The Twenty-First Annual Conference

PACON 2008

Energy and Climate Change
Innovative Approaches to Solving Today's Problems

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Ala Moana Hotel
Honolulu, Hawaii, USA
June 1-5, 2008

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2008 THEME SESSIONS
"Energy" and "Climate Change."

TECHNICAL SESSIONS
As the theme *Energy and Climate Change* suggests, the list of Technical Sessions is a comprehensive program to include (subject to change):

Adaptation to Climate Change
Aquaculture and Mariculture Technology
Climate Change
Coastal Hazards
Coastal Environment
Coastal Sediment Processes
Coastal Structures
Coastal Water Level Fluctuations
Coral Reef Science
Education in Marine Science and Technology
Environmental Finance
Fisheries Technology
Hydrodynamics of Coastal Waters
Marine Biotechnology
Mitigation of Climate Change
Ocean Observing Systems
Operational Experiences in Environmental Monitoring
Remote Sensing and Oceanographic Satellites
Renewable Energy
Sustainable Coastal Development
Traditional Energy Sources and Their Impact

The Pacific Congress on Marine Science and Technology

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PACON 2008: *Energy & Climate Change* on June 1-5, 2008 TECHNICAL PROGRAM

THEME SESSION ON CLIMATE CHANGE (C)

Chair: Lorenz Magaard (USA) Co-Chair: James Marsh (USA)
Tuesday, 3 June 2008
3:00 p.m. – 5:00 p.m.
Garden Lanai Room

The Catastrophe Archetype Structure that causes Global Warming
Maximilian Mrotzek, Guenther Ossimitz
Department of Mathematics, University of Klagenfurt, Klagenfurt, Austria

Continentality and Oceanity Indices in Turkey
Hüseyin Toros, Ali Deniz, Selahattin Incecik
Department of Meteorology, Istanbul Technical University, Maslak Istanbul, Turkey

The Impact of Over-Development and the Need to Achieve Sustainable Urban Forms
Hassan Al-Nakhli
Dammam, Eastern Province, Saudi Arabia

Natural Hazards, Key Human Capital, and Innovation
James B. Marsh
Shidler College of Business, University of Hawaii, Honolulu, Hawaii, USA

CONTINENTALITY AND OCEANITY INDICES IN TURKEY

Hüseyin Toros, Ali Deniz and Selahattin Incecik
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ABSTRACT

Continentality and oceanity are important concepts in climate researches. This study focuses on the Johansson continentality index and Kerner oceanity index for Turkey. This type of indices is useful tools to determine synoptic classification of any region. The climate of Turkey varies greatly from region to region. Central Anatolia is under the influence of a steppe climate with arid conditions while Eastern Black Sea coastal areas in the northeast have a relatively wetter climate.

In this study the climatic indices were calculated over Turkey by using annual range of monthly mean air temperatures for the period 1960-2006 at 232 stations. According to Kerner Oceanity Index, marine climates characteristics were dominant in the Black Sea region than its Aegean and Mediterranean region. Besides, Johansson Continentality Index which is used for the climatic classification between continental and oceanic climates indicated that the maximum continentality with 72 have been found in the Eastern Anatolia. Correlations between the values of Johansson Continentality Index and Kerner Oceanity Index are compared. This research may be benefit for agriculture and energy scenarios for the region.

Keywords: Climate indices, Continentality, Oceanity, Turkey.

1. INTRODUCTION

Turkey has many climate regions, complex topography, and microclimates. Indices are diagnostic tools used to describe the state of a climate system and understand the various climate mechanisms. Therefore, spatial distribution of various climatic indices determines the climatic conditions of a region. Many recent studies are based on indices derived from temperature and precipitation data. The studies on climate indices have been proved very useful for the forecasting of agricultural production (Dalezios and Zarpas, 1996; Dalezios et al., 2000). Temperature and precipitation time series are important in the climatological studies (Rosenberg et al., 1983; Charles-Edwards, 1984). Walter (1955); Gausen (1956); and Bagnouls and Gausen (1957) proposed the temperature and precipitation as best bilateral parameters in determination of the climate parameters. Generally, climate indices are derived from temperature and precipitation measurements. Temperature and precipitation data are climate indicators, and the sense of changes expected to accompany global warming are reasonably well defined. Also records of temperature and precipitation are often longer and probably have a better chance of revealing a detectable change than alternative climate variables such as cloud cover, winds, and humidity (Hansen et al., 1998).

Conventional readily-available climatological databases generally archive time series of monthly averages or totals (Hulme, 1994; Jones, 1994; Peterson and Vose, 1997 and New et al., 1998). Recent improvements have extended the archives from monthly mean temperatures, sea level pressures and total precipitation to include monthly mean maximum and minimum temperatures (Jones et al., 1999). Recently some climatic variabilities in Turkey were analyzed (Türkeş et al., 1996a; Türkeş et al., 2002a and Türkeş et al., 2002b).

In this study, we focused on the spatial variation of climate indices which were used in determining of the climate structure of a region. The climatic indices used in this study were calculated are the Johansson Continentality Index and the Kerner Oceanity index belonging to the category of continental-oceanic indices (Baltas, 2007). Johansson Continentality Index and Kerner Oceanity Index (Baltas, 2007) were calculated over Turkey by using monthly temperature and precipitation data. The indices were compared with the topographical effects on the temperature and precipitation in Turkey.

2. DATA AND STUDY AREA

In this study, monthly temperature and precipitation data for 232 stations across the Turkey were used to calculate the indices. The period of used slightly varied by station however it is generally covered 1960-2006. The monthly temperature and precipitation data were provided from Turkish State Meteorological Service (TSMS). Fig 1 shows the meteorological stations. Homogeneity has been assessed. Time series of the temperature and precipitation data in each station were tested.

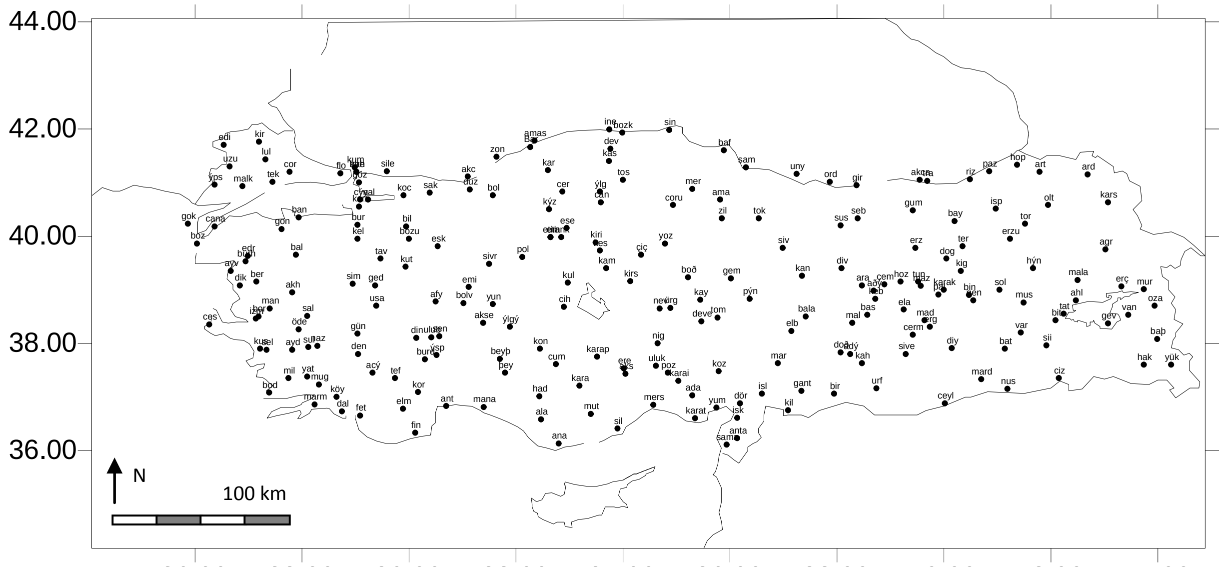

Fig. 1: The locations of the meteorological stations over Turkey.

Turkey is located in 36°- 42°N latitudes and, 26°-45°E longitudes. The country is surrounded by the Black Sea, Aegean Sea and Mediterranean Sea. The average altitude is 1130 m and gradually increases from central part to the east. A topographical map is given in Figure 2.

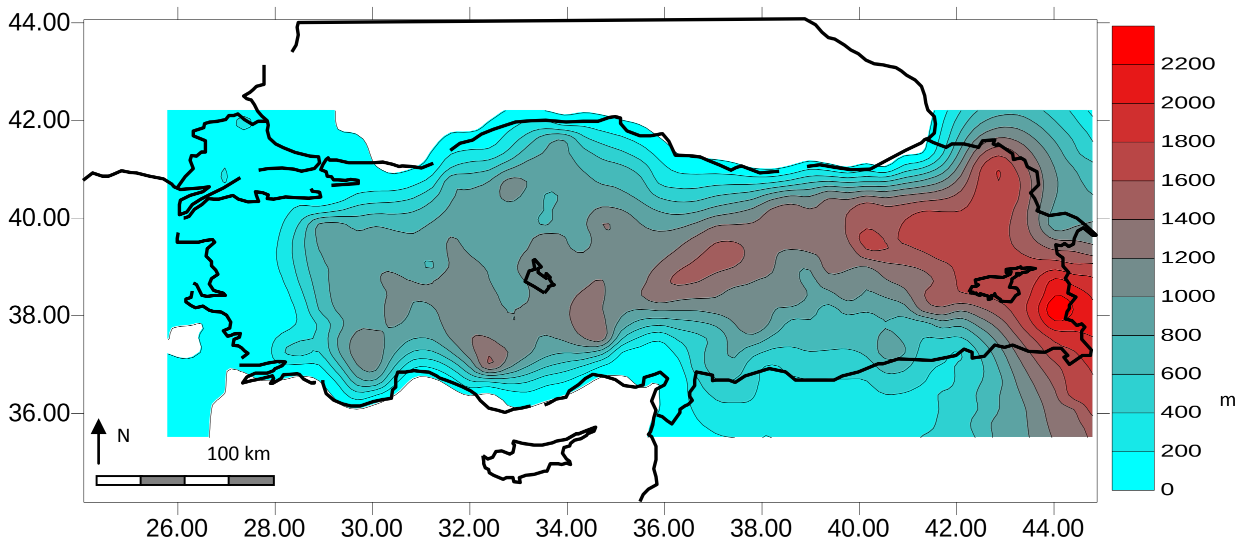

Figure 2: Topography of the study area (This figure is available in colour at

Turkey is situated over a transition region between polar and tropical air masses with Mediterranean climate characteristics in subtropical climate zone. Topographic effects associated with the mountainous terrain in particularly greatly complicate the variability. The general climate characteristics have been examined in the literature (Türkes, 1996a; Tayanç et al., 1997; Kadıoğlu, 2000; Karaca et al., 2000, Kömüşcü, 2001). The understanding of atmospheric processes in Turkey and its different geographical regions is key point for research programs related to behavior of the temperature and precipitation regime.

Figure 3 shows the average annual temperature distribution in Turkey for the period of 1960-2007. The annual average minimum and maximum temperatures has been observed in Ardahan (42.43 °E ; 41.07 °N) with 3.6 °C and Iskenderun (36.55 °N ; 36.10 °E) with 20.09 °C respectively. The average minimum temperatures appear in the Northeast Anatolia region. The average maximum temperatures occur in the south parts of Southern Anatolia and the Mediterranean coasts. The temperatures are generally gradually decreasing from South to North.

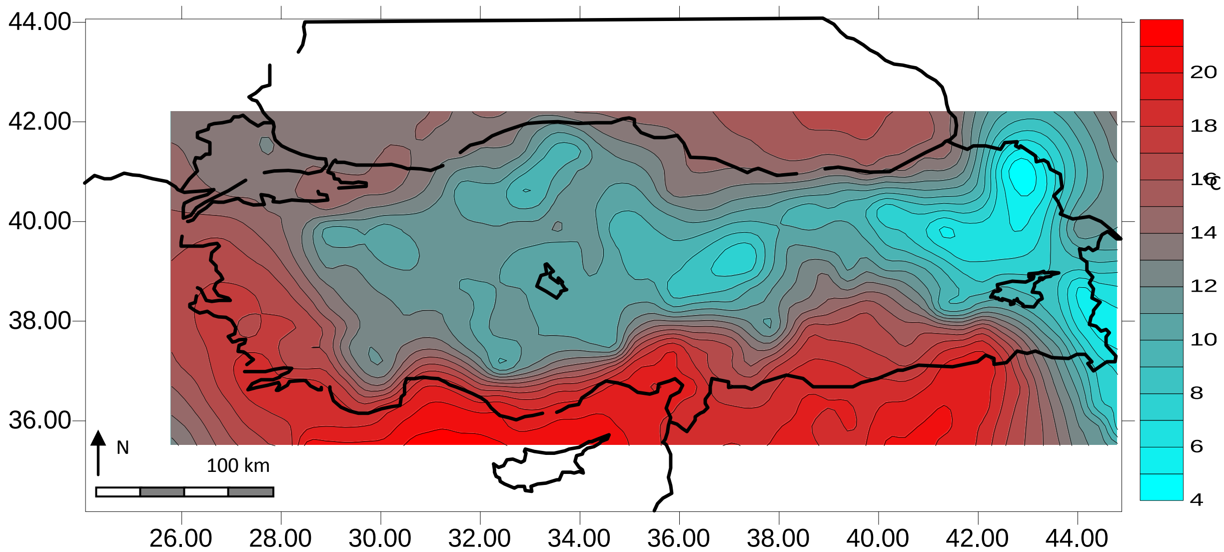

Figure 3: The average annual air temperature (°C) of the study area.

Figure 4 indicates the annual average rainfall distribution for 1960-2006. In Turkey there is significant variation in rainfall amounts due to the different topographical characteristics and different synoptic systems. The average annual minimum and maximum rainfall amounts are found in Konya-Karapınar (37.50 °N; 33.55 °E and 1044 m asl) region with 307 mm and in Rize (41.03 °N; 40.52 °E and 9 m asl) with 2220 mm. The climate in East of the Black Sea has a special importance. The average annual rainfall has been occurred over most of the region with 1000 mm and has been reached to 2400 mm in Rize-Hopa region. The climate is mild and average temperatures are around 4.0 °C in winter and 25.0 °C in summer. The average annual temperature is 14.0 °C. The inner part of the Turkey receives less rainfall according to coastal areas.

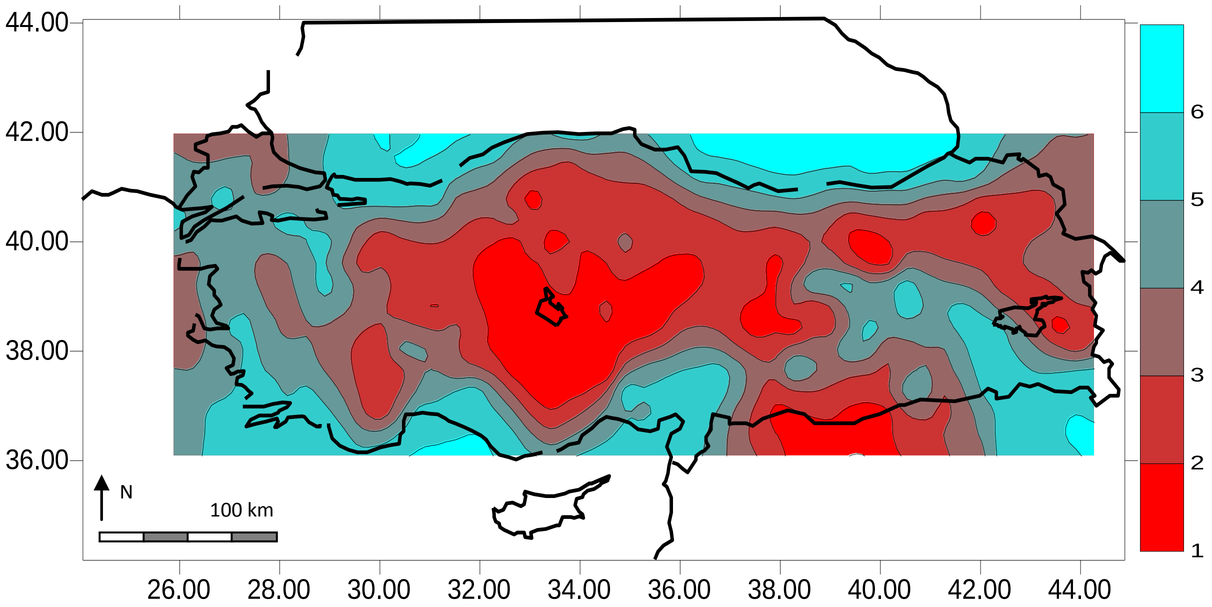

Figure 4: The mean total annual spatial precipitation (mm) of the study area.
(1 for P≤400mm, 2 for 400mm>P≤500mm, 3 for 500mm>P≤600mm, 4 for 600mm>P≤700mm)

3. JOHANSSON CONTINENTALITY INDEX

The Johansson Continentality Index is used for the climatic classification between continental and oceanic climates. The index is calculated by the following formula (Baltas, E., 2007; Flocas, 1994 and Chronopoulou-Sereli, 1996):

$$k = \frac{1.7E}{\sin f} - 20.4$$

where E 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 value of the annual difference of maximum and minimum air temperature is used to determine the continentality of the climate. There are many other methods to determine the index of continentality of a region, but the above formula is the most often used in many studies (Sjögersten and Wookey, 2004 and Filatov et al., 2005). 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 spatial variation of the Johansson Continentality Index map is shown in Fig. 5.

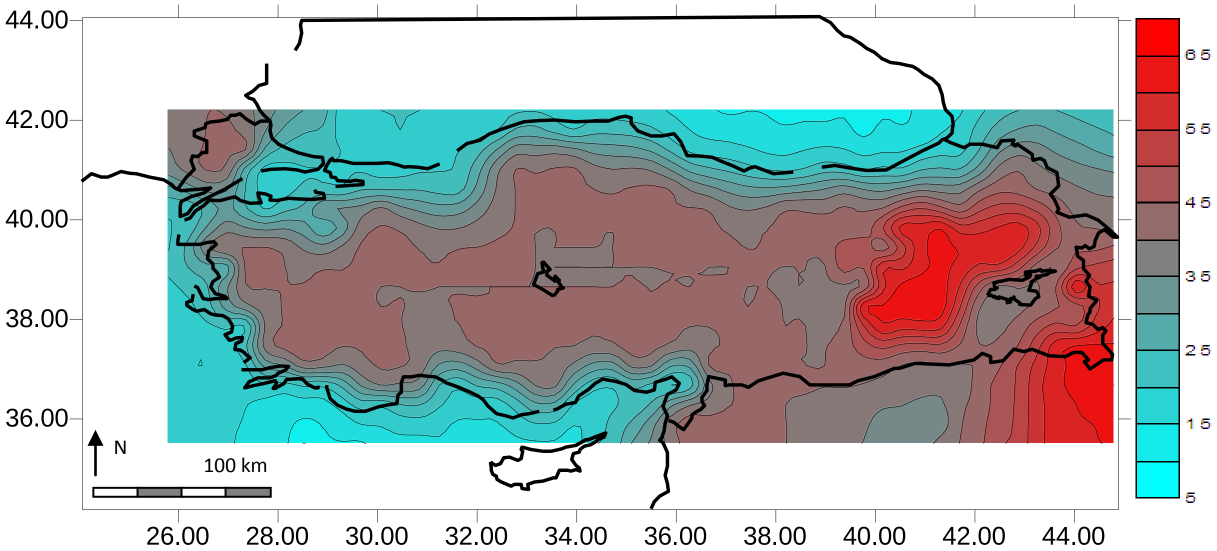

Figure 5: The Johansson Continentality Index for Turkey.

The meteorological stations which are highest effects of continentality and oceanity are given in Table 1.

Table 1: The stations which are affected by continentality and oceanity and their indices.

Continentality					Oceanality				
Stations	**Longitude**	**Latitude**	**Elevation**	**k**	**Stations**	**Longitude**	**Latitude**	**Elevation**	**k**
Mus	42	39	1320	72	**Unye**	37	41	20	24
Malazgirt	43	39	1565	71	**Hopa**	41	41	33	23
Agri	43	40	1632	70	**Amasra**	32	42	73	23
Yuksekova	44	38	1900	68	**Pazar (Rize)**	41	41	79	23
Genc	41	39	1250	64	**Bozcaada**	26	40	28	22

4. KERNER OCEANITY INDEX

Kerner motivated by the fact that in marine climates the spring months are colder than the autumn months, formed the thermoisodynamic fraction (Baltas, 2007; Retuerto and Carballeira, 1992 and Gavilan, 2005):

$$k_1 = \frac{100(T_o - T_a)}{E}$$

where T_o and T_a are the October and April mean values of air temperatures, respectively. E is the annual range of monthly mean air temperatures in °C. Small or negative values of k_1 imply a continental climate, while larger ones imply oceanity (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 Kerner Oceanity Index values is shown in Fig. 6.

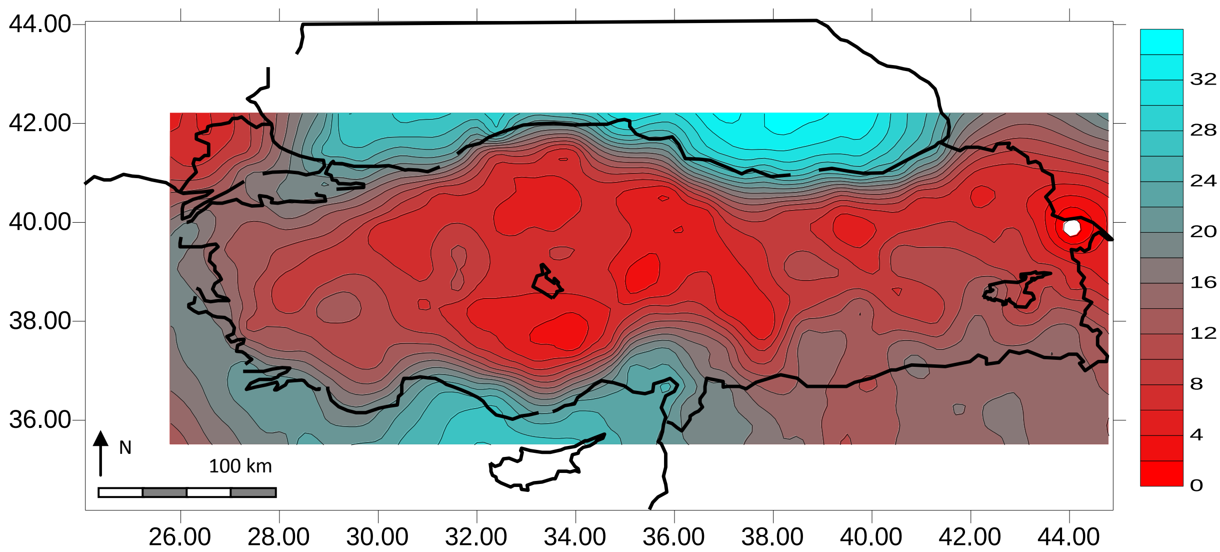

Figure 6: The Kerner Oceanity Index for Turkey.

Figure 6 shows the values of Kerner Oceaneaty index within the range of -2 and 32. Furthermore, spatial distribution of Kerner Oceanity Index exhibits similarities to the Johansson Index. The lowest index values which corresponding to the continent climate were found at inner regions.

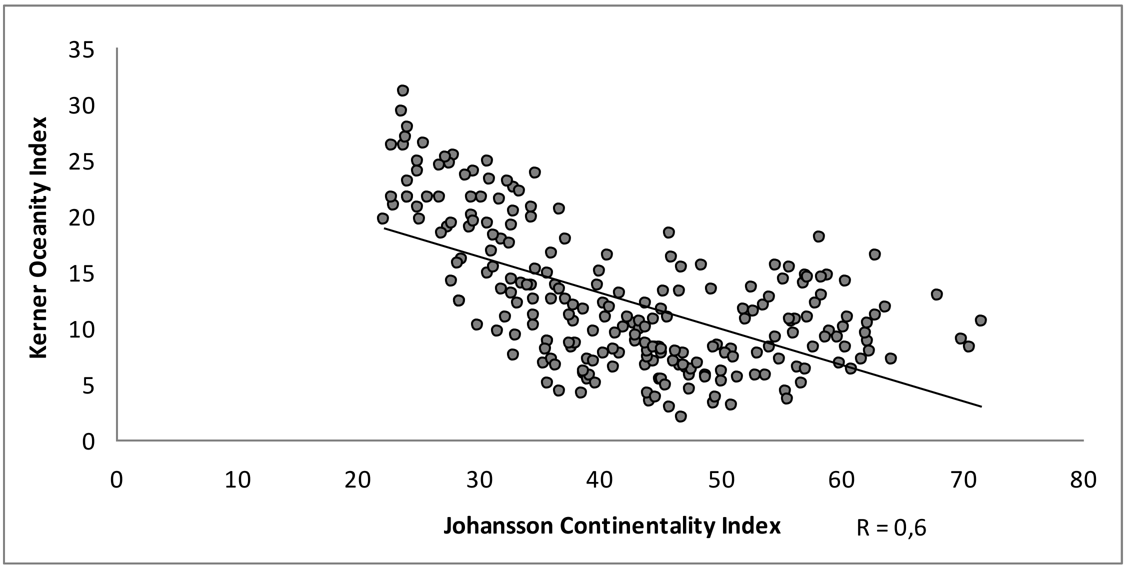

Figure 7: Statistical analysis between the indices of Johansson and Kerner. This figure is available in color online at www.bireygelisim.com/deniz/figures/hawaii/figure7.jpg

5. CONCLUSIONS

Johansson continentality index gives the reasonable results for Turkey. The index values are found in 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 Muş region with 72, Bozcaada with 22, respectively. The map of Johansson index and the average temperature distribution over Turkey has been compared in Figure 3. As expected that the continentality effect are increased by the distance from coastal areas. Especially, continentality effect is the maximum in eastern region of Turkey. It is clearly seen that continentaility effect reduced by the Salt Lake (Tuz Gölü), Van Lake and GAP regions.

Johansson index does not exhibit the seasonal continentality and marine effect due to the lower seasonal extreme temperatures comparing to annual differences.The continentality effect was found in 102 stations of 232. The oceanity effect seen in 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 Johansson ve Kerner indices. Furthermore, in spite of an acceptable difference between distribution of the temperature patterns with Kerner Index variations, due to the only April and October data used indices do not support the seasonal patterns.

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