IJMSIT

International Journal of Multidisciplinary Studies and Innovative Technologies

Volume : 3
Number: 1
Year: 2019
Pages: 25-27

Investigation of the Effects of North Atlantic Oscillation and Arctic Oscillation on Samsun Precipitation

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Abstract – Global atmospheric indices are effective on many hydrometerological parameters. North Atlantic Oscillation and the Arctic Oscillation is one of oscillations that act on Turkey. In this study, the relationship between the annual and seasonal precipitation data obtained from the Bafra, Carsamba, Samsun, Ladik and Vezirkopru meteorological observation stations in the province of samsun was investigated. As a result of the research, significant correlations were determined between atmospheric indices and seasonal and annual total precipitation. A significant portion of the correlations obtained is seen as a negative correlation with winter precipitation. The precipitation formed under the influence of positive and negative phases of atmospheric indices was determined and it was determined that the precipitation formed by the negative phase was more than the positive phase.

Keywords – Precipitation, North Atlantic Oscillation, Arctic Oscillation, Correlation Analysis, Samsun

I. INTRODUCTION

Precipitation, one of the hydrometeorological parameters, has an important role in the planning and operation of water resources as well as being an effective element of life on earth. Changes and irregularities in precipitation characteristics, one of the consequences of global climate change, affect life and water resources around the world. Researchers investigating this effect are trying to determine the relationship between global atmospheric indices such as precipitation and current temperature. The main global atmospheric indices are the North Sea Caspian Pattern (NCP), North Atlantic Oscillation (NAO), Southern Oscillation (SO) and Arctic Oscillation (AO).

Turkey is among the countries most vulnerable to global warming. The irregular precipitation in our country has emerged as a result of these effects. Kutiel et al. [1] investigated the effect of NCP indices on precipitation and temperature values of atmospheric oscillations. Kutiel and Türkes [2] investigated the relationship between NCP and Central Anatolia temperature and precipitation. Gokturk [3] investigated the influence of Turkey on the NCP's data flow. Karabörk et al. [4] studied northern atlantic oscillation and southern oscillation with minimum maximum temperature, precipitation and flow data. Göktürk and Karaca [5] determined the effect of NCP on the basins affecting the GAP region. Türkeş and Erlat [6] determined the relationship between AO index and winter temperature values. Karabörk and Kahya [7] investigated the relationship between flow, temperature and precipitation parameters with southern oscillation. Sezen and Partal [8] investigated the effect of NCP index on precipitation and temperature values in Aegean region. In the studies investigating the effects of atmospheric indices on climate data, monthly, annual or seasonal precipitation, temperature or flow parameters are used. In this study which investigates the effects of two of the atmospheric oscillations, North Atlantic Oscillation (NAO) and Arctic Oscillation (AO), the precipitation values of 5 meteorological observation stations in Samsun province were investigated.

II. MATERIALS AND METHOD

A. Materials

In this study, the precipitation values of Bafra, Carsamba, Ladik, Samsun and Vezirkopru stations belonging to the general directorate of meteorology located in Samsun province between 1965-2013 were used. These precipitation values are arranged to indicate seasonal and annual total precipitation values. Statistical information on the data is given in table 1.

Table 1. Statistical Data of Stations

1965-2013	Summer		Winter		Spring		Automn		Annual Total	
	Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.
Bafra	128.2	73.1	246.5	62.1	167.2	53.9	251.5	90.7	793.4	128.3
Carsamba	158.0	71.1	273.8	77.9	203.7	61.2	320.1	158.1	955.5	227.9
Ladik	102.9	56.8	180.2	85.6	187.6	84.7	152.4	77.9	623.0	212.5
Samsun	125.7	69.3	192.4	56.1	169.6	49.8	224.6	75.7	712.3	107.3
Vezirkopru	123.8	49.2	146.1	48.7	178.7	48.4	149.6	64.1	598.2	112.9

The North Atlantic release is an atmospheric oscillation of sea-level pressure differences between the Azores and the Icelandic regions.[9] Arctic oscillation is one of the atmospheric oscillations in the northern hemisphere and is caused by pressure differences between the arctic and northern mid latitudes.[6] The NAO and AO index data used in the study were obtained from the relevant web addresses by National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center (CPC).

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/norm.nao.monthly.b5001.current.ascii.table

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/monthly.ao.index.b50.current.ascii.table

In the study, the annual NAO / AO index values are averaged for the 12-month index values, and the seasonal index values are the average of the index values for the months in the seasons. If the index values are greater than 1.0, the positive phase (NAO (+), AO (+)); If it is less than -1.0, negative phase (NAO (-), AO (-)) is evaluated. [10]

B. Method

In this study, the Pearson correlation coefficients expressed in equation 1 were calculated to determine the relationship between atmospheric indices and precipitation. [11]

$$r_{X,Y} = \frac{\sum(x_i - \bar{x})\,(y_i - \bar{y})}{N S_X S_y} \qquad (1)$$

In Equation 1, $x_i$is the climate data for year i; $\bar{x}$ is the average of the climate data; y_i is the index data for the year i; $\bar{y}$ is the average of the index data; N, the number of data; S_X denotes the standard deviation value of the climate parameter and S_Y represents the standard deviation of the index data.

After the correlation coefficients are obtained; The values were evaluated with Student's t test shown in Equation 2 at α = 0.01, α = 0.05 and α = 0.1 significance levels.

$$t = \frac{r\sqrt{N-2}}{\sqrt{1-r^2}} \qquad (2)$$

III. Results And Discussion

A. The Effects of North Atlantic Oscillation for Annual and Seasonal Precipitation

The results of the correlation between the precipitation values of the meteorological observation stations and the North Atlantic Oscillation in Samsun are given in table 2. When the annual total precipitation was examined, significant negative correlation values were determined at 90% confidence level and 95% confidence level at Vezirkopru station. When the seasonal precipitation was examined, a significant negative correlation was determined at the 95% confidence level in Bafra and Samsun stations, and 99% confidence level in the Carsamba and Ladik stations. In autumn precipitation, only 90% confidence level was found to be significantly correlated in Vezirkopru station.

Table 2. Correlation Coefficients Between NAO and Precipitation

NAO	Summer	Winter	Spring	Automn	Annual Total
Bafra	-0.20	**-0.32[b]**	-0.07	-0.07	-0.15
Carsamba	0.09	**-0.45[c]**	-0.21	0.12	0.06
Ladik	0.10	**-0.49[c]**	-0.18	0.05	-0.07
Samsun	-0.05	**-0.32[b]**	-0.17	0.00	**-0.25[a]**
Vezirkopru	-0.11	-0.08	-0.12	**-0.27[a]**	**-0.30[b]**

a= 0.1 significance level b=0.05 significance level c= 0.01 significance level

During the observation period, NAO (+) and NAO (-) phases are determined to be effective and the total precipitation differences resulting from NAO (+) and NAO (-) phases are given in table 3. In summer, winter, autumn and annual total precipitation, NAO (-) phase produced more precipitation, whereas only NAO (+) phase of the spring rains produced more precipitation.

Table 3a. Seasonal Precipitation of Under The Effect of NAO(-) and NAO(+)

	Summer			Winter			Spring			Automn		
	NAO (+)	NAO (-)	Dif.	NAO (+)	NAO (-)	Dif.	NAO (+)	NAO (-)	Dif.	NAO (+)	NAO (-)	Dif.
Bafra	432.3	1115.6	**-683.3**	383.5	692.5	**-309.0**	548.6	442.6	**106.0**	230.1	1445.0	**-1214.9**
Carsamba	694.5	982.9	**-288.4**	438.6	717.3	**-278.7**	571.8	439.8	**132.0**	413.8	2031.0	**-1617.2**
Ladik	427.9	561.9	**-134.0**	186.2	427.9	**-241.7**	605.7	237.0	**368.7**	161.5	687.1	**-525.6**
Samsun	424.5	900.7	**-476.2**	386.3	488.0	**-101.7**	477.8	441.7	**36.1**	246.0	1244.7	**-998.7**
Vezirkopru	511.7	939.2	**-427.5**	304.1	346.9	**-42.8**	601.7	385.0	**216.7**	131.0	983.1	**-852.1**

Table 3b. Annual Precipitation of Under The Effect of NAO(-) and NAO(+)

	Annual Total Precipitation		
	NAO (+)	NAO (-)	Dif.
Bafra	0.0	234.6	**-234.6**
Carsamba	0.0	136.9	**-136.9**
Ladik	0.0	62.7	**-62.7**
Samsun	0.0	136.6	**-136.6**
Vezirkopru	0.0	134.0	**-134.0**

B. The Effects of Arctic Oscillation for Annual and Seasonal Precipitation

The correlation values between arctic oscillation and annual and seasonal total precipitation are given in table 4. While there is a significant negative correlation in the total precipitation in Ladik station at 90% confidence level, significant positive correlation is found in 90% confidence level in Bafra station in seasonal precipitation, while significant negative correlation values are found in Carsamba and Ladik stations in 99% confidence level and in 90% confidence level in winter. It was determined in Samsun and Vezirkopru stations. autumn season of the total precipitation significant correlation value of 90% confidence level of the Bafra station was also determined.

Table 4. Correlation Coefficients Between AO and Precipitation

AO	Summer	Winter	Spring	Automn	Annual Total
Bafra	-0.17	-0.14	-0.14	**0.26[a]**	-0.02
Carsamba	-0.15	**-0.37[c]**	-0.13	0.10	-0.05
Ladik	**-0.25[a]**	**-0.48[c]**	-0.12	0.20	**-0.24[a]**
Samsun	-0.11	**-0.25[a]**	-0.18	0.20	-0.10
Vezirkopru	-0.14	**-0.24[a]**	-0.13	0.05	-0.14

a= 0.1 significance level b=0.05 significance level c= 0.01 significance level

During the observation period, the AO (+) and AO (-) phases are determined to be effective and precipitation differences resulting from AO (+) and AO (-) phases are given in Table 5. In the winter season, the AO (-) phase produced more precipitation in all stations and the opposite was determined in the spring total precipitation. It was determined that there was no effect on the precipitation in the summer precipitation. In autumn precipitations, it was found that the positive phase produced more precipitation at the other stations and the positive phase at the Carsamba and Ladik stations.

Table 5a. Seasonal Precipitation of Under The Effect of AO(-) and AO(+)

	Summer			Winter			Spring			Automn		
	AO (+)	AO (-)	Dif.	AO (+)	AO (-)	Dif.	AO (+)	AO (-)	Dif.	AO (+)	AO (-)	Dif.
Bafra	0.0	0.0	**0.0**	1230.2	3491.2	**-2261.0**	663.8	482.3	**181.5**	230.1	271.6	**-41.5**
Carsamba	0.0	0.0	**0.0**	1221.5	4352.8	**-3131.3**	754.1	561.5	**192.6**	413.8	270.3	**143.5**
Ladik	0.0	0.0	**0.0**	603.3	3266.4	**-2663.1**	646.7	400.0	**246.7**	161.5	160.6	**0.9**
Samsun	0.0	0.0	**0.0**	859.6	2882.2	**-2022.6**	654.8	462.5	**192.3**	246.0	315.2	**-69.2**
Vezirkopru	0.0	0.0	**0.0**	538.8	2049.1	**-1510.3**	667.2	463.6	**203.7**	131.0	207.2	**-76.2**

Table 5 b. Annual Precipitation of Under The Effect of AO(-) and AO(+)

	Annual Total Precipitation		
	AO (+)	AO (-)	Dif.
Bafra	724.2	917.9	**-193.7**
Carsamba	932.1	820.1	**112.0**
Ladik	454.6	360.2	**94.4**
Samsun	615.7	736.5	**-120.8**
Vezirkopru	505.0	666.7	**-161.7**

IV. CONCULUSION

The results of this study that investigated the relationship between the annual and seasonal total precipitation values of the 5 stations in Samsun and the Northern Atlantic Oscillation and Arctic Oscillation:

1. There were significant negative correlations between the North Atlantic and Samsun and Vezirkopru stations in the annual total precipitation, and the Bafra, Carsamba, Ladik and Samsun stations in the winter total precipitation. This means that precipitation decreases due to the increase of index values.
2. During the observation period, NAO (-) phase precipitation caused more precipitation in winter, autumn and yearly precipitation, and NAO (+) phase produced more precipitation only in spring season.
3. Significant negative relationship between annual and seasonal total precipitation values with arctic emission was determined at Ladik station in annual precipitation and in winter precipitation at Carsamba, Ladik, Samsun and Vezirkopru stations. In the autumn precipitation, significant correlation was determined at Bafra station. Carsamba, Ladik, Samsun and Vezirkopru the total precipitation in the winter with the increase in total annual precipitation was determined as a result of the decrease in the index value. It was determined that the index values increased at the Bafra station and had an increasing effect on the total precipitation in autumn.
4. It was determined that AO (-) phase produced more precipitation than AO (+) phase in winter precipitation and positive phase was more effective in spring precipitation. In the autumn season, it was observed that the positive phase was effective in the Bafra, Vezirkopru and Samsun stations, and in the Carsamba and Ladik station, it was observed that there was more precipitation. Precipitation seen in summer was not the result of phases.
5. It is thought that the different effects of atmospheric indices in the studied geography are seen as a result of sea, lake and dam lake effects, local precipitation and irregular geography. Investigation of the relationships of various hydrometeorological data with different atmospheric indices in longer geographic periods will be the subjects of further studies.

ACKNOWLEDGMENT

A basic version of this stud presented as an oral presentation November 30 – December 2, 2018, ISAS 2018 – Winter, 2nd International Symposium on Innovative Approaches in Scientific Studies, Samsun, Turkey. The authors are thankful to the anonymous reviewers and the Editor for their insightful comments.

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