The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)

Volume 1, Pages 366-371

ICONTES2017: International Conference on Technology, Engineering and Science

THE RELATION OF NORTH ATLANTIC OSCILLATION (NAO) AND NORTH SEA CASPIAN PATTERN (NCP) WITH CLIMATE VARIABLES IN MEDITERRANEAN REGION OF TURKEY

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Abstract: North Atlantic Oscillation (NAO) and North Sea Caspian Pattern (NCP) is two of the atmospheric circulations which are efficient on climate parameters. The purpose of this study is determining the effects of NAO and NCP on the temperature and precipitation regime of Mediterranean region in Turkey. In this regard, Pearson correlation coefficients were calculated between respective atmospheric indices (NAO, NCP) and climate variables (temperature, precipitation) as annual and seasonal. The correlation results were assessed according to Student's t-test. In this context, it was found that NAO is negatively correlated with temperature in summer, winter seasons and annual, in addition, NCP has remarkable negative correlation with temperature data especially in winter, autumn seasons and annual, as well. As for the linkage between precipitation and aforementioned atmospheric circulations, it was detected that NAO is correlated with autumn and winter precipitation negatively, whereas NCP has negative correlation with winter precipitation and positive correlation with summer precipitation in some parts of the region. As a result, NAO and NCP have remarkable influences on temperature and precipitation regime of Mediterranean region of Turkey for either seasonal or annual.

Keywords: Mediterranean region, North Atlantic Oscillation, North Sea Caspian Pattern, precipitation, temperature

Introduction

The effects of atmospheric global indices on climate parameters such as stream flow, temperature and precipitation have been researched for years (Chowdhury and Beecham 2010; Zhang et al. 2007; Durkee et al. 2008; Kahya 2011). Türkeş and Erlat (2003) investigate the linkage between North Atlantic Oscillation (NAO) and precipitation regime in Turkey. Brönnimann (2007) scrutinized the influences of El Niño-Southern Oscillation (ENSO) on climate variables in Europe. Küçük et al. (2009) determined the remarkable impacts of NAO on some of the lake levels in Turkey. Besides, Karabörk and Kahya (2003) revealed that extreme phases of SO have substantial effects on the rainfall regime in some parts of Anatolia. Furthermore, Türkeş and Erlat (2009) analyzed the relation between NAO and winter temperature data in general of Turkey. That is to say, there have been a lot of researches in the literature which tend to determine the liaison between global atmospheric indices, especially NAO and SO, and climate variables (Cullen and deMenocal, 2000; Moron and Plaut, 2003; Halpert and Ropelewski, 1992; Burt and Howden, 2013). Likewise, the impacts of North Sea Caspian Pattern (NCP) which is also one of the atmospheric teleconnections, on climate parameters have been surveyed in different regions (Ghasemi and Khalili, 2008; Iqbal et al., 2016; Kutiel et al., 2002). North Sea Caspian Pattern (NCP) is characterized between the grid points of North Sea and North Caspian at the level of 500 hPa by Kutiel and Benaroch (2002). Kutiel and Türkeş (2005) searched for the relation between NCP and temperature, precipitation in the some parts of Central Anatolia in Turkey. Göktürk (2005) examined the influences of NCP on the precipitation and stream flow data as monthly in greater part of Turkey. Sezen and Partal (2017) analyzed the relationship between NCP and temperature and precipitation regime of Aegean region in Turkey, as annual and seasonal.

- Selection and peer-review under responsibility of the Organizing Committee of the conference

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In this study, it is sought how NAO and NCP affects the temperature and precipitation variability in Mediterranean region of Turkey, as annual and seasonal. Within this framework, Pearson correlation coefficients were obtained between aforementioned atmospheric teleconnections (NAO, NCP) and climate parameters (temperature and precipitation). The results of correlation coefficients were analyzed by means of Student t-Test at the significance level of α=0.01, α=0.05 and α=0.1.

Methods

Data

The temperature and precipitation data which were used in this research, are provided by Turkish State Meteorological Service. Although there are some missing data in the few of stations, the data cover the period between 1960 and 2015, in general. Seven stations in Mediterranean region were chosen for analyzing and the location of the stations were shown in Figure 1. Statistical data which belong to temperature and precipitation of each station were also indicated in Table I and Table II., respectively. In addition, North Sea Caspian Pattern Index (NCPI) data were obtained from that website: https://crudata.uea.ac.uk/cru/data/ncp/ (Climatic Research Unit, University of East Anglia). Moreover, NAO index data were attained via that website: http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/norm.nao.monthly.b5001.current.ascii.table (Climate Prediction Center, National Weather Service, NOAA). In this study, NCPI data that cover the period of 1960-2005 and NAO data which cover the period of 1960-2015, were utilized.

Figure 1. Stations across mediterranean region

Table I. Statistical data of measured temperature in each station

Stations	Winter		Spring		Summer		Autumn		Annual	
	Mean Tem. (°C)	Std.Dev.(°C)	Mean Tem. (°C)	Std.Dev.(°C)	Mean Tem. (°C)	Std.Dev. (°C)	Mean Tem. (°C)	Std.Dev. (°C)	Mean Tem. (°C)	Std.Dev. (°C)
Isparta	2.7	1.4	10.8	0.9	22.3	1	13	0.9	12.2	0.7
Antalya	10.4	1	16.4	0.9	27.2	0.7	19.7	0.9	18.4	0.7
Mersin	11	1.3	17.6	1	27.2	0.9	20.9	1.3	19.2	1
Adana	10.5	1	17.7	0.8	27.4	0.6	21	0.8	19.2	0.5

İskenderun	12.7	1.1	18.6	0.7	27.4	0.7	22.3	0.9	20.2	0.6
Antakya	9.3	1.2	17.2	0.8	26.6	0.6	20.2	0.9	18.3	0.7
Kilis	6.7	1.3	15.5	1	27.1	0.8	19	1	17	0.7

Table II. Statistical data of measured precipitation in each station

Stations	Winter		Spring		Summer		Autumn		Annual	
	Mean Prep. (mm)	Std.Dev.(mm)	Mean Prep. (mm)	Std.Dev.(mm)	Mean Prep. (mm)	Std.Dev. (mm)	Mean Prep. (mm)	Std.Dev. (mm)	Mean Prep. (mm)	Std.Dev. (mm)
Isparta	222.5	98.1	162.4	56.3	56.5	35.4	100.2	53.6	541.6	127.8
Antalya	658.1	261.2	198.4	99.2	13.1	14.2	248.4	196.8	1118	309.5
Mersin	329.2	150.3	114.8	50.2	20.2	19.7	127.3	81.8	591.5	168.9
Adana	322.5	139.4	170	76.1	32.7	28.2	136.3	82.3	661.4	189.5
İskenderun	283.6	115.9	203.1	70.6	58.1	42.5	202.5	73.1	747.2	146.2
Antakya	528.8	189.2	339.4	160.4	36.7	51.6	218.9	97.4	1123.8	268.3
Kilis	243.5	81.3	143.9	69.5	10.9	18.7	95.9	48.5	494.1	126.1

Methodology

At first, Pearson correlation coefficients between aforesaid atmospheric teleconnections (NAO, NCP) and climate variables (temperature, precipitation) were determined by using equation (1) (Bayazıt and Oğuz, 2005).

$$r_{x,y} = \frac{\sum\left(x_i - \bar{x}\right)\left(y_i - \bar{y}\right)}{N s_x s_y} \quad (1)$$

In equation (1) x_i stands for the annual and seasonal climatic data (mean temperature, precipitation total) value which pertains to i.th year, $\bar{x}$ for the mean of climatic data, y_i for the annual and seasonal atmospheric teleconnection (NAO, NCPI), $\bar{y}$ for the mean of atmospheric teleconnection, N for the number of data, s_x for the standard deviation of the climatic data and s_y for the standard deviation of the atmospheric teleconnection.

After the calculation of correlation coefficients, the outcomes were appraised by taking Student t-Test into consideration at the significance level of α=0.01, α=0.05 and α=0.1.

Results and Findings

The Effects of NAO on Temperature and Precipitation Data

The correlation coefficients between NAO and temperature were shown in Table III, as annual and seasonal. According to Table III, it can be realized that the relation between NAO and temperature is strong during summer season at the significance level of α=0.01. Moreover, significant negative correlation coefficients were obtained between NAO and annual temperature particularly Isparta, Antalya, and İskenderun stations at α=0.01. In addition, NAO has also negative correlations with winter temperature data in some of the stations (Isparta, Antalya, İskenderun, Adana and Antakya) in the region at α=0.01 and α=0.05. As it can be seen Table III, as for the spring temperature data, it has negative correlations with spring NAO at α=0.1 and α=0.05 in general, whereas correlations were not significant during autumn season except İskenderun and Antakya stations.

Negative correlations between NAO and temperature data indicate that as NAO index increases, temperature value decreases.

Table III. Correlation coefficients between NAO and temperature data

	Annual	Winter	Spring	Summer	Autumn
Isparta	**-0.46**[c]	**-0.41**[c]	**-0.29**[b]	**-0.49**[c]	-0.19
Kilis	**-0.30**[b]	-0.2	-0.21	**-0.59**[c]	-0.17
Antalya	**-0.43**[c]	**-0.38**[c]	**-0.36**[b]	**-0.25**[a]	-0.08
Mersin	-0.15	0.02	-0.09	**-0.52**[c]	-0.22
Adana	**-0.26**[b]	**-0.31**[b]	**-0.23**[a]	**-0.47**[c]	-0.15
İskenderun	**-0.40**[c]	**-0.32**[b]	**-0.30**[b]	**-0.52**[c]	**-0.24**[a]
Antakya	**-0.32**[b]	**-0.31**[b]	**-0.23**[a]	**-0.55**[c]	**-0.22**[a]

[a] at the significance level of α=0.1
[b] at the significance level of α=0.05
[c] at the significance level of α=0.01

As to the linkage between NAO and precipitation as illustrated in Table IV, significant correlation coefficients were obtained in autumn season particularly in Antalya, Mersin, Adana and İskenderun stations. Besides, in winter season precipitation data of Isparta, Antalya and İskenderun stations are negatively correlated with NAO significantly. On the other hand, it was not acquired any remarkable correlations in both spring and summer seasons. As annual, only in Isparta and İskenderun stations, correlation coefficients are substantial at α=0.05. In similar with the connection between NAO and temperature, negative correlations indicate that if NAO index raises, precipitation values diminish.

Table IV. Correlation coefficients between NAO and precipitation data

	Annual	Winter	Spring	Summer	Autumn
Isparta	**-0.29**[b]	**-0.36**[c]	0	0.08	-0.08
Kilis	-0.07	-0.17	-0.11	0.09	-0.19
Antalya	-0.12	**-0.29**[b]	0.12	-0.1	**-0.32**[b]
Mersin	-0.04	-0.05	0.14	0.05	**-0.29**[b]
Adana	-0.02	-0.06	0.1	0.11	**-0.35**[c]
İskenderun	**-0.26**[b]	**-0.26**[b]	-0.13	0.18	**-0.29**[b]
Antakya	-0.15	-0.19	0	0.1	-0.17

[a] at the significance level of α=0.1
[b] at the significance level of α=0.05
[c] at the significance level of α=0.01

The Effects of NCP on Temperature and Precipitation Data

As it is seen in Table V, negative correlation coefficients between NCP and temperature data are very high as annual and seasonal, in general. In particular, in winter season correlation coefficients are highly and negatively significant at α=0.01. Likewise, remarkable correlations were also calculated in autumn season and as annual. Even though there were not obtained notable correlations in Mersin and İskenderun stations, temperature data of most stations in the region are correlated with NCP significantly in spring and summer seasons.

Table V. Correlation coefficients between NCP and temperature data

	Annual	Winter	Spring	Summer	Autumn
Isparta	**-0.45**[c]	**-0.70**[c]	**-0.33**[b]	**-0.33**[b]	**-0.34**[b]
Kilis	**-0.53**[c]	**-0.73**[c]	**-0.29**[b]	**-0.51**[c]	**-0.56**[c]
Antalya	**-0.35**[b]	**-0.59**[c]	**-0.27**[a]	-0.21	**-0.34**[b]
Mersin	**-0.27**[a]	**-0.55**[c]	-0.08	-0.2	**-0.42**[c]
Adana	**-0.55**[c]	**-0.73**[c]	**-0.31**[b]	**-0.39**[c]	**-0.57**[c]

İskenderun	**-0.43**[c]	**-0.73**[c]	-0.22	-0.22	**-0.5**[c]
Antakya	**-0.54**[c]	**-0.75**[c]	-0.24	**-0.36**[b]	**-0.54**[c]

[a] at the significance level of α=0.1
[b] at the significance level of α=0.05
[c] at the significance level of α=0.01

When the Table VI is taken into account, it can be seen that negative correlation coefficients were obtained for winter period and as annual, whereas during spring and summer season positive correlations were attained. Positive correlations mean that as NCP index has an increasing tendency, precipitation amount also inclines to raise, and for negative correlations the vice versa is valid.

Table VI. Correlation coefficients between NCP and precipitation data

	Annual	**Winter**	**Spring**	**Summer**	**Autumn**
Isparta	-0.14	**-0.28**[a]	0.22	**0.29**[b]	0.12
Kilis	-0.03	-0.17	0.09	0.13	0.08
Antalya	-0.12	-0.11	0.21	0.09	-0.17
Mersin	-0.07	-0.23	0.06	0.17	0.06
Adana	-0.04	-0.23	0.07	**0.26**[a]	-0.05
İskenderun	-0.15	**-0.29**[b]	0.17	0.16	-0.07
Antakya	-0.16	**-0.28**[a]	0.01	0.23	0.13

[a] at the significance level of α=0.1
[b] at the significance level of α=0.05
[c] at the significance level of α=0.01

Conclusion

The most significant correlations between NAO and temperature data were reckoned in summer season, whereas NCP and temperature data are negatively correlated in winter season, significantly. Generally, it was obtained that both atmospheric teleconnections are correlated with temperature data negatively as seasonal or annual. For this reason, it can be concluded that when the value of aforementioned teleconnection rises, the temperature value reduces. However, the pattern of the correlations between mentioned atmospheric indices (NAO, NCP) and precipitation is different as compared with the connection between atmospheric teleconnections and temperature data. According to the results, it can be noticed that particularly NCP has significant positive correlations with the precipitation data especially in summer season in some parts of the region. So, this means that quantity of precipitation goes up as NCP index rises. In addition, significant correlations between NAO and precipitation data were observed particularly in winter and autumn season. Furthermore, between NCP and precipitation data the substantial negative correlations were acquired in winter season in some parts of Mediterranean region.

Recommendations

The authors would like to convey their thanks to Turkish State Meteorological Service for temperature and precipitation data.

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