INVESTIGATION OF TURKEY'S CARBON DIOXIDE PROBLEM BY NUMERICAL MODELING

PREVIEW

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INVESTIGATION OF TURKEY'S CARBON DIOXIDE PROBLEM BY NUMERICAL MODELING

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PREVIEW

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Approval of the Graduate School of Natural and Applied Sciences

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I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy.

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

INVESTIGATION OF TURKEY'S CARBON DIOXIDE PROBLEM BY NUMERICAL MODELING

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CO_2 emission is very important, because it is responsible for about 60% of the "Greenhouse Effect". The major objectives of this study were to prepare a CO_2 emission inventory of Turkey based on districts and provinces by using the fuel consumption data with respect to its sources, to find the CO_2 uptake rate of forests in Turkey based on provinces and districts, and to estimate the ground level concentrations of CO_2 across Turkey using U.S. EPA's ISCLT3 model for the preparation of ground level concentration maps. The basic sources of the CO_2 emission were taken as households, manufacturing industries, thermal power plants and road vehicles. The sinks of the CO_2 were forests. The CO_2 uptake by forests was calculated using the annual increment of forest biomass.

The results of the CO_2 emission inventory conducted in this study between the years 1990 and 2003 showed that the CO_2 emission in 1990 was 142.45 million tones/year and the highest emission was calculated in 2000 with a value of 207.97 million tones/year.

The regional distribution of CO_2 emissions showed that the Marmara Region emits the highest regional CO_2 emission throughout the years with an

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average value of 54.76 million tones/year. It was also concluded that Marmara and Aegean Regions are responsible for half of the CO_2 emission of Turkey.

The results of the CO_2 uptake calculations showed that the CO_2 uptake of forests in the coastal zone was higher than that in the inland zone. The CO_2 uptake in the Central Anatolia, Eastern Anatolia and South-Eastern Anatolia regions were 2.6, 1.9 and 1.1 million tons/year, respectively. The maximum CO_2 uptake is in the Black Sea region with a value of 16.4 million tons/year.

The highest ground level CO_2 concentrations without any sink effect were always obtained in the Marmara Region. However, the forest areas in this region decrease the concentrations considerably.

The dispersion model performance is determined highly without the result of the year 2002.

Keywords: Emission Inventory, Sink, Source, ISCLT3 Dispersion Model, IPCC Methods, CO_2 Emission, CO_2 Uptake

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ÖZ

TURKİYE'DEKİ KARBON DIOKSIT PROBLEMİNİN SAYISAL MODELLEME İLE İNCELENMESİ

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CO_2 emisyonu, Sera Gazı Etkisinin yaklaşık %60'ına sebep olmasından dolayı oldukça önemlidir. Bu çalışmanın en önemli hedefi ise, emisyon kaynaklarına göre yakıt tüketimlerini kullanarak il ve ilçe düzeyinde Türkiye CO_2 emisyon envanterini hazırlamak, il ve ilçe düzeyinde Türkiye ormanlarının CO_2 soğurmasını bulmak ve U.S. EPA ISCLT3 modeli kullanarak Türkiye'deki yer seviyesi CO_2 konsantrasyonu, konsantrasyon haritaları hazırlayabilmek için tahmin etmektir. CO_2'in en önemli kaynakları, haneler, imalat sanayii, termik santraller ve ulaşım araçları olarak ele alınmıştır. CO_2'i soğurma mekanizmaları ise ormanlardır. Ormanlardaki CO_2 soğurması yıllık biokütle artışları kullanılarak hesaplanmıştır.

Bu çalışmadaki, 1990 ve 2003 yılları arasına ait CO_2 emisyon envanter sonuçları, en düşük CO_2 emisyon değerinin 1990 yılında 142.45 milyon ton ve en yüksek değerin ise 2000 yılında 207.97 milyon ton olarak hesaplandığını göstermiştir.

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Yıllar itibariyle en yüksek bölgesel CO_2 emisyonu, Marmara Bölgesinden ortalama 54.76 milyon ton/yıl olarak yayılmıştır. Ayrıca, Marmara ve Ege Bölgelerinde, Türkiye CO_2 emisyonunun yarısının atıldığı da tespit edilmiştir.

CO_2 soğurma hesaplarından elde edilen sonuçlara göre, kıyı bölgelerde ormanlar tarafından soğurulan CO_2 , iç bölgelere göre daha yüksektir. İç Anadolu, Doğu Anadolu ve Güneydoğu Anadolu Bölgelerinde, CO_2 sırasıyla 2.6, 1.9 ve 1.1 milyon ton/yıl olarak soğurulmuştur. Karadeniz Bölgesinde CO_2 soğurması 16.4 milyon ton/yıl olarak maksimumdur.

Yer seviyesindeki soğurma olmaksızın, en yüksek CO_2 konsantrasyonu Marmara Bölgesinde elde edilmiştir. Ormanlar konsantrasyonu önemli ölçüde düşürmüştür.

Model dağılım performasının 2002 yılı verisi olmaksızın daha yüksek olduğu tespit edilmiştir.

Anahtar Kelimeler: Emisyon Envanteri, Soğurma, Kaynak, ISCLT3 Dağılım Modeli, IPCC Metodu, CO_2 Emisyonu, CO_2 Konsantrasyonu

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To My Parents

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LIST OF ABBREVIATIONS

α	Cronbach Alfa value
^{o}C	Degrees Celsius
Δh	Plume rise
$\Delta x, \Delta y, \Delta z$	Dimensions of a unit cube
μm	Micrometer
$\mu g/m^3$	Micrograms per meter cube
η_s	Total number of industries according to its size
η_d	Number of the industries in districts according to its size
η_p	Total number of industries in provinces according to its size
%	Percent
σ^{xy}	Correlation Coefficient
$\sigma_y;\sigma_z$	Standard Deviations
ψ_d	Number of households in district d
ψ_p	Number of households in province p
C(x,y,z)	Concentration of pollutant at location x,y,z
B	Volume of biomass
Ca_p	Number of car in province p
Ca_t	Total number of cars
cov (x,y)	Covariance between x and y
CFCs	Chlorofluorocarbons
CH_4	Methane
CS	Carbon Storage
CO_2	Carbon dioxide
CO	Carbon monoxide
D	Dry biomass density
df	Degrees of freedom
d_{ij}	Distance coefficient between two cases

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E(t)	Distribution mean of Mann-Kendall Rank Correlation Test
ef	Energy consumption factor of the industries according to its size
ef_p	Energy consumption factor of the industries in provinces according to its size
ef_{pn}	Normalized energy consumption factor of the industries in provinces according to its size
EPA	Environmental Protection Agency
fc_p	Total fuel consumption in provinces
fc^t_d	Fuel consumption in the industries in districts according to its size
f_{di}	Fuel consumption in district d according to fuel type i
f_d	Fuel consumption of households in district d
f_i	Fuel consumption by car according to fuel type *i*
f_r	Fuel consumption factor of region r per households
GAW	Global Atmosphere Watch
GCP	Global Carbon Projects
GHG	Greenhouse Gases
GIS	Geographic Information Systems
h	Physical height of stack
H	Effective stack height
HFCs	Hydrofluorocarbons
I	Annual biomass increment
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ISCLT3	Industrial Source Complex Long-Term Model, version 3
k	Total number of items
K; K_x; K_y; K_z	Turbulent Diffusion Coefficients
Kcal	Kilocalorie
kg	Kilogram
m^3	Metercube
m/s	Meter per second (speed)
MOE	Ministry of Energy

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MOEF*(1)	Ministry of Environment and Forestry
MOF*(1)	Ministry of Forestry
MW	Megawatts
N	Sample size
NMVOC	Non-methane Volatile Organic Carbon
N_2O	Nitrous oxide
NO_x	Nitrogen oxides
PFCs	Perfluorocarbons
ppm	Parts per million
ppmv	Parts per million by volume
r	Average correlation between pairs of items
RF	Root Factor
SIS*(2)	State Institute of Statistics
Q	Pollutant Emission Rate
SEM	Standard Error of Mean
S_y; S_x	Standard Deviation of Series
SF_6	Sulfurhexafluoride
SO_2	Sulfur dioxide
TB	Total biomass including roots
tC	Tones carbon
TEGTC	Turkish Electricity Generation Transmission Corporation
$t_{\alpha,df}$	Student t-table value
TJ	Tetajoule
TOE	Tones of Oil Equivalent
ONC	Optimum number of cluster
u	Horizontal wind speed
u(t)	Mann-Kendall Rank Correlation value
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
Up	CO_2 uptake
VOC	Volatile Organic Carbon

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