THE IMPORTANCE OF CYCLONE FREQUENCIES IN AIR POLLUTION IN TURKEY

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ABSTRACT

The main sources of air pollution are: automobiles, industry, and central heating systems in winter months. Apart from these, there are a number of meteorological elements or atmospheric events with great significance in the development of air pollution. Some of them are cyclone trajectories, cyclone frequencies and blocking events. In the formation of air pollution the degree of its intensity depends upon atmospheric conditions. The episodes of air pollution show itself on certain days in all seasons. On these days the concentrations of air pollutants (such as SO_2 and TSPM) are above the established standart limitations. In this study we have tried to find a connection among air pollutant (SO_2) with cyclone paths and frequencies in Turkey with a population over 100000. Regarding cyclone trajectories which effect Turkey, the five stations (Trabzon, İstanbul, Balıkesir, Ankara and Gaziantep) selected for their different cyclone paths, the analysis showed that in these five stations mean values of SO_2 had increasing trends except for Gaziantep. This study made within a period 1987-93 showed that air pollutants values in all these stations were above the limitations set by the World Health Organization. Finally, results show that there is inverse relation between air pollutants and cyclone numbers.

Keywords: Frequency, Cyclone, Air Pollutants.

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INTRODUCTION

Recently, many researches on air pollution have increasingly been in the literature. Kallos and et all have investigated the periods of air pollution episodes in Athens using by synoptic and meso-scale conditions, and they showed that this kind of pollution is because of high pressure systems occured in Mediterrenean frontal systems, cyclones and anticyclones [1]. In the long-range transport of air pollutants frontal systems, cyclones and anticyclones have a great important role [2]. The local and regional pollution problems and their durations are closely connected with blocking events by various pressure systems. Consequently air

pollution and its transportation processes depend upon atmospheric events in the synoptic scale.

Lu and et all showed that synoptic conditions associated with Pacific high pressure sysytem occured air pollution episodes in Los Angles [3]. In the long-range transport of air pollutants weather patterns and their cyclonic or anticyclonic frequencies are especially important as much as their trajectories. One of the studies on the relationship between frontal charecteristics and air pollution is made by Helmis and et all [4]. Kassomenos and et all used the mixing height and 850 mb temperatures in the interpretation of air quality control [5]. At the same time they showed that maximum air pollution episodes occured in the regions where there are anticyclonic flows and/or advection of warm air masses. The most popular studies on air pollution for Turkey is made by İncecik [6] and Karaca et all [7].

Many Studies have been conducted about cyclone frequencies and tracks. In the literature the studies about cyclone tracks and frequencies are focused on winter and spring instead of summer and autumn [8]. Analyses of surface low pressure systems, and their relationship with atmospheric variables such as precipitation, both regionally and globally, have long been of interest to scientists. Many studies can be found, mainly, for regions in the developed countries that deal about the determination of cyclonic tracks focused on seasonal variations, in particular winter versus summer or spring versus autumn cases and their frequencies. The objectives of such studies are first, to obtain the major interseasonal variations and second, to fulfill the desire of having a concise picture of the cyclonic track climatology. Important studies carried out on this subject are Petterssen [9], Whittaker and Horn [10], Lambert [11], Wallace et al. [12], Sanders and Gyakum [13], Fraedrich and Müller [14] and Rogers [15]. Reiter [8] and Alpert [16,17] focused on cyclones on the Mediterranean Basin. In some studies trajectory calculations are based upon wind analyses produced at the European Center for Medium Weather Forecast (ECMWF), employing a trajectory analysis based on the air mass transportation model of Reiff et al. [18]. Among the earlier studies on cyclones, Alpert [16] has suggested that conditional instability of the second kind (CISK) may play an important role in the eastern Mediterranean in keeping local depressions stabilize at certain locations for relatively long periods.

DATA AND METHODOLOGY

In this study, synoptic maps are used to determine cyclone tracks and frequencies in Turkey. The cyclone frequencies and tracks are defined according to the source regions by analysis of daily maps of 500 mb geopotential and surface maps at 07 UTC for the period of 1979-1992, [19]. SO_2 data are used to compare air pollution with cyclones. Monthly mean values of SO_2 are obtained from Turkish Bulletin of Environmental Statistics for five selected stations for winter season. The months of January, February and December of previous year are determined as winter months. Figure 1 shows the map of Turkey and selected stations. Turkey is located at the eastern corner of Southern Europe (36 °N and 42 °N latitudes, 26 °E and 45 °E longitudes) and its surface area is 77.106 km^2 with about 70 million population. Approximately 50 % of the population lives in the sea cost areas.

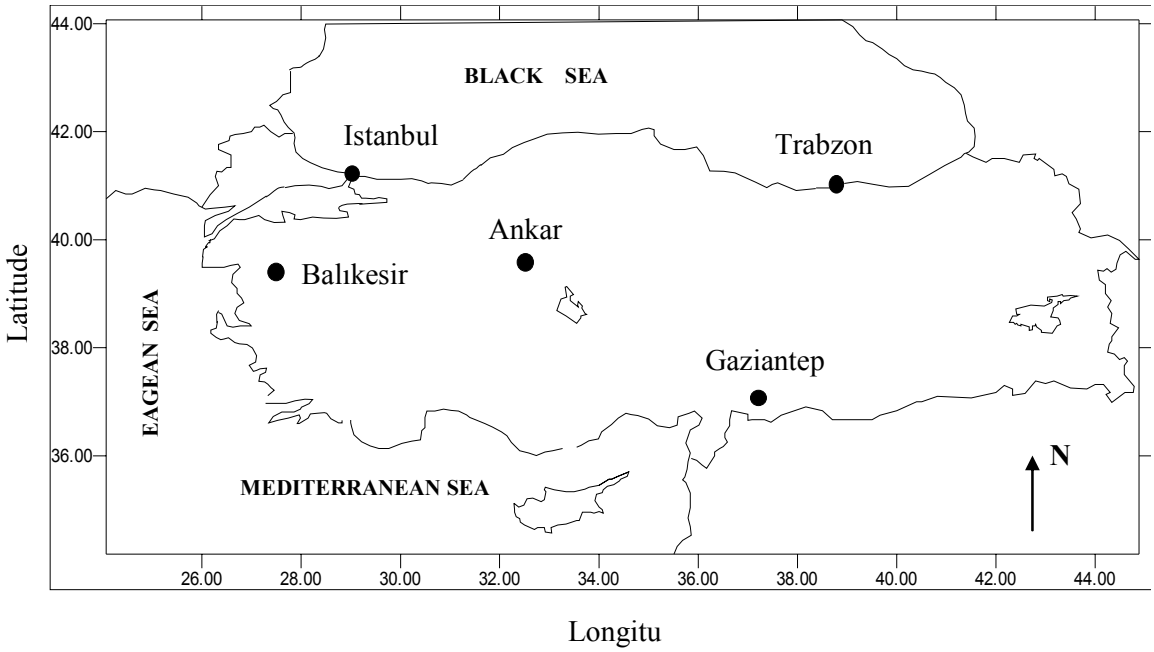

Fig. 1: Five selected stations according to the cyclone paths that are effected in Turkey.

Figure 2 shows the four main trajectory system of cyclones affecting the region. In general, the tracks of cyclones that have been effective on Turkey are classified in four groups, [20]. First; trajectories of cyclones that are created over Northern Europe and pass over Black Sea coasts (path 1), second; trajectories of cyclones that develop over Balkan Region and affect Marmara Region and the coastline of West Black Sea region (path 2), third; the cyclogenesis of Genoa Gulf often follows two type paths (path 3a,b), and fourth; trajectories of cyclones that are created over West or Middle Mediterranean Sea, or in some cases over Genoa Gulf and by moving towards East Mediterranean Sea effects Mediterranean coastline and southeast Anatolian region of Turkey and this kind of cyclones sometimes pass over Cyprus.

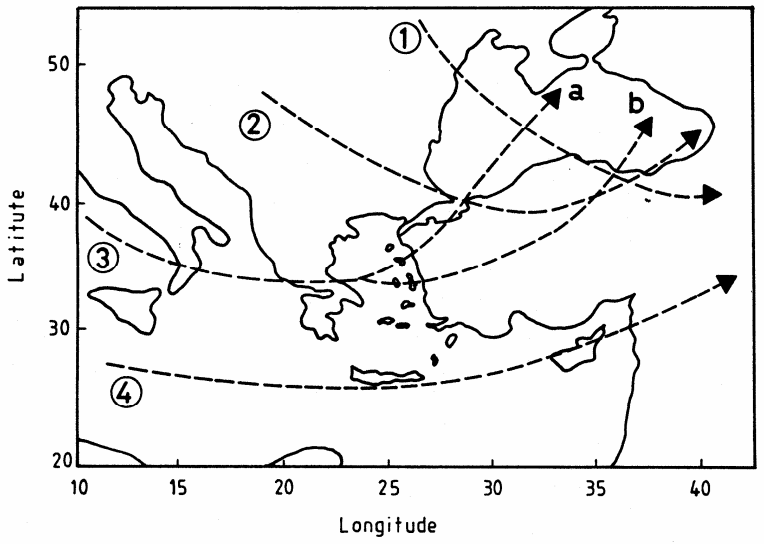

Figure 2: The tracks of atmospheric cyclones over Turkey, [19].

AIR POLLUTION APPLICATIONS AND RESULTS

In this study it is tried to find a connection among air pollution with cyclone paths and cyclone frequencies for 5 selected stations in Turkey with a population over 100000. Stations, their latitudes and longitudes and data periods are given in Table 1. Monthly mean values of SO_2 and cyclone numbers for selected cities that are Trabzon (path 1), İstanbul (path2), Balıkesir (path 3a), Ankara (path 3b) and Gaziantep (path 4) are shown in Fig. 3 representing different parts of Turkey. All of cities except for Gaziantep have increasing trends for SO_2 but decreasing trend for cyclone numbers. It is important that the levels of air pollutants in all cities were generally higher than the limits defined by the World Health Organization (WHO) in the data period. When we look at this figure it can be seen that there is locally converse relation between cyclone numbers and SO_2 values.

Stations	Cyclone Paths	Latitude (°N)	Longitute (°E)	Data Period
Trabzon	1	41.00	39.43	1989-1993
İstanbul	2	40.58	29.05	1987-1993
Balıkesir	3a	39.39	27.52	1988-1993
Ankara	3b	39.57	32.53	1987-1993
Gaziantep	4	37.05	37.22	1988-1993

Table 1: List of stations for air pollution analyses.

In the air pollution studies the number of blocking events are important as well as their duration. The number of blocking events that are occuring over Europe have less influence than the duration of the blocking event as far as cyclonic passages over Turkey is considered. High pressure system over Europe during December 1990 stayed almost whole the month (not shown). That created longer inversions over Turkey and therefore higher pollution levels. The frequency of blocking over Europe has less effective role the frequency of cyclone passages over Turkey than the duration of the blocking [21].

If you look at annual variability of cyclones (Fig. 4), we can see that the maximum number of the cyclones (68) was detected in 1980 and 1983 and the minimum number of cyclones (46) was observed in 1989 and 1992. During these 14 years period a decreasing trend can be detected. This result of the minimum number of cyclones observed in summer and the maximum number of cyclones monitored in winter is an expected one. It is interesting to have maximum number of cyclones in December with a number of 94 although there is decreasing trend in the number of cyclones in summer and winter, no any significant trend can be detected in spring. In the case of autumn where is a slightly increasing trend (not shown). The main trajectory of cyclones that is influencing Turkey is formed in the Genoa Gulf and passes over Aegean Sea, inland Anatolia region and Eastern Black sea, i.e. the trajectory classified as 3b. The lowest number of cyclones is associated with the first trajectory. According to the annual variability of cyclone frequencies there is decreasing trend in the cyclone tracks of 1, 2, 3a and 4, but disobeying this law there is a slightly increasing trend in the number of cyclones of the track 3b. In the track 3b there is a decrease in the total number of cyclones since 1984. This condition explains the drought of the period 1989-92 over İstanbul and over its neighboring regions to a certain extends.

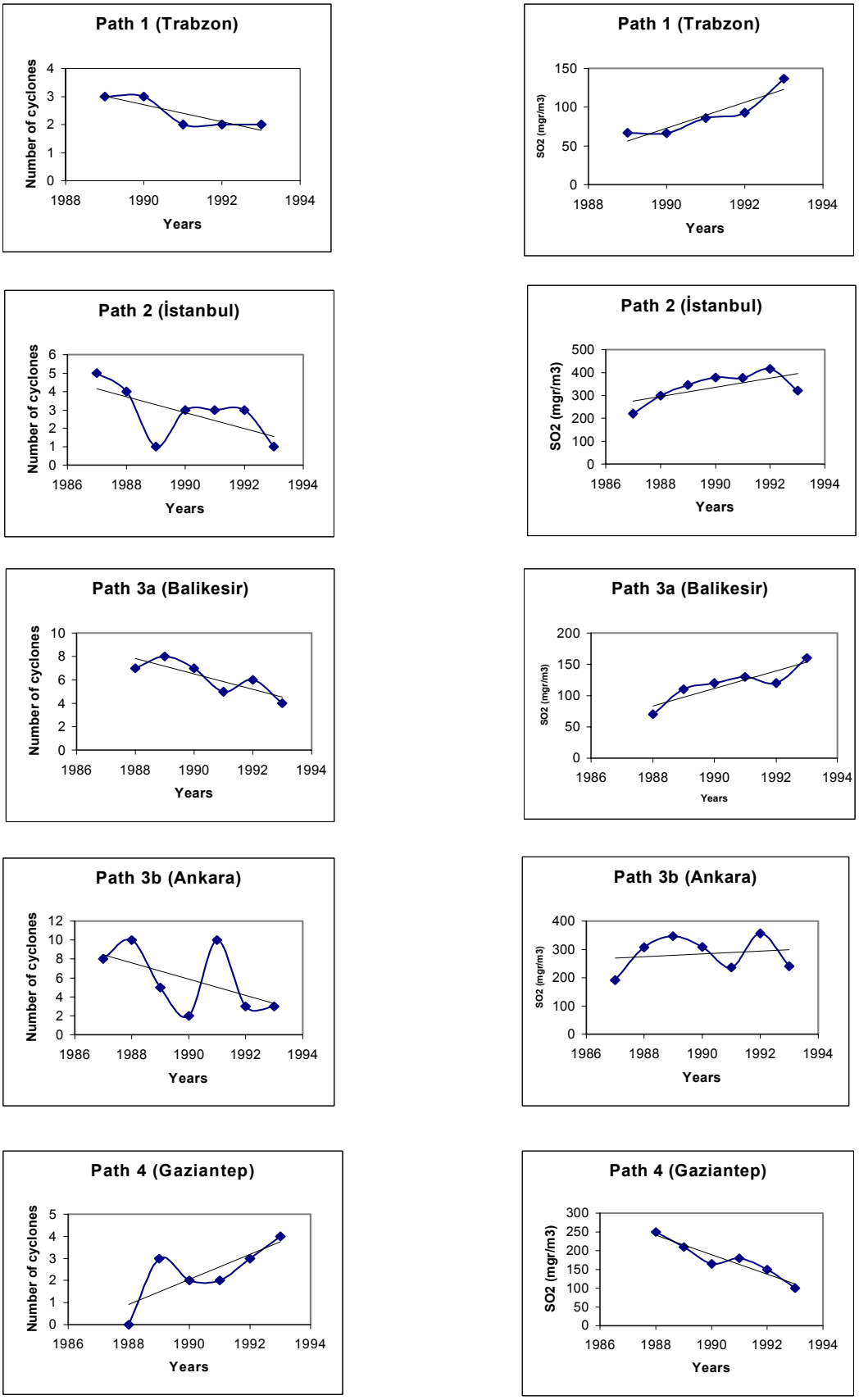

Figure 3: The variations of number of cyclones and SO_2 during winter according to the different paths over Turkey.

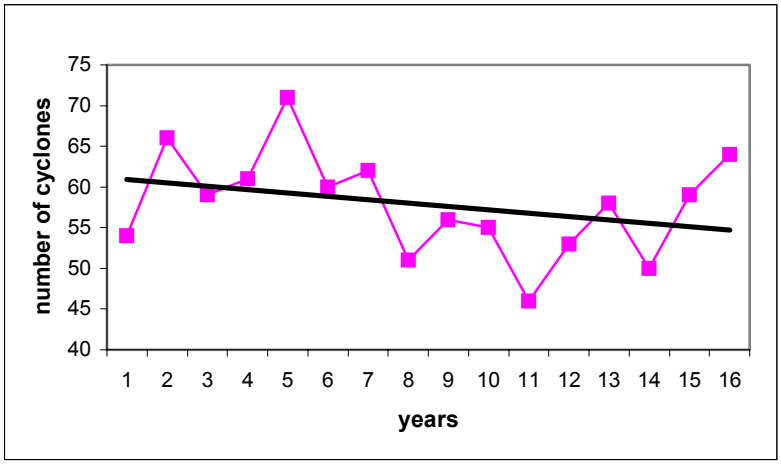

Figure 4. Annual frequency of cyclones over Turkey from 1979 to 1994.

Most important conclusion is drawn in this study that when the higher values of air pollutants in Turkish cities are observed from 1988 to 1992 the low value for cyclone passage over Turkey and higher duration of European Blocking event are found. In air pollution, the durations of cyclones are equally important as durations of blocking events. Therefore the relationship between durations of cyclones and the air pollutants in Turkey should also be investigated.

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