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The Effect of Remote Teleconnection Patterns on Temperature and Precipitation of the Euphrates-Tigris Basin

Beyza Reyyan Bensiz[1,a], Hakan Aksu[1,b,*]

[1]*Department of Özdemir Bayraktar Faculty of Aeoronotics and Astronotics, Samsun University, 55420 Ondokuzmayıs, Samsun, Türkiye*
[*]*Corresponding author*

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A B S T R A C T

The Euphrates-Tigris Basin is the most important water source in the Middle East. The present study examined the relationship between the precipitation and temperature characteristics of the basin using remote teleconnection patterns on a monthly time scale. The effects of the North Atlantic, Arctic Oscillations, North Sea Caspian Pattern, and Western Mediterranean indices were examined. The relationship between teleconnection patterns and precipitation/temperature was investigated by adopting Spearman's Correlation test. All of the remote teleconnection patterns had significant effects on the temperature and precipitation characteristics of the basin. However, the North Sea Caspian Pattern significantly affected the temperatures of the entire basin. Similarly, the Western Mediterranean index had a significant effect on the average temperatures for four months (February, April, November, and December) in almost the entire basin. Also, the Western Mediterranean Index corralates positively with the precipitation of the basin in January, while the correlation is negative in October, and November. Especially, the Western Mediterranean Index and the North Sea Caspian Pattern showed one-month and two-month delayed relationships in monthly total precipitation in some months. At the extremes of the index values, relationships often became strong and distinct. The study results may be useful for seasonal temperature and precipitation forecasts of the Euphrates-Tigris basin.

[a] *brbensiz@gmail.com* *https://orcid.org/0000-0002-0173-3113* | [b] *atk1240@gmail.com* *https://orcid.org/0000-0003-4686-7446*

Introduction

Remote teleconnection patterns have been widely used to determine the relationship of climate parameters of a place on Earth with atmospheric circulations (Trenberth, 2022). Remote teleconnection patterns are obtained utilizing surface or upper atmospheric pressure systems. They express the relative positions of the pressure centers that make up the circulations. Remote teleconnection patterns can be defined as recurring and persistent, large-scale patterns of atmospheric circulation anomalies extending large geographical areas (URL-1). The main objective of the studies carried out on this subject is not only to reveal the current teleconnection but also to determine the contribution of the climate parameter to predictability. The most commonly studied climatic parameters on this subject are average and extreme precipitations, temperature, and stream flows. These parameters, with their important role in the hydrological cycle, affect the supply of industrial, drinking, and irrigation water as well as agricultural and hydroelectric production.

The Euphrates-Tigris Rivers originate in Turkey and a very important part of the water resources are provided by this country. A significant part of Turkey's hydroelectric and agricultural production takes place in the Euphrates-Tigris basin (Altinbilek, 2004). Therefore, it is important to reveal the relationship between the hydrological cycle parameters of the basin using remote teleconnection patterns and to investigate the predictability of the precipitation and temperatures of the basin based on these relationships. The most important component of the streamflow in the basin is the snow melt. Temperature provides information on when the snow will melt, and this allows the dams to be operated more efficiently, especially in spring, and it provides great economic benefits.

Remote teleconnection patterns with determined effects for Turkey located in the northern hemisphere and mid-latitudes are North Atlantic Oscillation (NAO), Mediterranean, Western Mediterranean, and Eastern Mediterranean Oscillations (MO, WeMO, EMO), Arctic Oscillation (AO), Southern Oscillation (SO) and North Sea

Caspian Pattern (NCP). Within the scope of the present study, NAO, AO, NCP, which have effects on the basin, and WeMO, which have not been analyzed so far, were studied.

NAO is defined by a spatial dipole between Azores High and Iceland's low-pressure centers and it affects the weather in Europe and the Mediterranean region (Hurrell, 1995). In the negative NAO phase, Northern Europe receives less precipitation in winter, while Southern Europe and the Mediterranean receive higher precipitation. During its negative phase/positive phase, an increase/a decrease in precipitation has been reported from December to March in Turkey between 1930 and 2000 (Turkes and Erlat 2003). NAO is one of the main drivers of precipitation as well as drought variability in time and spatial scales in Turkey (Turkes and Erlat 2003).

AO is a dominant remote teleconnection pattern in the Northern hemisphere during winter. It is characterized by the variation in sea level pressures between polar and mid-latitudes (Thompson and Wallace, 1998). NAO and AO are highly correlated with each other (Aksu et. al.,2022) The effect of AO is spatially larger than that of NAO, and it affects the whole northern hemisphere. In the positive phase of the Arctic Oscillation, the polar vortex is quite strong in the polar region. Due to strong jet streams caused by the polar vortex, cold air cannot move to southern latitudes. The Mediterranean Basin, in which Turkey is located, remains under the dominance of high pressure and passes through a dry period. In the negative phase of the Arctic Oscillation, it causes rainy weather conditions in the Mediterranean Basin, where Turkey is located, and in the south of Europe. AO has a significant impact on the winter temperature in most of Turkey (Turkes and Erlat 2008; Sezen and Partal 2017).

NCP is a remote teleconnection pattern between the North Sea and the Caspian Sea regions resulting from a geopotential height difference of 500 hPa (Kutiel and Benaroch, 2002). The negative phase of the NCP, with south-southwesterly winds moving over Turkey leads to increases in temperatures, whereas the positive phase causes decreases in the temperature as a result of colder air masses caused by the winds coming from the north (Turkes and Kutiel, 2005). The monthly average temperatures of 33 stations from Turkey, Israel, and Greece were found to be significantly higher in the negative phase of the NCP compared to those in the positive phase for all months, and significant relationships were found between precipitations in different regions depending on the orbits of the systems in the negative and positive NCP phases (Kutiel and Benaroch, 2002).

The Western Mediterranean Oscillation, a different extension of the Mediterranean Oscillation, is a remote teleconnection pattern defined for the western part of the Mediterranean Basin. One end of the Western Mediterranean Oscillation is in San Fernando (Spain) while the other end is in Padua (Italy), and this index (WeMO) is obtained by the sea level pressure difference between the two regions (Martin-Vide and Lopez-Bustins, 2006). In the positive phase, high pressure occurs over Spain whereas low pressure occurs around Padua. As a result of clockwise and counterclockwise rotations, the region is affected by the northwest winds. In consequence, the Western Mediterranean experiences a short period of precipitation. In the negative phase, the low-pressure system is effective over Spain whereas the high-pressure system is effective over Padua. Therefore, moist air masses move to the Western Mediterranean over the Mediterranean. Thus, in the negative phase, the Western Mediterranean experiences a rainy period.

To understand the effects of remote teleconnection patterns on climate and hydrometeorological parameters, numerous studies have been carried out (Kutiel and Benaroch, 2002; Hurrell et al., 2003; Turkes and Erlat, 2003; Gallego et al., 2005; Karabörk et al., 2005; Kahya, 2011; Tabari et al., 2014). Sezen and Partal (2017) aimed to comprehend the effects of the North Atlantic Oscillation (NAO) and the North Sea Caspian Pattern (NCP) on temperatures and precipitation regimes in the Mediterranean Region of Turkey. Accordingly, the researchers tested different phases of NAO and NCP with Pearson's Correlation, with monthly average temperature and total precipitation data obtained from meteorological stations in the Mediterranean Region. The most significant negative relationship between temperatures and NAO was obtained in the summer. A negative correlation was found between NAO and precipitation in winter and autumn, whereas the most positive correlations were in the summer and spring. The relationship between NCP and temperatures was significantly negative in the winter. The most significant negative correlation was obtained between precipitation and NCP in the winter. In the summer season, the relationship was found to be positive. Kahya (2011) examined the effect of the North Atlantic Oscillation, from which Turkey and other Eastern Mediterranean countries were heavily affected, on the Eastern Mediterranean hydrology Çiçek et al. (2008) examined the effect of the Mediterranean Oscillation on Turkey's temperature values. For Turkey, significant negative relationships were found between streamflow, precipitation and NAO,while NAO was less determinant of temperatures. It was shown that there was an increase/decrease estimation potential of the streamflows, especially based on the delayed correlation between streamflow data and NAO indices. Cullen et al. (2000) examined the correlation between the NAO indices, monthly average temperature, and monthly total precipitation data. While the NAO index is positive, the conditions are dry and cool in Turkey whereas, in the negative phase of the index, more humid and warmer conditions were observed. Göktürk and Karaca (2005) examined the effect of NCP on the precipitation and streamflow regime of the basin feeding the Southeastern Anatolia Project (GAP) Region. In the study, in the negative phase of NCP, the west of the country was more affected by NCP in January whereas the east was more affected by NCP in February. In the negative phase of the NCP, an increase was observed in precipitation in many regions of the country, while a significantly high positive correlation was obtained especially in the Black Sea coastline. Bozyurt and Özdemir (2017) aimed to reveal the effect of the Arctic Oscillation on the minimum temperatures in Turkey. Karabörk et al. (2005), to comprehend how Southern Oscillations (El Nino, La Nina) and North Atlantic Oscillation affect Turkey's climatic data, including precipitation, streamflow, temperature, and the relationships between them, monthly total precipitation, monthly streamflow, monthly average temperature, monthly maximum temperature, and monthly minimum temperature data were analyzed with simultaneous and delayed cross-correlations. Turkes and Erlat (2003) investigated the effects of NAO, which directs the Atlantic and Northern air, including the Mediterranean Basin, on precipitation variations and variability in the 1930-2000 period. The researchers have stated that, except for summer, most of the annual and seasonal precipitation series were negatively related to NAO and the relationship was the strongest, especially in winter and this relationship weakened towards summer. Based on Turkey's long-term average precipitation, a wetter-than-average period was observed in the negative NAOI phase whereas a drier-than-average period was observed in the positive NAOI phase. Turkes and Erlat (2009) investigated the relationship between NAO and Turkey's average winter temperatures and revealed that there was a negative relationship between the winter temperatures and the NAO indices in Turkey. Tan and Unal (2003) analyzed the temperature and precipitation data for the years 1951-1998 to determine the effect of NAO on precipitation and temperature in Turkey and examined their relationship with the positive and negative phases of the winter NAO. During the positive NAO phase, dry winter conditions prevailed all over Turkey and this was more evident in the Southern Aegean and the Mediterranean. In the negative phase of NAO, wetter conditions in the South of Turkey and drier conditions in the Northeast compared to the South were determined. The researchers also emphasized that colder weather conditions prevailed in the negative phase of the winter NAO except for the coastlines.

In the present study, the effect of remote teleconnection patterns on the temperature and precipitation parameters of the Euphrates-Tigris basin, the effect of extreme values, and their contribution to predictability were examined by applying the recent data and adopting same methods. Monthly total precipitation and average temperature variables were analysed and the Spearman's Rank Correlation test was implemented after the reliability tests of the data. This study allows for comparing the effects of teleconnection patterns on the basin and analysing their contribution to predictability. A comprehensive study of the time-delayed and extreme values of the major remote teleconnection patterns affecting Turkey, as well as precipitation and temperature, was carried out. To the best authors' knowledge, the effects of WeMO on Turkey were examined for the first time in this present study.

Material and Methods

Study Area

The Euphrates and Tigris Basin in Turkey cover 176657 km^2 located in the eastern part of Turkey (Selek and Aksu, 2020). The basin has great importance in Turkey's economy with its hydroelectric energy production and agricultural production aspects. It is also one of the most important water resources in the Middle East. Within the scope of the present study, the part of the Euphrates and Tigris basins within the borders of Turkey has been examined. Thus, the data to be used within the scope of the study have been subjected to the same data supply and quality control processes. The highest monthly average temperature in the basin was 31.96°C in Şanlıurfa in July whereas the lowest was -10.9°C in January according to the Ağrı meteorology station values. This difference between the summer and winter months is mainly due to the elevation difference of the basin. Also, the effect of the Siberian anticyclone on the minimum winter temperatures of the basin and the Monsoon low-pressure system in the summer extreme temperatures comprise the other effective parameters. The variation in the yearly average temperatures of the winter months is higher (up to 4 ˚C standard deviations). The annual average rainfall of the basin is 565.3 mm (Selek and Aksu, 2020).

Data and Methodology

To understand the teleconnection of the Euphrates-Tigris Basin with remote teleconnection patterns, monthly average temperature and monthly total precipitation data of 17 stations in the Euphrates-Tigris Basin were used (Figure 1 and Table 1).

Figure 1. Map of the stations from which the data used in the study was collected

Table 1. Basic Characteristics of the Meteorological Stations

Station Number	Station Name	Latitude (N)	Longitude (E)	Elevation (Meters)	Record Period
17210	Siirt	37.93	41.94	890	1950-2020
17285	Hakkari	37.58	43.74	1729	1961-2020
17165	Tunceli	39.11	39.54	984	1960-2020
17199	Malatya	38.34	38.22	949	1950-2020
17265	Adıyaman	37.76	38.28	666	1963-2020
17094	Erzincan	39.75	39.49	1217	1950-2020
17270	Şanlıurfa	37.16	38.79	553	1950-2020
17201	Elazığ	38.64	39.26	990	1950-2020
17204	Muş	38.75	41.50	1287	1964-2020
17261	Gaziantep	37.06	37.35	859	1950-2020
17275	Mardin	37.31	40.73	1022	1950-2020
17203	Bingöl	38.89	40.50	1140	1961-2020
17095	Erzurum	39.91	41.25	1865	1950-2020
17099	Ağrı	39.73	43.05	1644	1950-2020
17172	Van bölge	38.47	43.35	1666	1950-2020
17281	Diyarbakır	37.91	40.21	677	1950-2020
17282	Batman	37.86	41.16	613	1959-2020

The stations are located in the Southeastern and Eastern Anatolian geographical regions of Turkey, where the altitude substantially changes over short distances. To establish a reliable statistical relationship, stations with data dating back to at least 30 years were selected. Therefore, Şırnak and Bitlis Stations located within the borders of the Euphrates-Tigris Basin were not included in the study. The monthly average temperature and monthly total precipitation data used in the study were provided by the General Directorate of Meteorology. In the data series, the ratio of missing data was lower than 1%. The missing data were completed with the average values of long-term data. To determine the data quality, outlier and homogeneity analyses were carried out. The detected outliers in the temperature and precipitation time series were changed with the nearest values.

The North Atlantic Oscillation Index (NAO) and Arctic Oscillation Index (AO) used in the study were provided by the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center CPC (URL_1). Similarly, the Western Mediterranean Oscillation Index (WeMO) and the North Sea Caspian Pattern Index (NCP) were provided by the CRU (URL_2) of the University of East Anglia’s Climate Research Division.

Methods

Rosner Test

A statistical test developed by Rosner (1983) can detect up to ten outliers in sample sizes of 25 or larger. Outliers that are significantly smaller or much larger than the rest of the data will be detected by the test.

The observed values are listed in descending order from smallest to largest. Then, using the equation below, a set of test statistics is calculated by subtracting the data that is farthest from the mean (large or small) and recalculating the test statistic (Eq. 1).

$$R_{i+1} = \frac{|x^{(i)} - \bar{x}^{(i)}|}{S^{(i)}} \qquad (1)$$

where $\bar{X}$ denotes the sample mean and S denotes the data’s standard deviation after the most extreme observations have been eliminated. $x^{(i)}$ is the observation in the subset farthest from $\bar{X}^{(i)}$.

Then each R test value (up to ten) is compared with the critical test value ($\lambda_{N,r_{o,a}}$) under the null hypothesis “no outlier detected”. The null hypothesis is rejected if the test result is greater than the critical test value, and vice versa.

Pettitt Test

Pettitt test (1979) is a rank-based statistical homogeneity test and the null hypothesis assumes the data series homogeneous (Eq. 2 and 3).

$$X_k = 2\sum_{i=1}^{k} r_i - k(n+1), \text{ k=1,……,n} \qquad (2)$$

If there is a break in year K, the statistic is the maximum or minimum around the year k=K_i.

$$X_E = \max|X_k| \text{ , } 1 \leq k \leq n \qquad (3)$$

The critical test values are determined according to significance level and data length from the table presented by Pettitt,1979 then compared with the X_E.

Spearman rank correlation

The correlation between teleconnection patterns and hydroclimatic parameters (temperature and precipitation was analysed by Spearman’s Rank Correlation Test which is a non-parametric test and does not require Gaussian distribution of time series. The Pearson correlation coefficient between the rank variables is defined as the Spearman correlation coefficient (Myers and Well,2003). The calculation procedure starts with the organization of the time series in ascending order, then a rank value is given to each data. the difference between the ranks of each data is calculated. The Spearman rank correlation coefficient is calculated by Equation (4):

The following equations represent the Spearman correlation (ρ) and normal distribution test statistic (Z), respectively.

$$r_s = 1 - \frac{6\Sigma d_i^2}{n(n^2-1)} \qquad (4)$$

$$z = r_s\sqrt{n-1} \qquad (5)$$

r_s is Spearman’s rbank correlation coefficient, di is the difference between the paired ranks and n is the number of observations. If the calculated z value is greater than the tabulated z_a value at a corresponding significance level in the normal probability distribution table (Eq.5), then the null hypothesis H_0 is rejected to conclude that a trend exists (Spearman,1904).

The Spearman Correlation coefficient values range between -1 and 1 and zero means no correlation between variables. In the case of ties, the average of the ranks is used for all tied observations. Spearman's full formula can be used to estimate correlation (Clef, 2013). In this study, the significance levels were classified into three categories: 0.01, 0.05, and 0.10.

First, correlation analyses were applied between the same months of index values and monthly average temperature/monthly total precipitation. Second, we investigated the correlation between extreme index values' impact on these climatological parameters. First and third quartiles were used to define extreme indices values. Third, we analyzed the time-delayed impact of indices on these parameters up to two previous months.

Results

Most of the monthly total precipitation data series were homogeneous. However, it was observed that the monthly average temperature data lost their homogeneity, especially after the 1990s. For example, in the monthly average temperature data series for March, a break was observed in 15 of 17 stations in 2000. This was related to a possible heat or cold wave in March 2000. Especially in the study area, increases in extreme temperatures were observed in the last few decades (Aksu, 2021). The general increasing trend in average temperatures in the study area showed that the deterioration of homogeneity was related to climate change. Therefore, a homogenization process that can eliminate the climate change signal in the monthly average temperature data was not performed.

Temperature and Remote Teleconnection Patterns

In this section, instead of individual results, the characteristics seen in general at the stations in the basin are summarized. Tables for each remote teleconnection pattern are presented in the order of importance as tables.

AO affects the average temperatures of almost all of the Euphrates-Tigris Basin stations, especially in October, November, and December, and this relationship takes place in the form of a negative correlation (Table 2). Although AO shows its effect in the basin in January, February, and March, it does not cover the entire basin as it does in October-November and December, and the relationship occurs at low levels. In particular, this relation may be caused by the dominance of the Siberian Anticyclone in these months. According to the results of the time-delayed correlation test (Table 3), for 5 stations (Siirt, Muş, Erzurum, Ağrı, and Diyarbakır) a significant negative correlation was obtained between the Arctic Oscillation and December temperatures with a delay of one month. Considering the other months, no significant relationships were obtained to represent the basin. Also, there were no two-month-delayed relationships.

Table 2. Monthly Average Temperature - Arctic Oscillation Correlation Test Results

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Siirt	-0.51**	-0.23*	-0.19	-0.05	-0.01	0.03	0.08	0.04	-0.01	-0.19	-0.30***	-0.46***
Hakkâri	-0.04	0.20	-0.16	0.04	0.03	-0.08	-0.08	0.00	-0.01	-0.25**	-0.27**	-0.32***
Tunceli	-0.20	0.31**	0.01	0.00	-0.02	-0.08	0.09	-0.02	-0.05	-0.31**	-0.22*	-0.36***
Malatya	-0.18	0.29***	-0.18	0.00	-0.09	-0.08	-0.04	0.00	-0.07	-0.38***	-0.35***	-0.35***
Adıyaman	-0.17	0.29**	-0.02	-0.01	-0.07	0.00	0.02	-0.09	0.09	-0.35***	-0.27**	-0.35***
Erzincan	-0.19	0.26**	-0.26**	-0.01	-0.15	-0.07	0.00	0.02	-0.11	-0.26**	-0.36***	-0.36***
Şanlıurfa	-0.18	0.24**	-0.10	-0.04	-0.02	-0.03	0.01	-0.01	0.01	-0.31***	-0.28**	-0.47***
Elazığ	-0.20	0.27**	-0.18	0.06	-0.10	-0.07	0.05	-0.01	-0.05	-0.30***	-0.34***	-0.39***
Muş	-0.43***	0.13	-0.21	-0.06	0.02	0.01	-0.01	0.00	-0.12	-0.43***	-0.29**	-0.36***
Gaziantep	-0.14	0.30***	-0.08	-0.04	-0.07	-0.07	-0.01	0.02	0.02	-0.38***	-0.27**	-0.40***
Mardin	-0.17	0.28**	-0.16	-0.05	-0.05	-0.04	0.04	0.02	-0.05	-0.27**	-0.27**	-0.44***
Bingöl	-0.23	0.26**	-0.17	-0.03	-0.09	0.02	-0.07	-0.10	-0.16	-0.35***	-0.26**	-0.37***
Erzurum	-0.38***	-0.03	-0.38***	0.01	-0.19	-0.05	0.02	-0.02	-0.11	-0.24**	-0.36***	-0.41***
Ağrı	-0.30***	0.05	-0.28**	-0.09	-0.18	-0.01	0.06	0.18	-0.17	-0.26**	-0.28**	-0.32***
Van	-0.15	0.22*	-0.21*	0.04	-0.11	-0.06	0.01	0.11	-0.07	-0.32***	-0.21*	-0.43***
Diyarbakır	-0.25**	0.19	-0.28**	-0.08	-0.09	0.13	0.12	-0.08	-0.02	-0.28**	-0.30***	-0.51***
Batman	-0.18	0.24*	-0.17	-0.08	-0.05	0.01	0.15	0.19	-0.08	-0.26**	-0.12	-0.42***

* 0.1-0.05 , ** 0.05-0.01, *** 0.01-0.00 Significance levels of the correlations

Table 3. Monthly Average Temperature - Arctic Oscillation 1 Month Lagged Correlation Test Results

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Siirt	-0.28**	-0.25**	-0.08	-0.03	-0.08	0.19	0.21*	0.02	-0.04	0.02	-0.15	-0.30***
Hakkâri	0.02	-0.08	-0.14	0.00	0.10	0.13	0.13	0.18	-0.11	0.02	-0.21	-0.20
Tunceli	-0.04	-0.06	0.05	0.08	-0.18	0.15	0.23*	0.19	-0.02	-0.06	-0.15	-0.13
Malatya	-0.10	-0.03	-0.02	-0.03	-0.13	0.09	0.04	0.06	0.09	0.01	-0.14	-0.20*
Adıyaman	-0.06	-0.10	0.00	0.05	-0.22*	0.05	0.16	0.09	-0.02	-0.07	-0.12	-0.14
Erzincan	-0.10	-0.11	-0.04	-0.09	-0.04	0.05	0.05	0.09	0.01	0.02	-0.17	-0.23**
Şanlıurfa	-0.08	-0.04	0.03	0.04	-0.20*	0.10	0.09	0.01	0 .02	-0.08	-0.14	-0.22*
Elazığ	-0.08	-0.05	-0.04	-0.04	-0.12	0.06	0.16	0.07	-0.05	0.03	-0.15	-0.21*
Muş	-0.18	-0.28**	- 0.09	-0.04	-0.08	0.09	0.22*	0.06	-0.12	-0.02	-0.15	-0.31***
Gaziantep	-0.03	0.01	0.03	0.07	-0.18	0.02	0.07	-0.08	0.08	-0.01	-0.18	-0.17
Mardin	-0.11	-0.02	-0.01	-0.01	-0.17	0.08	0.16	0.02	0.05	-0.08	-0.20*	-0.20*
Bingöl	-0.14	-0.20	-0.06	-0.04	-0.13	0.05	0.25**	0.09	-0.08	-0.15	-0.18	-0.22*
Erzurum	-0.18	-0.21	-0.19	-0.11	0.02	-0.02	0.22*	0.07	-0.06	-0.05	-0.13	-0.33***
Ağrı	-0.19	-0.25**	-0.14	-0.10	0.02	0.00	0.20*	0.15	0.12	0.01	-0.11	-0.30***
Van	-0.18	-0.10	-0.10	0.02	-0.01	-0.01	0.16	0.08	0.04	0.06	-0.13	-0.25**
Diyarbakır	-0.17	-0.09	-0.17	-0.09	-0.25**	0.11	0.28**	0.09	-0.13	0.05	-0.10	-0.33***
Batman	-0.15	-0.03	-0.11	0.02	-0.20	0.13	0.14	0.17	0.20	-0.05	-0.02	-0.17

* 0.1-0.05 , ** 0.05-0.01, *** 0.01-0.00 Significance levels of the correlations.

Table 4. Monthly Average Temperature - North Atlantic Oscillation Correlation Test Results

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Siirt	-0.30***	-0.13	-0.15	-0.21*	-0.12	-0.26**	-0.17	-0.36***	-0.15	-0.20*	-0.33***	-0.14
Hakkâri	-0.05	-0.04	-0.23*	-0.11	-0.09	-0.31**	-0.13	-0.23*	-0.21*	-0.13	-0.19	-0.10
Tunceli	-0.10	0.04	-0.03	-0.24*	-0.09	-0.31**	-0.04	-0.34***	-0.13	-0.21*	-0.29**	-0.04
Malatya	-0.29***	-0.07	-0.11	-0.17	-0.11	-0.31***	-0.22*	-0.39***	-0.22*	-0.32***	-0.33***	-0.05
Adıyaman	-0.14	-0.03	-0.08	-0.14	-0.13	-0.30**	-0.23*	-0.45***	-0.15	-0.18	-0.28**	-0.03
Erzincan	-0.30***	-0.17	-0.18	-0.17	-0.24	-0.25**	-0.16	-0.34***	-0.23*	-0.24**	-0.33***	-0.08
Şanlıurfa	-0.25**	-0.09	-0.07	-0.16	-0.11	-0.25**	-0.27**	-0.44***	-0.26**	-0.29***	-0.31***	-0.17
Elazığ	-0.27**	-0.12	-0.12	-0.17	-0.07	-0.30***	-0.11	-0.39***	-0.22*	-0.22*	-0.34***	-0.09
Muş	-0.20	-0.12	-0.20	-0.15	-0.09	-0.32***	-0.16	-0.33***	-0.09	-0.22*	-0.25*	-0.22*
Gaziantep	-0.17	-0.04	-0.07	-0.12	-0.11	-0.32**	-0.33***	-0.39***	-0.20*	-0.35***	-0.25**	-0.09
Mardin	-0.22*	-0.12	-0.12	-0.18	-0.13	-0.31***	-0.22*	-0.42***	-0.27**	-0.24**	-0.34***	-0.12
Bingöl	-0.21*	0.01	-0.17	-0.21	-0.14	-0.20	-0.09	-0.29**	-0.15	-0.14	-0.27**	-0.17
Erzurum	-0.38***	-0.41***	-0.32***	-0.15	-0.28**	-0.22*	-0.03	-0.36***	-0.14	-0.16	-0.38***	-0.17
Ağrı	-0.31***	-0.34***	-0.20*	-0.10	-0.26**	-0.27**	0.01	-0.20*	-0.21*	-0.23**	-0.24**	-0.13
Van	-0.21*	-0.14	-0.16	-0.07	-0.22*	-0.30***	-0.12	-0.17	-0.13	-0.25**	-0.32***	-0.17
Diyarbakır	-0.34***	-0.17	-0.27**	-0.26**	-0.02	-0.13	-0.11	-0.40***	-0.20*	-0.20*	-0.30***	-0.23**
Batman	-0.14	-0.07	-0.13	-0.27**	-0.16	-0.27**	-0.10	-0.20	-0.26**	-0.26**	-0.18	-0.18

* 0.1-0.05 , ** 0.05-0.01, *** 0.01-0.00 Significance levels of the correlations.

Table 5. Monthly Average Temperature - North Sea Caspian Pattern Correlation Test Results

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Siirt	-0.70***	-0.56**	-0.66***	-0.69***	-0.12	-0.44***	-0.48***	-0.47***	-0.37***	-0.49***	-0.52**	-0.71***
Hakkâri	-0.63***	-0.39***	-0.56**	-0.56**	0.05	-0.49***	-0.38***	-0.03	-0.17	-0.39***	-0.42***	-0.55*
Tunceli	-0.64***	-0.42***	-0.46***	-0.69***	-0.14	-0.49***	-0.22	-0.20	-0.26*	-0.43***	-0.51***	-0.54*
Malatya	-0.61***	-0.46***	-0.61***	-0.67***	-0.14	-0.46***	-0.35***	-0.47***	-0.48***	-0.59***	-0.44***	-0.56***
Adıyaman	-0.69***	-0.66***	-0.49***	-0.69***	-0.07	-0.45***	-0.49***	-0.30**	-0.20	-0.52***	-0.56*	-0.68***
Erzincan	-0.57***	-0.39***	-0.58***	-0.67***	-0.32**	-0.47***	-0.28**	-0.45***	-0.52**	-0.58***	-0.40***	-0.56**
Şanlıurfa	-0.67***	-0.68***	-0.59***	-0.67***	-0.09	-0.43***	-0.55***	-0.53**	-0.50*	-0.58***	-0.53**	-0.73***
Elazığ	-0.65***	-0.46***	-0.59***	-0.64***	-0.21	-0.44***	-0.39***	-0.54***	-0.47***	-0.47***	-0.43***	-0.55**
Muş	-0.54***	-0.42***	-0.42***	-0.54***	-0.13	-0.45***	-0.33**	-0.26*	-0.34**	-0.52***	-0.40***	-0.46***
Gaziantep	-0.63***	-0.62***	-0.56**	-0.62***	-0.11	-0.46***	-0.48***	-0.39***	-0.41***	-0.60***	-0.45***	-0.69***
Mardin	-0.67***	-0.64***	-0.62***	-0.64***	-0.09	-0.47***	-0.46***	-0.52**	-0.53**	-0.55***	-0.55**	-0.72***
Bingöl	-0.63*	-0.56**	-0.57**	-0.66***	-0.22	-0.45***	-0.50***	-0.31**	-0.36***	-0.44***	-0.52***	-0.51***
Erzurum	-0.60***	-0.43***	-0.60***	-0.65***	-0.41***	-0.47***	-0.28**	-0.39***	-0.40***	-0.48***	-0.45***	-0.58***
Ağrı	-0.53**	-0.30**	-0.40***	-0.49***	-0.31**	-0.49***	-0.22*	-0.17	-0.49***	-0.54***	-0.35***	-0.41***
Van	-0.53**	-0.46***	-0.58***	-0.61***	-0.13	-0.49***	-0.38***	-0.29**	-0.47***	-0.48***	-0.45***	-0.58***
Diyarbakır	-0.71***	-0.52**	-0.64***	-0.65***	-0.18	-0.35***	-0.50***	-0.37***	-0.33***	-0.44***	-0.43***	-0.63***
Batman	-0.55**	0.55**	-0.55**	-0.59***	0.01	-0.46***	-0.24	-0.13	-0.28*	-0.48***	-0.18	-0.35**

* 0.1-0.05 , ** 0.05-0.01, *** 0.01-0.00 Significance levels of the correlations.

The first quartile of AO indices and July average temperatures are highly correlated with each other over the basin, with the values in the range of 0.44-0.72. For the third quartile of AO, negative correlation values were determined in some of the stations in September and October. Correlation values between -0.41 and -0.61 were determined especially in Erzurum, Ağrı, Van, Batman, Bingöl, Mardin, and Diyarbakır for September.

NAO has a negative correlation with the average temperatures of the basin in January, June, August, and November (between -0.20 and -0.45). A negative correlation was found in December in approximately half of the stations with a one-month delay**.** The two-month-delayed correlation shows a positive correlation in more than half of the stations in March (0.23-2.28). The first quartile NAO index and the average temperatures present high negative correlations between the values of -0.40 and -0.64 in January and December.

In the analysis of temperature data with NCP, it was determined that it was the remote teleconnection pattern that most affected the basin temperatures throughout the year (Table 5). The correlation values of the winter and spring months were significantly higher. A significant negative correlation was obtained between NCP and temperatures for 12 months. According to the time-delayed correlation test results, significant negative correlations were found between NCP and temperatures, especially in the January-March period, with a one-month-delayed correlation. For the basin, it is not conceivable to consider a two-month delayed relationship. In the analysis for extreme NCP index values, negative relationships were obtained for both the first and third quartiles in March, September, October, and December.

WeMO plays a decisive role in basin temperatures in February, April, November, and December (Table 6). In these months, significant positive relations were obtained in almost all of the stations. A significant positive correlation with a one-month delay was obtained between WeMO and temperatures in January and March, whereas a significant negative correlation was determined with a two-month delay for August. The first quartile WeMO and monthly average temperatures were negatively correlated, especially in June.

Precipitation - Remote Teleconnection Pattern Relationships

Significant negative correlations were found between the precipitations of the Arctic Oscillation Euphrates-Tigris Basin at 10 stations in February and at five stations each in December and January (Table7).

Table 6. Monthly Average Temperature - Western Mediterranean Oscillation Correlation Test Results

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Siirt	0.14	0.46**	0.10	0.23**	-0.14	-0.21*	-0.07	-0.12	-0.02	0.15	0.47**	0.42***
Hakkâri	0.24*	0.42***	-0.05	0.17	-0.11	-0.17	-0.02	-0.15	-0.12	0.16	0.38***	0.36***
Tunceli	0.14	0.48*	0.04	0.22*	-0.02	0.00	-0.03	-0.08	-0.04	0.10	0.42***	0.39***
Malatya	0.13	0.40***	0.13	0.33***	0.00	-0.12	-0.01	-0.02	0.02	0.17	0.37***	0.48**
Adıyaman	0.19	0.59***	0.06	0.29**	-0.10	-0.08	0.00	-0.10	-0.13	0.24*	0.56**	0.37***
Erzincan	0.12	0.38***	0.03	0.25**	-0.04	-0.07	0.08	0.07	0.09	0.13	0.30***	0.46**
Şanlıurfa	0.11	0.51**	0.07	0.27**	-0.15	-0.15	-0.02	0.04	0.07	0.23*	0.52***	0.43***
Elazığ	0.16	0.39***	0.08	0.27**	0.00	-0.09	0.00	0.00	0.07	0.20*	0.40***	0.43***
Muş	0.22*	0.40***	-0.08	0.16	-0.13	-0.16	-0.08	-0.07	-0.22*	0.02	0.35***	0.24*
Gaziantep	0.14	0.45*	0.07	0.25**	-0.14	-0.13	0.00	-0.06	-0.07	0.09	0.39***	0.39***
Mardin	0.15	0.48**	0.11	0.21*	-0.11	-0.15	-0.07	-0.02	0.07	0.21*	0.52***	0.41***
Bingöl	0.10	0.54**	-0.12	0.28**	0.11	0.05	0.13	-0.02	-0.01	0.27**	0.49*	0.33***
Erzurum	0.25**	0.36***	0.10	0.29**	0.03	0.02	-0.02	-0.04	0.17	0.24**	0.30**	0.48**
Ağrı	0.18	0.19	-0.08	0.20*	-0.11	-0.11	-0.11	-0.18	0.04	0.02	0.16	0.29***
Van	0.12	0.33***	0.02	0.13	-0.19	-0.21*	-0.05	-0.09	-0.03	-0.04	0.33***	0.36***
Diyarbakır	0.18	0.46**	0.11	0.33***	0.09	-0.10	0.01	0.03	0.13	0.20*	0.38***	0.41***
Batman	0.11	0.51**	0.01	0.22*	-0.04	-0.01	-0.05	-0.03	-0.06	-0.04	0.17	0.18

* 0.1-0.05 , ** 0.05-0.01, *** 0.01-0.00 Significance levels of the correlations.

Table 7. Monthly Total Precipitation - Arctic Oscillation Correlation Test Results

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Siirt	-0.34***	-0.01	-0.03	0.24**	-0.15	-0.29**	-0.03	0.04	-0.16	-0.10	0.15	-0.24**
Hakkâri	-0.07	-0.20*	0.14	0.04	-0.10	-0.07	-0.05	-0.10	-0.04	-0.09	0.18	-0.16
Tunceli	-0.28**	-0.24*	-0.19	0.00	-0.04	-0.18	0.07	-0.03	0.11	0.22*	-0.05	-0.30**
Malatya	-0.27**	-0.16	-0.03	-0.07	-0.24**	-0.05	0.12	0.02	-0.03	0.01	0.09	-0.09
Adıyaman	-0.30**	-0.13	-0.15	0.05	-0.04	-0.06	-0.19	-0.03	0.08	-0.03	-0.03	-0.29**
Erzincan	-0.09	-0.22*	-0.26**	0.00	-0.12	-0.25**	-0.03	0.11	0.15	0.02	-0.02	-0.09
Şanlıurfa	-0.14	-0.20*	-0.05	0.15	-0.06	-0.27**	-0.09	0.05	0.02	-0.06	0.00	-0.19
Elazığ	-0.22*	-0.25**	-0.12	-0.11	-0.12	-0.23**	0.02	-0.07	0.06	-0.05	0.12	-0.15
Muş	-0.21	-0.22*	0.08	0.30**	-0.25*	0.00	0.04	0.00	0.12	0.15	0.02	-0.10
Gaziantep	-0.19	-0.16	-0.15	0.17	-0.08	-0.12	0.05	-0.08	0.11	-0.04	0.03	-0.19
Mardin	-0.04	-0.32***	-0.01	0.11	-0.05	0.16	0.00	0.03	-0.19	-0.07	0.02	-0.29**
Bingöl	-0.15	-0.32***	-0.09	0.13	-0.13	-0.10	0.09	0.18	0.07	0.08	-0.01	-0.27**
Erzurum	-0.18	-0.33***	-0.22*	0.19	-0.09	-0.11	0.14	0.07	0.10	0.07	-0.03	-0.14
Ağrı	-0.01	-0.24**	-0.11	0.07	-0.03	-0.14	-0.09	-0.03	0.03	0.03	0.06	-0.13
Van	-0.08	-0.18	-0.01	0.16	0.05	-0.12	-0.06	-0.14	-0.03	-0.07	0.07	-0.07
Diyarbakır	-0.18	-0.21*	0.06	0.21*	-0.01	-0.35***	0.10	0.01	0.16	-0.11	0.06	-0.16
Batman	-0.15	-0.22*	-0.05	0.26**	-0.11	-0.29**	-0.16	-0.03	-0.07	-0.08	0.01	-0.19

* 0.1-0.05 , ** 0.05-0.01, *** 0.01-0.00 Significance levels of the correlations.

Table 8. Monthly Total Precipitation - North Atlantic Oscillation Correlation Test Results

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Siirt	-0.11	-0.10	-0.10	0.22*	-0.02	-0.09	-0.16	-0.12	0.08	0.12	0.11	-0.26**
Hakkâri	-0.13	-0.15	-0.03	0.14	-0.12	0.09	-0.31**	-0.08	0.23*	0.05	0.22*	-0.22*
Tunceli	-0.19	-0.20	-0.23*	0.08	-0.06	0.13	-0.14	-0.26**	0.13	0.17	-0.09	-0.31***
Malatya	-0.03	0.04	-0.09	0.01	-0.13	0.19	-0.06	-0.12	0.18	-0.02	-0.04	-0.05
Adıyaman	-0.09	-0.04	-0.20	-0.08	-0.06	0.11	-0.30**	-0.02	0.14	-0.03	0.06	-0.18
Erzincan	-0.06	-0.25**	-0.28**	0.12	-0.06	-0.04	-0.01	0.02	0.15	0.06	0.01	-0.09
Şanlıurfa	0.00	-0.18	-0.04	0.04	-0.05	-0.11	-0.26**	-0.09	0.08	0.06	0.02	-0.21*
Elazığ	-0.12	-0.04	-0.18	0.00	-0.03	0.02	-0.16	-0.18	-0.01	0.01	0.08	-0.17
Muş	-0.03	-0.04	-0.02	0.13	-0.11	0.20	-0.20	-0.12	0.20	0.12	0.05	-0.15
Gaziantep	-0.01	-0.12	-0.17	-0.05	0.00	0.09	-0.05	-0.05	0.04	0.12	-0.03	-0.11
Mardin	-0.17	-0.17	0.02	0.07	0.00	0.27*	-0.12	-0.19	-0.04	-0.05	0.09	-0.24**
Bingöl	-0.11	-0.20	-0.12	0.09	-0.10	0.10	0.10	-0.07	0.02	0.00	-0.04	-0.28**
Erzurum	-0.16	-0.22*	-0.23*	0.05	-0.03	0.09	0.04	0.08	0.10	0.09	-0.01	-0.19
Ağrı	-0.10	-0.17	-0.14	-0.02	-0.01	0.12	-0.16	0.11	0.05	0.16	0.08	-0.13
Van	0.24**	-0.18	-0.08	0.32***	0.17	0.13	-0.07	-0.12	0.21*	0.15	0.17	-0.06
Diyarbakır	-0.01	-0.20*	-0.03	0.13	-0.05	-0.21*	-0.04	-0.02	0.18	-0.02	0.09	-0.16
Batman	-0.14	-0.19	-0.07	0.15	0.00	-0.06	-0.22*	-0.01	0.00	-0.02	-0.02	-0.20

* 0.1-0.05 , ** 0.05-0.01, *** 0.01-0.00 Significance levels of the correlations.

In the time-delayed correlation analysis, no effect was detected to represent the entire basin. The first quartile AO index values and monthly total precipitation exhibited high positive correlations in Siirt, Malatya, Elazig, Gaziantep, Van, and Diyarbakır stations during March. However, some stations showed negative correlations in September (Erzincan, Elazığ, Mardin Bingöl Erzurum and Batman). The third quartile AO index correlations were mainly station-specific and cannot be generalized over the study area.

According to the correlation results between precipitation and NAO with delayed, non-delayed, and extreme index values, significant correlations were not determined to represent the entire basin. Only in December, a negative low correlation was detected in six stations. The detected correlation values were low and of an isolated nature. In the correlation test analysis made for extreme values, a relationship representing the basin was not determined. On the other hand, the relationship between the first quartile and the monthly total precipitation for Van in December

was significantly high (0.67), and Adıyaman had a high correlation with a correlation coefficient of -0.62 in July. The determined relationships were isolated cases and cannot be generalized.

NCP and monthly total precipitation showed a positive correlation between 0.28 and 0.48 in February, October, and November in approximately half of the stations studied in the basin. One month of delayed correlation (between -0.22 and -0.42) was detected in December in approximately half of the stations. The monthly total precipitation in January showed a significant positive correlation with the NCP index values determined two months prior. According to the correlation analysis results for the extreme values, a very strong negative (max. 0.87) was determined for January for the third quartile, and a strong positive correlation (max. 0.81) was obtained for November for the first quartile.

According to the results of the time-delayed correlation test, it was determined that WeMO affected almost all the basin precipitation most significantly in January, October, and November (Table 10). A significantly positive correlation was determined between January WeMO and precipitation whereas significant negative correlations (between 0.20 and 0.51) were obtained between October and November WeMO and precipitation. In the results of the time-delayed correlation test between WeMO and precipitation, a significant positive relationship with a one-month delay and a significant negative relationship with a two-month delay was obtained in approximately half of the stations in the basin, especially in January. WeMO affects basin precipitation in autumn and January, and an increase/decrease in precipitation occurs in the January WeMOI positive/negative phase and a decrease/increase in precipitation in the October-November WeMOI positive/negative phase. According to the results of the correlation test analysis made for extreme values, a relationship representing the entire basin was not obtained.

Table 9. Monthly Total Precipitation - North Sea Caspian Pattern Correlation Test Results

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Siirt	-0.19	0.31**	0.18	0.17	-0.01	0.22*	-0.08	-0.21	0.04	0.28**	0.34***	0.15
Hakkâri	-0.03	0.24	0.13	0.22	-0.08	0.32**	-0.26*	-0.28*	0.07	0.16	0.49***	0.30**
Tunceli	-0.18	-0.12	0.02	0.21	-0.13	0.38***	0.10	-0.11	0.10	0.17	0.27*	-0.15
Malatya	-0.31**	0.13	-0.03	0.16	-0.26**	0.19	0.03	0.06	0.09	0.13	0.07	0.09
Adıyaman	-0.28*	0.22	0.01	0.08	-0.06	0.23	0.09	0.01	0.16	0.18	0.21	-0.23
Erzincan	-0.09	-0.08	-0.27**	0.15	-0.02	0.02	0.29**	-0.04	0.33***	0.30**	0.18	0.11
Şanlıurfa	-0.11	0.39***	0.08	-0.02	-0.09	0.18	-0.33***	-0.16	0.01	0.21	0.21	-0.03
Elazığ	-0.20	0.11	-0.13	0.03	-0.13	0.12	0.01	-0.05	0.14	0.20	0.10	0.14
Muş	-0.01	0.22	0.04	0.13	-0.15	0.29*	0.16	0.04	0.12	0.39***	0.48***	0.09
Gaziantep	-0.13	0.39***	0.10	-0.07	-0.12	0.24*	0.04	-0.05	0.00	0.24*	0.20	-0.15
Mardin	-0.12	0.34***	-0.06	0.05	-0.03	0.05	-0.06	-0.10	-0.07	0.16	0.18	-0.02
Bingöl	-0.13	0.03	0.05	0.22	-0.06	0.27*	0.02	0.19	0.13	0.19	0.41***	-0.09
Erzurum	-0.05	0.16	0.02	0.13	-0.07	0.23*	-0.05	0.10	0.23*	0.37***	0.25*	0.20
Ağrı	0.16	0.16	-0.03	0.30**	0.03	0.25*	-0.06	0.13	0.19	0.33***	0.35***	0.19
Van	0.17	0.35***	0.20	0.45***	0.11	0.30**	0.07	-0.27*	0.20	0.42***	0.40***	0.25*
Diyarbakır	-0.11	0.25*	-0.03	0.06	-0.06	-0.07	-0.08	-0.16	0.18	0.19	0.33***	0.09
Batman	-0.23	0.27*	-0.07	0.17	-0.10	0.15	-0.10	-0.17	-0.09	0.03	0.22	0.20

* 0.1-0.05 , ** 0.05-0.01, *** 0.01-0.00 Significance levels of the correlations.

Table 10 Monthly Total Precipitation - Western Mediterranean Oscillation Correlation Test Results

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Siirt	0.32***	-0.23**	-0.20*	-0.14	0.04	0.03	0.03	-0.06	-0.03	-0.50**	-0.32***	-0.04
Hakkâri	0.16	-0.24*	-0.15	-0.20	0.04	0.10	-0.04	-0.22*	0.02	-0.39***	-0.37***	-0.15
Tunceli	0.34***	0.06	-0.04	-0.18	0.10	-0.03	0.09	0.07	0.02	-0.33***	-0.22*	0.01
Malatya	0.30***	-0.06	-0.06	-0.23*	-0.04	0.18	0.05	-0.09	-0.05	-0.35***	-0.25**	-0.02
Adıyaman	0.32***	-0.12	-0.23*	-0.25*	0.00	-0.08	-0.03	0.02	-0.08	-0.41***	-0.37***	0.20
Erzincan	0.27**	0.02	0.12	-0.08	-0.13	0.08	-0.02	0.05	-0.02	-0.42***	-0.20*	-0.14
Şanlıurfa	0.25**	-0.19	-0.16	-0.18	0.03	-0.02	-0.04	0.10	-0.14	-0.45***	-0.29**	0.04
Elazığ	0.28**	-0.03	-0.02	-0.08	0.04	-0.04	0.00	0.08	-0.07	-0.46**	-0.34***	-0.03
Muş	0.23*	-0.15	-0.21	-0.10	0.04	-0.11	0.22	0.17	0.06	-0.44***	-0.23*	-0.09
Gaziantep	0.28**	-0.20*	-0.20*	-0.35***	0.12	0.08	-0.21*	0.01	-0.09	-0.47**	-0.32***	0.10
Mardin	0.26**	-0.20*	-0.09	-0.17	-0.10	0.01	0.04	-0.03	-0.05	-0.38***	-0.26**	0.08
Bingöl	0.29**	-0.06	-0.16	-0.23*	-0.01	-0.03	0.12	-0.01	-0.06	-0.39***	-0.31**	0.04
Erzurum	0.26**	-0.05	-0.14	-0.12	0.00	-0.02	0.18	0.02	-0.01	-0.36***	-0.20*	-0.12
Ağrı	0.15	-0.07	-0.04	-0.27**	-0.03	0.08	0.34***	0.00	-0.02	-0.46**	-0.19	-0.01
Van	0.19	-0.34***	-0.21*	-0.12	-0.05	0.06	0.15	0.12	-0.09	-0.51**	-0.24**	-0.19
Diyarbakır	0.28**	-0.21*	-0.17	-0.24*	-0.06	0.12	0.06	0.12	-0.22*	-0.44***	-0.41***	-0.02
Batman	0.25*	-0.25**	-0.12	-0.18	0.00	0.07	0.13	0.14	-0.06	-0.35***	-0.14	-0.05

* 0.1-0.05 , ** 0.05-0.01, *** 0.01-0.00 Significance levels of the correlations.

Discussion

The results presented the relationship of AO in winter temperatures and precipitaion are compatible with the previous studies (Turkes and Erlat 2008; Sezen and Partal 2017). Additionally, the temperature features of the basin can be predicted using the one-month delayed AO index. There are strong relationships between the NAO and average temperature in the months of January, June, August, and November. The effect of the NAO on basin temperature is not restricted to the winter season (Turkes and Erlat (2009). The winter precipitation of Southern parts of Turkey is highly affected by NAO (Tan and Unal, 2003), According to several factors, such as height and distance from the Mediterranean Sea, the relationship in the Euphrates-Tigris Basin is lessened. The result is also in line with the study of NAO, precipitation and temperature relationship investigation study over the Mediterranean Mountainous regions which reports the link lessens to the most eastern parts of Mediterranean. (Moreno et. al. 2011). Precipitation in the Mediterranean basin is generally negatively correlated with the NAO (Turkes and Erlat, 2003). However, this study found that AO, NCP, and WeMO are more influential on basin precipitation features. The NCP and WeMO indices are the most strongly linked to temperature and precipitation. Temperatures and NCP have a negative correlation. The link between NCP and precipitation is distinct from the reported previous study results. Especially the precipitation in the western parts of Turkey is reported as negatively correlated by NCP whereas the Black sea region is positively correlated (Sezen and Partal 2019). In this study positive correlations were detected over the Euphrates –Tigris Basin. This is sourced from the distinctive air flows during the positive and negative NCP phases. The positive and negative NCP phases results northern and southern maritime air flows respectively (Kutiel and Benaroch, 2002). WeMO affects all the February, April, November, and December temperatures over the region. Additionally, WeMO had an impact on almost all basin precipitations, with January, October, and November seeing the biggest changes. More attention must be paid to WeMO because it can predict the basin’s temperature and precipitation as well. With the extension of the Hadley cell, the dynamics of the atmosphere are altering (Grise and Polvani, 2016). Along with these modifications, the positions of the large-scale pressure patterns, the orbits of the cyclones, and their interactions shift. These discovered relationships are not constant and are vulnerable to modification by more recent data analysis.

Conclusions

The monthly average temperatures of the Euphrates-Tigris basin have a moderate correlation with the AO in the whole basin, especially in October, November, and December. The relationship was stronger in extreme index values. The one-month-delayed correlation between AO and December temperatures contributes to the predictability of December temperatures.

NAO has a negative correlation with the average temperatures of the basin in January, June, August, and November. The strength of the relationship between extreme index values and average temperatures increases. The NAO index shows a negative correlation with a one-month delay in December and a positive correlation with a two-month delay in March.

NCP is the remote teleconnection pattern (negative correlation) with the highest effect on the basin temperatures throughout the year. Considering the correlation values, the correlation values of the winter and spring months are significantly higher. With the increase in the higher values of the index, the strength of the correlation significantly increases. Significant negative relationships with a one-month delay were found between NCP and January, February, and March temperatures.

Significant positive correlations were found between WeMO February, April, November, and December temperatures in almost all stations. A significant positive correlation with a one-month delay was found for January and March whereas a significant negative correlation with a two-month delay was found for August between WeMO and temperatures in general.

Significant negative correlations were found between AO and the Euphrates-Tigris Basin precipitation at ten stations in February and at five stations in December and January. According to the correlation results between precipitation and NAO with delayed, non-delayed, and extreme index values, significant correlations were not determined to represent the entire basin. The detected correlation values were low and of an isolated nature. NCP and monthly total precipitation showed a positive relationship in February, October, and November in approximately half of the stations. Relationship strength was very strong in analyzes carried out with extreme index values.

A one-month delayed correlation was detected in December with NCP in approximately half of the stations in monthly total precipitation values. The monthly total precipitation in January showed a significant positive correlation with the NCP index values obtained two months prior. According to the correlation analysis results for the extreme values, a very strong negative (max. 0.87) was determined for January for the third quartile, and a strong positive correlation (max. 0.81) was obtained for November for the first quartile.

It was determined that WeMO affected almost all basin precipitations, most significantly in January, October, and November. A significant positive correlation was determined between January WeMO and precipitation whereas a significant negative correlation was determined between October and November WeMO and precipitation. In the results of the time-delayed correlation test between WeMO and precipitation, a significant positive relationship with a one-month delay and a negative relationship with a two-month delay were determined in approximately half of the stations in the basin, especially in January.

There were strong relationships between the temperature and precipitation characteristics of the Euphrates-Tigris basin and remote teleconnection patterns. These relationships can contribute to predicting the temperature or precipitation parameters of some months one or two months in advance. Remote teleconnection patterns facilitate seasonal climate forecasts. This information can also be used for seasonal streamflow forecasts. Considering the effects of climate change and variability, it is possible that the effects detected today will strengthen, weaken, disappear, or new relationships may emerge over time. Therefore, the studies on this subject should increasingly continue with new methods with current data.

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