM} < 10$	0	0	0	0
Semi-dry	$10 \leq I_{DM} < 20$	50	22	56	24
Mediterranean	$20 \leq I_{DM} < 24$	47	21	50	22
Semi-humid	$24 \leq I_{DM} < 28$	44	19	37	16
Humid	$28 \leq I_{DM} < 35$	45	20	45	20
Very humid	$I_{DM} \geq 35$	43	19	41	18

Equation (4) are shown in Figure 8.

$$\%\ I_{DM} = \{[I_{DM}(1991\text{–}2006) - I_{DM}\ (1960\text{–}1990)] / [I_{DM}(1960\text{–}1990)]\} \quad (4)$$

Additionally, as can be seen from Figures 3 and 7, the aridity isopleths as the spatial variation of the DM index follows the mean annual precipitation distribution in Turkey. The patterns of the semi-dry locations cover the 400 mm and less precipitation locations.

The results indicate a risk of aridity spreading. Water management system for agriculture in these regions should be improved. The increasing aridity represents a higher frequency of dry years over larger areas in central Anatolia and southeastern Anatolia.

4.4. Pinna Combinative Index

Pinna developed the combination index Ip (Zambakas, 1992; Baltas, 2007):

$$I_P = \frac{1}{2}\left(I_{DM} + \frac{12P'_d}{T'_d + 10}\right) \quad (5)$$

where P and T are the annual mean values of precipitation and air temperature and $P_d{}'$, $T_d{}'$ are the mean values of precipitation and air temperature of the driest month.

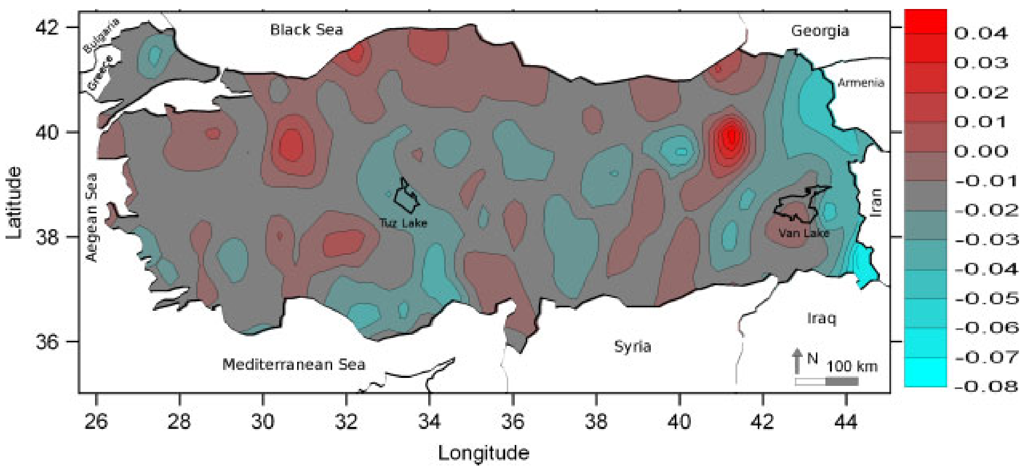

Figure 8. Variation of I_{DM} differences for the 1991–2006 and 1961–1990 periods. This figure is available in colour online at wileyonlinelibrary.com/journal/joc

This index describes in a better way the regions and seasons, where irrigation is necessary as it takes into account the precipitation and air temperature of the driest month.

When the value of the I_p is less than 10 ($I_p < 10$), the climate is characterized as dry and when the value of I_p varies between 10 and 20 ($10 \le I_p \le 20$) the climate is considered as semi-dry, Mediterranean vegetation. The spatial variation of the Pinna Combinative (PV) Index values is shown in Figure 9.

The DM Aridity and the PV indices were compared, and Figure 10 shows the correlations between them. A high correlation coefficient was found verifying the similar distribution of the two indices ($r^2 = 0.89$). Evaluating the results of the aridity–humidity indices of the DM and the Pinna, the DM index is more appropriate for the study area, as it defines more precisely the climate of each station. Its classification consists of six climate categories, ranging from dry to very humid, instead of just two categories of the Pinna Index.

4.5. Statistical summary of the indices values

Table IV presents the statistical summary of the JC, KOI, DM and PC indices. Average annual DM index is 28.1. This indicates a semi-humid and humid condition. The maximum and minimum values of both DM and Pinna indices were found in same locations. The wettest region of the country is Rize. This region was obtained and presented by the two DM and Pinna indices. Furthermore, Ceylanpınar which is located at southeastern region represented by the minimum values of the DM and the Pinna indices.

5. Conclusions

The goal of this study is to approach a regional climatic characterization using regional climate indices. For this purpose, an analysis of continentality, oceanity and aridity is presented using climate indices over Turkey based on temperature and precipitation data from 229

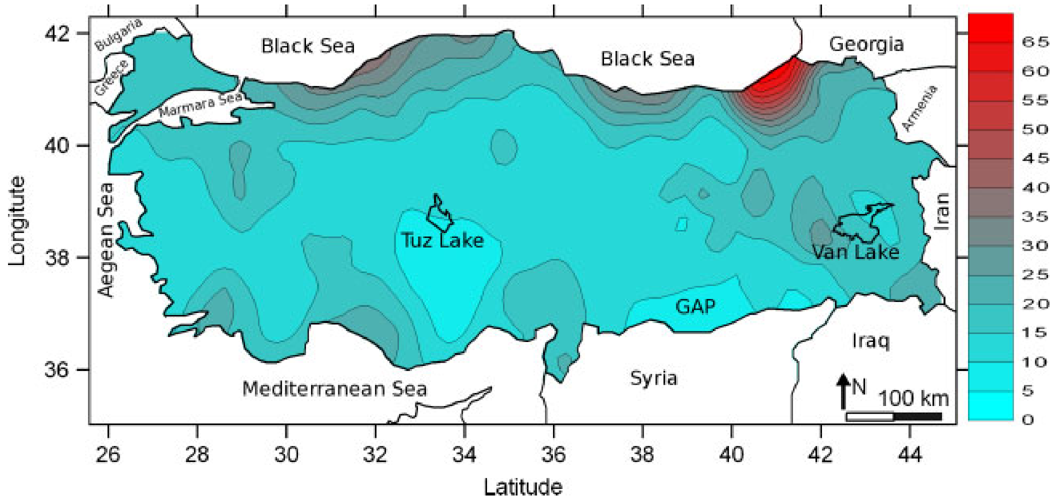

Figure 9. Pinna Combinative Index in the study area. This figure is available in colour online at wileyonlinelibrary.com/journal/joc

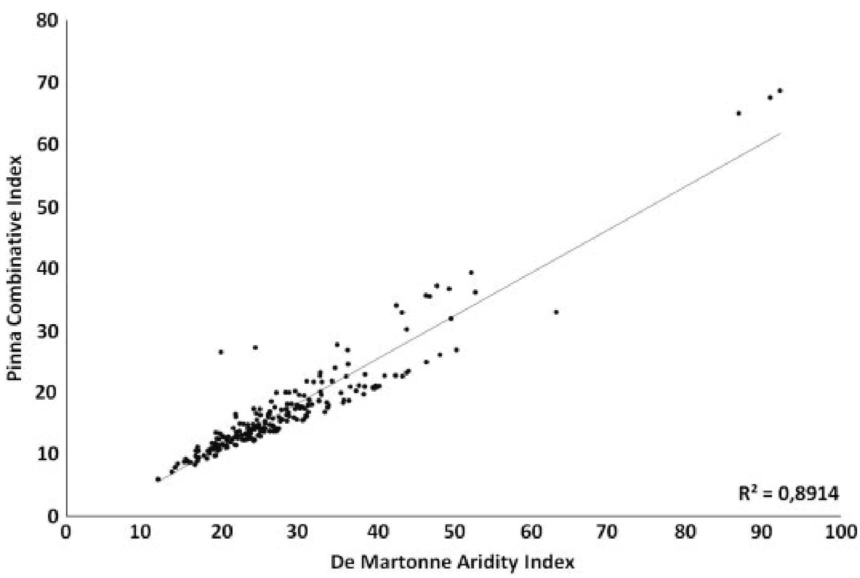

Figure 10. Statistical analysis between the De Martonne and Pinna indices.

Table IV. The statistical summary of the indices examined in the study.

	Johansson Continentality Index	Kerner Oceanity Index	De Martonne Aridity Index	Pinna Combinative Index
Mean	42.6	12.4	28.1	17.0
Maximum	71.5	31.1	92.2	68.7
	(Mus-mus-)	(Sinop-sin-)	(Rize-riz-)	(Rize-riz-)
Minimum	22.1	1.9	11.8	6.0
	(Bozcaada-boz-)	(Eregli-ere-)	(Ceylanpinar-ceyl-)	(Ceylanpinar-ceyl-)
Standard Deviation	11.6	6.2	11.3	8.4

stations for 47 years (1960–2006). Some conclusions can be drawn from the present analysis.

Increasing aridity represents a higher frequency of dry years over larger areas. With global warming, an increase in aridity implies that drought would persist in critical agricultural regions in central and southeastern Anatolia. According to the IPCC Fourth Assessment Report, the smallest increase in precipitation and the largest increase in temperature, and therefore an increase in the area of sub-humid climate and a significant increase in the area of semi-humid climate. Furthermore, increasing evaporation towards the interior of the southeastern and central of Turkey reduces the percentage of the already low rainfall.

The results show that the climate of Turkey is highly variable as well as the semi-dry, Mediterranean, semi-humid, and humid with about 20% each. For the country as a whole, there is no dry zone (defined as $I_{DM} < 10$). Most of central Anatolia and a part of the East and Southeast of Turkey have experienced semi-dry periods, whereas the northeast Black Sea coastal areas have a relatively wetter climate. Deforestation in these regions might be the cause of a gradual declination of rainfall and inclination of temperature, and consequently increase of aridity of the regions.

The JC index gives reasonable results for Turkey. The continentality effect was found in 58 stations of 229. This corresponds to 25% of the country. The index values were found to be between 0 and 33 over the coastal areas; 34 and 72 over the whole inner continental regions. According to the index, the highest and lowest continentality effects have been found in Mus (mus)region (southeastern Anatolia) with 71.5, Bozcaada (boz)Island (on the Aegean coast) with 22.1, respectively. According to World Climate Index, Nigde(nig) in central Anatolia and Rize (riz) in the eastern Black Sea coasts are the driest and wettest locations respectively. As expected, the continentality effects are increased by the distance from coastal areas. The continentality effect is a maximum in eastern region of Turkey. It is clearly seen that the continentaility effect reduced by the large salt lake, Tuz Lake (in central Anatolia), Van Lake (in eastern Anatolia) and GAP (in southeastern Anatolia Greater Dams Project) regions. The oceanity effect seen along the Black Sea coasts are greater than the Aegean and the Mediterranean coasts. This may be attributed to the general synoptic patterns over Turkey. There is a significant correlation between the Johansson and the Kerner indices. Furthermore, in spite of an acceptable difference between distribution of the temperature patterns with the Kerner Index variations, due to the only April and October data used, indices do not support the seasonal patterns. Furthermore, a significant correlation was found between the DM and Pinna indices (the correlation coefficient is 0.91). Additionally, coastal areas present the humid and semi-humid climate. In these areas, annual precipitation varied between 200 and 400 mm. According to the PV index, 9% of the total stations in the country were found under the drought limits. The extreme locations which were found using the DM aridity index were also addressed by the PV index. There is full agreement on the spatial classification between the two indices. A significant relationship was found between the results for both indices.

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