Relationships between Teleconnection Patterns and Turkish Climatic Extremes

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Abstract

This is a study on the effects of Teleconnection Patterns (TPs) on the extreme cases of the climate over Anatolian Peninsula. Relationships between five teleconnection patterns, North Atlantic Oscillation (NAO), Arctic Oscillation (AO), East Atlantic-Western Russia (EAWR), East Atlantic (EA) and Scandinavian (SCA) patterns, and 11 climate extreme indices were studied by using 94 homogeneously distributed meteorological stations over Turkey for the period 1965-2014. Winter analysis of patterns with warm and cold temperature extremes showed that the AO and EAWR patterns are more remarkable than the other circulation patterns. During the negative AO, generally more warm days occur over Black Sea (r=0.63) and Aegean regions (r=0.72). This phase of AO also generate above-normal precipitation in the western parts of the Anatolian Peninsula (-0.54<r<-0.48). Contrary, positive EAWR is mainly pronounced with cold nights over Black Sea (r=0.61) and Aegean regions together with positive precipitation anomalies at the seaside stations of the eastern Black Sea region. Winter-time negative AO is mainly associated with the presence of a deepened Genoa cyclone over Italy that can transport warm and moist air mass from Mediterranean Sea towards Turkey by strong westerly winds, leading to above-normal precipitation amounts and below-normal dry days in the western parts of Turkey. On the other hand, when EAWR (+) prevails, Azores high pressure center expands towards continental Europe bringing cold air by strong northerly winds together with higher moisture transport from the Black Sea, incrementing the numbers of cold weather conditions and high precipitation amounts in the northeastern parts of Turkey.

1. Background and Motivation

Weather and climate extremes including floods, droughts, heat waves, and cold spells have severe socioeconomic implications and environmental impacts (Kumkel and Andsager, 1999; Meehl *et al*., 2000). Continental Europe is shown as significantly influenced from these strong extreme events, and for example, many sectors negatively affected and in consequence mortality rates increased (Robine *et al*., 2008) during the 2003 and 2005 heat waves (Della-Marta *et al*., 2007) and cold and rainy/snowy winter 2009/2010 (Andrade *et al*., 2011). Therefore, understanding temporal and spatial patterns of extremes is crucial for predicting and modeling these events.

The climate extreme studies related to Turkey do not provide adequate information about the influence of large-scale climate patterns on the regional character of extreme climatic changes. Thus, there is a need for a study focusing on the effects of TPs on extreme cases of the climate over Anatolian Peninsula that we believe that this study is fulfilling this shortage.

The aim of this study can be given in two parts; firstly, we consider processes of the atmospheric circulation by linking five teleconnection patterns (i.e. NAO, AO, EAWR, EA, and SCA) with 8 temperature and 3 precipitation indices, in order to explain the relationships between TPs and climate extremes. Secondly, we explore the physical mechanisms behind the relationships.

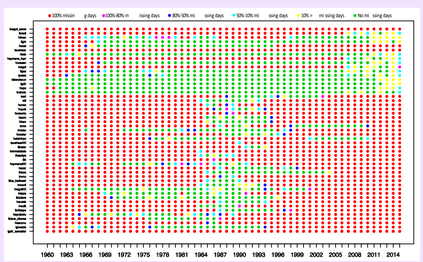

Figure 1. Daily maximum temperature (Tmax) missing days in a year belonging to a sample of 49 stations. The stations that are mainly characterized by colors other than yellow and green were eliminated from the study.

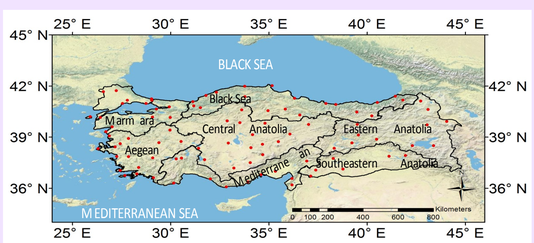

Figure 2. Distribution of 94 meteorology stations (red points) in Turkey. Borders of seven geographic regions are shown in the figure

3. Results

Teleconnection Patterns

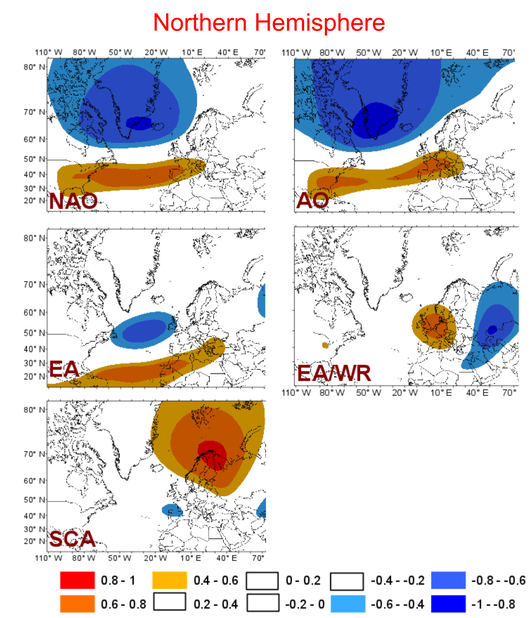

Figure 3. Illustration of the five teleconnection patterns (TPs) over the Northern Hemisphere. Figures show the correlations between winter (DJF) 500-hPa standardized height anomalies and index values of TPs for the 1965-2014 period.

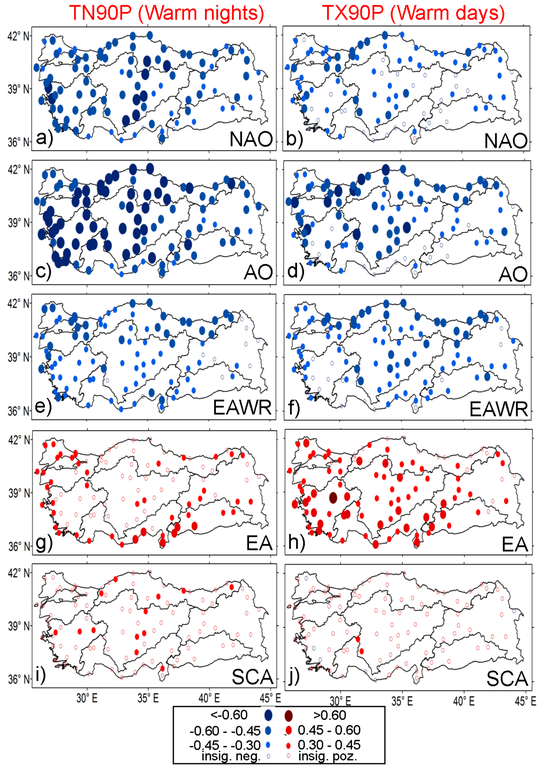

Figure 4. The correlation coefficients between the numbers of winter (left) warm nights and (right) warm days and the (a), (b) NAO; (c), (d) AO; (e), (f) EAWR; (g), (h) EA; and (i), (j) SCA indices .

Teleconnection patterns- climate extremes relationships

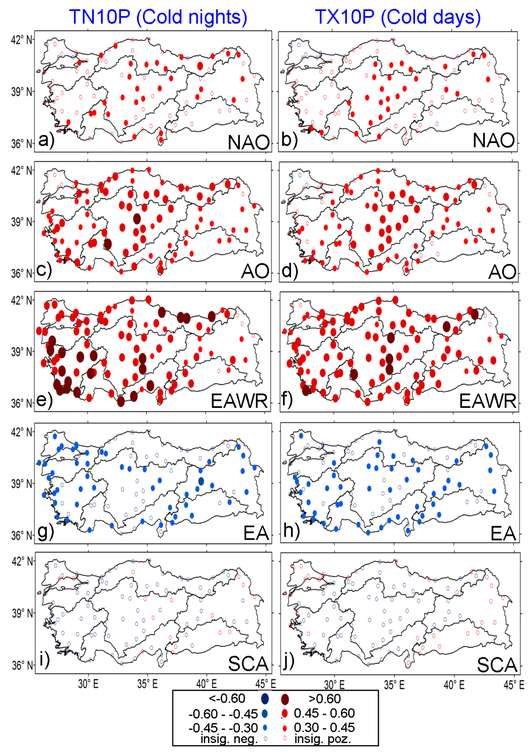

Figure 5. The correlation coefficients between the numbers of winter (left) cold nights and (right) cold days and the (a), (b) NAO; (c), (d) AO; (e), (f) EAWR; (g), (h) EA; and (i), (j) SCA indices .

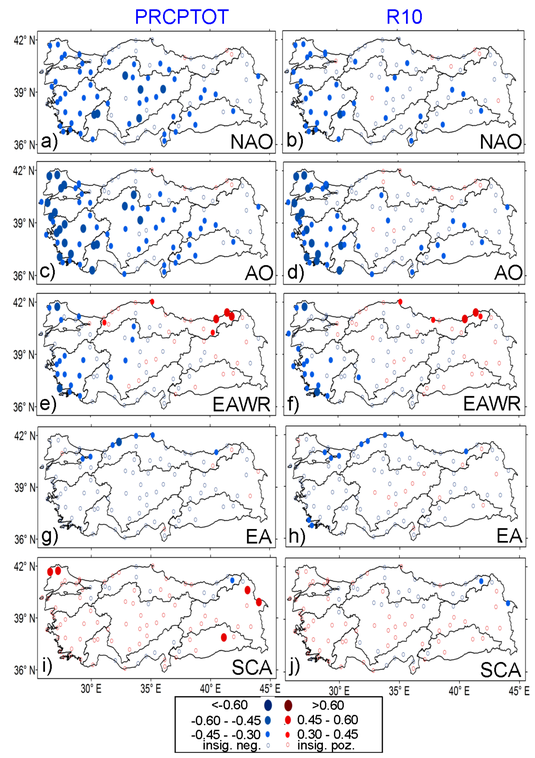

Figure 6. The correlation coefficients between (left) daily precipitation and (right) daily precipitation larger than 10 mm of the winters and the (a), (b) NAO; (c), (d) AO; (e), (f) EAWR; (g), (h) EA; and (i), (j) SCA indices .

Dynamics behind TPs

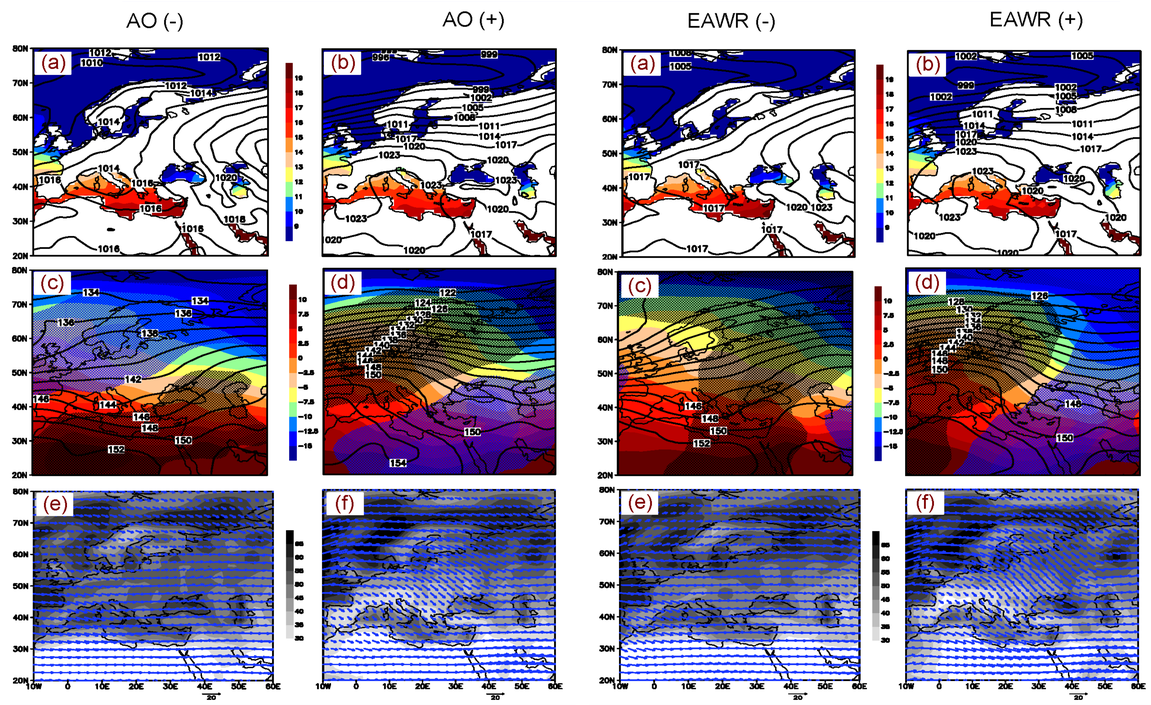

Figure 7. Composites of low (left) and high (right) winters of AO. (a,b) sea level pressure (SLP in contours, hPa) and sea surface temperature (SST in shaded, C); (c,d) heights (contours, dam) and temperature values (shaded, C) at 850-hPa.Black and blue grid points represent above 0.5 and below -0.5 C of the high/low AO winters when compared with their long-term (1965-2014) winter temperature means at 850-hPa level. Solid stippling indicates the correlation coefficients significant at the 95% level; (e,f) wind vectors (m/s) at 500-hPa and cloud cover (%).

Figure 8. Composites of low (left) and high (right) winters of EAWR. (a,b) sea level pressure (SLP in contours, hPa) and sea surface temperature (SST in shaded, C); (c,d) heights (contours, dam) and temperature values (shaded, C) at 850-hPa.Black and blue grid points represent above 0.5 and below -0.5 C of the high/low EAWR winters when compared with their long-term (1965-2014) winter temperature means at 850-hPa level. Solid stippling indicates the correlation coefficients significant at the 95% level; (e,f) wind vectors (m/s) at 500-hPa and cloud cover (%).

4. Results

During winter, NAO, AO, and EAWR patterns showed statistically significant negative correlations with warm extremes for most of the stations over Turkey; though the highest significant correlations were found with the AO. This suggests that thare are generally more warm nights and days during the negative-AO winters with opposite conditions during positive-AO years. For cold extremes, statistically significant positive correlations with the NAO, AO, and EAWR patterns were obtained, and EAWR pattern produced the highest positive correlation values. Therefore, it is possible to see more cold nights and days during this positive phase of the EAWR 1

Relationships between circulation indices and seasonal total precipitation from wet days (PRCPTOT) and daily precipitation larger than 10 mm (R10) lead to a conclusion that western parts of Turkey can have highest significant negative correlations with the AO. Winter-time negative AO is mainly associated with the presence of deepened Genoa cyclone over Italy that can transport warm and moist air mass from Mediterranean Sea towards Turkey by strong westerly winds leading to above-normal precipitation amounts and below-normal dry days in the western parts of Turkey. 2

During the positive phase of EAWR, Azores high pressure center expands towards continental Europe and this can induce the penetration of cold polar air masses to Anatolia by strong nortwesterly , northerly winds. The intrusion of this cold air can reduce cloud cover and thus can increase the number of days having cold extremes. The carriage of moisture over the relatively warm Black Sea by strong northwesterly flows can cause higher daily rainfall totals in the northeastern parts of Turkey 3

References

Andrede C, Santos JA,Pinto JG, Corte-Real J (2011) Large-scale atmospheric dynamics of the wet winter 2009-2010 and its impacts on hydrology in Portugal. Climate Research 46:29-41.

Della-Marta PM, Haylock MR, Luterbacker J, Wanner H (2007) Doubled length of western European summer heat waves since 1880. Journal of Geophysical REsearch 112: D15103, DOI:10.1029/2007JD008510.

Kunkel KE, Andsager K (1999) Long-term trends in extreme precipitation events over the conterminous United States and Canada. Journal of Climate 12:2515-2527.

Robine JM, Cheung SL, LE Roy S, Van Oven H, Griffiths C, Michel JP, Hermann FR (2008) Death toll exceeded 70,000 in Europe during the summer 2003. Contes Rendus Biologies 331(2):171-178.