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ESTIMATION OF CO_2 CONCENTRATION OVER MEDITERRANEAN AREA BY USING KRIGING TECHNIQUE

Ali Can[*] and Aysel T. Atimtay[**]

[*]State Institute of Statistics, Necatibey Cad. No:114, Bakanlıklar, 06100 Ankara, Turkey, ali.can@die.gov.tr
[**]Middle East Technical University, Department of Environmental Engineering, 06531 Ankara, Turkey, aatimtay@metu.edu.tr

ABSTRACT

Carbon dioxide (CO_2) concentration in the atmosphere is increasing and will continue to increase in the future unless a solution is found to replace fossil energy sources with the non-fossil ones. The increase in the concentration of CO_2 is mainly due to the combustion of fossil fuels for the generation of energy. Together with CO_2 many other pollutants are generated. However, CO_2 cannot be removed from exhaust gases like other pollutants and it causes Green House (GH) effect and plays an important role in climate change. The increase of CO_2 concentration in the atmosphere derived from natural and anthropogenic sources over time is due to its long half life in the atmosphere. It is estimated that CO_2 concentration is responsible for about 60% of the greenhouse effect.

In this study, the measurements of CO_2 concentration in the Mediterranean area at various stations (22 stations) were used and the Kriging Method was employed for calculation of the CO_2 concentrations in the Mediterranean area. CO_2 concentration contours were drawn and the results were mapped by using the GIS techniques. The results of the study showed that there is an increase in the CO_2 concentration over the years in the area.

Key Words: Green House Gases, CO_2 Emissions, CO_2 Contours, Average CO_2 Concentrations in the Mediterranean Area

1. INTRODUCTION

It is an observational fact that atmospheric CO_2 concentration which is mainly formed during generation of energy with combustion reactions, is increasing and will continue to increase in the future (CC, 2001; Reck and Hummel, 1981). The increase of CO_2 concentration in the atmosphere derived from global sources over time is due to its long life in the atmosphere (CS, 2004). The industrial revolution has been considered as the beginning of the growth of the CO_2 concentration through the years (Alcoma et. al., 1995). This pollutant is emitted into the atmosphere due to combustion of fossil fuels, land-use and changes in the forestry area (IPCC, 1996). The global CO_2 budget is complex and involves transfer of CO_2 between the

atmosphere, the oceans and the biosphere (CEOSR, 2004). Together with CO_2 many other pollutants are generated. However, CO_2 cannot be removed from exhaust gases like other pollutants and it causes Green House (GH) effect. It is estimated that CO_2 concentration is responsible for about 60% of the greenhouse effect (OECD/IEA, 1991; Rabinson et. al., 1998). However, CO_2 cannot be removed from process gases like other pollutants and it ultimately causes climate change in the world (IPCC, 1994).

The main purpose of this study was to investigate the CO_2 concentrations measured in the stations around the Mediterranean area, calculate the average CO_2 concentrations over countries like Turkey where a CO_2 measurement station does not exist, and estimate the increase of CO_2 concentration over the Mediterranean region for the time period of 1995-2002. The depletion of CO_2 concentration by the sea has not been taken into account.

2. METHODOLOGY

The CO_2 concentration has been measured in most of the European countries and some countries in Asia and Africa. The locations of the stations are shown in Figure 1, and the names, latitude, longitude and altitude of the stations are given in Table 1. The total number of CO_2 measurement stations around Mediterranean region is 22. However, some of the stations that make CO_2 concentration measurements were not included in this study because of the missing data for some years. Some stations like the ones in the U.K., Austria and Ireland were included in the study in order to get a better result with the Kriging method.

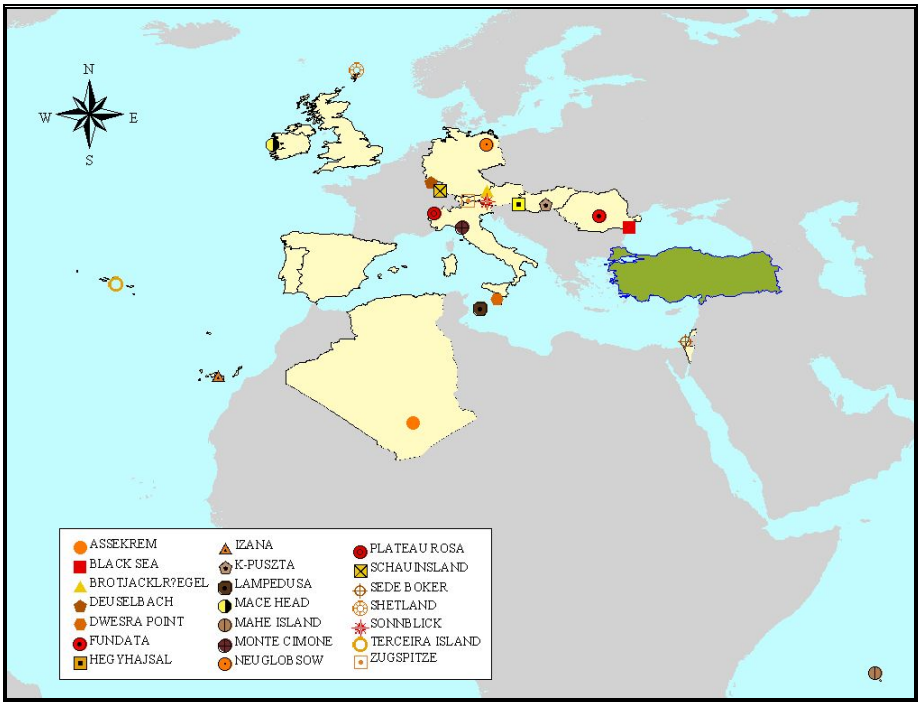

Figure 1. CO_2 measurement stations around Mediterranean area and in Europe

Table 1. CO_2 measurement stations in Europe and Mediterranean area

COUNTRY	STATION	NO	LATITUDE	LONGITUDE	ALTITUDE
HUNGARY	HEGYHAJSAL	1	46,57	16,39	344
HUNGARY	K-PUSZTA	2	46,58	19,33	125
ISRAEL	SEDE BOKER	1	31,80	34,53	400
ITALY	LAMPEDUSA	1	35,31	12,38	45
ITALY	MONTE CIMONE	2	44,11	10,42	2165
ITALY	PLATEAU ROSA	3	45,56	7,42	3480
MALTA	DWESRA POINT	1	36,30	14,11	30
ROMANIA	BLACK SEA	1	44,10	28,41	3
ROMANIA	FUNDATA	2	45,28	25,18	1383,5
GERMANY	BROTJACKLRİEGEL	1	48,49	13,13	1016
GERMANY	DEUSELBACH	2	49,46	7,3	480
GERMANY	NEUGLOBSOW	3	53,1	13,2	65
GERMANY	SCHAUINSLAND	4	47,55	7,55	1205
GERMANY	ZUGSPITZE	5	47,25	10,59	2960
GERMANY	ZUGSPITZE	6	47,25	10,59	2656
SEYCHELLES	MAHE ISLAND	1	-4,4	55,1	3
ALGERIA	ASSEKREM	1	23,11	5,25	2728
SPAIN	IZANA	1	28,18	-16,3	2367
PORTUGAL	TERCEIRA ISLAND	1	38,46	-27,23	40
UNITED KINGDOM	SHETLAND	1	60,5	-1,15	30
AUSTRIA	SONNBLICK	1	47,3	12,57	3106
IRELAND	MACE HEAD	1	53,2	-9,54	25

The CO_2 concentration data for the stations was obtained from the World Data Centre for Greenhouse Gases (WDCGG). The measured CO_2 concentration data was used to estimate the CO_2 concentration over the Mediterranean region. There are many countries in the region where a CO_2 measurement station does not exist. For example in Turkey, Greece and Egypt there are no stations for measuring CO_2 concentration, however, we are interested in knowing, for example in Turkey, what the average CO_2 concentration is. Therefore, the results of this study will give an idea about the CO_2 concentration in the regions where CO_2 concentration is not measured and will also give the trend where CO_2 concentration is going throughout the years, because this region is very close to Irak and there is a war in this region.

In this study the Kriging Method (Delfiner and Delbomme, 1975) was used to calculate the average CO_2 concentrations over the countries where a CO_2 measurement station is not present. After average concentrations are found between the stations, the CO_2 concentration contours have been drawn for the years between 1995 and 2002, and the results are mapped by using GIS techniques (Townshend, 1991; Mahoney, 1991). Also, the trend in CO_2 concentrations for the years between 1995 and 2002 has been plotted over the Mediterranean area.

3. RESULTS AND DISCUSSIONS

Figure 2 shows the contours of the CO_2 concentrations for the study area in 1995 obtained by using the Kriging method. The concentrations shown by contour lines are between 360.5 ppm and 376 ppm. The highest concentration contours are seen in Europe such as in Germany, Austria and Nothern Italy with contour values of 376, 371 and 374 ppm, respectively. However, in the Mediterranean region CO_2 concentration contours are between 360-365 ppm. The contours over Turkey are with values of 365-366 ppm. CO_2 concentration contours for the years between 1996 and 1999 are given in Figure 3. A similar trend is seen in these figures, too.

CO_2 concentration contours in year 2000 are shown in Figure 4. In this figure the CO_2 concentration contours range between 370 ppm and 376 ppm. Germany, Austria, Hungary and Romania again show the highest CO_2 concentration with the values of 375, 373, 374 and 372 ppm, respectively. The contours over Turkey are with values of 374-375 ppm, and over Mediterranean sea with values of 371-373 ppm.

As can be seen from the Figures, the CO_2 concentration is increasing approximately 1.5 ppm per year over the European countries for the period of 1995-2000. CO_2 concentration contours for years 2001 and 2002 are also given in Figure 5 and Figure 6. The latest CO_2 concentration measurement data available on the data base used in this study was for 2002.

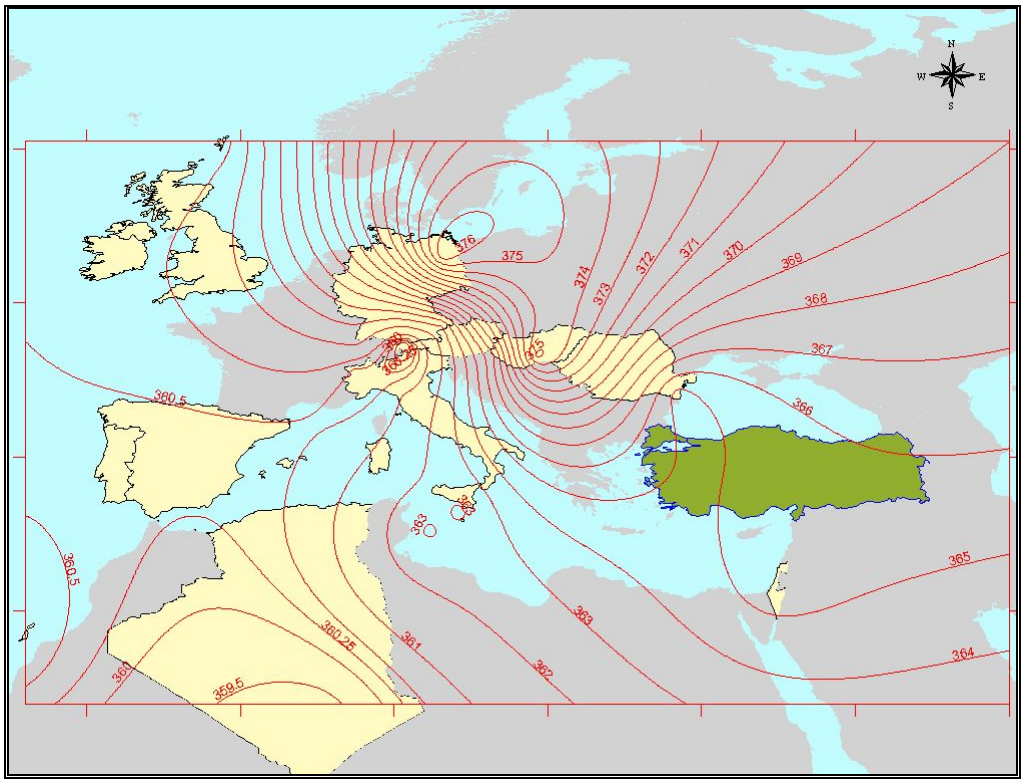

Figure 2. Contours map of CO_2 concentration in 1995

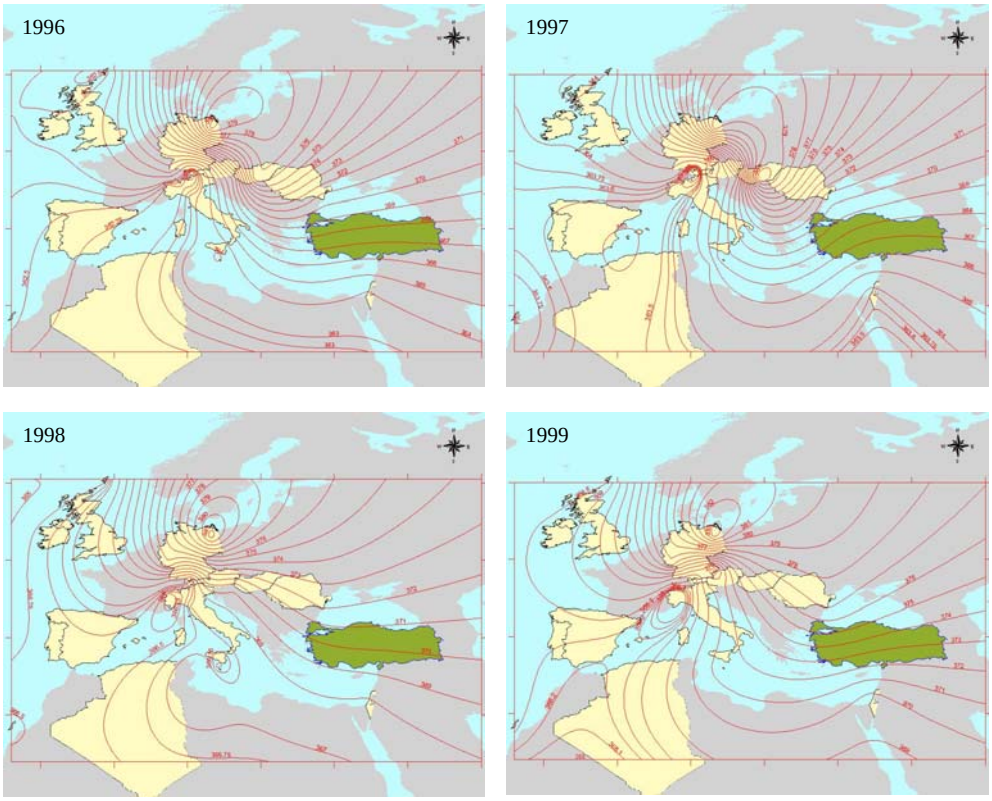

Figure 3. Contours map of CO_2 concentration for the period of 1996-1999

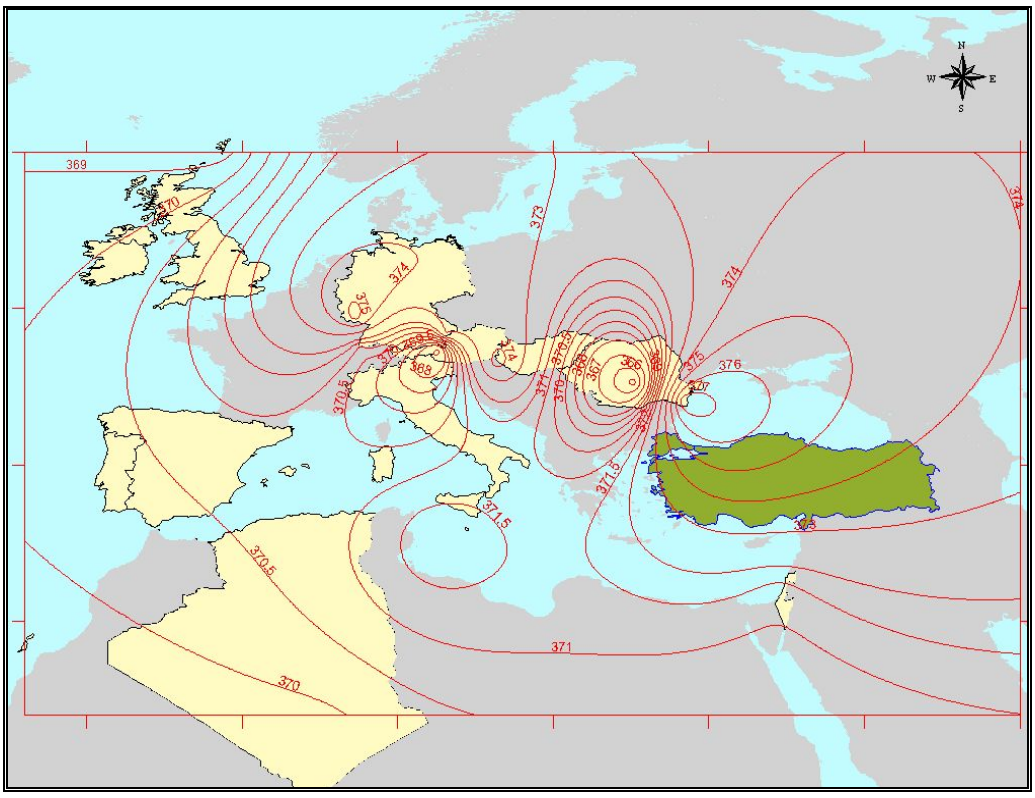

Figure 4. Contours map of CO_2 concentration in 2000

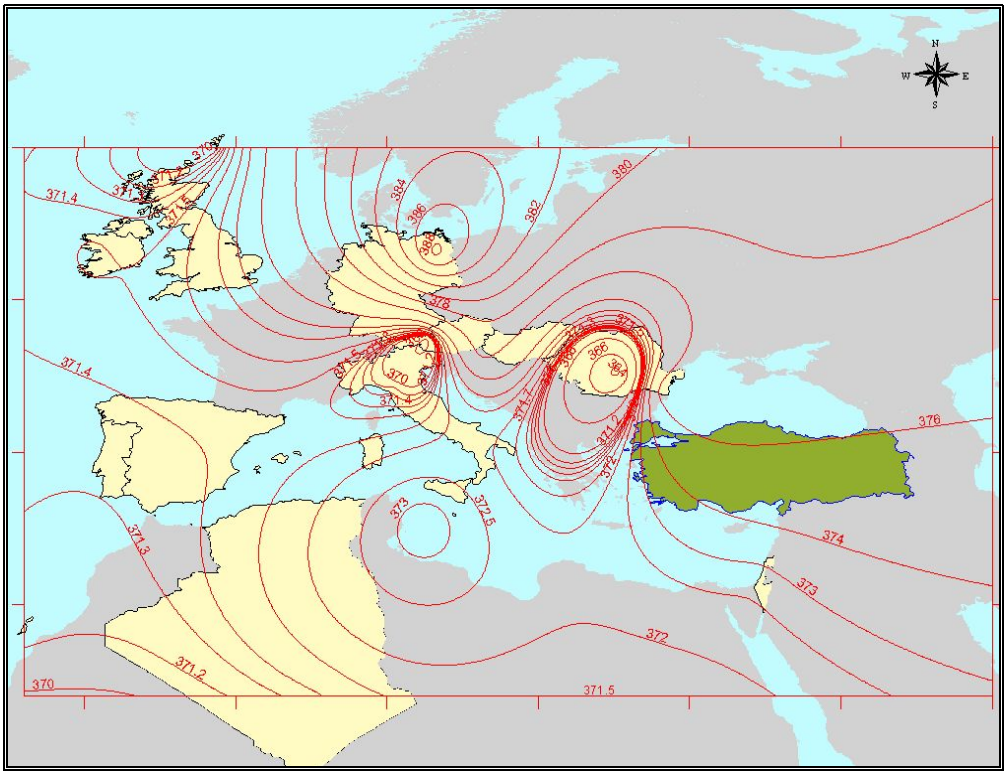

Figure 5. Contours map of CO_2 concentration in 2001

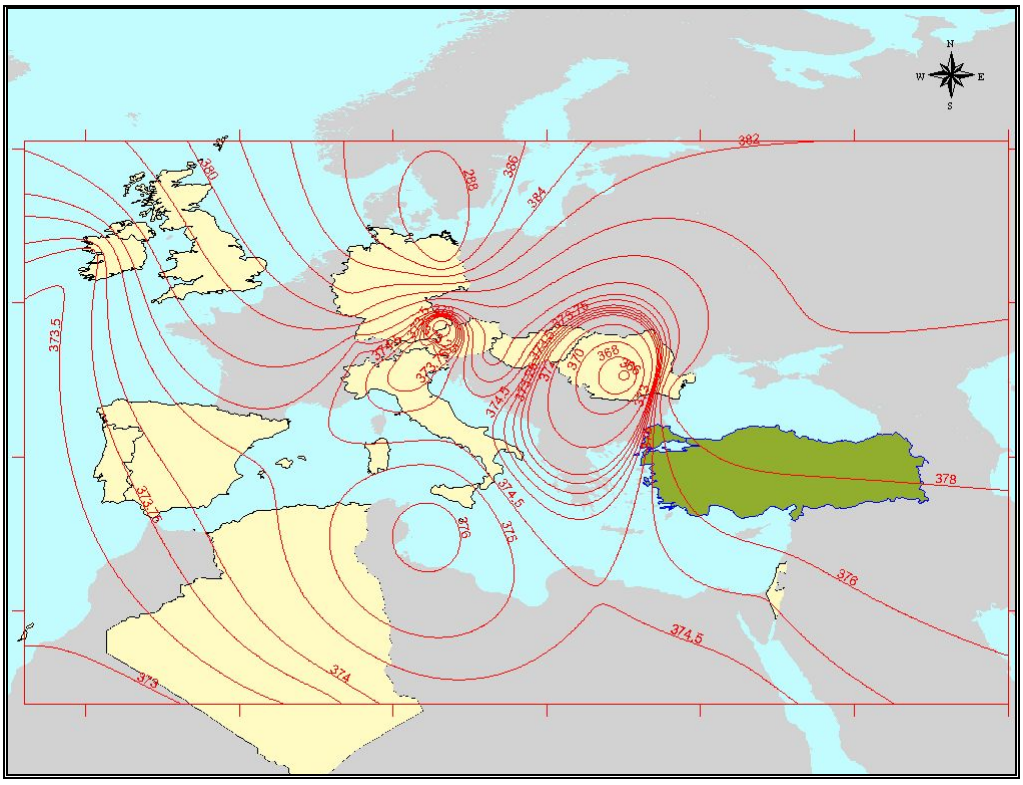

Figure 6. Contours map of CO_2 concentration in 2002

CO_2 concentration contours in year 2001 show that contours range between 370 ppm and 376 ppm. Germany, Austria, Hungary and Romania again show the highest CO_2 concentrations with values of 375, 373, 374 and 372 ppm, respectively. The contours over Turkey are with values of 376-378 ppm, and over Mediterranean sea with values of 374-376 ppm.

CO_2 concentration contours in year 2002 show that contours range between 374 ppm and 384 ppm. Germany, Austria, Hungary and Romania again show the highest CO_2 concentrations with values of 375, 373, 374 and 372 ppm, respectively. The contours over Turkey are with values of 376-378 ppm, and over Mediterranean area with values of 374-376 ppm.

The result of this study showed that the CO_2 concentration over Mediterranean region has been increasing throughout the years.

CO_2 concentrations in Turkey are lower than in Western Europe with a value of 376-378 ppm in Turkey in 2002. However, the CO_2 concentration is increasing greatly all over the Mediterranean zone. Figure 7 gives the maximum and minimum CO_2 concentrations between years 1995 and 2002 for the Mediterranean area.

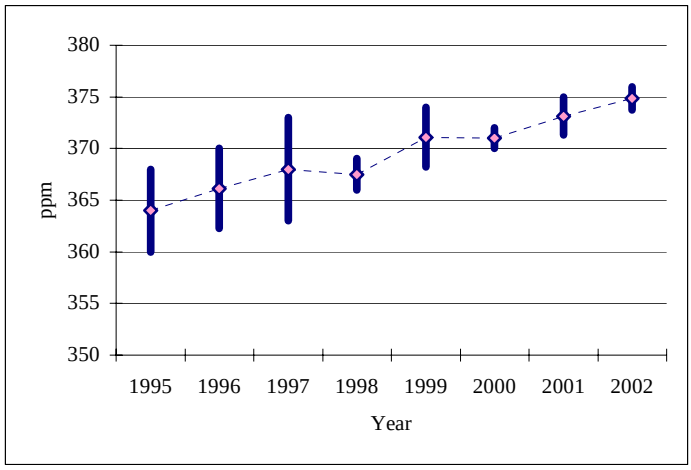

Figure 7. Maximum, minimum and average CO_2 concentrations over the Mediterranean area

According to Figure 7, the average CO_2 concentration over the Mediterranean area has increased approximately 11 ppm between the years 1995 and 2002. If the minimum and the maximum CO_2 concentrations are considered, the increases between those years are 14 ppm and 12 ppm, respectively. Although, the average CO_2 concentrations have shown a slight decrease in 1998, generally CO_2 concentration has shown a tendency to increase between the years 1995 and 2002. This is an important result which is in parallel with the increasing trend of CO_2 concentration in the world.

4. CONCLUSIONS

The results of this study have shown that CO_2 concentration over Mediterranean area has been increasing throughout the years and this increase is approximately 11 ppm between the years 1995 and 2002. The increase is about 1.5 ppm/yr. Germany, Austria, Hungary and Romania show the highest CO_2 concentrations in Western Europe. CO_2 concentrations in Turkey are lower than in Western Europe.

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