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EAST ASIAN OZONE POLLUTION: EVALUATION FROM OBSERVATION AND REGIONAL MODEL IN CHINA

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ABSTRACT

The increases in anthropogenic emissions of air pollutants in China, resulted from the rapid industrialization and economic growth, potentially have impact on both domestic and hemispherical scale. Since many studies have predicted the upward trend of these emissions in the near future, it is likely that China will dominate the regional and global emissions in the earlier decades of the 21st century.

One of the important concerns on air pollution problem for East Asia is the increase of regional ozone pollution, its trans-boundary transport, and the environmental impact. In order to elucidate these problems, key research approaches considered necessary must include both atmospheric measurements and simulation by model. In this work, we have recently established ozone and carbon monoxide observatory at three regional sites in China. All of them are regional mountain sites: Taishan (Mt. Tai, 36N 117E 1520m asl) in Shandong Province, Huashan (Mt. Hua, 34N 110E 2060m asl) in Shaanxi province, and Huangshan (Mt. Huang, 30N 118E 1840m asl) in Anhui province as shown in Figure 1.

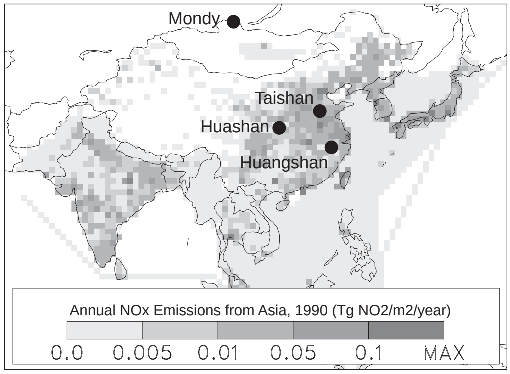

Figure 1. Locations of the three mountain sites in China, shown together with the annual NOx emissions for 1990

The results obtained from these site are analyzed and compared with the background and carbon monoxide data at Mondy (51N 100E 2006m asl) in eastern Siberia and with the results from regional-scale model simulation.

From the observations, high levels of ozone and carbon monoxide have been found in China, especially in springtime. The ozone mixing ratios at our sites are well-correlated and clearly higher than those observed at other remote mountain sites in northeast Asia and Siberia. The good correlation among different monitoring sites indicates that the high ozone mixing ratio events are regional-scale pollution. While trajectory analysis confirms that the seasonal variation of ozone in China are primarily due to East Asian monsoon regime, many pollution episodes found at the three observatories indicate the enhanced effect of regional anthropogenic sources, mega-cities, and regional transport within China. These high ozone episodes would likely have an impact on air quality in China and east Asia. For example, considering that the ambient air quality standard for China (environmental level) is 60 ppb, about 65% of Taishan data in spring 2004 shows mixing ratios that exceed the ambient standard.

The results from RAMS/CMAQ simulation having domain over East Asia have been made and compared with the results from observation. As shown in Figure 2, RAMS/CMAQ model reproduces the ozone mixing ratios and its variation observed at Taishan very well. Good agreements between model and observation, though with lower correlation, are also found at Hunagshan and Huashan. The good correlation between observation and model verifies the regional-scale representatives of our observatories and makes it possible to clarify the characteristics of ozone pollution in China. Details on these results and discussion will be presented in the conference.

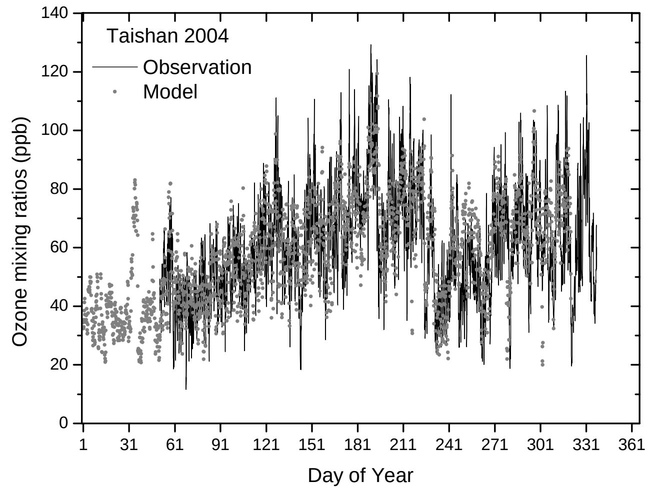

Figure 2 Ozone variations at Taishan in 2004 from observation and regional model.

Keywords: air pollution, long-range transport, ozone observation, regional source.

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LONG-RANGE TRANSPORT AND CHEMICAL TRANSFORMATION OF POLLUTANTS IN THE SOUTHERN AFRICAN REGION

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ABSTRACT

The paper presents the first results of a long-range chemical transport model developed for Southern African conditions. The model utilizes a combined Eulerian-Lagrangian description of the transport and diffusion of pollutants, and incorporates a description of the chemical transformations, dry and wet deposition as well as an estimation of the pH value of precipitation. A unique feature of the model is the use of an atmospheric boundary layer dynamics model to account for the major role this layer plays in the turbulent diffusion process. The comparison of the model results with experimental data from the DEBITS (Deposition of Biogeochemically Important Trace Species) programme confirms its reliability and usefulness in the quantification of environmental problems typical for the region of Southern Africa. Result maps illustrating concentration and deposition fields allow for the development of regional environmental policies and corrective activities.

Key Words: long-range pollution model, atmospheric boundary layer, atmospheric chemistry, turbulent diffusion.

1. INTRODUCTION

Dispersion modelling of transport, diffusion and chemical transformation of pollutants and trace gases over the Southern African region which spans between 52^o South to 1^o North, 28^o West to 68^o East, presents a special challenge due to three major factors. The first factor is associated with the frequent occurrence of a stable anticyclonic environment. This environment inhibits the vertical exchange of air masses and stratifies the troposphere into persistent layers, in which residence times of pollutants are prolonged from several days to weeks over the region. The second factor stems from the different distribution of emission sources in Africa. Biogenic emissions from biomass burning, vegetation and soils are equal or substantially bigger than anthropogenic emissions over larger parts of the region. Thirdly, long-range transport is vital for the existence or destruction of many fragile ecosystems that receive nutrients or pollutants mainly from the atmosphere. In addition to these major factors, experimental studies on the tropical meteorological factors affecting the long-range transport and chemical transformation of pollutants are limited, and theoretical understanding of the atmospheric processes in the regions with negligible

Coriolis force, are still lacking. Special emphasis should be placed on the identification of key linkages between the physical, chemical and anthropogenic processes governing the functioning of the bio-geophysical and biogeochemical systems of Southern Africa that lead to significantly elevated ozone concentrations over considerable sections of the tropics.

The paper describes the development and application of an appropriate dispersion package for studying the peculiarities of the long-range transport, diffusion and chemical transformation of pollutants and trace gases in the Southern Africa region. Special attention is given to the transport of harmful substances from the highly industrialized regions to the predominantly rural areas of the region as well as wet and dry deposition over sensitive land and water ecosystems.

2. THE LAGRANGIAN-EULERIAN DIFFUSION (LED) MODEL

The Lagrangian-Eulerian Diffusion (LED) model (Djolov *et al.*, 1987) utilizes in a complimentary way the positive features of the Lagrangian and Eulerian description of hydrodynamic flows. It is well known that the essence of the Lagrangian method consists of studying the properties and variation of a fixed fluid volume during its motion. Using this idea in the model, any volume of polluted air is identified by the trajectory of its center of mass. The diffusion and transformation processes of pollutants are investigated on the basis of analytical solutions of the appropriate differential equations in Eulerian coordinates with origin at the center of mass of puffs. As part of the basic structural element of the model, the puff allows for approximation of any type of emission source by using proper puff volume and emission time intervals. Experimental and theoretical studies reveal the fundamental fact that the transport and diffusion of pollutants in the atmosphere can be studied by separating the horizontal and vertical processes (Syrakov e*t al.*, 1983). Indeed, the turbulence in vertical direction is small-scale and it would be appropriate to use the law of mass conservation (the diffusion equation) while in horizontal direction the turbulence is large-scale, the turbulent eddies are not limited by the earth surface and the diffusion process requires a statistical description. This idea is expressed by the critical key formula for the concentration C^K of pollutant K in a point (x, y, z) which reads:

$$C^K(x,y,z) = \sum_{i=1}^{M}\sum_{j=1}^{N_j} Q_{ij}^K(t_{ij}) q_h(x, x_{ij}^c, y, y_{ij}^c, t_{ij}) q_z(z, z_{ij}^c, t_{ij}) q_w(t_{ij}) \quad (1)$$

where $Q_{ij}^K(0)$ is the quantity of the K^{th} pollutant in the j^{th} puff emitted by the i^{th} source in the moment $t_{ij} = 0$, M is the number of sources, N_j is the number of puffs, q_h and q_z are the horizontal and vertical distribution functions, q_w is the wash-out function and t_{ij} is the life time of the puff. The time variation of Q_{ij}^K is due to chemical transformations, dry and wet deposition processes. The analytical expressions for the functions q_z, q_z and q_w, and more details for the LED model are presented in Djolov *et al.* (1987). It should be pointed out that the vertical and horizontal diffusion functions are explicitly dependent on the atmospheric boundary layer (ABL) turbulence through the eddy transfer coefficients in vertical and horizontal directions. Therefore, LED needs input from an appropriate simple enough and reliable boundary layer model which, allows for incorporation of new research developments in the ABL dynamics.

3. ATMOSPHERIC BOUNDARY LAYER MODEL (ABL)

A unique feature of LED is the use of an appropriate ABL model calculating its dynamics and turbulent characteristics. Usually, the long-range models are driven by the output of the best available meso-scale forecast models or in the diagnostic case by observed meteorological fields. In both cases however, the ABL dynamics are not properly represented due to the restrictions in the model vertical resolution or insufficient number and distribution of observations. This is a serious simplification since the changes in wind velocity and atmospheric stability occurring in the ABL influence dramatically the transport and diffusion processes. For example, the value of the vertical exchange coefficient changes by order of magnitudes depending on the stability conditions in the ABL. The magnitude and direction of the wind velocity vary considerably with height, and the angle between the geostrophic and surface wind can surpass 50-60 degrees. The wind variations in the ABL are even more complicated when the baroclinicity effects are present. Turbulent friction convergence creates vertical motions that in spite of their small value, lead to substantial displacement of the polluted air volumes because of their perseverance. Another important consideration is that most of the emissions of pollutants and trace gases are released from sources located near the earth's surface up to few hundred meters. The existence of frequent inversion layers at the top of ABL forces the diffusion and transport of pollutants to take place in the lower parts of the atmosphere for prolonged periods of time. These facts underline the importance of inclusion of an appropriate ABL model in any turbulent dispersion package aimed at modelling long-range diffusion and transport phenomena.

In the LED model the two-layer parametric ABL model proposed by Yordanov *et al.* (1983) is included. The ABL model is driven by the following meteorological variables: 1) the geostrophic wind vector $\vec{v}_g$; 2) the potential temperature ϑ_H at the top of the ABL; 3) surface temperature ϑ_s which can be calculated from the energy balance equation or taken from observation or numerical weather forecast model. Note that these are the boundary conditions for the turbulent ABL equations for momentum and heat exchange at arbitrary stratification.

From these external to ABL meteorological variables, and the local parameters: the Coriolis parameter - f, the roughness parameter z_0 and the buoyancy parameter $\beta = g / \overline{\vartheta}$, the following non-dimensional external parameters can be composed:

$$Ro = \frac{|v_g|}{fz_0} \qquad (2)$$

the Rossby number, and

$$S = \frac{\beta(\vartheta_H - \vartheta_s)}{f \mid v_g \mid} \tag{3}$$

the external stratification parameter.

These parameters uniquely determine the turbulent regime in a horizontally homogeneous ABL. The details of the ABL model are presented in Yordanov *et al.* (1983).

4. CHEMICAL MODEL

The major anthropogenic atmospheric pollutants at present in Southern Africa are sulphur, nitric and hydrocarbon compounds. In this paper only the results for the sulphur and nitric oxide chemical transformations are presented due to their abundance, relatively long residence times and being the main precursors for the formation of acid deposition. The complicated and numerous chemical photochemical reactions of the hydrocarbons have a pronounced effect on the environment in the vicinity of the major sources.
The most important mechanism for the formation of acid deposition is the direct transformation of sulphur dioxide to sulphate:

$$\boldsymbol{SO_2 \xrightarrow{K_1} SO_4^{2-}} \tag{4}$$

where $\boldsymbol{K_1(t,r)}$ is the constant of transformation which is a function of the time and space. The $\boldsymbol{K_1}$ value can be obtained assuming that it can be written as a sum of homogeneous and heterogeneous components. The rate of homogeneous transformation is taken from the Endlich *et al.* (1984) paper where it is calculated as a function of the solar insulation using data for a clear atmosphere. The heterogeneous component is chosen on the basis of the review presented by Möller (1980).

The chemical transformations that NO and NO_2 undergo are complicated. Smog chamber measurements of the typical reactions of NO compounds show that 90% of the reactions result in the formation of NO, NO_2, PAN (Peroxyacetyl nitrate) and NO_3. This allows the chemical transformations of these five components to be included in the model. The equations describing the rate of transformation of the nitrogen compounds due to chemical and physical processes are based on Brodzinsky *et al.* (1984). The rate equations used in the model are linear. The equilibrium of NO and NO_2 reflects the photolysis of NO_2 to NO and the photo and thermal pathways of NO to NO_2 conversion.

5. MODEL INFORMATION

A Cartesian grid with 60 x 50 grid cells, on a 50 km resolution was superimposed over the modelling domain of 10°E – 40°E to 10°S – 35°S. Model input parameters (meteorological data, surface roughness lengths, emission database, etc.) used conform to the grid resolution.

The meteorological data (annual dataset for 2000) needed for input in the model was taken from the short-range forecasting Eta model, obtained from the South Africa Weather Service (SAWS), Pretoria, South Africa. The horizontal resolution of the model is 48 km with 38 Eta levels in the vertical dimension.

The wind field presented in Figure 1 has persisted for large parts of August giving an idea of the closed anticyclonic circulation clearly visible by the vector fields. This typical circulation pattern normally embraces the whole southern Africa region, and persists up to two to three weeks during the winter season.

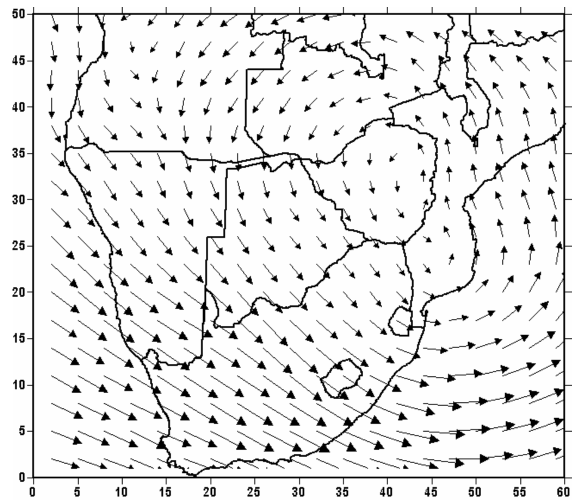

Figure 1.Typical anticyclonic circulation pattern experienced during winter seasons over the region.

The emission database utilized in the model was obtained from Fleming and van der Merwe (2000). The methodology followed and sectors included in the inventory were done according to the guidelines provided by the Intergovernmental Panel on Climate Change (IPCC) (1996). The database includes emissions from various sources on a 20 km grid resolution. The 20km resolution database was reworked to a 50km resolution database, and Figure 2 is a graphical presentation for total sulphur dioxide (SO_2) emissions emanating from the modelling domain.

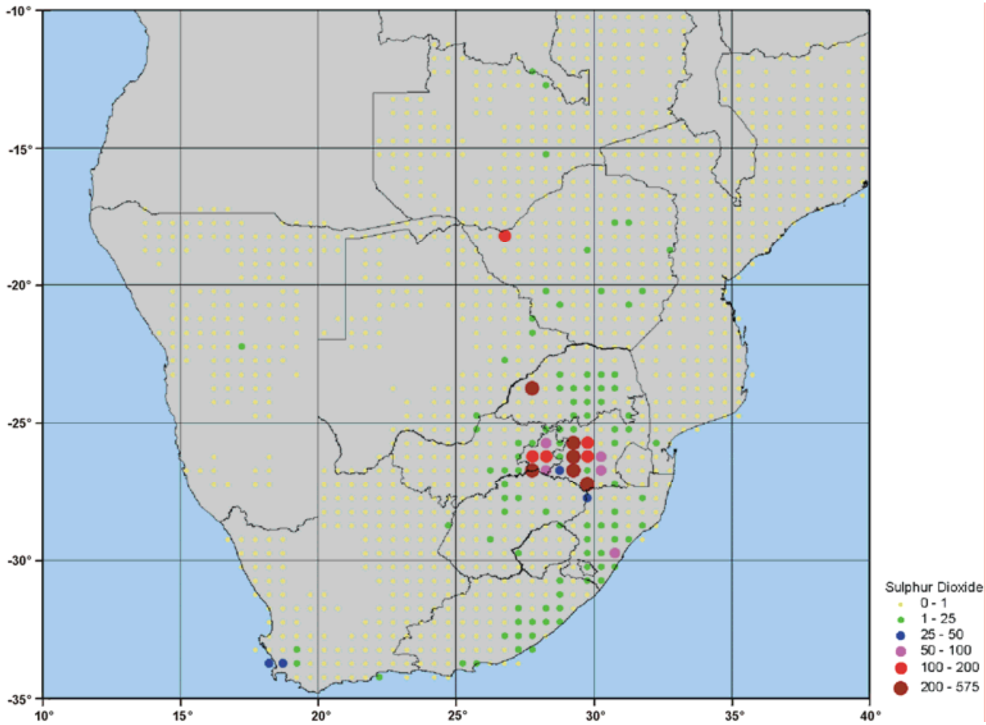

Figure 2.Total SO_2 emissions for the modelling domain (units in Gg per annum) (Fleming and van der Merwe, 2000).

6. RESULTS & DISCUSSIONS

Figures 3 to 5 illustrates modelling results of ambient SO_2 concentration, total dry deposition of SO_X *as S* and total dry deposition of NO_X *as N* experienced during the winter season of 2000. The total *N* deposition field illustrates pollution caused by the emissions emanating from industry, transport and domestic biofuel use.

The first evaluation of the model performance is done using data from the DEBITS (Deposition of Biogeochemically Important Trace Species) programme. Surface sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ammonia (NH_3) and ozone (O_3) concentrations are monitored at several sites in South Africa in the DEBITS (Deposition of Biogeochemically Important Trace Species) programme. Five stations were used for the validation of the model in this study. Cape Point was selected for its proximity to marine ecosystem, Louis Trichardt for its dry savanna ecosystem, and Amersfoort, Palmer and Elandsfontein as industrial highveld sites. The location of the monitoring sites is shown on the base map in Figures 3 to 5.

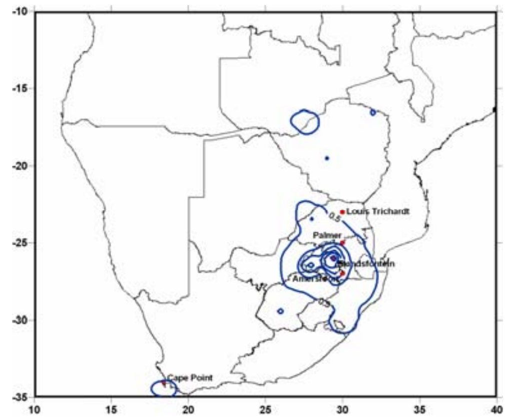

Figure 3.Ambient SO_2 concentrations predicted for the winter season during 2000 (Isopleths units in $\mu g.m^{-3}$).

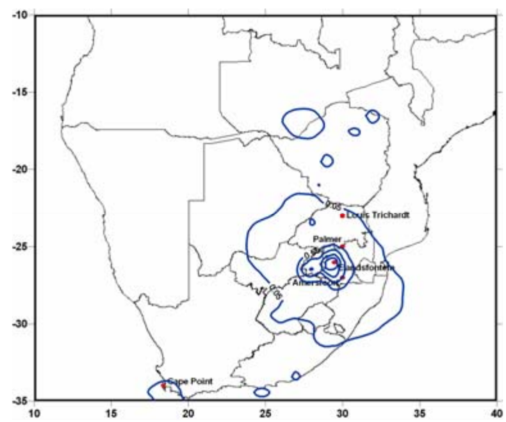

Figure 4.Total dry deposition SO_X *as S* accumulated during the 2000 winter season (Isopleths in $kg.ha^{-1}.3\ months^{-1}$).

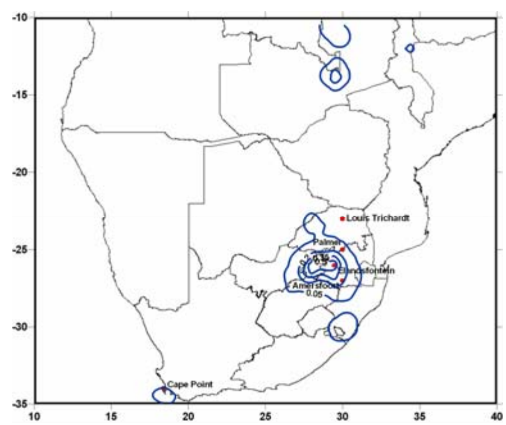

Figure 5.Total dry deposition NO_X *as N* accumulated during the 2000 winter season (Isopleths in $kg.ha^{-1}.3\ months^{-1}$).

Table 1 is a summary of the mean ambient SO_2 concentrations at the DEBITS sites in Southern Africa, compared to simulated results by the LED model, while Table 2 specifies the comparison of dry deposition of SO_X *as S* measured at the DEBITS stations with simulated results by the LED model respectively.

An evaluation of the data in Table 1 indicate that the LED model under predict ambient air concentrations for the majority of DEBITS sites in 2000. The highest under prediction occurs at the Louis Trichardt site. A possible reason for this might be the complicated topography around these stations which is not properly accounted for in the ETA meso-scale forecast model. Moreover, data in Table 2 indicates an over prediction of dry deposition at the different DEBITS stations respectively. Once more only Louis Trichardt demonstrated an under prediction of the total dry SO_X *as S* deposition simulated against measured vales at the site.

Table 1. Mean ambient SO_2 concentrations in μg.m^{-3} measured during 1996 to 1998 at DEBITS sites in southern Africa compared to simulated ambient concentrations for 2000.

Site	Value	Autumn	Winter	Spring	Summer
Cape Point	**Measured**[1]	1.2	1.3	1.9	1.2
	Modelled[2]	1.7	1.2	1.3	1.6
Amersfoort	**Measured**[1]	5.9	9.6	7.7	10.5
	Modelled[2]	4.4	5.0	7.3	3.7
Louis	**Measured**[1]	2.9	4.1	3.0	2.1
Trichardt	**Modelled**[2]	0.5	0.5	0.8	0.5
Elandsfontein	**Measured**[1]	20.0	33.5	20.0	19.5
	Modelled[2]	16.6	15.3	19.5	14.7
Palmer	**Measured**[1]	10.3	14.9	5.4	3.2
	Modelled[2]	7.8	6.1	7.8	7.2

[1]Mean values measured from 1996 to 1998.
[2]Modelled LED values for 2000.

Although the results presented are preliminary, a conclusion can be made that the deposition velocities for SO_2 utilized in the model should be reduced, based on the discussion above. Tables 1 and 2 confirm that LED turbulent diffusion package is capable of producing reliable results.

Table 2. A comparison of total deposition of SO_X *as S* / kg.ha^{-1}.3 months^{-1} measured during 1996 to 1998 at DEBITS sites in southern Africa with simulated total S deposition values for 2000.

Site	Value	Autumn	Winter	Spring	Summer	Annual Total[3]
Cape Point	**Measured[1]**	n/a	n/a	n/a	n/a	n/a
	Modelled[2]	0.27	0.18	0.20	0.24	0.89
Amersfoort	**Measured[1]**	0.43	0.47	0.55	1.08	2.52
	Modelled[2]	0.79	0.72	1.06	0.74	3.31
Louis Trichardt	**Measured[1]**	0.22	0.19	0.21	0.21	0.84
	Modelled[2]	0.15	0.11	0.16	0.13	0.56
Elandsfontein	**Measured[1]**	2.12	2.08	2.09	3.06	9.36
	Modelled[2]	2.77	2.02	2.43	2.52	9.74
Palmer	**Measured[1]**	0.83	0.72	0.50	0.43	2.47
	Modelled[2]	1.44	0.89	1.18	1.27	4.79

[1]Mean values measured from 1996 to 1998.
[2]Modelled LED values for 2000.
[3]Total deposition as kg.ha^{-1}.yr^{-1}.

7. CONCLUSION

The model results obtained with the Southern African version of the LED model, which incorporates ABL model and new comprehensive chemical scheme, give assurance that it can be used as a diagnostic and prognostic tool for air pollution studies at different time and space scales. The comparison with the available experimental data demonstrates that the results are reliable. For example, the values of the monthly average concentrations field of SO_2 in Figure 4 and deposition field of S in Figure 5 are of reasonable order of magnitude and compare favorably with the measured values at the three DEBITS stations. The results by LED are expected to improve by upgrading the ABL model on the basis of the contemporary understanding and parameterization of the convective process in the tropics that is dominated by non-local turbulent transport. This also means taking into account the baroclinicty effects on the ABL dynamics. A refinement of deposition velocities utilized for the different species in the model is also needed.

Figures 4 to 6 indicates that industrial pollution emanating from South Africa contributes significantly to its own and neighbouring countries pollution problem. Reliable information aimed at regional environmental policy and planning, as well as adequate and effective remedial actions for the individual countries and the region as whole, can be obtained by using sufficiently monthly, seasonal and annual meteorological records. Special attention also deserves case studies of the typical for the region prolonged anticyclonic circulation.

There are several applications with the model, namely, simulations with the natural emissions (vegetation, forest, soils) in order to partition the contribution of anthropogenic and natural sources to the pollution in the region; study the formation of ozone over the tropics; quantify the pollution episodes during a persistent gyre (anticyclonic) circulation and the fluxes of pollutants to the adjacent oceans and continents.

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BIOGENIC EMISSIONS OF VOLATILE ORGANIC COMPOUNDS FROM TURKEY

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ABSTRACT

This study shows the results of the first to our knowledge detailed biogenic emission inventory of volatile organic compounds (VOCs) for the whole of Turkey. Of the thousands of VOCs present in the atmosphere, the emission inventory was prepared for isoprene and monoterpenes, which are known to be the most important biogenic VOCs considering their role in photochemical reactions and the formation of ozone. The other VOCs were also calculated but the results for this category have very great uncertainty and should be taken only informative. The basis for the calculations was a land cover dataset depending mainly on satellite data. The emission results were found to be higher than some earlier global studies, especially for isoprene.

Key Words: Biogenic emissions, volatile organic compounds, Turkey, isoprene, monoterpenes

1. INTRODUCTION

Photochemical smog, focusing mostly on tropospheric ozone, has been an important subject of air quality studies especially from the last quarter of the past century. Because of several factors like computational limitations, relatively poor explanation of the chemical mechanisms and the natural interest in urban sources of pollution, the earlier studies focused on the anthropogenic emissions of precursors of photochemical smog components. In the following years, with the help of the developing models and better explanation of the chemical mechanisms, the extent of the studies became greater and the contribution of biogenic emissions of VOCs is being considered in most recent and current studies (Biswas et al., 2001). Because of the great number of VOCs emitted, most studies are limited to the contribution of the emissions of isoprene and monoterpenes, which are known to have the most important role in photochemical reactions.

Considering the relatively new interest in ozone modeling in Turkey and the fact that the current studies are realized by considering the contribution of anthropogenic emissions only, the estimation of biogenic emissions of VOCs from Turkey was realized in this study. To our knowledge, this is the first national biogenic VOC emission inventory for Turkey.

2. METHODOLOGY

Considering the known effect of the biogenic volatile organic compounds (VOCs) in the formation of ozone, an inventory of biogenic VOCs for the whole area of Turkey has been prepared with a resolution of 1 km x 1 km.

Because of the known effect of solar radiation and temperature on the emissions of the biogenic VOCs (Guenther et al., 1993), it is important to consider the variation of these parameters on monthly and hourly basis and the inventory should be prepared accordingly. Hence, the inventory was prepared for each hour of a typical day of each month of the year. As in many other similar studies worldwide, the emission inventory was prepared for three main groups of compounds; isoprene, monoterpenes and "other VOCs".

The level of uncertainties for the group called "other VOCs" is too high and the results should be considered only informative. Therefore, the results of other VOC emission estimates are not included here. These calculations are carried out only for having a general idea of the level of emissions and for most of the species the default emission factor of 1.5 μg C m^{-2} h^{-1} has been used. Since a large number of VOC species are included in this group, the problem of uncertainty in the emission factors of this group is likely to continue for quite some time.

Although the mechanisms of emissions from vegetation and their importance and role in the metabolism of the plants are still not exactly well known, the important role of isoprene and monoterpenes in photochemical reactions is well known and there has been quite a number of studies in order to precisely determine the emission factors for different species. The members of the same family of plants can exhibit different emissions depending on the region in which it is found in the world. In the literature, there are no such studies carried out in Turkey. Therefore, the emission factors accepted in the scientific literature were used for the calculations, sticking to EMEP-CORINAIR emission factors when they were available.

The model developed by Guenther et al. (1995) formulizes the foliar emissions of VOCs as:

$$F = D\,\varepsilon\,\gamma \qquad (1)$$

F: Foliar emissions (μg-C m^{-2} h^{-1})
D: Foliar density (g m^{-2} : dry weight of leaves per unit area of land)
ε: Emission Factor (μg g^{-1} h^{-1}) (Since the emissions are dependent on temperature and solar radiation, the published emission factors are normalized to a reference state, most frequently the reference PAR being 1000 μmol m^{-2} s^{-1} and the reference leaf temperature being 303.15 K)
γ: A correction factor for the emissions (rising from the difference of real PAR and leaf temperature values to the reference values for which the emission factor has been given)

The sources of the inputs to the biogenic emissions model and the way of handling these inputs are explained in the following part.

Land Cover Data: The source of the land cover information used in this study was the Seasonal Land Cover Characterization dataset provided by USGS (http-1). These data are distributed by the Land Processes Distributed Active Archive Center (LP DAAC), located at the U.S. Geological Survey's EROS Data Center (http://LPDAAC.usgs.gov). This dataset has been prepared from the interpretation of satellite data and is updated by local contributions where possible. Of the 253 total different land cover classes included in the dataset, 138 were found to exist within the land of Turkey.

Temperature: In order to have a general picture of the biogenic VOC emissions, the climatic dataset "IPCC Data Distribution Centre Climate Baseline Download" was chosen (http-2). The dataset contains the minimum and maximum temperatures of each month averaged between the years 1981-1990 with a resolution of 0.5°. Temperature values for every hour of the day was assigned by an assumption of a linear daily change between the minimum and maximum temperatures obtained from the dataset. The temperatures defined at certain points of the world were transformed to continuous raster datasets by interpolation methods embedded in the GIS system.

PAR (Photosynthetically Active Radiation): The PAR values which control the emissions of isoprene, and in some cases monoterpenes, were estimated by the use of the TUV model developed by The National Center for Atmospheric Research (NCAR)- Atmospheric Chemistry Division (ACD) (http-3). The PAR values at given locations were interpolated by the GIS software in order to have a continuous spatial data.

The TUV model was run in order to estimate the visible range net solar radiation. According to CORINAIR documents, the PAR value is approximately half of the values of the visible range solar radiation (EEA, 2004). In this study, the ratio of the photosynthetic photon flux density (which is a measure of PAR) to the solar broadband irradiance was taken to be 1.990 µE/J as advised by Gonzalez and Calbo (2002) and the PAR values were assigned accordingly.

Of the essential inputs to the TUV model are the geographical coordinates of the point for which the radiation amount will be estimated and its elevation from sea level. Elevation values, together with their geographical coordinates were obtained from the dataset "The Global Land One-km Base Elevation (GLOBE) Project" that has a resolution of 0.0083333° (approximately 1 km) available from the website http://www.ngdc.noaa.gov (http-4).

The estimations for PAR were realized with the assumption of clear skies. Although this assumption leads to some mistakes especially for winter months, the scope of being able to estimate the total emission potential from biogenic sources together with the fact that the bulk of the isoprene emissions occur during summer months and that the sensitivity of biogenic emissions to radiation decreases significantly after certain values of PAR (EEA, 2004) may lead to the idea that the error rising from this assumption can be expected to be relatively small (Symeonidis et al., 1999).

Emission factors: The two main references during the selection of the emission factors were EMEP CORINAIR emission factors (EEA, 2004) and the emission factors assigned by Guenther et al. (1995) for the ecosystem types compiled by Olson (1992). The factors given by Guenther et al. (1995) are generally for more general classes while CORINAIR documents list factors for commonly observed types of species, stating factors for European species where available. This made the CORINAIR documents the more preferable reference in the selection of emission factors. The other references used were the studies by Guenther et al. (1994), Levis et al. (2003), Lamb et al. (1993) and Parra (2004).

Foliar density: For foliar densities (sometimes referred to as biomasses also), the values given by CORINAIR were used where possible.

There are temporal changes in foliar densities of deciduous trees and agricultural products, resulting from climatic changes and agricultural activity. Adopting the assumption used by Symeonidis et al. (1999), the deciduous tress were assumed to possess the maximum foliar densities given in the literature from May until September while the foliar densities are reduced to half of these values during October, November and April and are zero during other months of the year. For the temporal changes related to agricultural products, the assumptions were based on communications with experts.

Since the land cover dataset used contain mostly classes of a mixed type (i.e. classes containing deciduous and evergreen species together, or containing isoprene and monoterpene emitters together), the dataset of foliar densities and emission factors were prepared in order to have foliar density and emission factor values separately for all 12 months and again separately for isoprene, monoterpenes and other VOCs (leading to a dataset of 138 rows by 36 columns of foliar densities and 36 columns of emission factors). Table 1 shows the land cover classes from the used land cover data set (SLCR (Seasonal Land Cover Region) version 2.0) that occur most frequently within the land of Turkey, the percentage of their spatial coverage to the whole area, foliar densities (biomasses) and emission factors of isoprene, monoterpenes and other VOCs for the months of June and July as examples of low and high emission conditions.

Correction factor for emissions (γ): Since the emission factors are given at a reference PAR and leaf temperature, a correction factor is included in the calculations in order to estimate the emissions for the actual PAR and leaf temperature values (EEA, 2004). All isoprene emissions are dependent on both solar radiation and temperature and the correction factor includes both the PAR and temperature as a variable. The emissions of most monoterpenes, on the other hand, are controlled only by temperature and the correction factor includes only temperature as a variable. Some of the monoterpene emissions, however, have been found to be controlled by both solar radiation and temperature. For vegetation classes related with such monoterpene emissions, the same algorithm with isoprene emissions was used and hence the correction factor calculation is the same. Generally, monoterpene emissions that are controlled both by radiation and temperature arise from some evergreen oak species and evergreen shrub-like species.

Table 1. Biomasses (foliar densities) and emission factors for isoprene, monoterpenes and other VOC's for January and July for the most frequently observed land cover classes

SLCR 2.0 LABEL	%	JAN-BIO (ISOP)	JUL-BIO (ISOP)	JAN-BIO (MT)	JUL-BIO (MT)	JAN-BIO (OVOC)	JUL-BIO (OVOC)	JAN-EF (ISOP)	JUL-EF (ISOP)	JAN-EF (MT)	JUL-EF (MT)	JAN-EF (OVOC)	JUL-EF (OVOC)
Cropland (Small Grains) with Grassland	6.50	0	0	100	200	100	200	0.000	0.000	0.100	0.100	1.500	1.500
Grassland with Winter Wheat	6.47	0	0	100	200	100	200	0.000	0.000	0.100	0.100	1.500	1.500
Short Grassland	6.27	0	0	200	400	200	400	0.000	0.000	0.100	0.100	1.500	1.500
Cropland (Wheat, Orchards)	6.21	0	180	0	180	0	180	0.000	0.150	0.000	0.490	0.000	1.370
Cropland/Shrubland Mosaic	5.73	409	818	409	818	409	818	1.540	1.541	0.225	0.225	1.500	1.500
Short Grassland/Oak Woodland/Cropland	5.51	223	552	289	685	289	685	0.090	11.674	0.123	0.135	1.500	1.500
Oak Woodland/Grassland	5.46	0	160	100	360	100	360	0.000	60.000	0.100	0.140	1.500	1.500
Grassland/Cropland (Corn, Wheat) Mosaic	4.85	0	0	67	133	67	670	0.000	0.000	0.100	0.100	1.500	1.500
Cropland/Woodland Mosaic	4.22	334	885	552	1103	552	1103	0.090	7.932	0.394	0.394	1.500	1.500
Sparse Short Grassland	3.57	0	0	200	400	200	400	0.000	0.000	0.100	0.100	1.500	1.500
Short Montane Grassland	3.21	0	0	200	400	200	400	0.000	0.000	0.100	0.100	1.500	1.500
Cropland (Small Grains, Sugar Beets, Orchards)/Pasture	2.49	0	424	50	524	50	524	0.000	0.103	0.100	0.186	1.500	1.478
Deciduous Broadleaf Forest	2.40	0	300	0	300	0	300	0.000	24.000	0.000	0.800	0.000	1.500
Oak Woodland	2.35	0	320	0	320	0	320	0.000	60.000	0.000	0.200	0.000	1.500
Cropland (Winter Wheat, Small Grains)	2.24	0	0	0	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000
Grassland/Cropland (Small Grains) Mosaic	2.06	0	0	100	200	100	200	0.000	0.000	0.100	0.100	1.500	1.500
Inland Water	1.77	0	0	0	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000
Sparsely Vegetated Shrubland/Grassland	1.74	75	150	175	350	175	350	8.000	8.000	0.340	0.340	1.500	1.500
Woodland/Cropland Mosaic	1.57	334	885	552	1103	552	1103	0.090	7.932	0.394	0.394	1.500	1.500
Cropland and Pasture (Wheat, Orchards, Vineyards) with Woodland	1.54	0	533	109	641	109	641	0.000	6.623	0.800	0.392	1.500	1.482
Small Grains (Barley, Wheat) with Grassland	1.51	0	0	67	133	67	133	0.000	0.000	0.100	0.100	1.500	1.500
Cropland (Wheat, Barley, Corn)	1.48	0	0	0	0	0	537	0.000	0.000	0.000	0.000	1.500	1.500
Woodland (Pine, Oak, Gum)	1.42	125	232	358	465	358	465	8.000	31.942	2.163	1.713	1.500	1.500
Grassland/Irrigated Cropland	1.40	334	668	434	868	434	868	0.090	0.090	0.123	0.123	1.500	1.500
Oak Woodland/Cropland (Small Grains, Orchards)/Pasture	1.21	0	170	50	270	50	270	0.000	28.315	0.100	0.260	1.500	1.457
Larch Forest/Woodland	1.11	0	218	218	585	218	585	0.000	32.000	0.800	0.979	1.500	1.500
Short Grass and Sparse Shrub	1.03	75	150	175	350	175	350	8.000	8.000	0.340	0.340	1.500	1.500

BIO: Biomass (foliar density) (g m^{-2}) **EF**: Emission factor (μg-C g^{-1} h^{-1})

JAN: January **JUL**: July **ISOP**: Isoprene **MT**: Monoterpenes **OVOC**: Other VOCs

3. RESULTS

The emission inventory for isoprene, monoterpenes and other VOCs from vegetation of Turkey has been prepared on hourly basis for a typical day of every month of the year. Both during the calculations and the presentation of the results on maps, GIS has been used intensively. As observed in Figure 1, which shows the yearly total emissions of isoprene, the emissions of isoprene is quite low (even zero in certain parts, depending on the vegetation cover) in central Turkey where green canopy is sparse, while it is much higher in the Black Sea region where dense green forests are found and in the Aegean, Marmara and Southeastern Anatolia where irrigated agriculture is practiced. In Figure 2, which shows the yearly total monoterpene emissions, the high emission regions observed for isoprene in the Black Sea and Marmara regions are not observed any more, while the monoterpene emissions are higher for the Aegean and Mediterranean regions, the canopy of which are generally maquis which is known to have higher monoterpene emissions.

Because of different values and assumptions used in different studies, the results of studies carried out for the same area can vary significantly from each other. When the results of this study are compared with the results of the study of Simpson et al (1995), it is seen that the results of this study are generally higher than those of the earlier study of Simpson et al (1995). As can be seen in the mentioned study of Simpson et al (1995), there can be significant differences in the results depending on the method used for modeling (In Simpson et al. (1995), emissions are estimated with differnet methodologies, the results of which range from 200 to 400 kilotons per year). In the mentioned study, the highest total observed emission of isoprene (total of emissions from April to September) is around 400 kilotons while in this study, emissions up to 1090 kilotons are observed for the same period . Such differences can be a result of:

- The vegetation classes used in Simpson et al. (1995) are much more general groups, while in this study, the classes used are much more detailed.
- In the years that passed between the two studies, there have been important changes in the generally accepted emission factors as a result of new and more detailed studies. Especially the emissions of isoprene from oak populations have turned out to be even more than they were known earlier and the isoprene emission factors have been revised.
- There is a difference between the resolutions of the two studies. The former study is a global model study and has a much coarser resolution while the resolution in this study is a fine resolution of 1km x 1km.

When the total emissions of isoprene are calculated, the value found is 1131 kilotons per year, a value slightly larger than the value of 1090 which is the emissions from April to September. This is expectable because of the dependence of isoprene emissions on solar radiation and the foliar density and also because of the fact that the isoprene is emitted mainly by deciduous trees.

It can be said that the monoterpene emission estimations are more comparable with the EMEP CORINAIR estimates. In the EMEP CORINAIR emission inventory guide, biogenic emissions are listed only for those from forests for each country. The

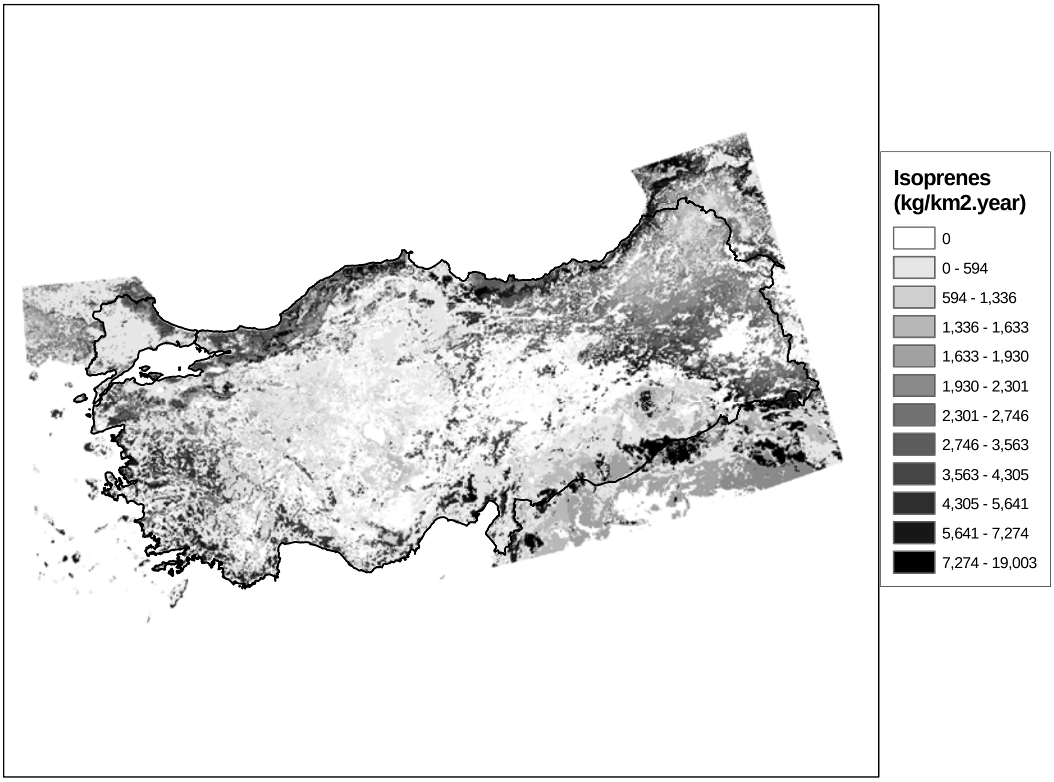

Figure 1. Yearly emissions of isoprene (kg/km^2.year)

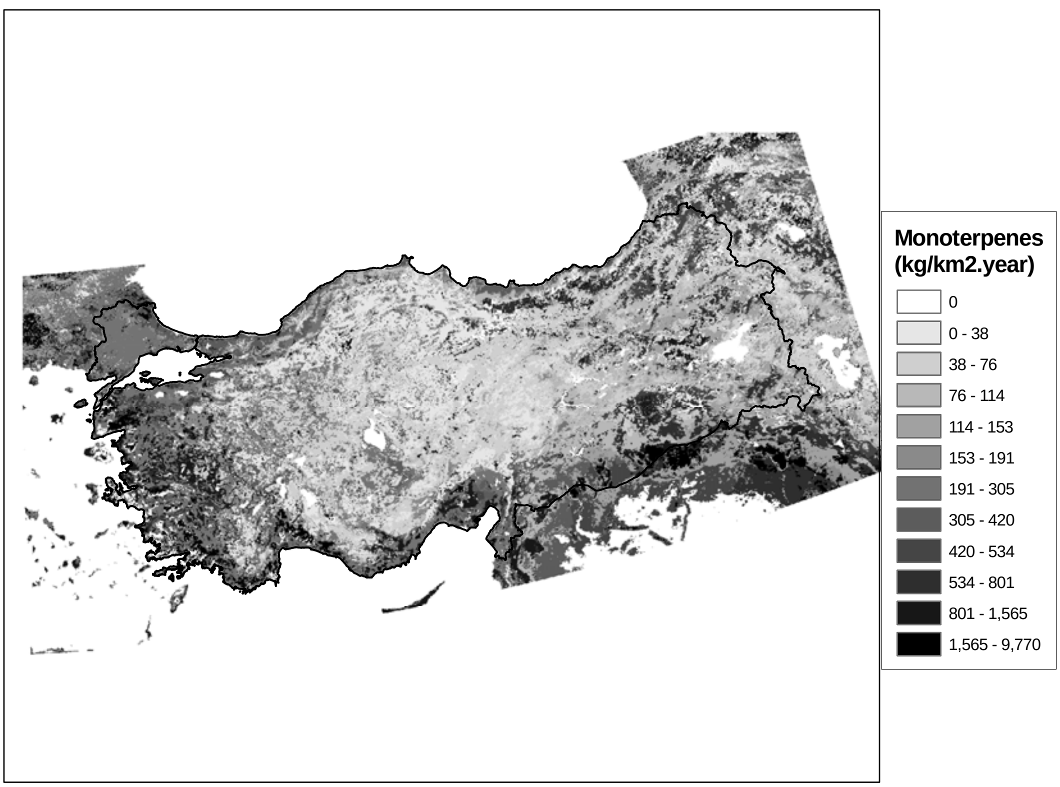

Figure 2. Yearly emissions of monoterpenes (kg/km^2.year)

total monoterpenes emissions of 224 kilotons per year estimated in this study seems to be in better agreement with the value of 175 kilotons per year given by CORINAIR, which is the emission value from forests. The isoprene emissions' estimation of CORINAIR from forests is only 213 kilotons per year, a value rather below the total emissions estimate of this study which is 1131 kilotons per year.

The advantage of the current study was the use of more specifically defined vegetation classes, allowing to assign more specific emission factors. The satellite-based data which gives this opportunity, however, comes with its disadvantage also as any other remote sensing dependent study, which may always have misinterpretations. The future study should revise these results by using real observations of vegetation classes, when a national land cover database is available.

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http-2) http://ipcc-ddc.cru.uea.ac.uk/asres/baseline/climate_download.html (The IPCC Data Distribution Centre Climate Baseline Download)

http-3) http://www.acd.ucar.edu/TUV/ (Tropospheric Ultraviolet & Visible Radiation Model)

http-4) http://www.ngdc.noaa.gov/seg/topo/globe.shtml (The Global Land One-km Base Elevation (GLOBE) Project)

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THE COMPUTER WITH PARALLEL ARCHITECTURE IN A PROBLEM OF WIND TRANSPORT OF POLLUTANTS AT EMERGENCE

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ABSTRACT

The problem of a wind transport of pollutants in an atmosphere is considered. The algorithm for the solution of finite-difference equations by a method of splitting on physical processes is briefly described in view of an opportunity of concurrent execution of a program on supercomputer of the SKIF family. The specialized databases together with digital maps on emissions of pollutants in an atmosphere, on parameters of land surface, characteristics of polluting substances are used. Results of the solution of two demonstration problems are given: wind transport of burning products at forest fire and transboundary transport on Byelorussian region.

Key Words: Air Quality, Wind Transport, Computing System with Parallel Architecture, Forest Fire, and Transboundary Transport.

1. INTRODUCTION

The objectives of work are:

- Development of concurrent algorithm for problem of wind transport of pollutants for supercomputer SKIF realized on classical clusters from computing units of wide application.

- Productivity estimation of a supercomputer on two real problems: transport of pollutants at forest fire and transboundary transport on territory of Belarus.

- Development of experimental system for the operative forecast of wind transport of pollutants with use of GIS-technologies.

Mathematical models of wind transport of pollutants at emergence are described by significant number of the equations and variables that demands the massive capacities of used computers. In work the experimental program-information complex realized on distributed system from two computers is considered: PC (the cartographic module, input of parameters, visualization of results on maps) and supercomputer SKIF (calculating modules of problems on modeling of forest fire and transport of pollutants).

Many authors discussed the problem of pollutant transport in an atmosphere; see, for example, (Marchuk, 1982, Zlatev, 2002). It is necessary to solve system of the equations with partial derivatives

$$\frac{\partial c_s}{\partial t}+\frac{\partial (uc_s)}{\partial x}+\frac{\partial (vc_s)}{\partial y}+\frac{\partial (\tilde{w}c_s)}{\partial z}=$$

$$=K_x\left(\frac{\partial^2 c_s}{\partial x^2}+\frac{\partial^2 c_s}{\partial y^2}\right)+\frac{\partial}{\partial z}\left(K_z\frac{\partial c_s}{\partial z}\right)+E_s-(k_{1s}+k_{2s})c_s\,, \qquad (1)$$

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0\,.$$

Here c_s - concentration of *s*-th pollutant, $s = 1, 2, \ldots, q$; $\tilde{w}=w-w_s^g$; *u, v, w* – components of a wind velocity; w_s^g - velocity of gravitational sedimentation of *s*-th pollutant in an atmosphere; K_x, K_z - eddy diffusivity coefficients of air; functions E_s describe spatial sources of emissions of pollutant in an atmosphere, and k_{1s} and k_{2s} - coefficients of dry and wet deposition.

It is necessary to attach to the equations still corresponding initial and boundary conditions, in particular for imitation of pollutants emissions from a land surface.

2. THE BRIEF DESCRIPTION OF ALGORITHM

For the solving of the equations (1) the method of their splitting on physical processes is used, (Marchuk, 1982, Marchuk, 1989):

- *Transport of pollutants on trajectories* $\frac{\partial c_s}{\partial t}+\frac{\partial (uc_s)}{\partial x}+\frac{\partial (vc_s)}{\partial y}+\frac{\partial (\tilde{w}c_s)}{\partial z}=0;$ (2)
- *Eddy diffusivity of pollutants* $\frac{\partial c_s}{\partial t}=K_x\left(\frac{\partial^2 c_s}{\partial x^2}+\frac{\partial^2 c_s}{\partial y^2}\right)+\frac{\partial}{\partial z}\left(K_z\frac{\partial c_s}{\partial z}\right);$ (3)
- *Interaction of pollutants sources* $\frac{\partial c_s}{\partial t}=E_s-(k_{1s}+k_{2s})c_s\,.$ (4)

For numerical integration of the equations (2) the two-cyclic implicit finite-difference scheme of the second order of the accuracy was used. For the sake of simplicity the index *s* at a variable *c* is omitted, *h* - step of a grid on *x* and *y*, $\{\Delta z_{n+1/2}\}$ - steps of a grid on *z*, $\tau=\frac{1}{2}(t_{j+1}-t_j)$, $u_{k+1/2}=\frac{1}{2}(u_{k+1}+u_k)$, $v_{m+1/2}=\frac{1}{2}(v_{m+1}+v_m)$, $\tilde{w}_{n+1/2}=\frac{1}{2}(\tilde{w}_{n+1}+\tilde{w}_n)$, $\Lambda_1^j\varphi=\frac{u^j_{k+1/2}\varphi_{k+1}-u^j_{k-1/2}\varphi_{k-1}}{2h}$, $\Lambda_2^j\varphi=\frac{v^j_{m+1/2}\varphi_{m+1}-v^j_{m-1/2}\varphi_{m-1}}{2h}$,

$\Lambda_3^j \varphi = \dfrac{\tilde{w}_{n+1/2}^j \varphi_{n+1} - \tilde{w}_{n-1/2}^j \varphi_{n-1}}{\Delta z_{n+1/2} + \Delta z_{n-1/2}}$, $E\varphi = \varphi$ - identity operator. Those indexes that differ from k, m, n on only ±1 are written out.

First cycle	*Second cycle*	
$\left(E + \frac{\tau}{2}\Lambda_1^j\right)c^{j+1/6} = \left(E - \frac{\tau}{2}\Lambda_1^j\right)c^j,$	$\left(E + \frac{\tau}{2}\Lambda_3^j\right)c^{j+4/6} = \left(E - \frac{\tau}{2}\Lambda_3^j\right)c^{j+3/6},$	
$\left(E + \frac{\tau}{2}\Lambda_2^j\right)c^{j+2/6} = \left(E - \frac{\tau}{2}\Lambda_2^j\right)c^{j+1/6},$	$\left(E + \frac{\tau}{2}\Lambda_2^j\right)c^{j+5/6} = \left(E - \frac{\tau}{2}\Lambda_2^j\right)c^{j+4/6},$	(5)
$\left(E + \frac{\tau}{2}\Lambda_3^j\right)c^{j+3/6} = \left(E - \frac{\tau}{2}\Lambda_3^j\right)c^{j+2/6},$	$\left(E + \frac{\tau}{2}\Lambda_1^j\right)c^{j+1} = \left(E - \frac{\tau}{2}\Lambda_1^j\right)c^{j+5/6}.$	

The equations of eddy diffusivity (3) are solved by traditional method of splitting on spatial variables and one-dimensional factorizations, and the system (4) can be treated in each point of integration domain as system of the ordinary differential equations, in which coefficients depend on spatial variables as parameters.

The considered problem demands knowledge of a wind field and eddy diffusivity coefficient $K_z(z)$ in a boundary layer of an atmosphere. For their calculation we used the Monin-Obukhov's *K*-ε theory of similarity which realization is described in (Yordanov et al., 2002).

The problem possesses by natural parallelism: calculation of concentration of each impurity can be conducted on the separate processor, reducing due to it time of calculations almost in *q* time, where *q* - number of impurity (several tens).

Primary parallelisation is done on pollutants when calculation of *q* impurities was distributed on *P* processors of a supercomputer. If the number of processors *P* is more than number of considered pollutants *q* calculation of impurity it is possible to divide on *P/q* concurrent streams. This internal parallelisation uses splitting the general three-dimensional problem on a series of one-dimensional problems. Calculation is done in four consecutive stages.
1-*st stage* – transport of substances on trajectories (the first cycle of finite-difference scheme):

- (*M*-1) · (*N*-1) simultaneous factorizations on *x*,
- then (*K*-1) · (*N*-1) simultaneous factorizations on *y*,
- then (*K*-1) · (*M*-1) simultaneous factorizations on *z*.

2-*nd stage* - transport of substances on trajectories (the second cycle of finite-difference scheme):

- again (*K*-1) · (*M*-1) factorizations on *z*,
- (*K*-1) · (*N*-1) factorizations on *y*,
- (*M*-1) · (*N*-1) factorizations on *x*.

3-*rd stage* – diffusion of pollutants:

- (M-1) · (N-1) simultaneous factorizations on x,
- then (K-1) · (N-*1)* simultaneous factorizations on y,
- then (K-1) · (M-1) simultaneous factorizations on z.

For example, factorizations on z are shown on Figure 1.

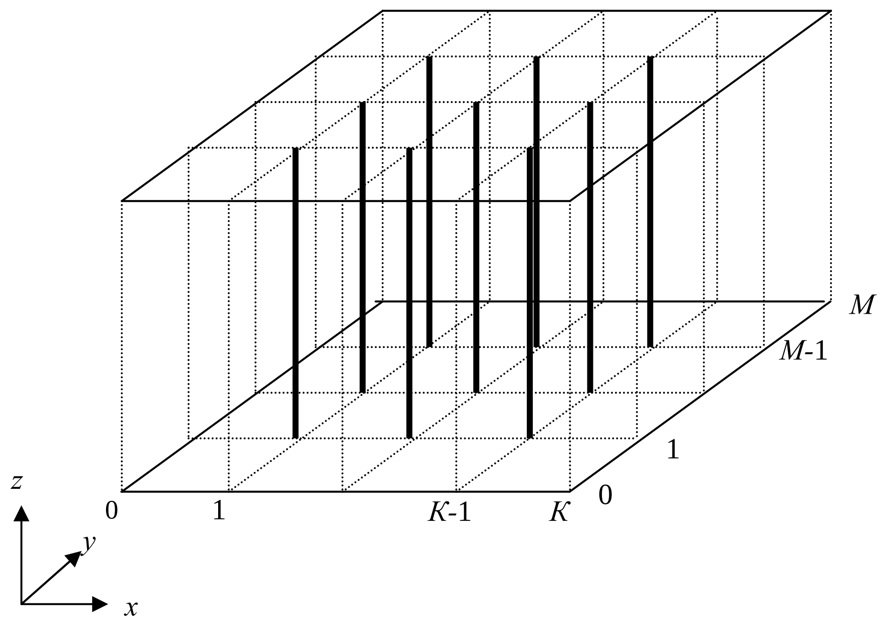

Figure 1. Organization of concurrent calculations in one direction

It is possible to note one more kind of parallelism inherent in the considered method of the program execution. Apparently from (5), all calculations break up to separate one-dimensional factorizations. For example, factorizations in a vertical direction can be carried out simultaneously in all points (K-1) (M-1) a land surface (Figure 1). If, for example, number of nodes K = 31 and M = 31, it is potentially possible to speed up calculations almost in 900 times. However, thereof that number of accessible processors are less than 900, the service of simultaneous factorizations are necessary to organize specially. It would be interesting to carry out experiment with an estimation of an arising overhead charge in this case.

3. AN EXPERIMENTAL COMPLEX

The problem was solved on the two-machine complex consisting of terminal personal computer Pentium 4 and supercomputer K-500 of the SKIF family (Ablamejko and Abramov, 2003). The PC was used for preparation of the initial data (meteorological, cartographic and on emissions of pollutants in an atmosphere), for management of calculations on a two-machine complex and processing of results (drawing of pollution maps of territory and their storage). The supercomputer was used as the powerful calculator for the numerical tasks prepared on the personal computer.

Family of supercomputers SKIF. The basic principles of family of supercomputers (open scaled architecture, a set of base computing modules and configurations, etc.) allow optimum way to create an adequate supercomputer configuration for each concrete applied problem. The key features of supercomputer SKIF are done in Table 1.

Table 1. The SKIF key features

Attribute	*Characteristic*
Scope	Scientific and engineering calculations
Type of a computer	Cluster
Peak productivity	2 534,4 Gflops
Operating system	Linux SUSE Linux Enterprise Server 8 + SP3
Amount of processors	576
Total volume of operative memory	1 152 Gb
Total volume of disk memory	23 040 Gb
Amount of nodes	288
Number of processors on node	2
The firm-manufacturer of the processor	AMD
Type of the processor	Opteron 248
Clock frequency of the processor	2 200 MHz
Operative memory on node	4 000 Mb
Disk memory on node	80 Gb
Communication network	InfiniBand
Transport network	Gigabit Ethernet
Service network	SKIF – ServNet

The SKIF K-1000 is the superior model of family. As the much as possible reached productivity on the test Linpack is 2 032 Gflops for a matrix by a size of 274 000 units. The supercomputer model SKIF K-1000 inscribed in the list of 500 most productive computers of a world in 2004 (http://www.top500.org).

4. THE CARTOGRAPHIC MODULE

All results of the calculations are processed and displayed by cartographic system (Kruchkov et al., 2003) on a digital map of district. The cartographic system uses as the initial data the digital maps of Belarus and the adjoining regions in scale 1:500000 and 1:100000.

The output of cartographic system and a complex as a whole comprises the map of analyzed territory with results of modeling as fields of concentration and isolines on a map and a legend of a thematic map (levels of concentration, a drawing scale, conventional signs, the text).

5. THE DEMONSTRATION TASKS

Two demonstration tasks were solved: the FIRE - the forecast for several days the spread of the pollutants arising at forest fire, and TRANS - calculation of pollution of Belarus territory by the substances which are starting with some ground sources within 30 days.

In the first task as sources of the pollutants acting in an atmosphere, the centers of forest fires on the territories of Belarus fixed in space pictures 11.09.2002 in Northeast of Byelorussia (Figure 2) were considered.

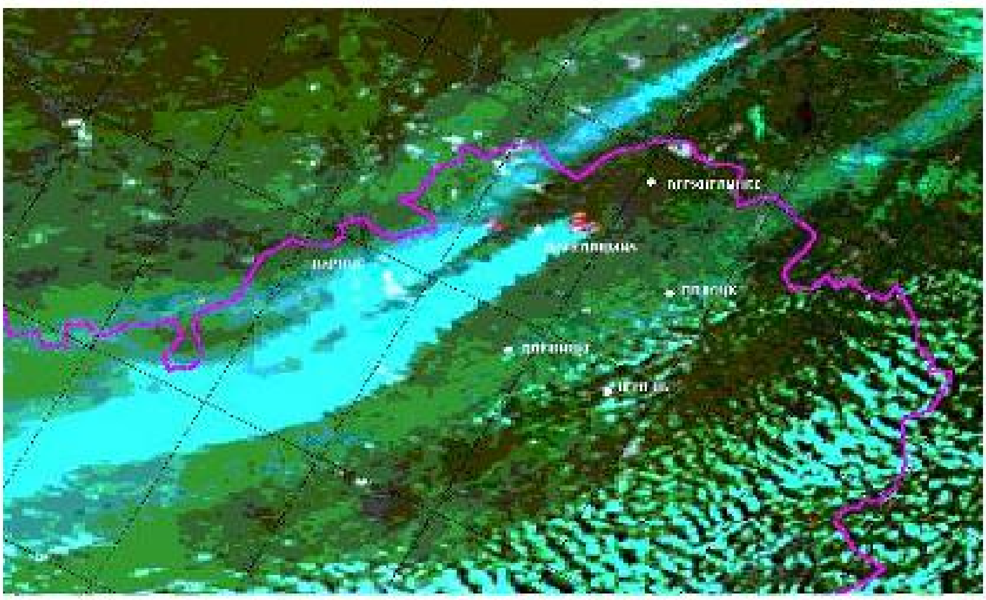

Figure 2. A snapshot of a forest fire in Northeast of Belarus

The coordinates of a fire were taken from a snapshot by means of a special measuring complex and were entered into a program through the personal computer. The quantity of burning products emitted for an elementary step on time was determined by a method, described in (Technique, 2002), and calculation of wind transport - by the way described in article. Concerning a land surface it was necessary to know its type (a forest, a field, a combustible land surface whether or not), absorption coefficient of pollutants dropping out on the ground, a specific output of burning products, a degree of land pollution by radionuclides and some other. The main part of these data was taken from a digital map of district, and also from special-purpose databases.

Meteorological data (approximately 5-6 parameters) were acquired from the meteorological station nearest to place of a forest fire.

The example of calculation of wind transport of smoke aerosol for 18 hours is resulted on Figure 3: on it the field of volumetric concentration of a smoke aerosol at height of 20 m is shown. To this time the smoke was disseminated to distance more than 30 km.

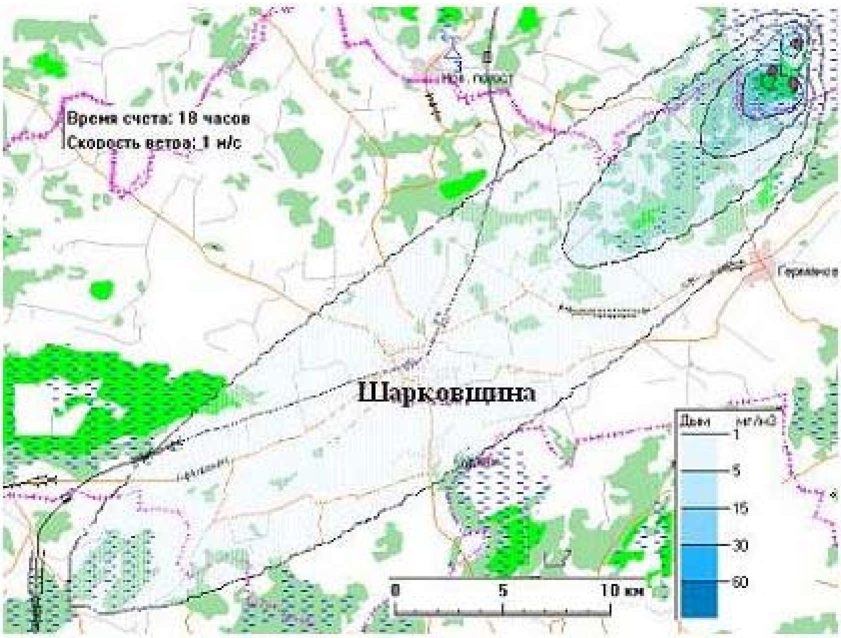

Figure 3. Transport of smoke at the forest fire

In the second task the field of wind velocity was set as follows. In eight base points of the meteorological observations placed on territory of Byelorussia the vertical profiles of velocity were calculated, starting from average climatic values for one month (Climate, 1996, Hand-book, 2003). Then the spatial fields of a wind in all grid points were defined on these profiles by the method of interpolation. As the permanent sources of emissions of pollutants in an atmosphere, 14 cities of Byelorussia have been considered, each of which throws out more than 2000 tons of impurities per year (Environment, 2001). On emissions it was necessary to know their sources, structure of emissions, a mode of functioning, sedimentation velocity of pollutants, etc. Nine impurities participated in calculations: solid particles (dust), CO, SO_2, NO_2, phenol, H_2CO, NH_3, CH, H_2S.

The transboundary transport of pollutants on territory of Byelorussia for 30 days within June, 2003 is shown on Figure 4. Volumetric concentration of all pollutants was calculated, and in Figure 4 isolines normalized concentration of CO is shown at height 500 m after 9 hours of modeling time. The normalized concentration is defined as $c_{norm} = \frac{c(x,y)}{\max(c)}$.

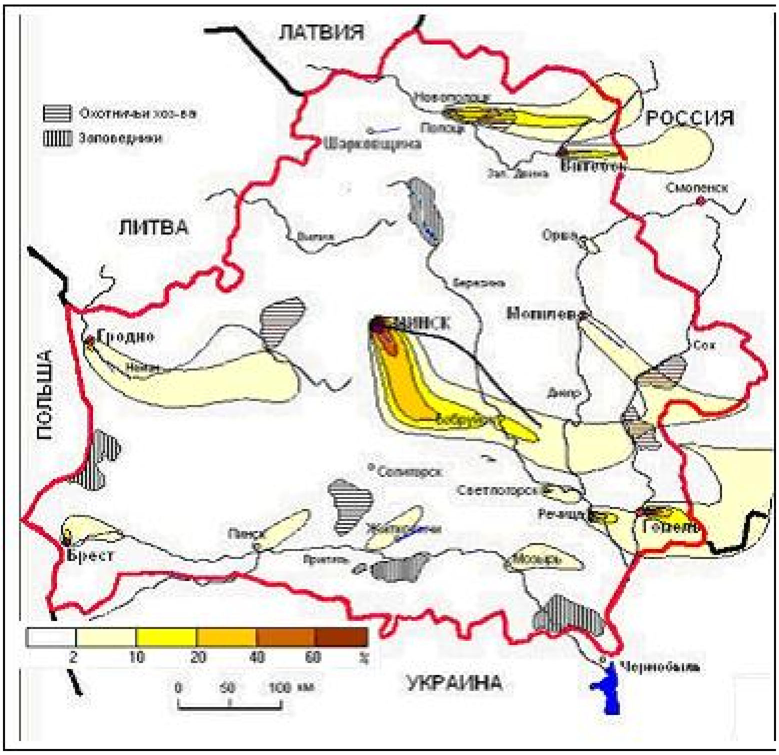

Figure 4. Transboundary transport of pollutants within a month. Horizontal and vertical shading marks the hunting facilities and reserves.

6. INTERCOMPARISON OF METHODS

For an estimation of accuracy of obtained results the special calculations on our program, on a technique adopted in USSR (Technique, 1987), and on a technique of Environmental Protection Agency of USA (U.S. Screening, 1988) were carried out.

The model, offered us, (we shall referred it "UIPI") is based on a numerical solution of the equations of mathematical physics well enough describing a continuous medium. At the same time, it is possible to expect an incongruity of our outcomes of simulation with outcomes OND and American in a neighbourhood of point sources of ejection owing to not enough their precise approximating at replacement of the differential equations of a continuous medium by the finite-difference equations for numerical calculations.

We examined an example from (Technique, 1987) about atmospheric emission SO_2 from single smoke-stack by height 35 m. Figure 5 shows the graphs of concentration $c(x)$ on axis of emission plume near land surface down wind, obtained by the models OND, SCREEN, and UIPI. The Figure displays, that the results of models UIPI and OND are well consisted with themselves: the location of the concentration peaks coincide, both maximal values coincide, and the graphs practically have the identical form.

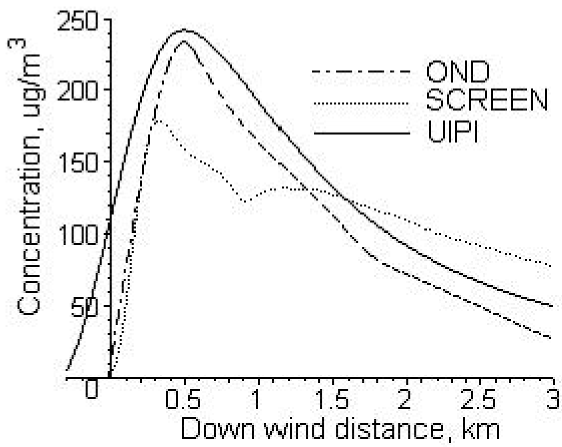

Figure 5. Intercomparison of methods

7. CONCLUSION

In Table 2 the execution time for demonstration tasks for supercomputer SKIF is resulted.

Table 2. Time of the task execution

Number of pollutants *N*	*N* pollutants on *N* processors	*N* pollutants on one processor	Acceleration
Forest fire for one day			
N = 4	10.2 min..	37 min.	3.6
Transboundary transport on 30 days			
N = 9	9.3 hours	56.1 hours	6.0

It is visible, what even the simplest parallelisation on pollutants results execution of demonstration tasks in significant acceleration of computing process. The developed program-information complex can be assumed as a basis system of the operative forecast of wind transport of pollutants at emergency situations.

The results, obtained on model UIPI, well enough coincide outcomes of a state technique OND, adopted at problem wind transport of pollutant in former USSR.

8. ACKNOWLEDGEMENT

The author is grateful A.N. Kruchkov for useful discussions at a statement of a problem, and A.D. Gavriluk, E.E. Sotikova, L.A. Ushatskaja, and R.N. Burak, taken part in implementation of the computer system.

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REGULATING MINERAL AND ENERGY INDUSTRIES: A CHALLENGE FOR DEVELOPING COUNTRIES

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ABSTRACT

This paper will attempt to bring out the challenges of regulating mining and energy industries in a developing country like Zambia whose economy has depended heavily on mining since 1930s. The mining industry in Zambia has gone through major changes the last decade and thereby bringing in a range of challenges for the regulators. The challenges are political, technical, economical and social in nature.

The paper will also discuss the energy industry challenges under similar themes.

The Environmental Council of Zambia is a regulatory body formed in 1992 under an act of parliament called Environmental Protection and Pollution Control Act of 1990. Under this Act the institution is charged with environmental management in the country on behalf of the government. The mandate includes coordinating all other institutions that take care of specific aspects of the Environment.

Keywords: Spontaneous combustion, Long term limit, Sulphur dioxide

1.0 INTRODUCTION

Environmental management in Zambia is governed by the provisions of the Environmental Protection and Pollution Control Act (EPPCA) of 1990, which forms the basis for Environmental Council of Zambia (ECZ) as a regulatory body. The EPPCA also recognizes the other pieces of legislation that take care of specific aspects of the environment such as the Forestry Act, which was passed much earlier than EPPCA.

Regulating the mineral and energy sector in a developing country like Zambia has a lot of challenges due to a wide range of reasons. Under mining, the paper will focus on copper smelting at Mufulira smelter in Mufulira, Zambia. However, the situation there is very similar to the one prevailing at Smelterco in Kitwe. The focus will be on Air pollution though Smelting activities have various other environmental impacts which are equally significant.

On the other hand, the main sources of energy in Zambia are hydroelectricity, thermal electricity, petroleum, wood fuel (firewood and charcoal) and coal. These contribute to air pollution in varying proportions. For instance about 69% of the total energy supply comes from wood fuel with most of it being for domestic purposes.

2.0 MINING

Zambia is a developing country whose economy has been heavily dependent on copper and cobalt mining since 1930s. Furthermore, the mines have been and are still the second largest employer after the Civil Service. In the past, the mines provided a lot of social services like water, electricity and medical services to their employees. The same applies for Maamba colliery which is the only coal mine in Zambia. In this paper, Maamba Colliers, being the major coal producer in Zambia and unique, will be used as a case study.

2.1 Air Pollution from Smelters

The particulate and SO_2 emissions from the point sources at Mufulira smelter are way above the Zambian limits as seen in table1and table 2 below:

Table 1 Particulates

Point Source	**Zambian Limits/ mg/Nm^3**	**Actual emissions mg/Nm^3**	**Pollution load Kg/hr**
Drier Cyclone	150	6314	175
Electric Precipitator outlet (1)	150	2709	317
Precipitator outlet (2)	150	4460	441

ECZ: 2001

Table 2 Sulphur Dioxide

Point Source	**Zambian Limits/ mg/Nm^3**	**Actual emissions/ mg/Nm^3**	**Pollution load Kg/hr**
Electric Precipitator outlet	1000	13146	709

ECZ: 2001

The technology currently used at Mufulira Smelter for dust cleaning is a combination of cyclones and electrostatic separators (ESP) with no provision for reducing SO_2 emissions into the environment. The cyclones and ESPs are meant to remove the particulates but even with them in operation, the emission levels are more than 20 times the statutory limits as shown in the table above. In addition, infrastructure is run down and has lost the effeiciency. The converter section has never had any air pollution abatement equipment. However, a sulphuric acid plant is currently under construction adjacent to the smelter in Mufulira. When completed, SO_2 will be captured and made into sulphuric acid thereby reducing the amount of SO_2 to be emitted into the atmosphere. This is a capital investment.

2.2 Air pollution from Coal mine

Coal represents 6 % of the total national energy consumption (Energy policy, 1994). This is extracted by open pit mining in Sinazongwe district situated about 350 km south of Lusaka. The removal of topsoil exposes the underlying carbonaceous material to oxygen in the air resulting in spontaneous combustion. The emissions emanating from this activity are unquantifiable as they occur.
The only means of controlling the emissions is by rehabilitating the mined areas so as to deprive the carbonaceous material of oxygen. This is a very expensive venture, as it requires heavy-duty machinery. The government currently owns the mine such that with the current economic situation, both the mining and rehabilitation has slowed down. .

Even with all this pollution from both the Smelter and coal mine, ECZ has not shut them down as stipulated in section 91D of the EPPCA (see the extract) as doing so would have consequences. Instead, ECZ adopted a long-term limit approach.

Extract from section 91D (1) of the EPPCA

An inspector can by way of an ex-perte application, apply to a court for an order in respect of any premises on which an offence is suspected of being committed under this act to:

a) To prohibit the carrying on of a process or operation causing pollution or is likely to cause or is likely to cause significant damage to human, plant, animal health or environment;
b) To prohibit the use of machinery, plant, equipment or appliance whose use is causing or is likely to cause significant damage to human, plant or animal health or environment

After having given the owner or occupier seven days notice of the intention to make the application to court.

3.0 CONSEQUENCES OF SHUTITNG DOWN THE SMELTERS AND COAL MINE

i) There can be a major drop in the revenue for the government
ii) An increase in unemployment
iii) Increase in poverty
iv) Increase in secondary effects such as crime and prostitution among the directly affected communities
v) Political instability

4.0 CHALLENGE IN REGULATING THE SMELTER AND COAL MINE:

4.1 Smelter

The major challenges in regulating this sector are as follows:

i) The rehabilitations of the smelter require huge investment in terms of new technology and equipment. With current economic situation in Zambia coupled with lowering of the copper prices at the world market, this remains a challenge as investing in the infrastructure. Therefore, the smelters cannot meet the limits in a short time. So the Environmental Council of Zambia adopted what is known as an intermediate limit approach, which requires that, the company measures it's emissions. The initial measurement will become its intermediate or temporary limits. Thereafter, the Company puts in place an environmental management plan (EMP) to control these emissions as it works towards achieving the statutory limits also referred to as long-term limits.

ii) According to the Air Pollution Control (licensing and Emissions Standards) regulations of 1996, the limit for SO_2 is $1000 mg/Nm^3$. This does not give a clear indication on the pollution loads and can easily be distorted by dilution. Therefore, there is need to incorporate the pollution loads in the legislation in the forth coming review under the Copperbelt Environment

iii) Fugitives cannot easily be quantified rendering it difficult for ECZ as a regulator to quantitatively assess the improvements

iv) A lot of polluting facilities do not have the equipment and the technical know-how in order for them to monitor their own air emissions. As a result, most companies are not submitting the retains in time for ECZ to do the trend analysis. In the absence of data, an accurate inventory of emissions can not be produced

v) So far, there is only one consulting firm in the country that suitable equipment to do the measurements iso-kinetically according to ECZ requirements. The rest are using other methods that do not easily attain iso kinetic conditions such as cegrit, thereby rendering their data unreliable

.

4.2 Coal Mine

At Maamba collieries, air emissions come from the spontaneous combustion of the carbonaceous material. The carbonaceous material occurs naturally in the ground just above the coal layer but below the overburden. To extract the coal, the overburden and the carbonaceous material is removed and placed aside. When this carbonaceous material is exposed to air, it burns resulting in the formation of sulphur dioxide, carbon monoxide, and Nitrogen oxides (NO_x)

The following are the major challenges associated with regulating this industry:

- The emissions occur more like fugitive emissions thereby making it difficult to quantify the pollutants
- Establishing the sustainable means to monitor regularly as ECZ does not have the equipment that would monitor continuously. Besides, the maintenance costs for such equipment are prohibitive

5.0 ENERGY

In Zambia, wood fuel is the largest source of energy followed by petroleum products, electricity and coal. Some of these are discussed below:

5.1 Fire Wood and Charcoal

Wood fuel (firewood and charcoal) is the principal source of energy in most households and also the nation's largest source. In the rural areas wood fuel is mainly consumed in form of firewood while in urban areas, both firewood and charcoal are used. The permits for cutting down tree are issued under the forestry act by department of forestry in the Ministry of Tourism, Environment and Natural Resources. The forestry act has been in place since the 1940s. The table below shows a break down of consumptions pattern as at 1990:

Table 3 Energy Supply and consumption by energy source in 1990

Energy Source	Primary Supply		Final Consumption	
	Quantity	Percent	Quantity	Percent
Fuel wood	2500	43	2500	58
Charcoal	1900	33	480	11
Electricity	580	10	520	12
Coal	260	4	260	6
Petroleum	570	10	570	13
Total	5800	100	4400	100

Source: Department of Energy 1990

Table 4 A break of consumption by sector.

Year	Sector	Firewood	Charcoal	Wood for charcoal production	Total wood consumption
1990	Household (Rural)	5331.14	78.66	393.3	5724.44
	Households (Urban)	534.45	514.24	2571.2	3105.65
	Agriculture	222.86	0	0	222.86
	Industry	668.01	27.16	135.80	803.81
	Mining	0.25	1.49	7.45	7.70
	Total	6756.71	621.55	3107.75	9864.46

Source: Department of Energy, Unpublished

5.2 Petroleum

As at 1999, petroleum accounted for 8% of the total national energy supply in the country. However, this figure could be reflective of the supply problems experienced after the destruction of the Indeni refinery by fire in May 1999. As at January 9 companies had obtained licenses to import refined petroleum products following the issuing of the statutory instrument no. 119 of 1999 by the Government of the Republic of Zambia (GRZ) opening the way for marketing companies to import Crude oil. This is imported from the Middle East mainly and refined at Indeni Refinery in Ndola, Zambia. The refinery is not designed to process pure crude oil and so the quality of the feed has to be monitored closely. The sources of crude oil may differ from time to time and this in turn influences the impact on the environment. The Energy Regulation Board (ERB) monitors the quality of this crude oil.

The major challenges for ECZ in this sector are:

i) Quantification of emissions from mobile sources such as cars. The emissions from the refinery are monitored regularly.
ii) Development of regulations for mobile sources; these are expected to be developed by end of 2007 under the Copperbelt Environment Project
iii) Limited capacity to enforce the regulations for mobile sources especially at national level due to insufficient resources

6.0 ENVIRONMENTAL CONCERNS ASSOCIATED WITH WOOD FUELS

The following are the environmental concerns with wood fuels:

6.1 Deforestation

The trees (in forests or woodlands) are being cut down at a rate greater than their replacement. Therefore the sustainability of this source is threatened. Besides would cause major upsets in the climatic patterns.

The table below shows gaseous emissions from charcoal and wood fuel as at 1990:

Table 5 Gaseous emissions in Zambia, 1990

Emission	Quantities, 000 tonnes		
	Emissions from Charcoal burning (Central Zambia) 000 tonnes	Emissions from other Sources 000 tonnes	National total 000 tonnes
Carbon dioxide CO_2	535	32,965	33500
Sulphur dioxide SO_2	0.048	199.952	200
NO_x	2.9	3.6	6.5
Volatile Organic Compounds	54	-	-

Source: Hibajene et al, 1993

Zambia has no capacity at the moment to effectively regulate these emissions.

6.2 People's health

The table below shows average concentrations of respirable suspended particles (RSP) and Carbon monoxide (CO) during cooking with different fuels.

Table 6 Average Concentrations of RSP and CO

Fuel Users	Emissions concentrations	
	Particulates (micro grammes RSPM)	Carbon monoxide (ppm)
Fire wood users	890	8.5
Charcoal users	380	13.0
Electricity users	240	2.1

Ellegard & Egneus, 1992, in Hibajene et al, 1993

As seen from the table above, the levels of CO are highest for charcoal users. This explains the prevalence of CO poisoning in during the cold season when people keep braziers in doors to keep themselves warm while windows are closed.

With all the environmental impacts associated with charcoal and firewood, stopping the use of these fuels is impossible if an alternative is not provided.

Even with all these known setbacks, regulating air pollution as charcoal and firewood remains a challenge.

6.3 BUSH FIRES

These are common especially in rural and peri urban areas and contribute significantly to the air pollution in Zambia. In most cases, the people that start the fire are not known.

The challenges are as follows:

i) Accurate quantification of these emissions
ii) Limited capacity for ECZ to enforce the existing regulations on open air burning

7. RECOMMENDATIONS

The following are the recommendations if the regulating of both mining and energy industries is to be improved in Zambia:

i) There will be need to harmonise legislation.
ii) The Air Pollution Control (Licensing and Emissions Standards) will need to be reviewed to incorporate pollution loads as these will be easier to monitor
iii) There is need to develop regulations for mobile sources.
iv) ECZ should further strengthen it's ties with other already established regulatory bodies to enhance the operations especially for combating deforestation
v) Government should support the development of cheaper alternatives to charcoal or firewood
vi) The government should consider giving incentives for using more environmentally friendly fuels

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CONTRIBUTION OF NATURAL AND ANTHROPOGENIC SOURCES TO FINE AND COARSE PARTICLE FRACTIONS IN THE EAST MEDITERRANEAN

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ABSTRACT

This study deals with the characterization of fine (<2.5μm) and coarse (2.5 to 10 μm) particles along the east coast of the Mediterranean Sea. The following tools were applied:

(1) Analyses of continuous PM10 monitors to provide general trends.
(2) Sampling of fine and coarse particles with dichotomous samplers in several sites in Israel. Filters were analyzed for gravimetric and elemental analysis by XRF.
(3) Scanning electron microscopy (SEM) of selected samples.
(4) Back trajectories of air masses during sampling events.

Continuous data showed that PM-10 levels were highest in fall and spring due to intrusion of dust storms in the region. In the summer sulfates and elemental carbon dominated the fine fraction (<2.5μm). Minerals were found at fairly low concentrations. Sulfates were probably transported from Eastern Europe. Sea salt (Na, Cl) was found at both size fractions. Electron microscopy showed association of chlorides with mineral particles. The co-occurrence of high concentrations of sea salt and mineral particles has to do with the stormy meteorological conditions associated with Saharan Dust transported along the North African continent. V and Ni are highly correlated, indicating the heavy use of crude oil in Europe and East Mediterranean.

Those findings may indicate the possible coating of minerals with soluble sulfates and chlorides, in line with earlier results that minerals are efficient in removing these constituents from either anthropogenic or natural sources. The coating of particles may have a significant impact on the radiative properties of minerals.

Key Words: PM10, Fine and coarse particles, mixed particles, dichotomous sampler, XRF, Electron microscopy, minerals, sulfates, sea salt, east Mediterranean

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ESTIMATION OF CO_2 CONCENTRATION OVER MEDITERRANEAN AREA BY USING KRIGING TECHNIQUE

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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.

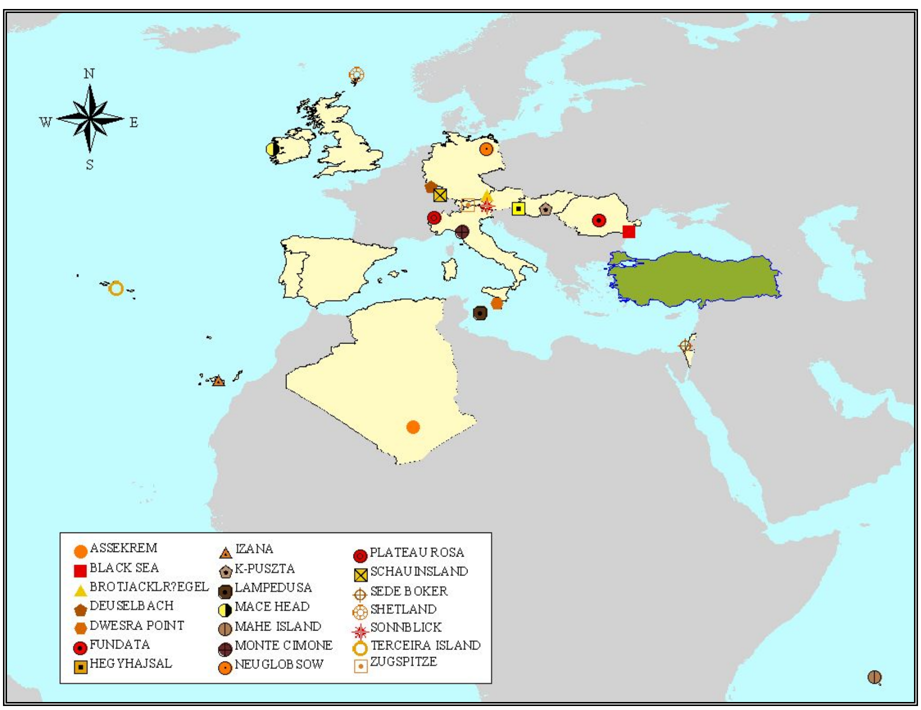

Figure 1. CO_2 measurement stations around Mediterranean area and in Europe

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.

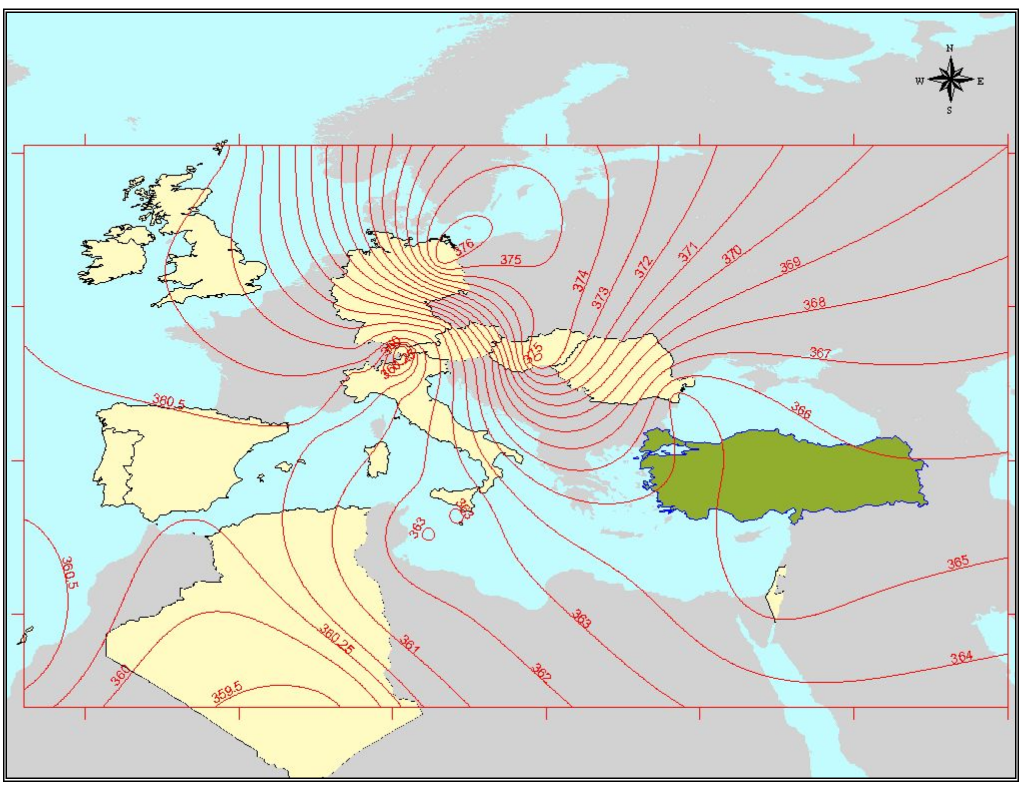

Figure 2. Contours map of CO_2 concentration in 1995

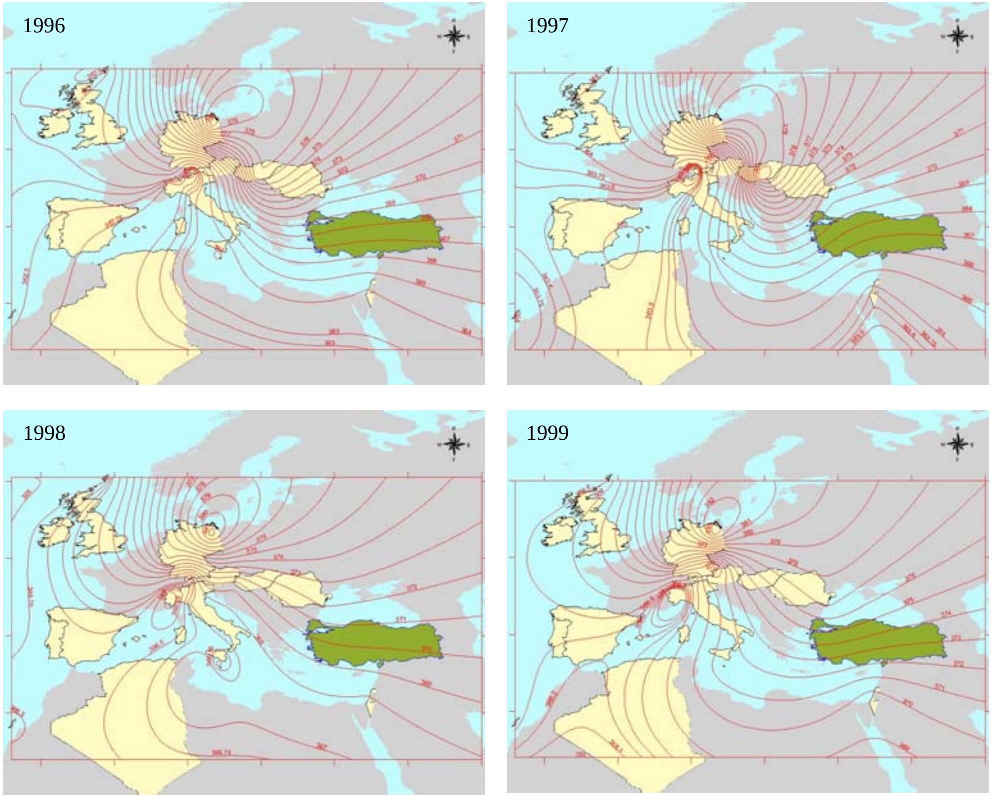

Figure 3. Contours map of CO_2 concentration for the period of 1996-1999

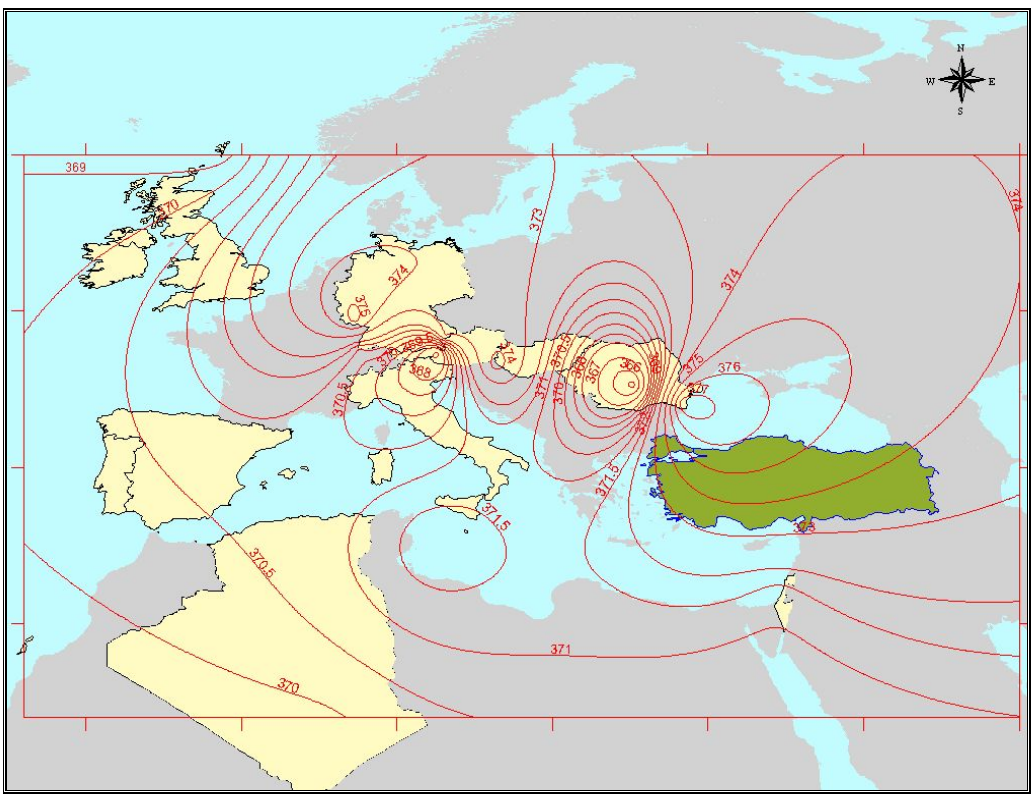

Figure 4. Contours map of CO_2 concentration in 2000

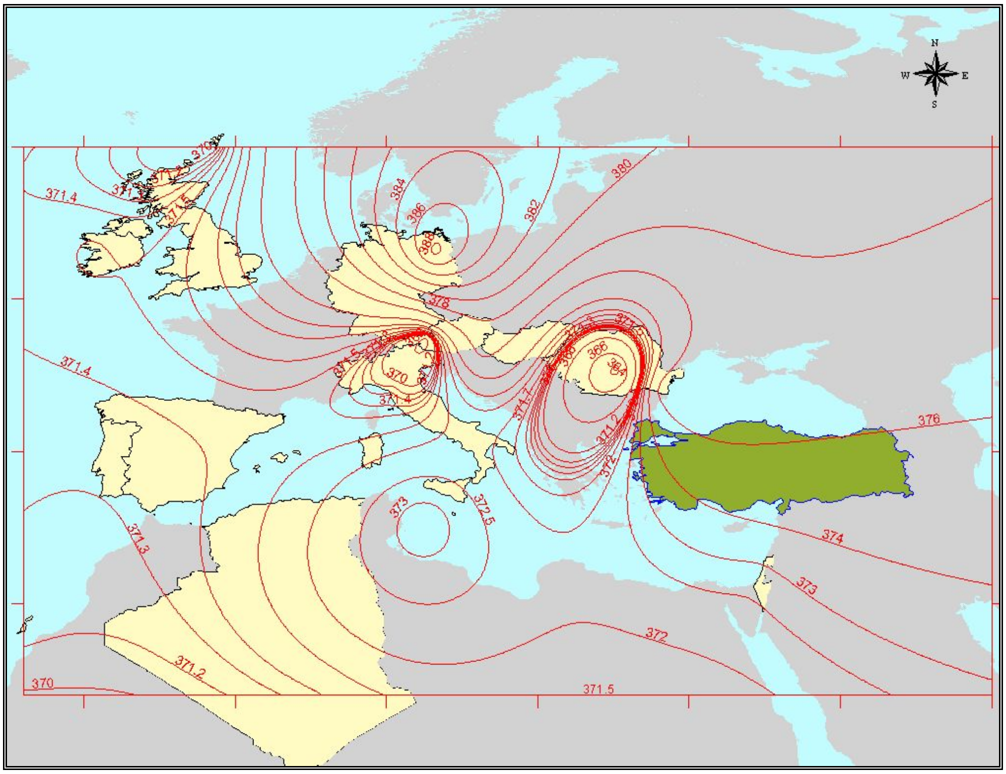

Figure 5. Contours map of CO_2 concentration in 2001

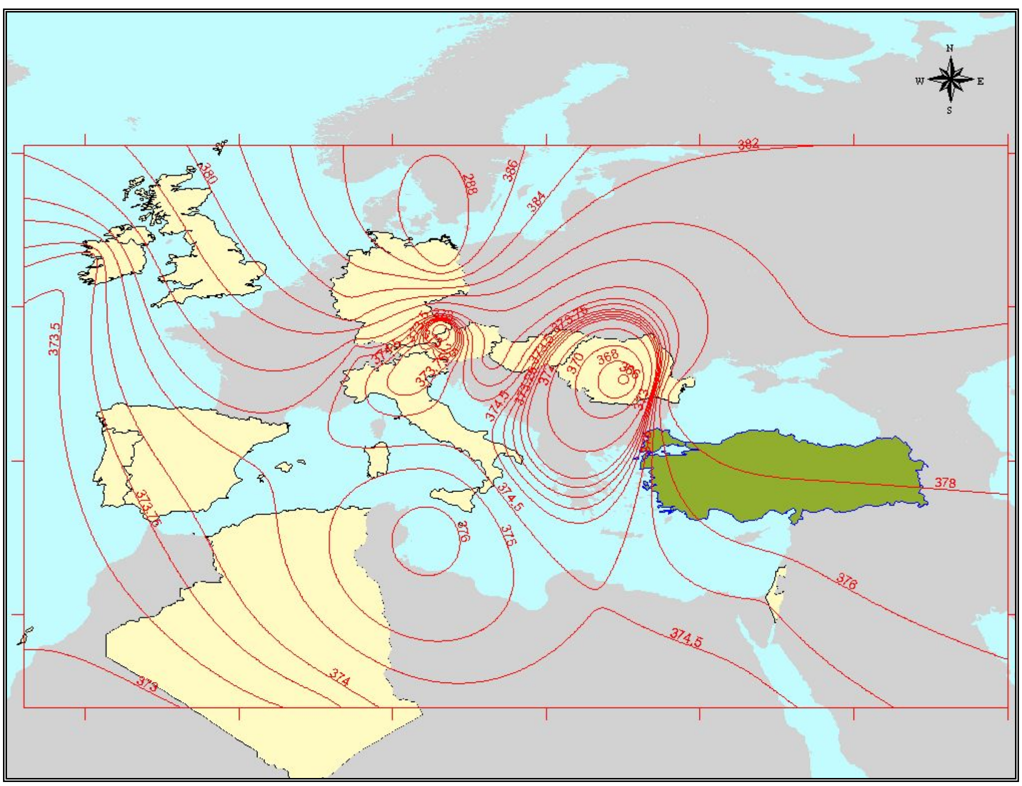

Figure 6. Contours map of CO_2 concentration in 2002

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.

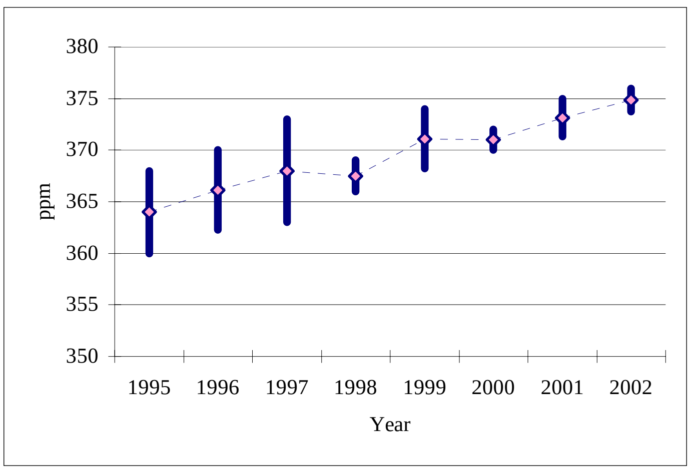

Figure 7. Maximum, minimum and average CO_2 concentrations over the Mediterranean area

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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THE IMPORTANCE OF BLOCKING EVENTS 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 and so on. Apart from these, there are a number of meteorological elements or atmospheric events with great significance in the development of air pollution. One of these is "Blocking Events" which occurs when baroclinic westerly flows do not go forward to all latitudes. During the blocking events, zonal movements of short-waves are locked effectively and as a result of the movement to upper level systems the basic mechanism of vorticity advection can be neglected. Blocking patterns oblige many people to live under bad weather or poor environmental conditions.

In this study frequencies and durations of blocking events that cause air pollution in Turkey are investigated using by surface and 500 mb maps obtained from Germany Meteorological Bulletins. The frequencies and the durations of blocking events are determined for a period 5 or over 5 days. Therefore we tried to find a connection between air pollutant (SO_2) and blocking event in some selected cities in Turkey with a population over 200000.

Key Words: Frequency, Blocking event, Air Pollutant.

INTRODUCTION

The definition of a blocking event is rather subjective, and various indices have been derived to quantify the blocking intensity. Blocking highs were first studied by D.F. Rex in 1950 and later by Austin in 1980. To be called blocking, the high must split the mid-latitude jet stream meridionally into winds at least 45 degrees of latitude apart, and persist for 5 days or more. In the case of blocking, the same pattern repeats for several days to even weeks. This can lead to flooding, drought, above normal temperatures, below normal temperatures, air pollution and other weather extremes. It is synoptically important to recognize a blocking pattern in its initial development. Atmospheric blocking is best seen on upper air analysis and forecast charts. Blocking over large regions is most common with high-pressure since high pressure covers a large spatial area and tends to move slower than low pressure. Blocking has been studied extensively over the last several decades, largely for the Northern Hemisphere (Rex 1950; Lejenas and Økland 1983; Dole 1986; Colucci and Alberta 1996; Sinclair 1996; Lupo 1997; Lupo and Bosart 1999; Lupo and Smith 1995a,b).

Blocking situations occur most frequently in April and least frequently in August and September in the Northern Hemisphere. There are three types of blocking patterns in general. They are (Bluestein, 1993):

1. High-over-low block;
2. Omega block;
3. Stationary, high-amplitude ridge.

The "high-over-low" blocking type occurs frequently over the west of Europe and North America (Fig. 1). Because of the geographical structure for this type of block, horizontal variations in surface heating and/or topography probably play an important role in occurring the block. In the omega block the flow pattern has the shape of the capital Greek letter Ω (Fig. 2). It is zonally oriented in between two lows. The third type of block the stationary, high-amplitude ridge (Fig. 3) is associated with hot, dry, dull weather.

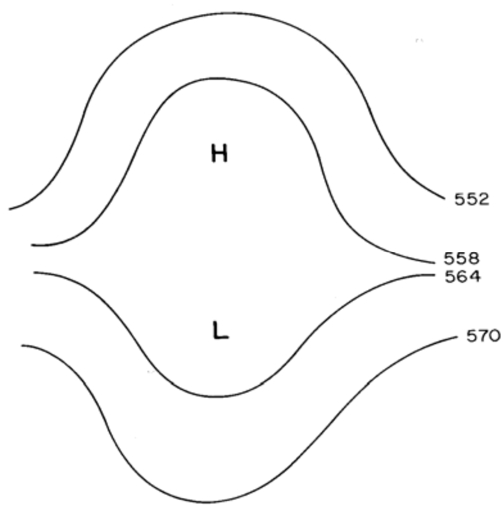


Fig. 1: Idealized illustration of a high-over-low block in the Northern Hemisphere. 500-mb height contours in dam (solid lines). North is toward the top of the figure (Bluestein, 1993).

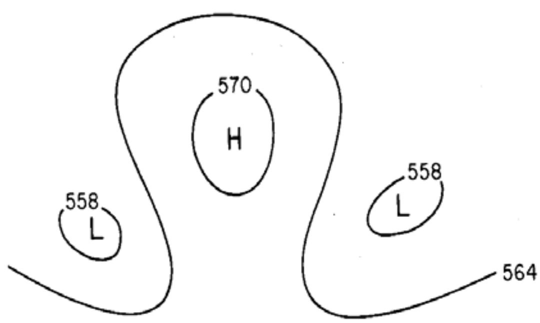


Fig. 2: Idealized illustration of an omega block in the Northern Hemisphere. 500-mb height contours in dam (solid lines). North is toward the top of the figure (Bluestein, 1993).

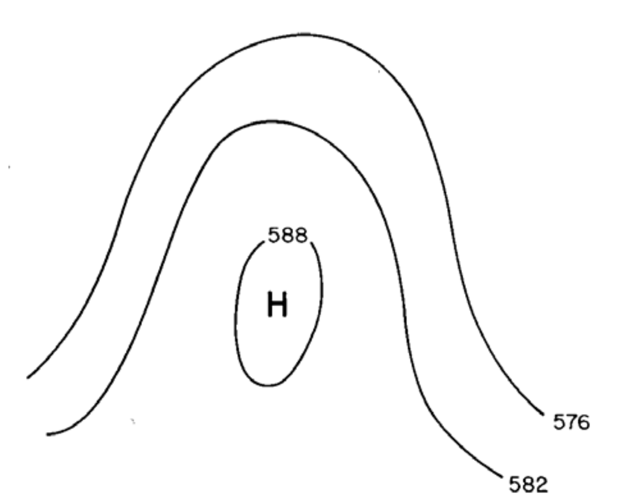


Fig. 3: Idealized illustration of a stationary, high amplitude ridge in the Northern Hemisphere. 500-mb height contours in dam (solid lines). North is toward the top of the figure (Bluestein, 1993).

DATA AND METHODOLOGY

In this study synoptic maps are used to determine blocking numbers and their durations observed in Turkey subjectively. Blocking durations are defined according to the 5 or more days by analysis of daily maps of 500 mb geopotential and surface maps at 00 GMT for the period of 1995-2004 (http://wetterzentrale.de, 2005). SO_2 data are used to compare air pollution with blocking events. Monthly mean values of SO_2 are obtained from Turkish Bulletin of Environmental Statistics (2005) for five selected stations (İstanbul, Ankara, Erzincan, Bursa and İzmir) for all season. The map of Turkey and selected stations are shown in Fig. 4.

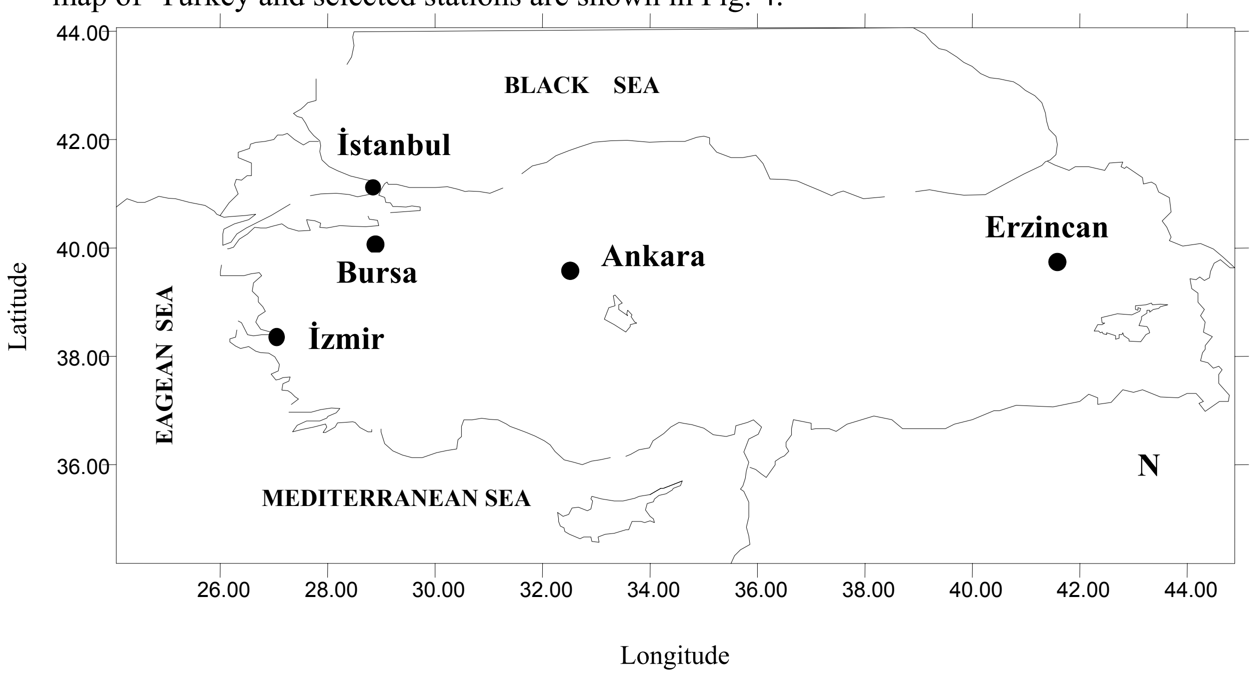
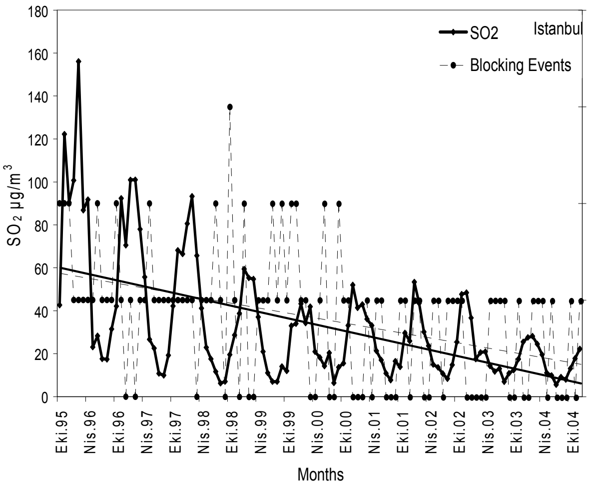


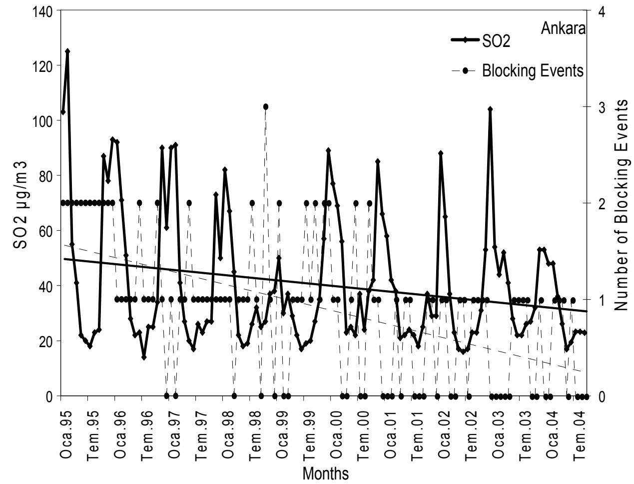
Fig. 4: Map of Turkey and five selected stations.

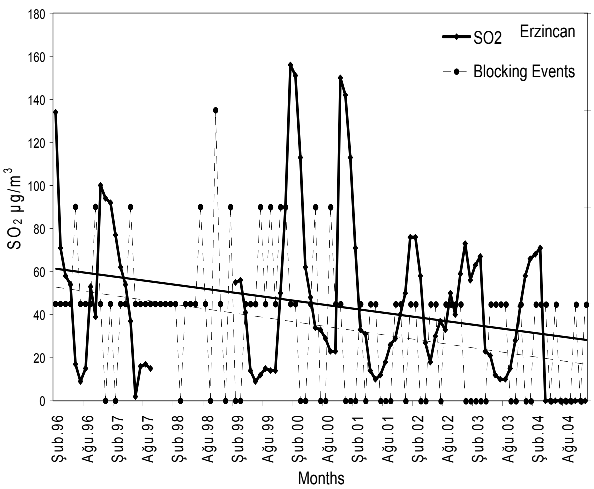
Turkey is located at the eastern corner of Southern Europe (36 °N and 42 °N latitudes, 26 °E and 45 °E longitudes) and its surface area is 77.106 km^2 with about 70 million population. Approximately 50 % of the population lives in the sea cost areas.

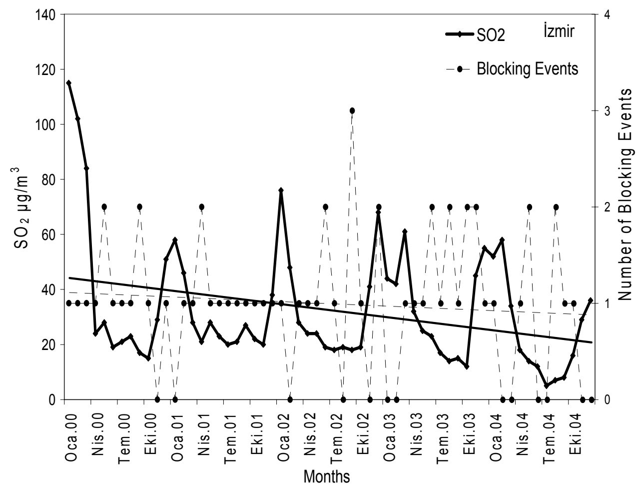
ANALYSES AND RESULTS

In this study it is tried to find a relationship between air pollution and blocking events in some selected cities in Turkey. For this, the variations of the number of blocking events and SO_2 can be seen from Fig. 5. It is thought that the blocking durations are important as well as their numbers in the air pollution studies. Therefore both of them are associated with environmental problems. Fig. 6 shows also the variations of European blocking durations (5 or over 5 days) and SO_2 in İstanbul, İzmir, Bursa, Erzincan and Ankara. When we compare all of the figures (see Fig. 5 and Fig. 6) it is found that there are decreasing trends in the number of blocking events and their durations in general for all cities (except for Bursa) for the period of 1995-2004. Recently, because of intense industry and its topography air pollution has been increasing in Bursa. On the other hand it is possible to say that decreasing trends are approximately valid for SO_2 variations. This means that there is a strict relationship between air pollution and blocking events in Turkey. To verify and generalize this result it must be increased the data period.









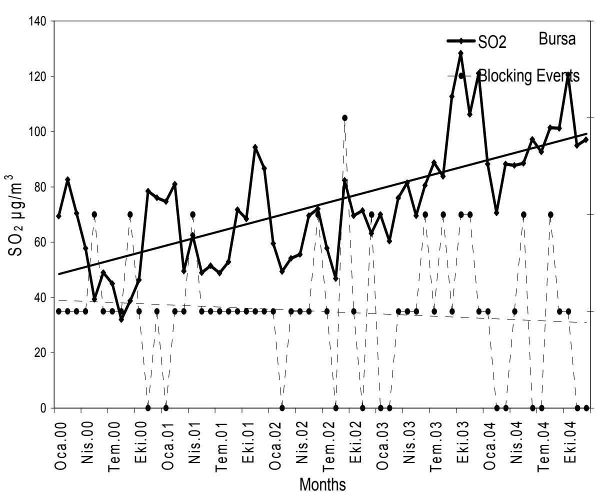


Fig. 5: Monthly variations of number of blocking events and SO_2 in İstanbul, Ankara, Erzincan, İzmir and Bursa for the period of 1995-2004.

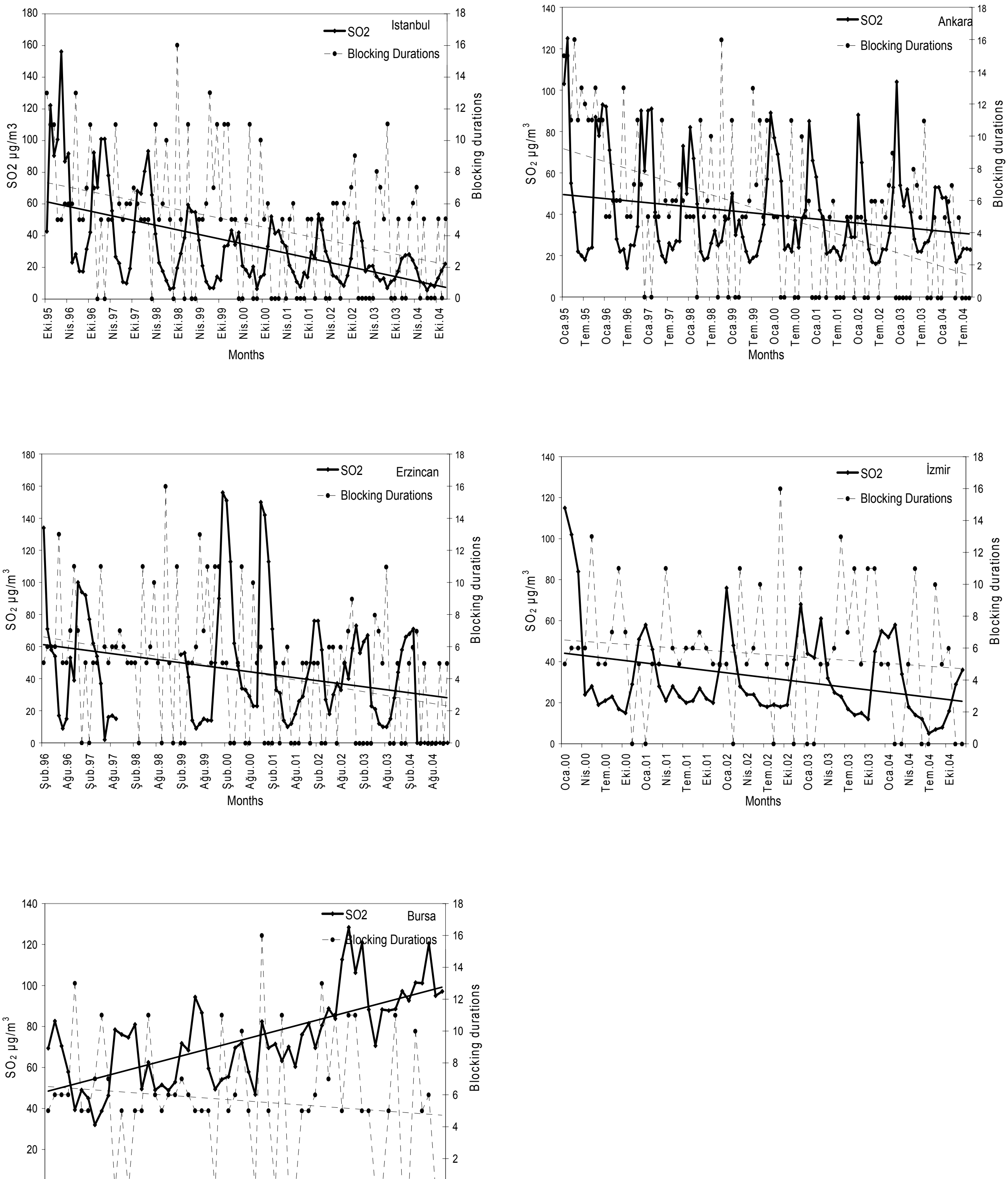


Fig. 6: Monthly variations of blocking durations and SO_2 in İstanbul, Ankara, Erzincan, İzmir and Bursa for the period of 1995-2004.

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AIR POLLUTION PREVENTION STUDIES FOR THE PETROLEUM INDUSTRY IN LIBYA

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ABSTRACT

The paper is designed to present a pollution prevention approach based upon a consistent emission accounting, estimating and reporting system being developed at Petroleum Research Center. The goal is to device problem free and prevention oriented administration of petroleum industry vital to build its image as a truly environmental friendly.

It is based on scenario building based upon prediction of air quality in real time. It examines alternative effective management measures to reduce pollution levels in hot spot areas. It is being achieved through integrating air quality models with real time information from pollutant concentration on hot spots and meteorological conditions.

Finally, some case studies are presented to highlights the need for future cooperative efforts among petroleum industry companies, regulators and other industries to address this important issue vital to meet international obligation envisaged in Climate Change Convention.

1. INTRODUCTION

Linkages between air pollution and economic issues lie at the heart of sustainable development policy making and planning. Rapid urbanization and increased industrialization specially in oil & gas related industries in Libya over the past three decades have adversely impacted air quality in the country in general and coastal area in particular. The resulting effects have posed threats to human health and losses in economic productivity in terms of manpower and industrial output. While a strong correlation exists between increased air ollution and its social and economic effects, little or nothing has been attempted to quantify the cost of these effects in the country. The objective of this paper is high light a PRC led initiative aimed at not only to prevent, prepare and respond to air pollution threat to safe guard Libyan society but also to quantify the cost of these effects. The purpose is provide Libyan public and private decision makers an account of the magnitude of problem and to propose recommendations so as to facilitate a dialouge and action in support of air quality.

Like in other countries in Libya too, the main sources of air pollution are industries like stationary plants mainly for oil & gas or petrochemical industry and mobile source like local traffic. Systems, instruments and tools for air quality management are not well known. Spatial and urban planners do not use emission cadestress and atmospheric distribution models to the extent necessary. Methodologies developed for reporting to international organizations take in to account local specifications of fuel quality and data collection capabilities. Of late Corinair and IPCC methodologies are being introduced. PRC is committed to use DEM (Data Exchange Module) software adopted by European Environmental Protection Agency and COINAIR methodology and softwares like COLLECTOR, COPERT, and IMPORTER AND REPORTER.

2. AN APPRAISAL OF AIR POLLUTION IN LIBYA

An appraisal shows that main sources of air pollution are combustion of fuels used in Libyan oil & gas industrial process in petroleum industry, traffic and other sources like incineration and self-ignition of waste. Excessive air pollution from combustion processes is due to irrational use of energy in total life cycle of products. Other causes are poor maintenance of power and industrial plants.

Traffic in urban areas of large towns like Tripoli, Benghazi, Misurata and Sabrata is a significant source of air pollution. In adequate regulations, low speeds, frequent stop and go endanger the health of the population as it causes high emission of pollutants.

Almost half of all Libyan are living in municipalities where the air quality places them at risk for decreased lung function, respiratory infection, lung inflammation and aggravation of respiratory illness. Over 20 percent of the Libyan population lives in areas with unhealthful short-term levels of particle pollution.

Some Libyan live in areas where they are exposed to unhealthful short-term levels of particle pollution. Short-term, or acute, exposure to particle pollution has been shown to increase heart attacks, strokes and emergency-room visits for asthma and cardiovascular disease, and most importantly, increase the risk of death.

Some Libyan suffer from chronic exposure to particle pollution. Even when levels are fairly low, over time exposure to particles can increase risk of hospitalization for asthma, damage to the lungs and significantly increase the risk of premature death.

About nearly 15 percent--live in municipalities with unhealthful levels of all three: ozone and short-term and year round particle pollution. With the risks from airborne pollution so great, PRC seeks to inform people who may be in danger. Many groups are a greater risk because of their age or the presence of asthma or other chronic lung disease, a cardiovascular disease or diabetes. Some people with chronic bronchitis live with unhealthful year-round levels of particle pollution.

Some people with cardiovascular diseases live in areas with unhealthful levels of short-term particle pollution; live with unhealthful levels of year-round particle pollution. Cardiovascular diseases include heart disease, heart attacks and strokes.

People live with diabetes in areas with unhealthful levels of short-term particle pollution; with unhealthful levels of year-round particle pollution. Research indicates that diabetics face risks from particle pollution's threat to their cardiovascular systems.

Old, power plants are among the biggest industrial contributors to unhealthful air, especially particle pollution in Libya. The toll of death, disease and environmental destruction caused by old power plant pollution continues to mount.

3. PRC LED ZERO AIR POULLTION RESEARCH INITIATIVE (ZAPRI) IN LIBYA

PRC right from its inception in 1979 promotes supports and undertakes long term multi-disciplinary research to assist policy makers especially of petroleum industry in the country. It tackles the most pressing issues like air pollution that require a vision and a concerted effort. It engages the best minds to secure the continuos flow of oil & gas in the country without affecting the critical balance of the ecosystem. It is in this framework that PRC is proposing the establishment of the Zero Air Pollution Research Initiative (ZAPRI). PRC has identified the methodology that involves following four steps in line with United Nations University proposal.

1. Total Throughput Models (to secure a production system with a minimum in put and maximum out put)
2. Output-Input Models (that helps identify industries that could effectively use out put waste)
3. Industrial Clusters Modeling (ideal and optimal level of clustering of industries that use waste as raw material)
4. Breakthrough Technologies Identification. (effective and economical integration of sectors concerned)

The goal is to help design an industrial policy for oil & gas industry in the country. This is based upon a pollution prevention approach based upon a consistent emission accounting, estimating and reporting system being developed at Petroleum Research Center. The PRC initiative aims at meeting 'users'needs in the field of air quality monitoring, forecasting and warning by the introduction of innovative telematics and integrated multimedia systems.

The final objective is to develop new approaches to the use of air quality and meteorological data for the improvement of life in urban areas. This will involve the integration of existing technologies to enable responses to be made at the most appropriate time and at the most appropriate level. Particular emphasis is placed on forecasting over 24 and 48 hours and providing information to general public. The system will be based on sophisticated computer models such as those, which calculate ozone levels from road traffic emissions. It would combine these models with up to date measurements of current metorological conditions and pollution by linking directly in to local databases and pollution measurement stations. It would also link coastal water and air to ensure that as complete a picture as possible can be predicted of environmental conditions. In addition PRC led initiative would help predict poor air quality in real time and then to initiate effective pollution levels in particular problem areas. This would be achieved by integrating air quality models with real time information on traffic flows, pollutent concentrations and meteorological conditions and thereby identifying pollution hot spots. This could help designing traffic demand management strategies using Variable Message Signs (VMS) and traffic messages broadcast on FM radio digitally to reduce pollution levels at hot spots.

Thus PRC led ZAPRI initiative is able to assess the impacts of air pollution on society and estimate the costs of air pollution. We are facing inherent difficulty in quantifying indicators such people's health and value of life. The problem is further complicated by lackof reliable air quality monitoring equipment and system in the country. We have attempted to analyse limited available air quality data and adhoc health records. Our efforts have resulted in an interesting dialogue between society and policy makers in order to identify an integrated solution for improving air quality in the country.

4. SOME SALIENT RESULTS FROM A CASE STUDY IN LIBYA

PRC had recently undertaken a lead monitoring study with a view to reduce the lead content in atmosphere in Libya. It involved monitoring of lead levels in both small and main roads and dusts and vegetation of near gas stations and play grounds. Samples of dusts from various locations in Tripoli area were collected by using random sampling technique .The sample sizes were as follows: 34 samples were near gas stations; 23 samples from near small streets; 27 samples from near play grounds ; and 123 samples from near main streets .

The lead contents in dust samples was determined by using atomic absorption specto photometric technique and the samples were prepared according to standard procedure described elsewhere. All samples were dried by heating at 105 c for 24 hours .An accurately weighed 1, 0000 g of sample was taken into 250 ml. Beaker then 10ml.of 65%concentrated nitricacid was added and the mixture was evaporated to dryness by heating on a hot plate. Then it was left for cooling. After cooling this procedure was repeated using a second aliquot of nitric acid. Again left for cooling and 10ml. of conc. hydrochloric acid was added and the mixture was again evaporated to dryness . Cooled and the residue was warmed to 40-50 C with 75 ml of 1M hydrochloric acid and the mixture was filtered through whatman 50 filter paper into 100 ml. volumetric flask .The residue was washed with 1M hydrochloric acid and the volume was made up to 100ml.1M hydrochloric acid. This solution was analyzed by flame atomic absorption spectrophotometric technique using varian AA-1475 Atomic Absorption Spectrophotometer .The parameters of the instrument were adjusted as described in the manual of the instrument.

The lead concentrations in street dusts of near gas stations ,small streets, play grounds and main streets were determined show that the observed ranges of lead content determined were: dusts of main streets 236.3 -1697 .0 ; dusts of small streets

197.8 – 465.4; play grounds 184.8- 1479.3 ; and gas stations 453 .4 – 785. 8 g/ g dry weight .The overall mean value of lead in the dusts of near gas stations ,small streets , play grounds and main streets , respectively . The overall mean value of lead in the dusts of main streets is significantly higher yhan those values of other sites .This is very well explainable since there is more traffic on the main roads . The observed values of lead content was compared with those values reported for the cities of different geographical locations show the values in Libya was found to be lower than those reported for other nations .

Samples of vegetation (ga5den leaves, leaves of small bushes from the streets) were collected from 12 locations in Tripoli area . These samples were prepared for analysis of lead content by atomic absorption spectrophotometry according to standard procedure.

The samples were divided into two portions i. e, unwashed and washed. Washing was carried out with 20 L of running water to remove the surface dust .Both the samples (10 g each) were oven dried at 150 c for two hours and ashed by using muffle furnace at 450 c for 4 hours .The samples were then cooled in dessicator in the presence of anhydrous calcium chloride for keeping over night. The dry weight of the sample was noted and the ash was dissolved in 2M HC1 and filtered through whatman 50 filter paper to make up the volume 50mL

These solutions were analyzed by flame atomic absorption spectrophotometer by using Varian AA- 1475 Atomic Absorption Spectrophotometer. Lead concentrations in unwashed samples of road side vegetation ranged from 328.3 to 3462..4 g/ g dry weight of ash while for washed samples the value ranged from 182.o to 1800.8 g/ g dry weight. The overall mean values were calculated to be 995.9and 590.1 g/ g dry weight of ash in unwashed and washed samples of roadside vegetation respectively..

Further studies initiated to find out the ways to reduce lead content in motor gasoline produced in Libyan refineries show that following available components have been identified as the potential blending components in Libya for gasoline blend:

1 . Refformate (available at Az- Zawiya refinery)

2 . Light naphtha (available at Az –Zawiya refinery)

3 .Treated pyrolysis gasoline, TPG (available at Ras Lanuf)

4 . Straight run naphtha (available at Az –Zawiya and Ras Lanuf)

5 . Methanol (available at Mersa Brega)

6 . Liquefied petroleum gases. LPG (It is excluded because of its high Rvp)

5. CONCLUDING REMARKS

PRC initiative has proven its worth by raising awareness to reduce the burden of air pollution on those people most at risk. There is strong evidence that dangerously unhealthful air is an unfortunate reality for much of the urban areas in the nation. We must do more to reach the day when the air is consistently safe for all Libyan to breathe.

PRC encourages everyone to take individual steps to combat air pollution and to support national and local efforts to clean the air. Reduce your driving by combining trips, walking, biking or carpooling. Turn off your lights and use power-saving appliances to keep electric power production down. Don't burn wood or trash. These simple things can make a difference as we join forces to curb air pollution. Many communities have begun planning to reach national standards for ozone and particle pollution. Local officials must take strong measures to clean up the biggest polluters, especially dirty diesel and power plants.

Over 80% Libyan people live in coastal and urban areas of the Libya where the air quality puts their health at risk. These are children, families, neighbors and friends. Too many people remain at risk and there is much we can do to protect them. PRC ZAPRI initiative pledges to continue fighting for clean air for everyone.

PRC has plans to present information on air pollution on a municipal basis, using the most up-to-date quality assured data available for nationwide comparisons.

There is need to give municipalities tools to clean up these plants. The rules need to be stronger and, most of all, made final so work can begin. Individuals can do a great deal to help reduce air pollution outdoors as well. by reduced driving. Combine trips, walk, bike, carpool or vanpool and use buses, subways or other alternatives to driving. Vehicle emissions are a major source of air pollution. Support community plans that provide ways to get around that don't require a car, such as more sidewalks, bike trails and transit systems. Refuel cars after dark. Gasoline emissions evaporating while you fill up your gas tank contribute to ozone formation. Filling up after dark helps prevents the sunlight from turning those gases into ozone.

Don't burn wood or trash. Burning firewood and trash are among the largest sources of particles in many parts of the country. If you must use a fireplace or stove for heat, convert your wood stoves to natural gas, which has far fewer emissions. Compost and recycle as much as possible and dispose of other waste properly; don't burn it. Support efforts in your community to ban outdoor burning of construction and yard wastes.

Get involved. Participate in your community's review of the air pollution plans and support local efforts to clean up air pollution.

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AIR POLLUTION KNOWLEDGE AMONG SECONDARY STUDENT : CASE STUDY IN SELECTED SCHOOLS IN IPOH CITY, PERAK, MALAYSIA.

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ABSTRACT

This paper discusses the results of a study to assess the knowledge levels of the secondary students on the air pollution knowledge. The aim of the study is to gauge the Malaysia secondary students on their knowledge, awareness, understanding of the environment and air pollution. Data were gathered sample size of 400 respondents from selected schools in Ipoh City, in the state of Perak, Malaysia. The key results show that 60 % of the respondents obtained their knowledge in environmental issues from the news paper compared to only 12 % from an education magazine. Nearly 43 % of the respondent says that their knowledge on air pollution is moderate compared to only 7 % of respondents who didn’t have any knowledge on the same issue. The study shows that the secondary student in Malaysia already has basic knowledge of air pollution and environmental issues.

Key Words ; Air Pollution Awareness, Secondary Student, Environment.

1. INTRODUCTION

The new era poses an equally new challenge for Malaysia young generation. Having moved from an agricultural based economy in 1960s to an industrial country in 2020, embracement to prepare young generation to broaden their knowledge especially in environmental issues is very important. To achieve a fruitful ending, proper preparation to the next generation on their knowledge, ability, background, expertise and exposure are needed by the nation. The prosper for a better future environment in the nation only can be achieve through an education, as they are the future citizens of the country. They are the person who will plan and implement various activities in future.

Therefore, action has been taken by the authority to strengthen the curriculum by including the environment elements in the Malaysian education curriculum. Nevertheless, not much effort has been done to evaluate the effectiveness of the programmed in this country. This paper discusses the preliminary results of a study to assess the knowledge levels of the secondary students on an environmental issues especially the air pollution.

The aim of the study is to gauge the Malaysia secondary students on their knowledge, awareness, understanding of the environment and air pollution. For that purpose, data were gathered from a sample size of 400 respondents from selected schools in Ipoh City, in the state of Perak, Malaysia. The face to face interview technique with the aid of structured questionnaires was used to collect the data.

2.0 ENVIRONMENTAL ISSUES IN MALAYSIA.

In general, there are some series of studies have been done by The Malaysian Science and Technology Information Center (MASTIC) since 1994. The study focus on inquiring the level of awareness of Science and Technology Malaysia amongst Malaysian. For instance, it was reported by MASTIC(2000) indicates a the significant finding that Malaysians perception of knowledge of science and technology continue to decline over the years despite continue and tireless efforts by the relevant authorities to encourage science and technology participation by all levels of the society.

2.1 CURRICULUM IN MALAYSIA EDUCATION SYSTEM.

United Nations (UN) hosted many conferences including those in Stockholm (1972), the Rio Summit (1992), Langkawi Declaration (1989) and Johanesburg Summit(2002) which committed to protect the environment and strengthening of national, regional and international institutions responsible for environmental protection and education. The outcomes of these conferences are the leading role of the UN in environmental protection. It initiated a special division – the United Nation Environmental Program (UNEP) to coordinate and assist in environmental related matters at all levels amongst countries.

With the onslaught of environmental problems globally, the urgency to face this challenge is also felt in Malaysia. Education has an important role to play in motivating and empowering people to participate in the protection and improvement of the environment. In creating an environmental knowledgeable society in an organized and structured manner, neither the governmental nor the non governmental agencies play a significant role except for the Ministry of Education. Thus, the Education Ministry's role in integrating environmental education into the school curriculum is to create an environment – friendly society through the dissemination of environmental 'knowledge, skills and values' are of great significant.

In Malaysia, curriculum development is centralized and coordinated by the Curriculum Development Center (CDC) which is allocated at The Ministry of Education, Malaysia. The task focused in CDC curriculum has focused in integration because of the growth in knowledge and technology. Integration is, therefore, seen as an ideal strategy which avoids expanding subjects in the school system because the focus is on general education for all (Ministry of Education, 1980). Generally, in

Malaysia the environmental themes are integrated across all subjects such as science, geography, technical subjects (Engineering Technology, Engineering Studies). Students can apply knowledge learnt in one area to another much more readily through cross-curricular connections. Communication skill, reflective thinking and problem solving, extended from the thematic focus, are developed through instructional activities. Integrated curriculum incorporates method and skill more the academic disciplines to teach and examine a central theme or topic. The UNESCO_UNEP (1986) acknowledges that the philosophy of environmental education needs to be understood before it's implementation. It has both the environmental and education dimensions. The Ministry of Education Malaysia defines the environmental education as follows;

"To create student who are sensitive and aware of environmental issues, acquire knowledge, skills, values and attitudes to sincerely work as an individual or group towards solving environmental issues".

(Ministry of Education, 1996:6)

In conjunction with the commitment by the government of Malaysia concerning the environmental issues, some afford have been taken by the local education and environmental expert to look in to the outcomes of the curriculum achievement among the students. Not much study has been done to look into the outcome upon the implementation of the curriculum. There is a study conducted by Ponniah (1981) on evaluation the knowledge and attitude of Malaysian secondary student on environmental pollution. However, there are no follow up studies that has been done after that to evaluate the current peoples perception on air pollution concern especially among young generations.

2.2 AIR POLLUTION KNOWLEDGE STUDIES.

There are number of studies that has been done by many agencies at international and elsewhere. For instance, the study conducted by H.C. Monir (1999) to the students, teachers and community on verifying the piloting program on environmental awareness among the secondary school student in Bangladesh. According to the respondent, school students awareness program on environmental issues is a important and effective program. The latest study was done by Georgia (2005) which conducted a study among respondents represents of consumers aged 15-64 were interviewed via telephone in the markets of several countries in South East Asia region namely China, Hong Kong, Bangkok, Philippines and include Malaysia. Table 1 show the findings obtained from the study which assess to what extent is the air pollution affecting the respondents.

Table 1 : The findings obtained from the study which assess to what extent is the air pollution affecting the respondents.

COUNTRY	China	Hong Kong	Bangkok	Malaysia	Philippines
Number of respondents	1935	1001	506	1020	502
Percentage	%	%	%	%	%
Very much affected	34	40	34	19	46
Affected a little	54	56	52	55	52
Not affected at all	12	4	14	26	2

Sources: Georgia., 2005. Air Pollution Adversely Affecting 98 % of Residents. News Release 31. January 2005 by Synovate Ltd, Hong Kong, www.synovate.com.

Table 2 show some of the findings obtained from the study which indicates that they are agree that every citizen are responsible to improve the environment. From the Table 2, it's show that the highest percentage of the respondents which either agree or strongly agree comes from Republic of China which is 95 % and followed by Malaysia which obtained 94 % of the respondent agree on the improving the environment is their responsibility of every citizen.

Table 2 : The survey finding on an agreement on improving the environments is the responsibility of every citizen.

COUNTRY	China	Hong Kong	Bangkok	Malaysia	Philippines
Number of respondents	1839	984	505	1015	501
Percentage	%	%	%	%	%
Strongly agree	86	76	79	74	87
Agree	9	15	14	20	6
Neither agree nor disagree	3	7	5	4	5
Disagree	1	1	0	1	1
Strongly disagree	1	1	2	1	1

Sources : Georgia., 2005. Air Pollution Adversely Affecting 98 % of Residents. News Release 31. January 2005 by Synovate Ltd, Hong Kong, www.synovate.com.

In addition, it was reported by the research that only 74 % of the total respondents indicates that the air pollution was affected to the health in Malaysia. In the other hand, nearly 50 % of the respondent agree that they are actively involved in clean up the environment. In general, it can be concluded that the residents' awareness and perceptions of air pollution concern was high in Malaysia.

3.0 RESEARCH METHODOLOGY.

The objectives of this study are as below;

i. to investigate the air pollution awareness level amongst the respondents in the area study.
ii. To identify the main source of air pollution knowledge among the respondents.
iii. To determine the knowledge level of the respondents of the health effects of the air pollution.

3.2 SAMPLING SITE LOCATION AND CATEGORIES.

The data were gathered sample size of 400 respondents randomly from eight selected schools in Ipoh City, in the state of Perak, Malaysia. These localities were then stratified in terms of ‘urban’ sector. The classification of ‘Urban’ and Rural’ sector was made in accordance to the definition employed by the Department of Statistics, Malaysia with a ratio 5.1 urban to 4.9 rural. In general, the secondary school students from boarding and ordinary secondary school students aged 16 who are studying in the science stream were selected as a sample in this study is shown in Table 3. The questions were divided into 5 section namely; respondents profile, air pollution issues, mass media, air pollution knowledge and the air pollution health effects.

Table 3 : Sampling distribution .

NO.	SCHOOL NAME	SAMPLE STREAM CATEGORY	NUMBER OF SAMPLING
1	Raja Chulan Secandary School	Pure Science Students	50
2	Sri Ampang Secandary School	Pure Science Students	50
3	Gunong Rapat Secondary School	Pure Science Students	50
4	Anderson Secondary School	Pure Science Students	50
5	Izzudin Secondary School	Science Boarding School Students	50
6	Tunku Abd Rahman Secondary Sch	Science Boarding School Students	50
7	Persiaran BrashTechnical School	Science Technical School Students	50
8	Lebuh Catur Technical School	Science Technical School Students	50

4.0 RESULTS AND DISCUSSION.

The study successfully managed to get the gender distribution of the respondents. Hence, 80 % of the respondents were male and the rest are female. All of respondents are at the secondary level of education are in the science stream and science technical stream. Among those respondents, 54 % of them are coming from middle to the high income family which is from RM 1000 to RM 5000 (Euro 200 to Euro 1000) monthly.

4.1 AIR POLLUTION KNOWLEDGE.

In discussing to the general knowledge on pollution, more than 50 % of the total respondents are agree that they have a moderate and good knowledge of pollution. Figure 1 show the general knowledge on pollution obtained in this study. It's can be concluded that the finding in this study is the same conclusion in comparing with the study conducted by MASTIC(2001) which indicate that the understanding of environmental issues in general is high amongst the respondents. In addition, the understanding of air pollution is the highest comparing to other environmental issues for instance issue on acid rain, global warming, and ozone layer (MASTIC, 2001). Furthermore, almost 95 % of the respondents indicated that they are agree that the respiratory system will the most affected on the health effects of the air pollution. The results obtained in answering whether the respiratory system is the most affected body system is shown in Figure 2.

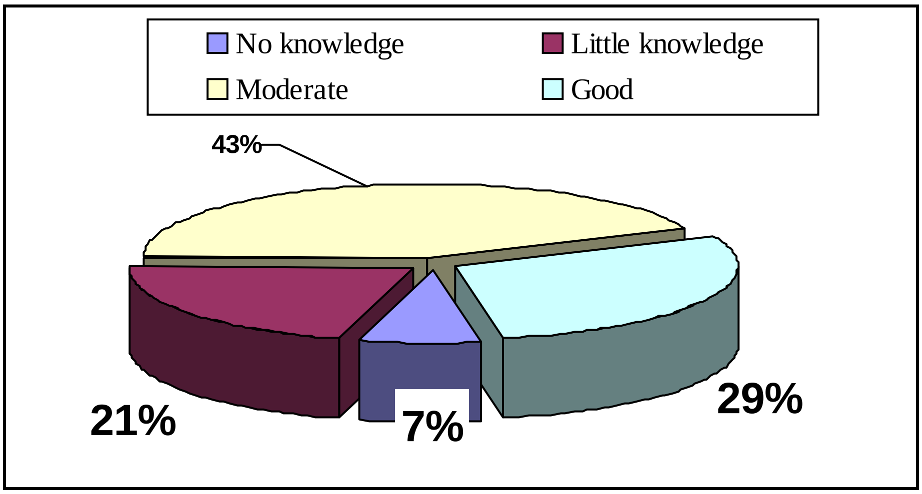

Figure 1 : The general knowledge on pollution obtained in this study.

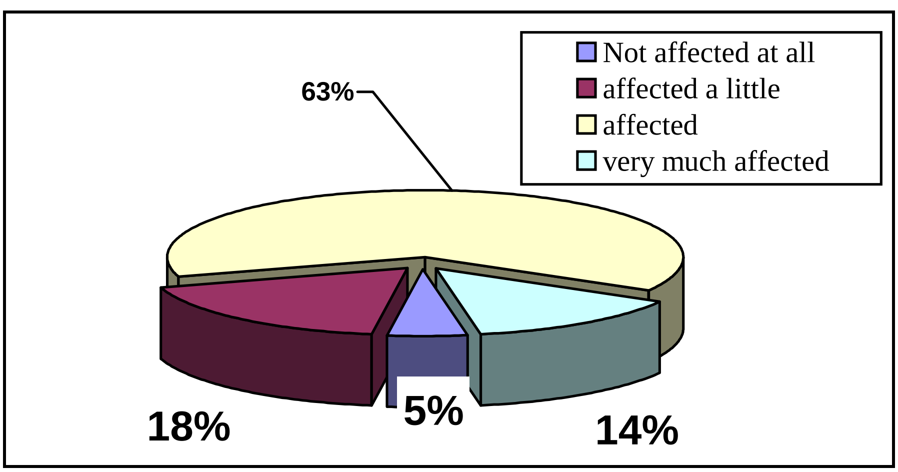

Figure 2 : Total percent of the air pollution health effects to the respiratory system.

4.2 INFORMATION ON SOURCES OF AIR POLLUTION KNOWLEDGE.

In discussing on the information sources of the air pollution knowledge, more than 50 % from the boarding school found the information on air pollution from the science and technology segment from the newspaper. The low percentage, 30 % of the respondents from an ordinary school obtained their information on air pollution from the newspaper. From this analyses, it can be concluded that the selected student in a boarding school in this particular study have a boarder knowledge and more update resources compared to the others. It's also shows that the selected student learnt and gather more knowledge from other resources rather than only depends to the text book. It also can be concluded that the results in this study is approximately the same and will support the study conducted by MASTIC(2001) which indicated that the youth recorded a slightly higher rate (95.7 %) of consumption in getting an information from the newspaper. Figure 3 show the media consumption of the main sources of information which most frequent used by the respondents.

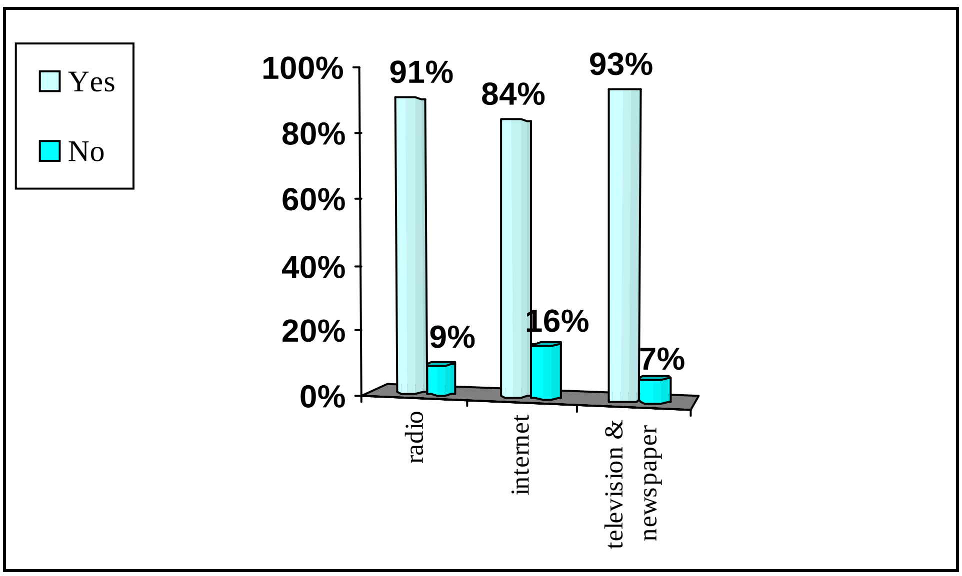

Figure 3 : The media consumption by the participants.

5.0 CONCLUSION AND RECOMMENDATIONS.

The findings of this study will provide significant contributions in highlighting the pertinent issues regarding the extent of understanding interest and attitude of Malaysian school students particular in air pollution. When comparison is made between respondents of different school stream, significant differences are also seen. The study shows that respondents representing a pure science from the boarding school displayed higher levels of knowledge and awareness compared to the other stream.

Ministry of Education and The Ministry of Environment has initiated and implemented various programs and awards to increase the awareness of science and technology, particularly in an environmental issues. In addition, an effort by the university to enhance the air quality management training with the conjunction with the World Bank Institute is being devoted (Noor Zaitun *et. al.,* 2005) in Malaysia. These were organized with the co-operations of the state government, Ministry of Education, research institutions, higher institution and universities under the human resources development program. At the school level in addition, various activities have also be implemented such as camps, quizzes, seminars, workshop and exhibition.

Lastly, at this stage there are many more studies which representing more samples from other cities in Malaysia in plan. This study gives some indicator on the the levels of air pollution awareness amongst the student. From the findings, it can be concluded that the curriculum developed by the Ministry of Education has contribute to the high level of awareness amongst the school student. It is expected that many more study on this issues will be plan in the future which involved more representatives from various cities.

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USING SPATIAL SYNOPTIC CLASSIFICATION TO ASSESS ATMOSPHERIC POLLUTION CONCENTRATION IN TEHRAN

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ABSTRACT

The quality of environmental phenomenon is control by recurrent of synoptic system and air masses. In this study relation of air masses with pollution concentration in Tehran. In the current study spatial synoptic classification (SSC) was used to identify and classify air masses in to six groups on the based on origin and their moderation in its direction. These masses include Dry Polar (DP) , Moist Polar (MP),Dry Tropical(DT), Moist Tropical(MT) , Dry Moderate(DM)and Moist Moderate(MM) air masses .Seed days are needed to determine the properties of air masses and their classification. Surface level maps and 850 mb level represent the transference of special air mass to case study. Primary criteria of seed day selection for each air mass at each station were used through the exact evaluation of data and surface level climatologic maps and 850 mb level .The selected seed days can determine the properties of air mass. The data used in this paper are hourly synoptic station observation of temperature , dew point , cloud cover , sea level pressure and u- and v- component of the wind Related variable was merged using PCA method. In this study mode P was used to identify air masses. And discriminate analysis was used to classify air masses. So that the features representative of seed days were used as input for discriminate analysis function for the purpose of air masses classification. Results this study showed that certain air masses at particular locations were highly correlated with increases mortality. This study also determined which air masses are associated with high concentration of air pollutants for example DT air masses with heat island days (which is typical of all day air masses) has correlated with high concentration of air pollutions.

Keywords : Spatial Synoptic Classification – air masses - discriminate analysis –Air pollution - Tehran