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Relationship between Mediterranean region temperatures and precipitation with atmospheric oscillations and ITA results

Utku Zeybekoglu[1] · **Oguz Sımsek**[2] · **Emir Cengiz Durgun**[2]

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Abstract

This study analyzes the relationship between precipitation and temperature data measured in the Mediterranean Region of Turkey from 1970 to 2022, and the Mediterranean Oscillation Indexes (MOI1 and MOI2) and the Arctic Oscillation (AO). In the study, correlation analyses and Innovative Trend Analysis (ITA) methods were applied using data from 24 meteorological observation stations in the region. As a result of the correlation analyses, it was determined that AO had a negative correlation with the precipitation data of all stations in the region. This situation shows that the increase in AO values reduces the amount of precipitation. While a generally negative relationship exists between MOI1 and precipitation from the two versions of MOI, a mostly positive relationship was determined between MOI2 and precipitation. However, statistically significant relationships were determined in some stations. When evaluated in terms of temperature, negative correlations were determined with MOI1, MOI2, and AO indices in all stations in the region. This situation shows that atmospheric oscillations effectively influence temperature changes and that fluctuations in temperature values may be mainly due to these atmospheric systems. When the ITA results were examined, a significant increasing trend in temperature data was observed. However, there was no stable increasing or decreasing trend in precipitation data. While an increasing trend was observed in small and medium-sized precipitation in the Western Mediterranean, a decreasing trend was observed in large precipitation. In the Eastern Mediterranean, changing trends were detected at different stations. These results reveal that the risk of drought may increase due to rising temperatures in the region, and strategic planning should be implemented for water resource management. As a result, the study's findings indicate that atmospheric oscillations, such as the Mediterranean Oscillation (MOI) and the Arctic Oscillation (AO), significantly affect precipitation and temperature regimes in the Mediterranean Region of Turkey. The increase in temperature in the region may increase the pressure on water resources in the future and cause drought events to occur more frequently. In this context, reviewing regional water management policies and developing sustainable water use strategies is important.

Keywords Atmospheric oscillation · Mediterranean region · ITA · Meteorological parameters

✉ Utku Zeybekoglu
utkuz@sinop.edu.tr

Oguz Sımsek
oguzsimsek@harran.edu.tr

Emir Cengiz Durgun
emir_cengiz89@hotmail.com

[1] Boyabat Vocational School of Higher Education, Department of Construction, Sinop University, Boyabat, Sinop 57200, Turkey

[2] Faculty of Engineering, Civil Engineering Department, Harran University, Sanliurfa 63050, Turkey

Introduction

Global atmospheric oscillations are defined as regular, recurring, and occasionally long-term changes in the large-scale dynamic movements of the atmosphere (Hurrel 1995; Hurrel et al. 2003). It is imperative to acknowledge the significance of these oscillations in determining global climate and weather conditions, as they play a pivotal role in combating global climate change. Global atmospheric oscillations serve as a crucial indicator of variations in fundamental atmospheric parameters such as temperature, precipitation, wind, and air pressure over time. These oscillations are of paramount importance in understanding climatic variations. It is evident that oscillations have the capacity to influence both long-term climatic variations and seasonal changes. The most well-known examples of such oscillations are El Niño and La Niña events, which have been shown to exert significant effects on global weather patterns, particularly concerning changes in surface water temperatures in the tropical Pacific Ocean (Trenberth 1997). These oscillations directly influence agricultural productivity, water resources management, and human settlements, particularly through their impact on weather events such as precipitation patterns, temperature variations, and natural disasters. In recent years, the relationship between atmospheric oscillations and climate change has been the focus of increased attention. Global warming has been demonstrated to modify the terrestrial and oceanic dynamics, thereby increasing the intensity and frequency of these oscillations (Alexander et al. 2002). Specifically, the intensification and prolongation of El Niño and La Niña events have been observed, resulting in an escalation in extreme weather events and a consequent increase in climate unpredictability (Kosaka and Xie 2013). Consequently, a more profound comprehension of atmospheric oscillations is imperative to determine the extent of climate change.

The effects of many global atmospheric teleconnections such as the North Atlantic Oscillation (NAO), Arctic Oscillation (AO), Mediterranean Oscillation (MOI), Southern Oscillation (SO), and the North Sea Caspian Pattern (NCP) on the climate of the Earth and Turkey have been investigated in many studies (Kadioglu et al. 1999; Karabork et al. 2005; Bjerknes 1969; van Loon and Rogers 1978; Barnston and Livezey 1987; Hurrell 1995; Hurrell and Van Loon 1997; Cullen and deMenocal 2000; Kahya and Karabork 2001; Higgins et al. 2002; Chowdhury and Beecham 2010; del Rio et al. 2013; Gehlot et al. 2021; Keskin et al. 2024). According to Thompson and Wallace (1998), a significant relationship between NAO and AO was determined. They also proved that AO is more dominant in the Northern Hemisphere than NAO. Cullen and deMenocal (2000) demonstrated the existence of a relationship between NAO and temperature/precipitation in Turkey. Gong et al. (2001) demonstrated the existence of a significant relationship between AO and the Siberian Anticyclone. Erlat (2002) demonstrated the negative relationship between NAO and precipitation in Turkey. Karabork and Kahya (2003) determined that the Southern Oscillation (SO) is effective on precipitation in Western and Eastern Anatolia. Turkes and Erlat (2003) investigated the effect of the North Atlantic Oscillation on winter precipitation in 78 stations in Turkey. They mainly observed a negative relationship in the Marmara Region. Wang et al. (2005) studied the effects of NAO and AO indices on temperature values in the Northern Hemisphere. They concluded that NAO is particularly effective in North Africa, while AO is effective over a broader area. According to Feidas et al. (2007), the North Atlantic Oscillation (NAO) and the Mediterranean Oscillation (MO) affect the precipitation in Greece. Turkes and Erlat (2008) determined a negative relationship between AO and winter temperatures in 70 stations in Turkey during the period 1950–1999. Gonzalez-Hidalgo et al. (2009) stated that NAO and MOI affect the precipitation in the Iberian Peninsula. Nastos et al. (2011) examined the effects of the NAO, Mediterranean Oscillation (MO), and NCP on temperatures in Greece. Ramadan et al. (2012) reported that MOI positively correlated with winter precipitation in the Litani Basin. Criado-Aldeanueva and Soto-Navarro (2013) determined the existence of a negative relationship between MOI and precipitation in the Mediterranean basin. Givati and Rosenfeld (2013) stated the relationship between Israeli precipitation and the AO index. Partal (2018) stated that Turkey's Mediterranean Region precipitation is negatively related to the NAO. Sezen and Partal (2019) investigated the relationship between precipitation and temperature records in Turkey for the period 1960–2015, as well as the AO and the North Sea Caspian Pattern (NCP). They revealed that these two indices are particularly effective for winter temperatures. Sezen and Partal (2020) concluded that MOI is effective on Turkey's temperature and precipitation regime.

The Mediterranean Oscillation, one of the two atmospheric oscillations used in this study, indicates fluctuations in weather dynamics around the Mediterranean Sea, leading to climatic changes, especially in Southern Europe, the Middle East, the Iberian Peninsula, and North Africa. This oscillation precipitates significant climatic events, including substantial precipitation or drought within the region (Thompson and Wallace 1998; Mariotti et al. 2002a, 2022b; Xoplaki 2002; Dunkeloh and Jacobeit 2003; Acar 2008; Kebapcioglu 2022; Kebapcioglu and Partal 2022, 2024). The other oscillation in this study, the Arctic Oscillation, involves atmospheric pressure disparities in the Arctic region that dictate weather conditions across the Northern Hemisphere (Thompson and Wallace 1998). The area of influence of AO is comparable to that of NAO. Despite this similarity, AO affects the entire northern hemisphere, while NAO has a particularly strong influence around the Atlantic Ocean (Wang et al. 2005).

In addition to understanding the relationship between atmospheric oscillations and meteorological parameters, identifying the trends of these parameters also plays a vital role in assessing possible risks. Although statistical methods such as Mann–Kendall and Spearman's Rho are frequently used in determining the trend of a time series, there are restrictions, such as the data set not being affected by internal dependency and the data length being at least 30, for applying these methods. In addition to these methods, the ITA method, a graphical trend analysis tool developed in recent years to determine trends in time series and is easy to apply, is widely used by researchers (Gumus et al. 2022, 2023). The ITA method has significant advantages due to its features, such as visually presenting the results and providing the opportunity to evaluate trends in different value ranges rather than the entire data set with a single statistical parameter.

The aims of this study, which was conducted with precipitation and temperature series at 24 meteorological observation stations in the Mediterranean region of Turkey between 1970 and 2022, are twofold: a) to evaluate, analyze and map the spatial extent of the influence of the MOI and AO on the temperature and rainfall; b) to investigate and analyze possible trends in precipitation and temperatures. The present paper is divided into four chapters. The first chapter elucidates the objective of the study. The second chapter details the geographical area under investigation, the data sources, the atmospheric indices, and the analytical method employed in the study. Chapter 3 presents the findings derived from the analyses. The final section offers a conclusion of the study.

Materials and methods

Study area

Turkey is divided into seven geographical regions, and the Mediterranean region, which forms the southern border of Turkey, is one of these regions. The Mediterranean region has hot, dry summers and warm, rainy winters. The Taurus Mountains are in the north of the region, and the Mediterranean is in the south. Therefore, the elevation difference is high. Tourism activities are quite common in the region, and it is one of the regions where agricultural products that Turkey exports are produced. Greenhouse activities are quite common in the region and are seen as the most important source of income. Many researchers have stated that the region is the most sensitive to global warming and climate change in Turkey (Simsek 2021). The spatial distribution of the stations examined in the study region is given in Fig. 1. The information on the province, station number, and name, elevation, latitude, and longitude of the stations used in the study is presented in Table 1. Precipitation and temperature data measured between 1970 and 2022 at 24 meteorological observation stations were used in the study. These data were obtained from the Turkish State Meteorological Service. Within the provincial borders of Adana, Antalya, Hatay, Isparta, Kahramanmaras, and Mersin, there are 6, 6, 4, 2, 2, and 4 meteorological observation stations, respectively. As can be seen from Table 1, the altitude varies between 2 and 1344 m.

Arctic oscillation

The Arctic Oscillation (AO) is defined as an atmospheric circulation pattern over the mid to high latitudes of the

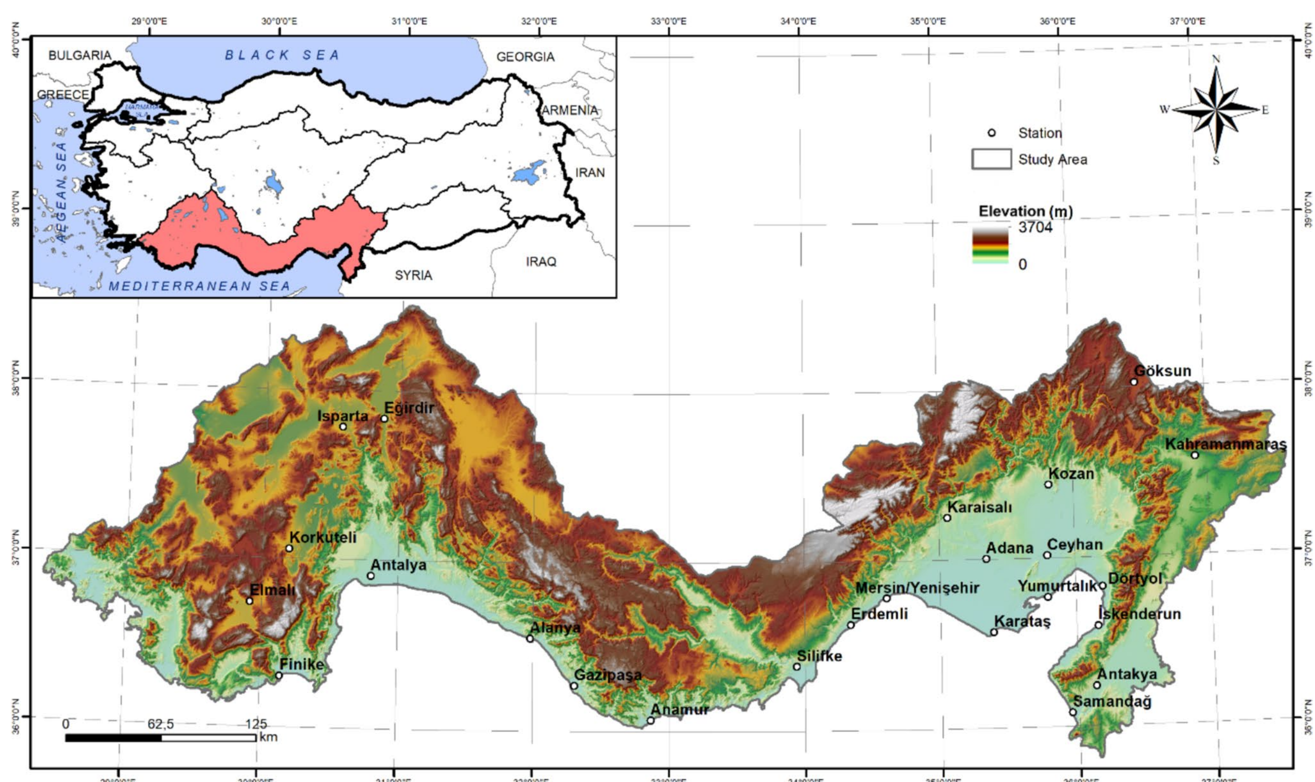

Fig. 1 Spatial distribution of meteorological stations throughout the Mediterranean Region of Türkiye

Table 1 Summaries of the stations located in the Mediterranean Region

State	No	Station Name	Altitude (m)	Latitude (N)	Longitude (E)
Adana	17351	Adana	23	37.0041	35.3443
	17908	Kozan	112	37.4337	35.8202
	17960	Ceyhan	30	37.0153	35.7955
	17979	Yumurtalık	34	36.7701	35.7902
	17936	Karaisalı	240	37.2506	35.0628
	17981	Karatas	22	36.5683	35.3894
Antalya	17974	Gazipasa	21	36.2747	32.3076
	17300	Antalya	61	36.9063	30.7990
	17952	Elmalı	1095	36.7372	29.9121
	17310	Alanya	6	36.5507	31.9803
	17375	Finike	2	36.3024	30.1458
	17926	Korkuetli	1017	37.0565	30.1910
Hatay	17962	Dortyol	29	36.8244	36.1981
	17372	Antakya	104	36.2368	36.1329
	17986	Samadag	4	36.0814	35.9492
	17370	Iskenderun	4	36.5924	36.1582
Isparta	17240	Isparta	997	37.7848	30.5679
	17882	Egirdir	920	37.8377	30.8720
Kahramanmaras	17866	Goksun	1344	38.0240	36.4823
	17255	Kahramanmaras	572	37.5760	36.9150
Mersin	17320	Anamur	2	36.0686	32.8649
	17958	Erdemli	7	36.6268	34.3380
	17340	Yenisehir	7	36.7808	34.6031
	17330	Silifke	10	36.3824	33.9373

Northern Hemisphere (Xoplaki 2002; Turkes ve Erlat 2008; Lindsey 2009). The AO is defined by the change in the difference between high pressure in the Arctic and low pressure in the mid-latitudes (Hurrell et al. 2000). The most obvious manifestation of the phase of this oscillation is the north–south position of the storm driving the mid-latitude jet stream. Consequently, the AO can exert a significant influence on weather and climate in major population centres in North America, Europe, and Asia, especially during winter (Thompson and Wallace 1998, 2000, 2001; Zhou et al. 2001; Thompson et al. 2003; Higgins et al. 2000, 2002; Larson et al. 2005; Lindsey 2009). The impact of the AO on glacial melt and polar interactions in the Arctic region is critical to contemporary climate change studies.

Mediterranean oscillation

The MOI, as defined by Palutikof et al. (1996) and Conte et al. (1989), is expressed as the standardised pressure differential between Algiers (36.4°N, 3.1°E) and Cairo (30.1°N, 31.4°E). This initial version of the index (MOI1) is the foundation for further analysis. A second version of the index (MOI2) can be calculated from Gibraltar's Northern Frontier (36.1°N, 5.3°W) and Lod Airport in Israel (32.0°N, 34.5°E) (Palutikof 2003). The Mediterranean Oscillation (MO) has been identified as a distant connection pattern that is effective during the winter months, with a partial weakening in spring and a complete dissolution in summer. Furthermore, it has been observed to develop less extensively in autumn compared to winter. In winter, the MO exhibits a substantial correlation between precipitation and temperature, fostering humid conditions in the Mediterranean basin through southerly currents. This phenomenon is attributed to a deep cyclonic circulation encompassing southern Europe and the Mediterranean, which engenders dry conditions in the Mediterranean basin (Colacino and Conte 1993; Kutiel et al. 1996; Maheras et al. 1999; Maheras and Kutiel 1999; Acar 2008). Piervitali et al. (1999) recommend the utilisation of this index within the Mediterranean basin.

Methodology

In this study, Pearson correlation coefficients, as expressed in Eq. 1, were calculated to determine the relationship between the atmospheric oscillation index and meteorological records (Bayazit and Oguz 2005).

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

In the context of the given equation, x_i denotes the i-year climate data, $\overline{x}$ the average of the climate data, y_i the i-year index data, $\overline{y}$ the mean of the index data, N represents the total number of data points, S_X the standard deviation value of the climate parameter, and S_Y the standard deviation of the index data. Following the determination of the correlation coefficients, the significance levels of α=0.01, α=0.05, and α=0.1 were evaluated by employing Student's t-test. The correlation breakpoints were obtained with the t distribution, as illustrated in Eq. 2 (Bayazit and Oguz 2005).

$$t = \frac{r\sqrt{N-2}}{\sqrt{1-r^2}} \tag{2}$$

In Eq. 2, t represents the test statistic, r represents the correlation value, and N represents the number of data.

Innovative trend analysis (ITA)

The Innovative Trend Analysis (ITA), a methodology proposed by Sen (2012), involves dividing a data set into two parts and then sorting them in ascending order in a Cartesian coordinate system. The ITA facilitates the clear definition and graphical representation of the hydrological and meteorological time series trends of low, medium, and high values. The ITA method does not require the conditions of the classical statistical methods, Mann–Kendall and Spearman's Rho, such as the absence of internal dependence in the time series, the availability of at least 30 months or years of data, and the requirement to conform to any statistical distribution. Furthermore, while these methods allow for evaluating the time series as a whole, the ITA method enables the evaluation of values of varying magnitudes within the time series. Because the ITA method presents the trend in the time series graphically, its interpretation and evaluation are simpler than other classical trend methods. In this method, the initial data set (y_1) is arranged in order along the X-axis, and the subsequent data set (y_2) is organized in sequence along the Y-axis. The trend is identified by examining the scatter of the data points above the 1:1 line (Fig. 2). No trend is present if the data is accumulated around the 1:1 line. An upward trend is indicated by the data's position above the 1:1 line, while a downward trend is signalled by the data's position below the 1:1 line. The distance of the data points from the line in the scatter plot indicates the trend's strength. Data points near the line indicate a weak trend, while those far from the line suggest a strong trend. Recent studies have incorporated indicators into graphs to specify confidence levels (Caloiero 2018; Caloiero et al. 2018; Achite and Caloiero 2021). These indicators aim to help readers understand the distance between the non-trend line and the occurrence of a strong trend. To this end, two confidence limit lines (±5% and ±10%) have been included in the ITA graph in this study. The assumption is made that there is "no trend" for values between the 1:1 and ±5% lines, a "trend" for values between the ±5% and ±10% lines, and a "strong trend" for values exceeding the ±10% lines, as illustrated in Fig. 2.

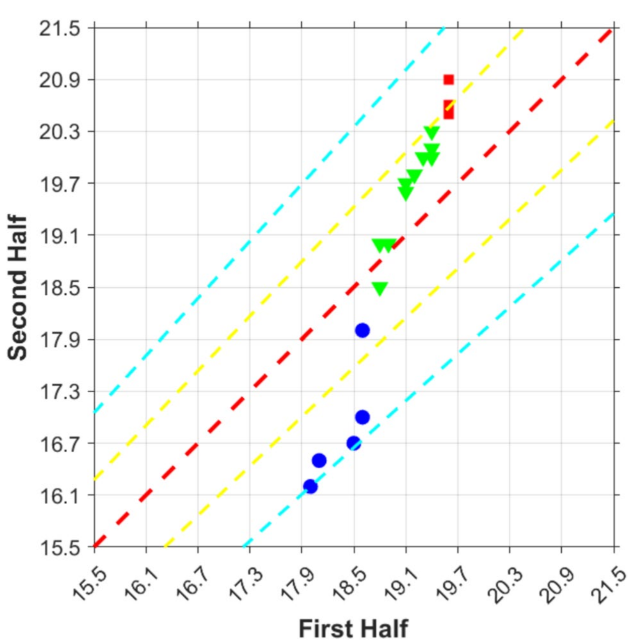

Fig. 2 The innovative trend analysis method graph

In the context of a unidirectional trend, characterized by a consistent increase or decrease in all data points, the conventional "low (blue), medium (green), and high (red)" range evaluation becomes redundant due to the absence of varied trend slopes. However, in scenarios where data distributions exhibit both increasing and decreasing trends, a data set can be segmented into distinct groups to ascertain the prevailing trend (Alashan 2018; Caloiero 2018; Caloiero et al. 2018). In this study, the data set was classified as low, medium, and high, and the lower and higher value limits were calculated by subtracting the standard deviation from the mean and adding the standard deviation to the mean (Alashan 2018).

Results and discussion

Results of the correlation analysis between MOI1, MOI2, AO and precipitation values

The correlation coefficients that have been calculated between the precipitation series and the MOI1/MOI2/AO belonging to the 24 meteorological observation stations in the Mediterranean region of Türkiye are presented in Table 2. The correlation coefficients identified as significant at the $\alpha = 0.05$ level are shown in bold in the table. The correlation coefficients, calculated from the Student's t-test results, are presented on separate maps for each atmospheric oscillation in Fig. 3. Downward triangles indicate a negative correlation, while upward triangles indicate a positive correlation. Filled triangles indicate statistically significant correlation values at the $\alpha = 0.05$ level. Stations with a correlation value of "0" are indicated with a dash.

Correlations were determined between the precipitation series of the stations in the Mediterranean region and MOI1. Negative correlations were calculated in 14 stations, and positive correlations in 9 stations. No relationship was determined with MOI1 in Anamur, located in the western part of the region. Positive correlations were calculated in Antalya, Korkuteli, Elmalı, and Finike in the west of the region; negative correlations were calculated in Isparta, Eğirdir, Gazipaşa, and Alanya. This balanced distribution in the west of the region is remarkable. In the east of the region, positive correlations were determined in Silifke, Antakya, İskenderun, Adana, and Ceyhan, and negative correlations were determined in the other 10 stations. In other words, despite the balance in the region's west, a negative relationship prevails in the east.

A positive relationship with MOI2 was determined in 19 stations of the region. A negative relationship was determined in 5 stations, and 4 of these stations are Dörtyol, Göksun, Kozan, and Yumurtalık in the east of the region.

Table 2 Correlation coefficients between atmospheric indices and precipitation records

Name	MOI1	MOI2	AO	Name	MOI1	MOI2	AO
Adana	0.14	**0.27**	−0.18	Dortyol	−0.09	−0.07	**−0.27**
Kozan	−0.13	−0.05	**−0.30**	Antakya	0.01	0.18	−0.25
Ceyahn	0.02	0.09	−0.13	Samadag	−0.02	0.06	−0.07
Yumurtalık	−0.16	−0.06	−0.26	Iskenderun	0.01	0.16	−0.22
Karaisalı	−0.13	0.02	**−0.32**	Isparta	−0.03	0.02	**−0.29**
Karatas	−0.09	0.09	−0.23	Egirdir	−0.06	−0.04	**−0.28**
Gazipasa	−0.03	0.17	**−0.28**	Goksun	−0.09	−0.05	**−0.28**
Antalya	0.05	0.10	**−0.29**	Kahramanmaras	−0.06	0.02	−0.22
Elmalı	0.02	0.07	−0.21	Anamur	0.00	0.14	**−0.40**
Alanya	−0.02	0.09	**−0.29**	Erdemli	−0.06	0.05	−0.21
Finike	0.17	0.17	**−0.33**	Yenisehir	−0.07	0.08	**−0.27**
Korkuetli	0.05	0.12	−0.24	Silifke	0.02	0.06	−0.18

A negative relationship with the index was calculated only in Eğirdir, in the west of the region. The correlation determined in Adana in the east of the region is statistically significant at a level of significance. In other words, it is highly probable that precipitation will decrease as the MOI2 index value increases. The existence of a positive relationship with MOI2 in Antalya and Mersin is remarkable in all stations with MOI2.

Negative correlation values were calculated between the precipitation series of all stations in the Mediterranean region and the Arctic Oscillation (AO). Twelve of these calculated values are statistically significant at a significance level of 0.05. Seven of the significant relationships determined belong to the stations in the west of the region: Isparta, Eğirdir, Anamur, Gazipaşa, Alanya, Antalya, and Finike. Of the seven stations in the west, Anamur, Gazipaşa, Alanya, Antalya, and Finike are in the coastal area. The five stations in the east, where a statistically significant relationship was determined with the index, are Yenişehir, Karaisalı, Kozan, Göksun and Dörtyol. It is expected that precipitation in the region will decrease as AO values increase in general. It is highly probable that this situation will be observed in the 12 stations where a significant relationship has been determined.

Results of the correlation analysis between MOI1, MOI2, AO and temperature values

The correlation coefficients that have been calculated between the temperature series and the MOI1/MOI2/AO belonging to the 24 meteorological observation stations in the Mediterranean region of Türkiye are presented in Table 3. The correlation coefficients where a relationship was identified at the $\alpha=0.05$ significance level between temperature records and atmospheric oscillations are shown in bold in Table 3. The correlation coefficients calculated based on the Student's t-test results are presented on separate maps for each atmospheric oscillation in Fig. 4. Downward triangles indicate a negative correlation, and upward triangles indicate a positive correlation. Filled triangles indicate statistically significant correlation values at the $\alpha=0.05$ level. Stations with a correlation value of "0" are indicated with a dash.

Negative correlations were calculated at all stations in the Mediterranean region with MOI1, which is defined as the first version of the Mediterranean oscillation. In other words, temperatures in the region are expected to decrease with increasing MOI1 values. These correlation values calculated for MOI1 in the Mediterranean region are not statistically significant at the 0.05 significance level.

Correlations were determined between the second version of the Mediterranean Oscillation (MOI2) and the stations in the Mediterranean region. Negative correlations were calculated in 19 out of 24 stations. Positive correlations were determined in Gazipaşa, Korkuteli, and Eğirdir in the west of the region. Negative correlations were calculated at other western stations. No statistical relationship was found with MOI2 in Adana and Kahramanmaraş, which are in the east of the region. A negative relationship was determined in all stations in the east of the region, except for the following two stations. While a decrease in temperatures is expected with an increase in MOI2 at the 19 stations with a negative correlation, it is noteworthy that temperatures will increase at the three stations showing a positive correlation. Another striking point is that a negative relationship was observed across all stations in Hatay and Isparta.

A negative relationship was determined between the stations in the Mediterranean region and the Arctic Oscillation (AO) throughout the entire region. Among the 17 stations with a negative relationship with the index, the correlation determined in Eğirdir in the west of the region is statistically significant at a level of significance. In other words, temperatures will probably decrease as the AO index value increases. Of the six stations with a positive correlation,

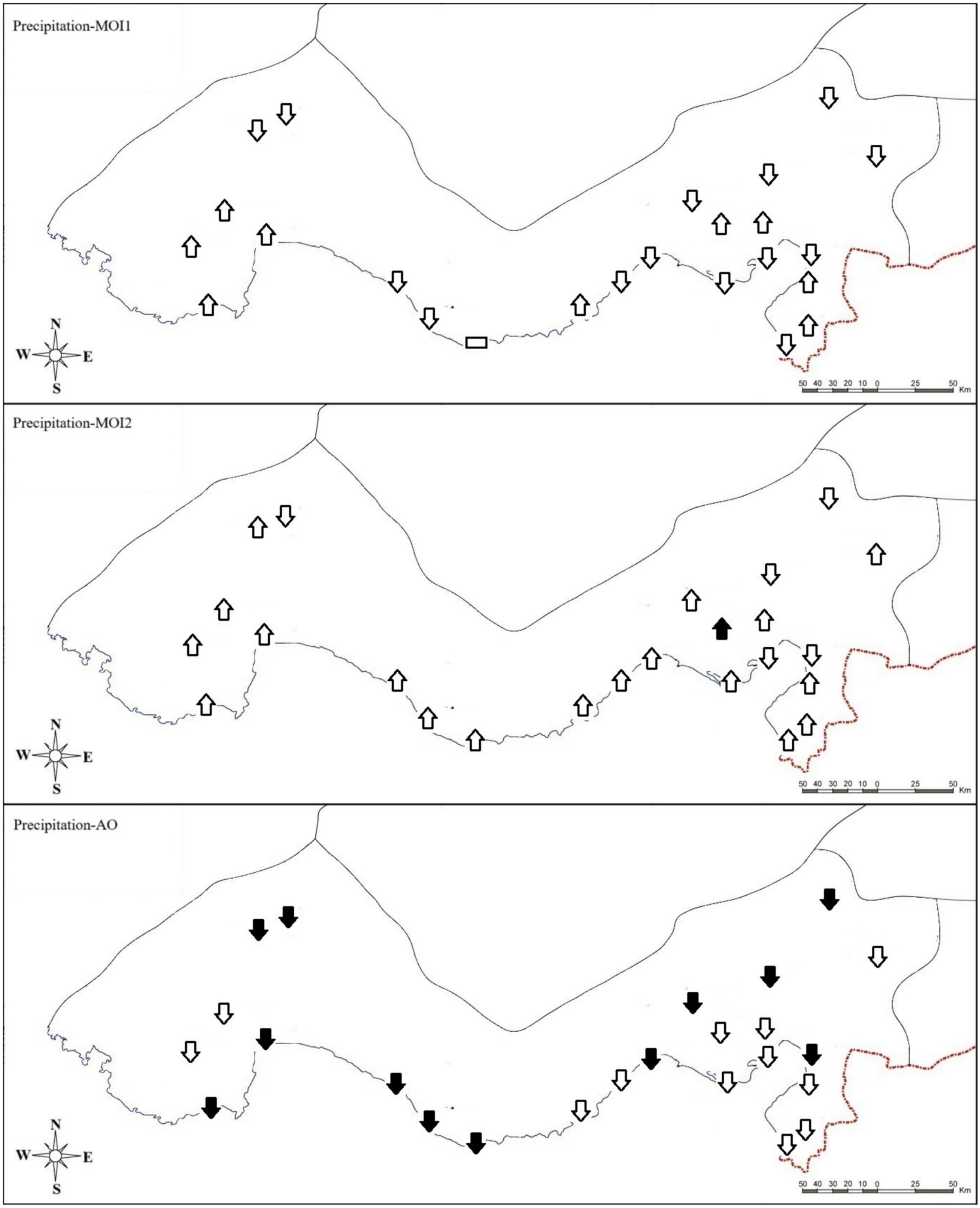

Fig. 3 Spatial distribution of correlation between atmospheric indices and precipitation records

Table 3 Correlation coefficients between atmospheric indices and temperature records

Name	MOI1	MOI2	AO	Name	MOI1	MOI2	AO
Adana	−0.03	0.00	0.05	Dortyol	−0.08	−0.02	−0.08
Kozan	−0.06	−0.02	−0.05	Antakya	−0.13	−0.09	−0.15
Ceyhan	−0.07	−0.03	0.03	Samadag	−0.10	−0.03	−0.12
Yumurtalık	−0.10	−0.06	−0.10	Iskenderun	−0.09	−0.06	−0.05
Karaisalı	−0.03	−0.02	−0.02	Isparta	−0.13	−0.10	−0.12
Karatas	−0.14	−0.06	−0.18	Egirdir	−0.07	0.02	−0.30
Gazipasa	−0.01	0.01	−0.04	Goksun	−0.20	−0.11	−0.20
Antalya	−0.04	−0.01	−0.15	Kahramanmaras	−0.03	0.00	0.01
Elmalı	−0.15	−0.16	−0.15	Anamur	−0.05	−0.04	0.03
Alanya	−0.09	−0.07	−0.01	Erdemli	−0.19	−0.14	−0.10
Finike	−0.08	−0.05	0.02	Yenisehir	−0.04	−0.01	0.03
Korkuetli	−0.05	0.04	0.00	Silifke	−0.09	−0.02	−0.08

Finike and Anamur are in the region's west. The other four stations with a positive correlation with the index are Kahramanmaraş, Yenisehir, Adana, and Ceyhan, located in the east of the region. No statistical relationship was determined with the AO index in Korkuteli in the west. The negative relationships determined with the AO index are striking in all stations in Isparta, in the west of the region, and in Hatay, in the east.

Trend analysis results of climatic parameters

The ITA results of precipitation values belonging to the stations located in the west of the study region are presented in Fig. 5. In the stations in the western part of the study region, an increasing trend is clearly seen in small precipitation values exceeding the 10% significance level. While an increasing trend is observed in medium precipitation values at the stations in Elmalı, Korkuteli, Finike, Isparta, Eğirdir, Gazipasa, and Anamur, no trend is observed at the Silifke station. In Alanya and Antalya stations, there is an increasing trend in some medium precipitation values and a decreasing trend in others. According to the trend analysis results of large precipitation values, there is a decreasing trend in Elmalı, Isparta, and Eğirdir stations and an increasing trend in all the remaining stations. If the ITA results of precipitation data in the study region are to be evaluated in general, an increasing trend will be seen in the region's precipitation values (small, medium, and large). Considering that floods occur in the study region at certain times, it can be said that large precipitation trends cause disasters in the western part of the study region.

Figure 6 shows the ITA results of precipitation values obtained from 13 meteorological observation stations located in the eastern part of the study area. There is a general increasing trend in precipitation values at Yenisehir, Iskenderun, and Kahramanmaraş stations, both small, medium, and large. There is no significant trend at Erdemli and Karaisali stations. A decreasing trend was identified for precipitation values greater than 640 mm at Adana station, while an increasing trend was observed for values less than 640 mm. There is an increasing trend in both small and large precipitation values at Karataş, along with a decreasing trend in medium precipitation values. There is no significant increase or decrease trend in precipitation data in any interval at the Yumurtalık and Ceyhan stations. While there is an increasing trend in medium precipitation values at Dörtyol, there is a decreasing trend in large precipitation values. A general decreasing trend was determined at Göksun and Kozan. There is an increasing trend in small precipitation values and a decreasing trend in medium and large precipitation values at Antakya station. The ITA results of the average temperature values of the stations in the western and eastern regions are presented in Figs. 7 and 8, respectively. There is a significant increasing trend in all stations and all value ranges in the region. An increasing trend exceeding the 10% limit is observed in Alanya stations in the region's west and in Yenisehir stations in the east. In addition, most regional stations clearly detected an increasing trend exceeding the 5% limit. A decreasing trend was not detected in any station or range of temperature values.

When the ITA results of precipitation and temperature parameters are evaluated together, the fact that there is no significant increasing trend in precipitation parameters (generally decreasing, increasing, or no change) despite the increasing trend in temperature values in the stations in the region provides the opportunity to evaluate that there will be an increase in drought events due to temperature in the region. Considering the increasing temperature and population in the region in the coming years, it is concluded that precipitation will be insufficient to meet the water resource needs.

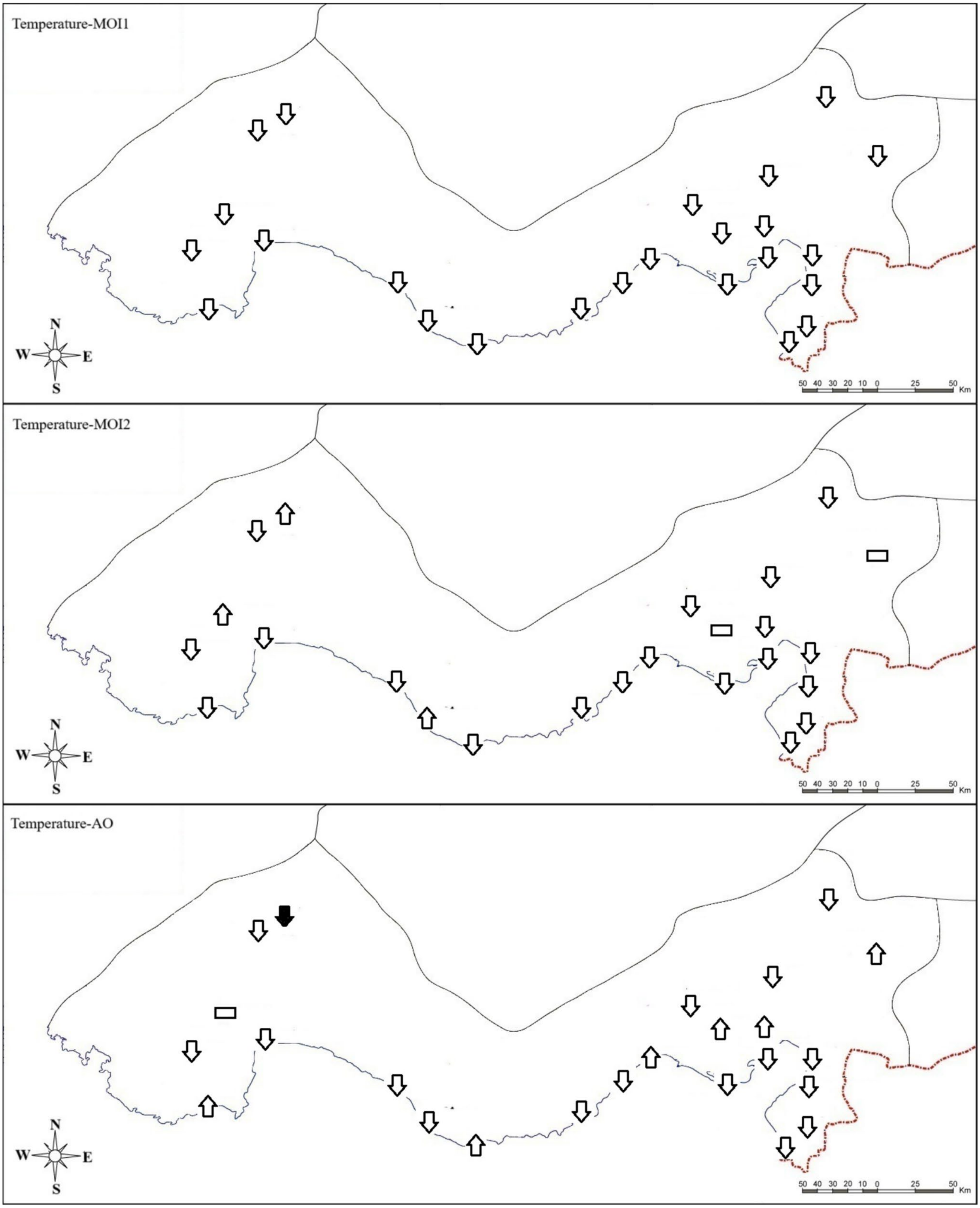

Fig. 4 Spatial distribution of correlation between Atmospheric indices and temperature records

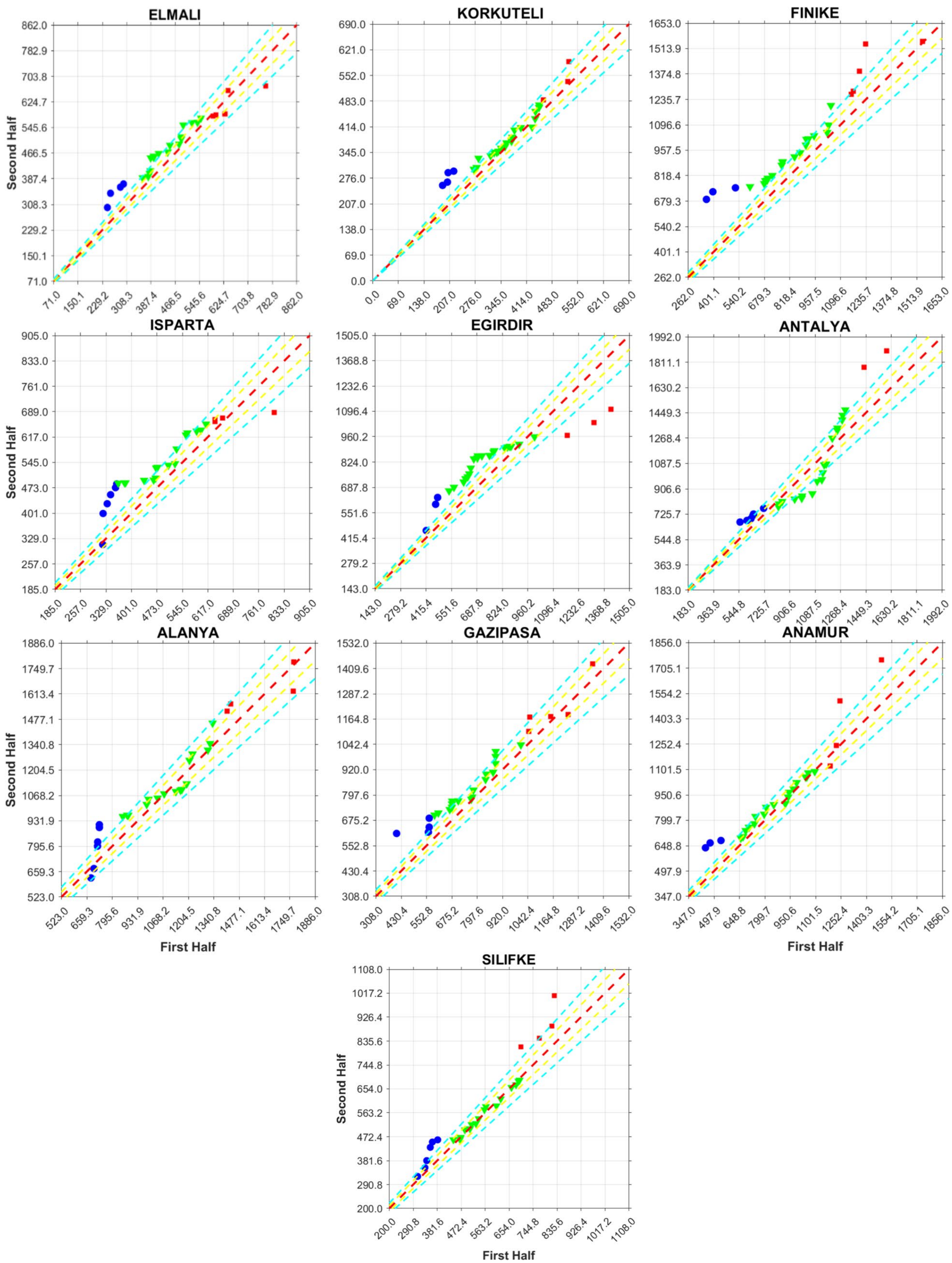

Fig. 5 ITA results of precipitation values of stations in the western region

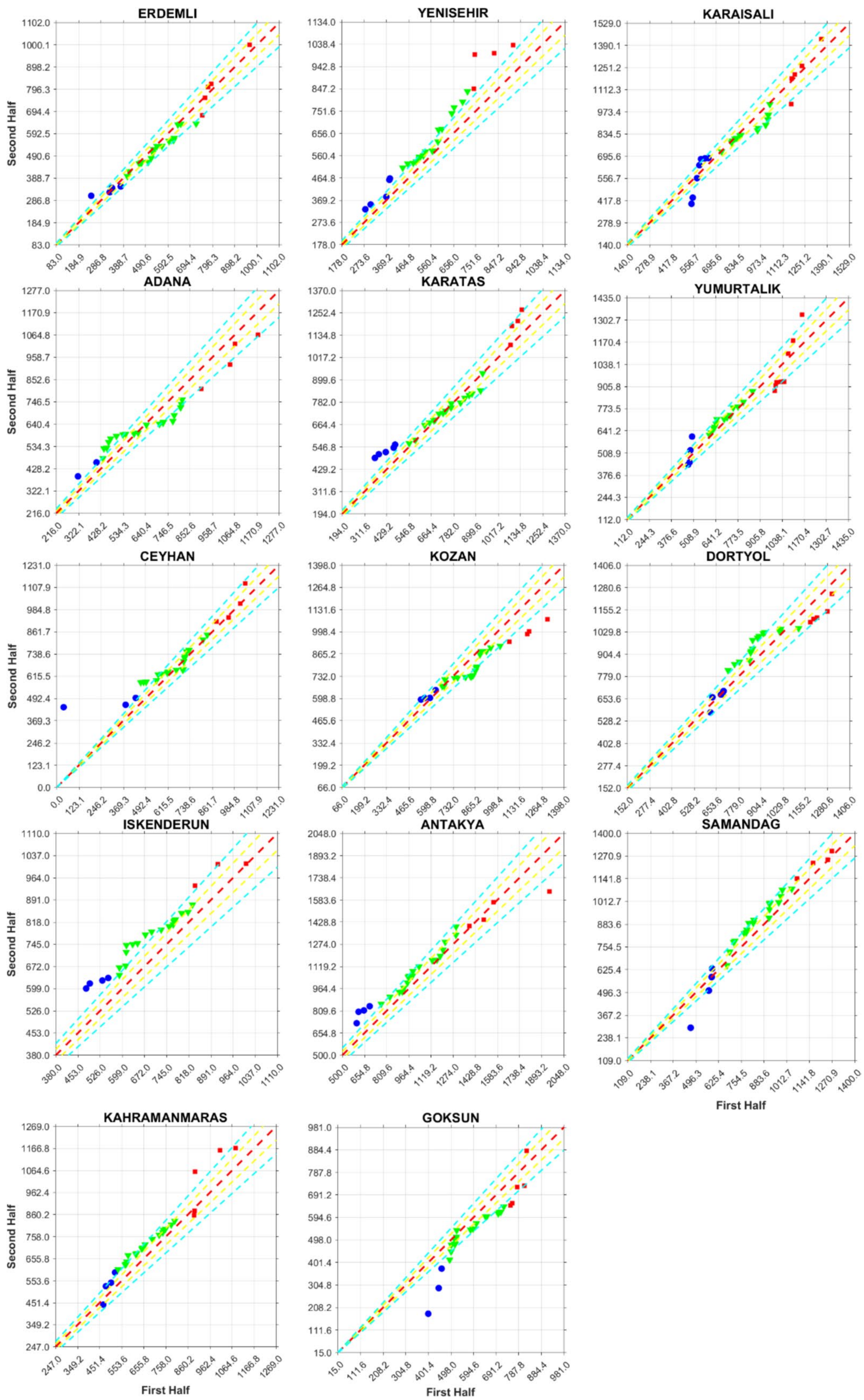

Fig. 6 ITA results of precipitation values of stations in the eastern region

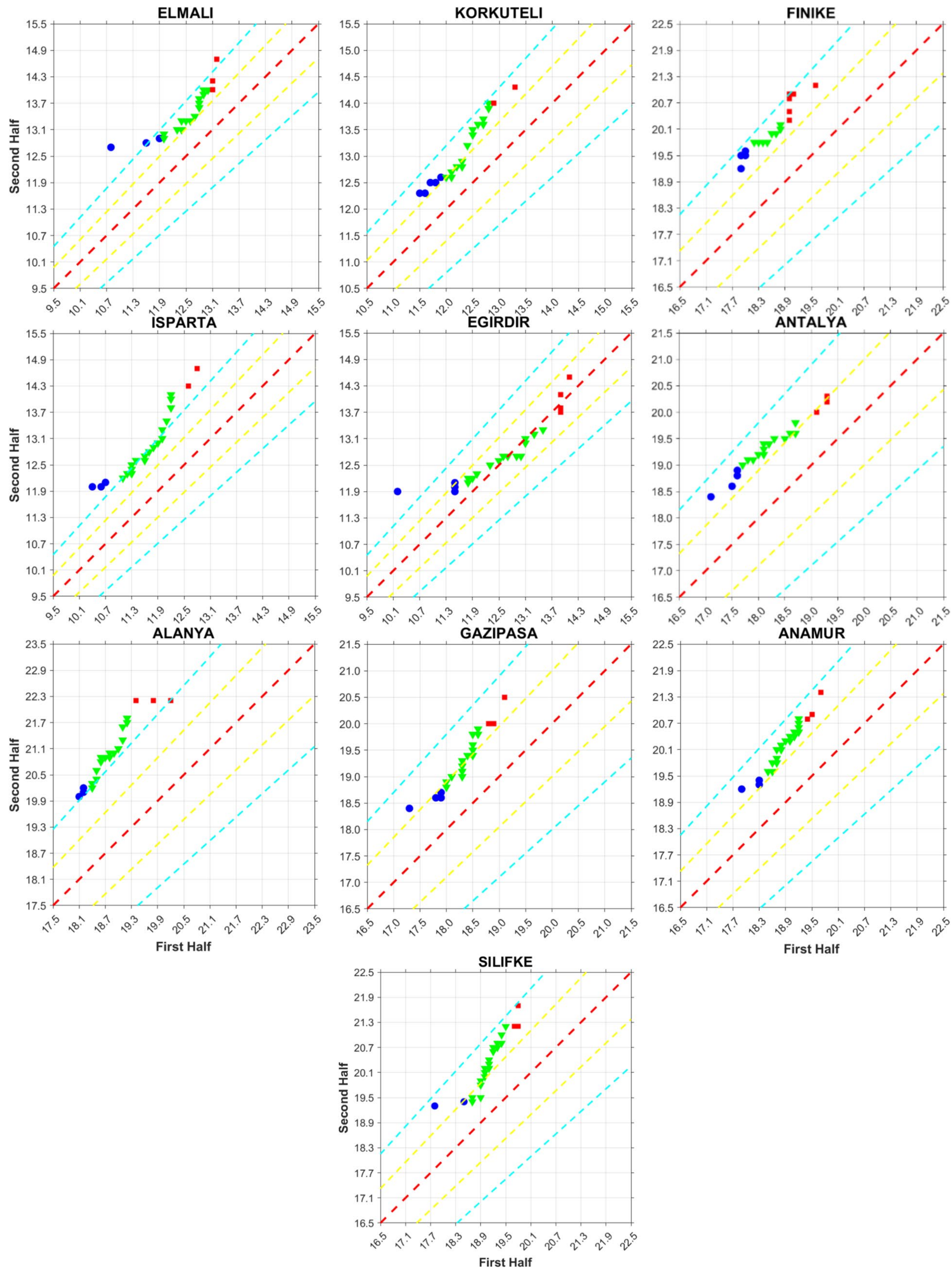

Fig. 7 ITA results of temperature values of stations in the western region

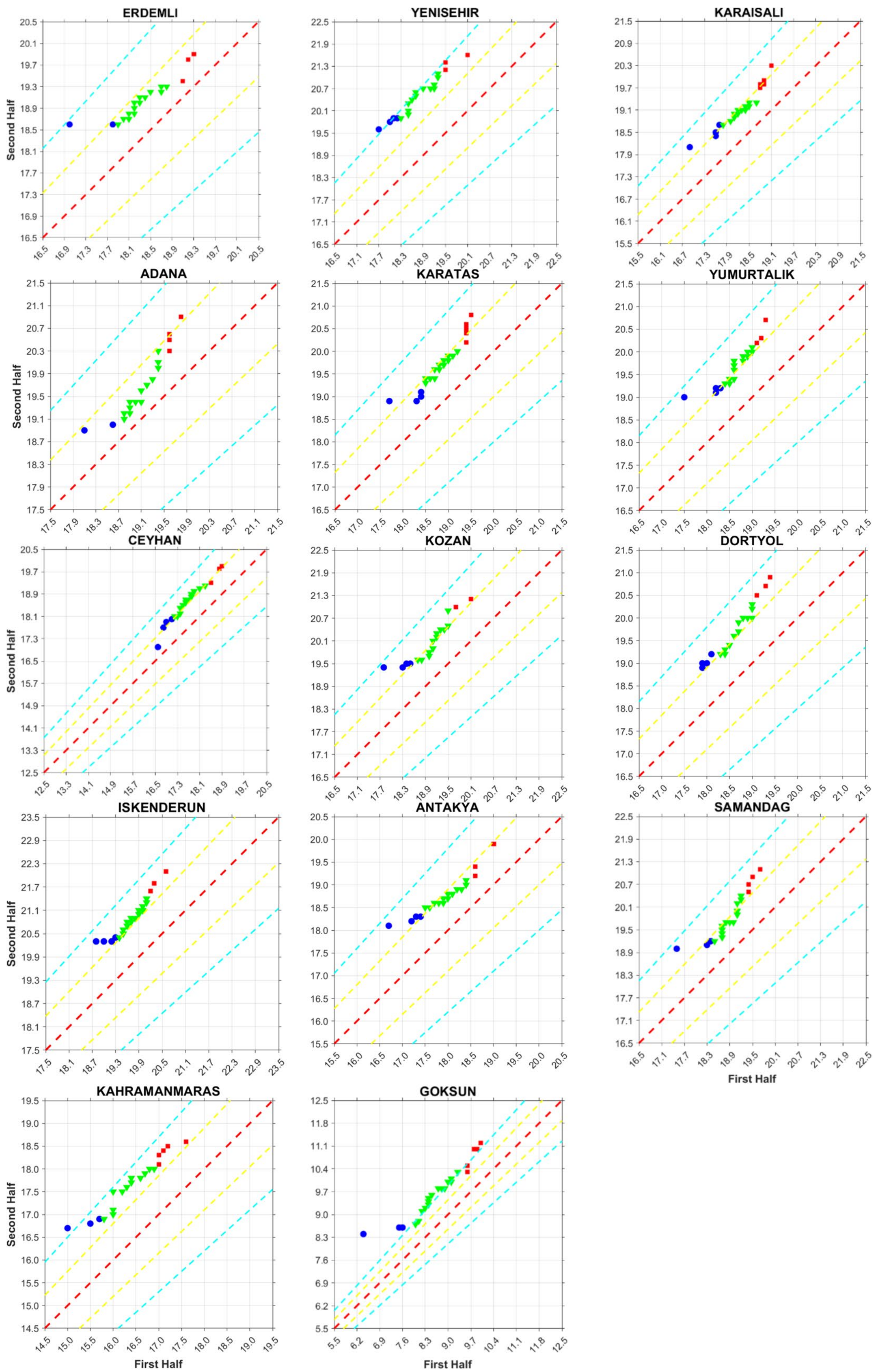

Fig. 8 ITA results of temperature values of stations in the eastern region

Conclusion

In this study, the effect of Arctic Oscillation (AO) and Mediterranean Oscillation (MOI1 and MOI2) on the precipitation/temperature records of the Mediterranean Region of Türkiye was enquired. According to the correlation analysis for precipitation/temperature with atmospheric indices at 0.05 significance level:

Regarding the effects of atmospheric oscillation indices on precipitation records in the Mediterranean region, it was observed that AO has negative correlations with precipitation data in all stations of the region. 12 out of 24 stations show significant negative relationships with AO; these stations are Finike, Antalya, Isparta, Eğirdir, Alanya, Gazipasa, Anamur, Yenisehir, Karaisali, Kozan, Göksun, and Dörtyol. It was also observed that MOI1 is negatively correlated with precipitation records throughout the region. On the other hand, it was observed that MOI2 generally has positive correlations with precipitation values over the region. 1 out of 19 stations has a significant positive relationship with MOI2. The station where a significant relationship was found is Adana in the region's east. A positive relationship was found at all stations in the coastal part of the region except Dörtyol and Yumurtalik.

Regarding the impact of atmospheric indices on the temperature series in the Mediterranean region, it was observed that all atmospheric indices have negative correlations with temperature. It was observed that MOI1 has negative correlations with the temperature series of all stations in the region. Also, MOI2 and AO generally have negative correlations with temperature series data over the region. 19 out of 24 stations show negative relationships with MOI2. A negative relationship with MOI2 was found at all stations in the coastal part of the region except Gazipasa. 17 out of 24 regional stations show a negative relationship with AO. A significant negative relationship with AO was found at only 1 station. The station with a significant relationship is Eğirdir, which is in the region's west.

While there is a clear increasing trend in average temperature at the regional stations, it is impossible to talk about a similar clear trend in precipitation. The increase in temperature indicates that the demand for water resources for living beings in the region will rise, especially during the summer when the average temperature is high.

To prevent activities in the region, which depend on precipitation, from being affected by rising temperatures, necessary precautions should be taken, and water resources should be used efficiently. In addition, rising temperatures will lead to increased evapotranspiration in the region. By evaluating these results together, it is recommended that decision-makers create emergency action plans against increasing drought and temperature events.

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Data availability Data will be made available on request.

Declarations

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