ENSO effects on mean temperature in Turkey

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Abstract. The ENSO effects on Turkish streamflow and precipitation patterns were previously analyzed by applying the t-test on eight standard seasons beginning with the JJA (-1) season of the year before the event year and ending with the MAM (+1) season of the year after the event year. The objective of this study is to identify the ENSO effects on the mean temperature data in Turkey by using the same methodology used for streamflow and precipitation. The methodology mainly comprises of two phases: first, composite analysis; and second, statistical t-test analysis. An overall result shown by this study is that the response of temperature to ENSO events was not much noticeable than those of the two hydroclimatological variables. Any positive anomaly could not be detected during the classical seasons of the event year, indicating that the mean temperature values occur below the average. The dominancy of cold anomaly conditions begins with the JJA (-1) season and continues until the DJF (+1) season. Furthermore the MAM (0) season has a maximum number of negative anomalies when compared to other cold anomaly seasons. Besides the positive anomaly conditions of streamflow and precipitation at the event year, the temperature values exhibited negative anomaly conditions at the same time period. In this study we aimed to determine whether there exists any relationship between temperature, streamflow and precipitation patterns of Turkey in terms of responding to the ENSO forcing. In conclusion, a sign of the tropical biennial cycle was, to some extent, evident surface climate variables.

1. Introduction

El Niño Southern Oscillation (ENSO) is a coupled ocean-atmosphere phenomenon centered in the tropical Pacific that it has two opposite extreme phases of El Niño (warm phase) and La Niña (cold phase). Today, it is clearly known that ENSO has been considerably affecting climatic characteristics of many places on the earth, especially the tropical Pacific countries generating negative or positive anomalies in the surface variables such as precipitation, streamflow, temperature, evaporation, and so on (Philander, 1985; Rasmusson, 1985; Rasmusson and Wallace, 1983).

ENSO effects on Turkish streamflow and precipitation patterns were previously analyzed by Martı and Kahya (2002) and Kahya et al. (2002). They used a methodology based on the statistical t-test first proposed by Kiladis and Diaz (1989) who analyzed the SO-related signals based on the differences of El Niño and La Niña composites using a worldwide data set of mean tempera-

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ture and precipitation. Kiladis and Diaz considered eight standard seasons beginning with the JJA (-1) season of the year before the event year and ending with the MAM (+1) season of the year after the event year.

Among the other major recent studies concerning the SO-related signals, Kahya and Karabörk (2001) and Karabörk and Kahya (2002) documented El Nino and La Nina signals in Turkish streamflow and precipitation patterns in terms of geographical extents. They showed that the northwestern Anatolia and the eastern Anatolia regions had coherent consistent and significant streamflow and precipitation responses to the extreme events of the SO. The signal seasons usually emerged starting from the end of spring extending to the end of fall of the event year.

The objective of this study is to identify the geographical extent of ENSO effects on the mean temperature values using the same methodology of Kiladis and Diaz (1989). The results will facilitate to find out whether there exists any relationship between temperature, streamflow and precipitation climate variables in Turkey in terms of the existence of ENSO signal.

2. Data

In this study, the mean temperature values of 62 observation stations are more or less uniformly distributed around Turkey (Figure 1). The record of each station spans from 1951 and 2005. The temperature data set used here is the same data set as in Karabörk et al. (2005). Ünal et al. (2003) have already confirmed the homogeneity of climatic data used in this study.

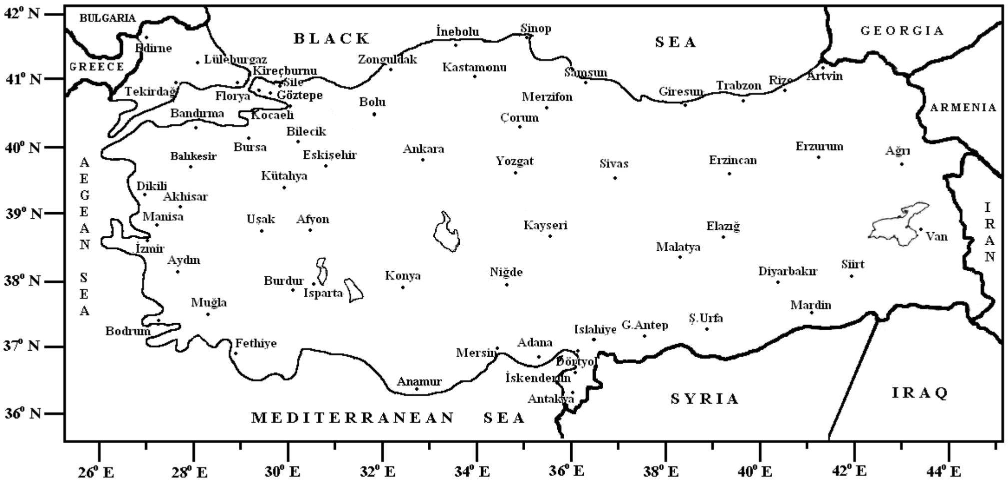


Figure 1. The distribution of temperature observation stations used in the study.

3. Methodology

Following Kiladis and Diaz (1989), we separately calculated the composite anomalies of mean temperature at each station considering standard seasons; namely, December-January-February (DJF), March-April-May (MAM), June-July-August (JJA) and September-October-November (SON). The list of El Niño and La Niña years (herein designated by 0 year) are given in Table 1.

These years were adapted from Kiladis and Diaz (1989) and Ropelewski and Halpert (1987).

These seasonal composites are formed starting from the second half of (-) year (the year before the event year) and continuing the first half of (+) year (the year after the event year). The years in which the events happened in the Pacific Ocean are shown by (0) year and given in Table 2. It is worth noting that the analysis composite at each station is centered at the (0) year (Kahya et al., 2002). At each station, we first subtracted the mean value of the El Nino composite formed for each season from that of the La Nina composite. Then the t-value of this difference was computed by using the following equations (Benjamin and Cornell, 1970):

$$S_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{(n_1 + n_2 - 2)} \qquad \text{Eq. (1)}$$

$$S_e = S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}} \qquad \text{Eq. (2)}$$

$$t = \frac{\overline{X}_1 - \overline{X}_2}{S_e} \qquad \text{Eq. (3)}$$

If n is less than 25 then S_e should be calculated with Eq. (1), Eq. (2) and Eq. (3), otherwise it can be taken as $S_e = \sigma$. The n value of this study was equal to 26, including 15 warm events and 10 cold events.

Table 1. "0" years of the El Niño and the La Niña events used in the composite analysis.

Warm Events (year 0)
1951, 1953, 1957, 1963, 1965, 1969, 1972, 1976, 1982, 1987, 1991, 1993, 1997, 2002, 2004
Cold Events (year 0)
1955, 1956, 1964, 1970, 1971, 1973, 1975, 1988, 1999, 2000

In our analysis, there were eight standard seasons considered and labeled by JJA (-1), SON (-1), DJF (0), MAM (0), JJA (0), SON (0), DJF (+1), and MAM (+1). Each extreme event (El Niño or La Niña) used in the calculation should have at least five sample points for the composite analysis in this study (Kiladis and Diaz, 1989). The obtained t-values were evaluated according to the two-tailed t-distribution for the 90% and 95% significance levels and showed on a map for each season. These maps were compared with the streamflow and precipitation maps that previously plotted by Martı and Kahya (2002) and Kahya et al. (2002).

4. Results and Discussion

The following maps presenting the signals at the 90% and 95% significance levels were obtained trough the application of the t-test on the mean temperature values of Turkey using the standard seasons (Figure 2). We summarized the results of visual inspection of each map depicted in Figure 2 in a tabular fashion for convenience (Table 2).

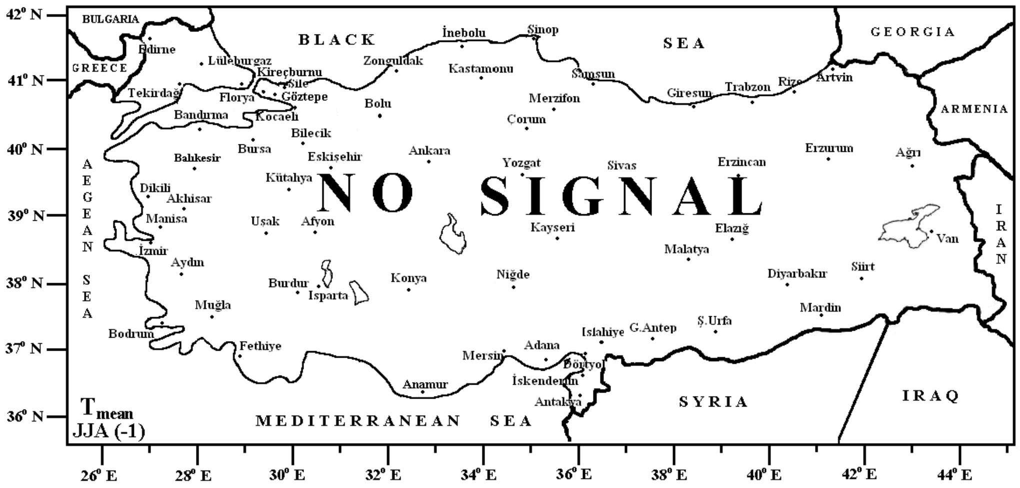
Table 2. The number of stations presenting anomalies in the standard seasons.

Seasons	**Number of Warm Anomalies**		**Number of Cold Anomalies**	
	% 90	**% 95**	**% 90**	**% 95**
JJA (-1)	-	-	-	-
SON (-1)	-	-	-	-
DJF (0)	-	-	7	-
MAM (0)	-	-	40	17
JJA (0)	-	-	5	3
SON (0)	-	1	-	-
DJF (+1)	-	2	-	-
MAM (+1)	-	-	-	-

When Table 2 and the maps shown in Figure 2 are examined thoroughly, the climate conditions occurring below the average temperature for the event year throughout the country are evident. No anomaly signal has any effect during the seasons of the (-1) year, namely JJA (-1) and SON (-1). The dominancy of negative anomaly conditions begins in DJF (0) season observed in seven stations and ends in JJA (0) season observed in five stations. The largest geographical extent of the SO signal, including 40 stations (that is to say, 64.5% of the total number of the entire stations), was identified for MAM (0) season. Nearly half of these stations exhibit a significant signal at the 95% level.

The warm signals appear only during SON (0) and DJF (+1) seasons at one and two stations, respectively. It is possible to conclude that warm signal is barely sensible in Turkey. The stations located in the southern coastal region and interior Turkey did not show any significant response to the tropical forcings during all of the seasons.

(a)


NO SIGNAL
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JJA (-1)
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SYRIA
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42° N
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40° N
39° N
38° N
37° N
36° N
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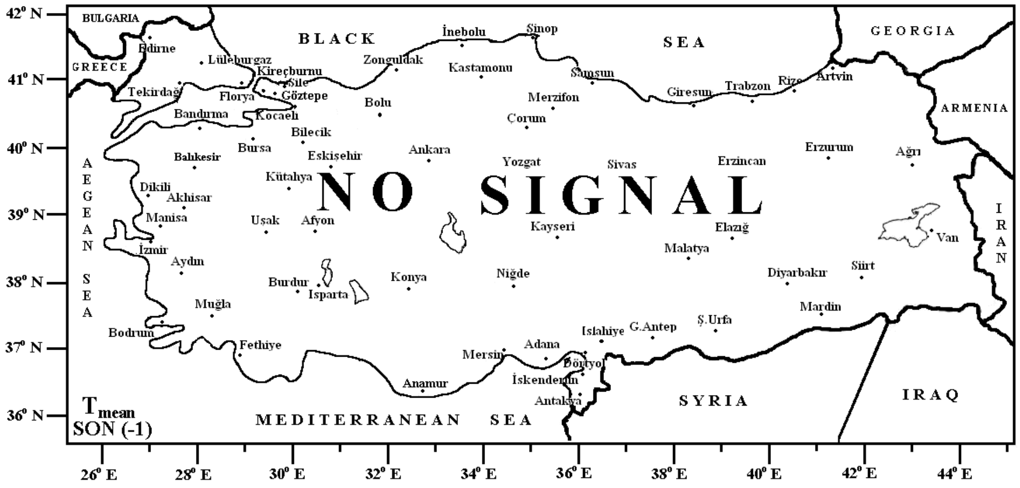
38° E
40° E
42° E
44° E

(b)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SON (-1)
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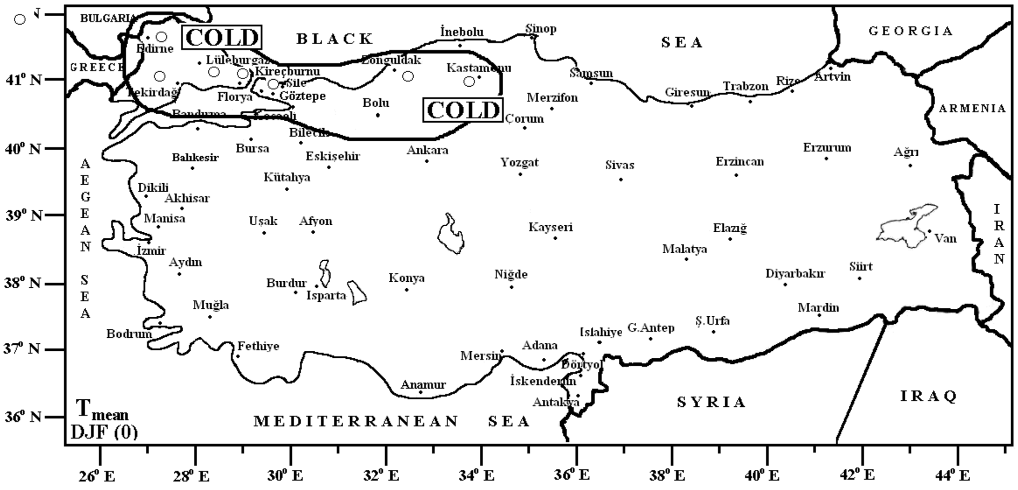
SYRIA
IRAQ

(c)


COLD
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DJF (0)
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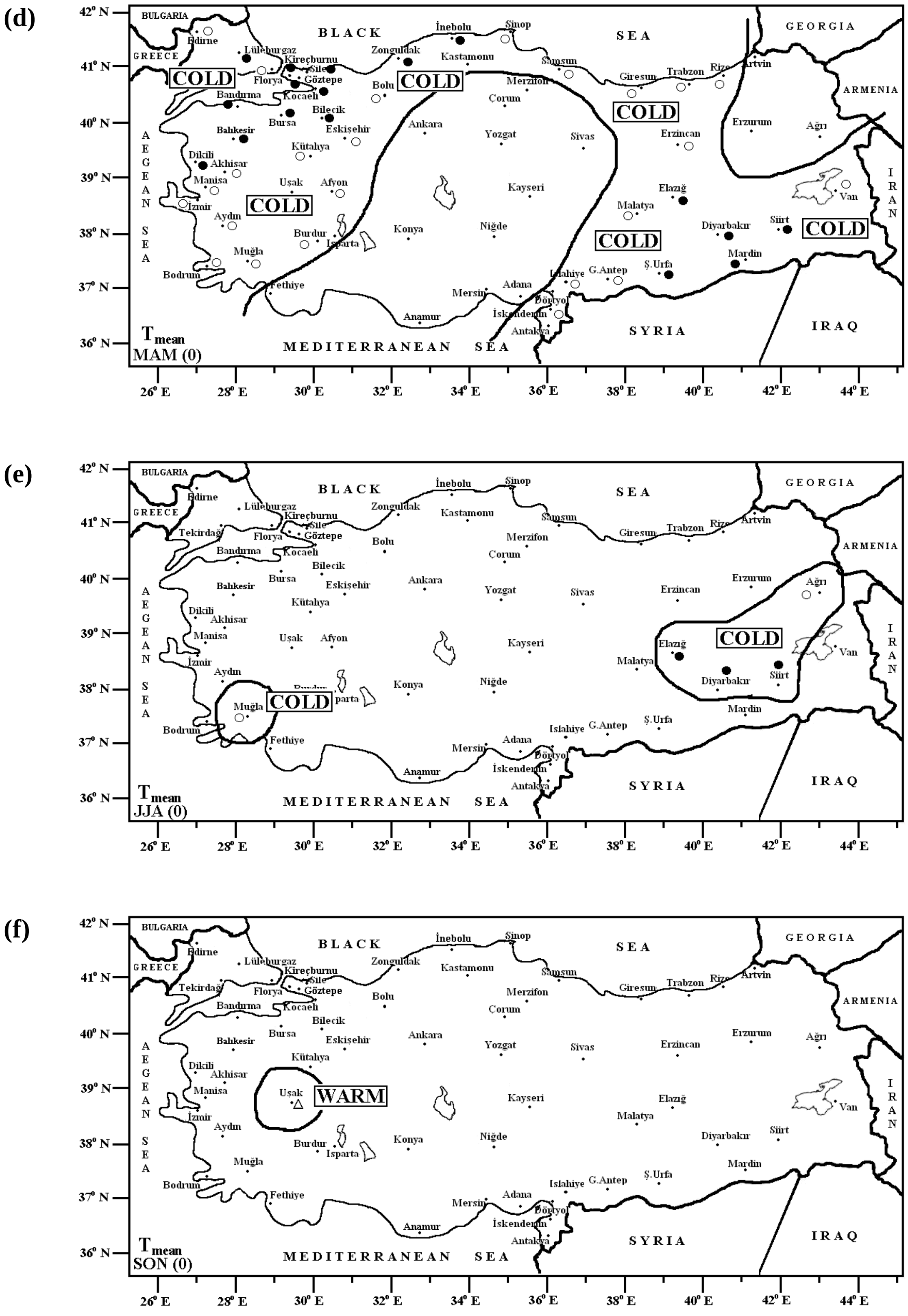
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MAM (0)
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WARM
T mean
SON (0)
BLACK SEA
MEDITERRANEAN SEA
AEGEAN SEA
BULGARIA
GREECE
GEORGIA
ARMENIA
IRAN
IRAQ
SYRIA
Edirne
Lüleburgaz
Kireçburnu
Şile
Göztepe
Florya
Tekirdağ
Kocaeli
Bandırma
Bilecik
Bursa
Balıkesir
Eskişehir
Kütahya
Dikili
Akhisar
Manisa
İzmir
Uşak
Afyon
Aydın
Burdur
Isparta
Muğla
Bodrum
Fethiye
Zonguldak
İnebolu
Sinop
Kastamonu
Bolu
Samsun
Merzifon
Çorum
Ankara
Yozgat
Sivas
Kayseri
Konya
Niğde
Anamur
Mersin
Adana
İskenderun
Dörtyol
Antakya
İslahiye
G.Antep
Ş.Urfa
Malatya
Elazığ
Diyarbakır
Siirt
Mardin
Erzincan
Erzurum
Ağrı
Van
Giresun
Trabzon
Rize
Artvin
42° N
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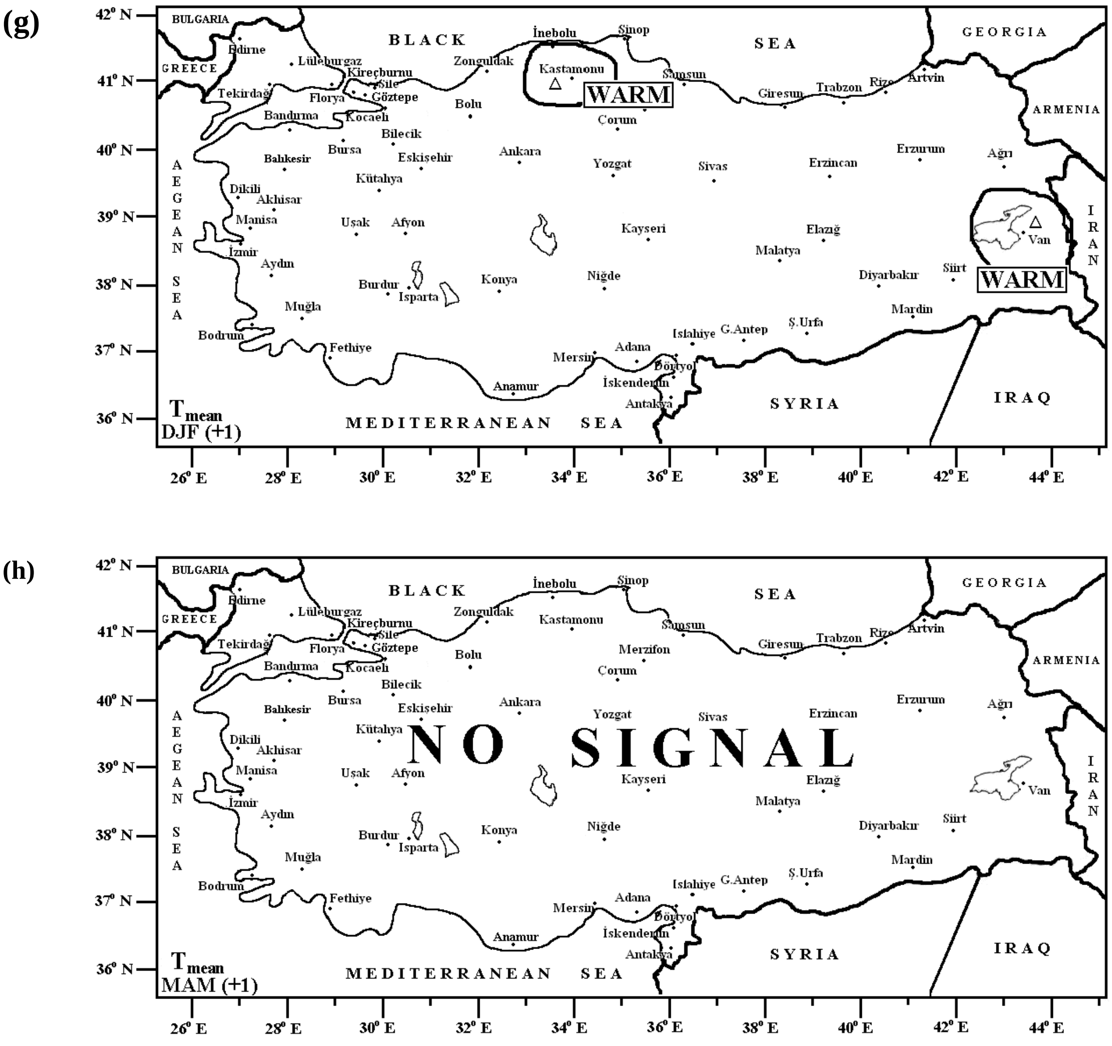

Figure 2. Maps obtained for the standard seasons (a) JJA (-1), (b) SON (-1), (c) DJF (0), (d) MAM (0), (e) JJA (0), (f) SON (0), (g) DJF (+1) and (h) MAM (+1) showing the sign of the composite difference (warm minus cold event) of Turkey's temperature. Open circles (triangles) denote the negative (positive) anomalies with 90% significance and the solid circles (triangles) indicates the anomalies significant at the 95% level.

Consequently, the number of the anomalies detected during the study period varied dramatically from one season to other: zero in the first two seasons; seven during DJF (0) season; forty during MAM (0) season which is the maximum; five during JJA (0) season; one during in SON (0) season; two during DJF (+1) season, and finally zero again during in the last season MAM (+1).

5. Conclusions

The following conclusions are drawn from this study:

a. No positive temperature anomaly prevailed during the event year.
b. In contrast, negative temperature anomalies were dominant all along the event year by the fall season.
c. The negative temperature anomaly seasons have the opposite anomaly signals to those for the streamflow and precipitation. However, an overall result shown by this study is that the response of temperature to ENSO events was not much noticeable compared to those of the two hydrologic variables.
d. The presented results here are consistent with those of Kiladis and Diaz (1989). They noted that the anomalies of almost all the regions of the world appeared to be negative beginning with the JJA (-1) season and ending with the JJA (0) season. This is the indication we made in our study, except for the seasons JJA (-1) and SON (-1). However, Kiladis and Diaz (1989) also could not find any anomaly response in a large region surrounding our country during these two seasons, but found negative anomalies in other regions in the world. After the season SON (0), warm anomalies started taking place of the negative anomalies in the both studies**.**
e. While the mean temperature of the eastern and western regions in Turkey is affected by the extreme events of the SO, the southern coastal regions and the central regions of Turkey do not show any teleconnection to ENSO events.
f. The number of the station anomalies detected during the study period was quite variable, ranging from zero to 40 (during MAM (0) season) (Table 2).

In conclusion, a sign of the tropical biennial cycle was, to some extent, evident surface temperature variable in a distant location, Turkey, during the spring season of the event years.

6. References

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