ORNL/CDIAC-97
NDP-058
DOI: 10.3334/CDIAC/ffe.ndp058

Geographic Patterns of Carbon Dioxide Emissions from Fossil-Fuel Burning, Hydraulic Cement Production, and Gas Flaring on a One Degree by One Degree Grid Cell Basis: 1950 to 1990

R. J. Andres
University of Alaska, Fairbanks

G. Marland
Oak Ridge National Laboratory

I. Fung and E. Matthews
Godddard Institute for Space Studies

A. L. Brenkert, Editor

Carbon Dioxide Information Analysis Center

Carbon Dioxide Information Analysis Center
Oak Ridge National Laboratory

Environmental Sciences Division
Publication No. 4646

DISCLAIMER

ORNL/CDIAC-97
NDP-058

Geographic Patterns of Carbon Dioxide Emissions from Fossil-Fuel Burning, Hydraulic Cement Production, and Gas Flaring on a One Degree by One Degree Grid Cell Basis: 1950 to 1990

Contributed by

Robert J. Andres
Institute of Northern Engineering, School of Engineering
University of Alaska Fairbanks, Fairbanks, Alaska

Gregg Marland
Environmental Sciences Division
Oak Ridge National Laboratory, Oak Ridge, Tennessee

Inez Fung[1]
University of Victoria, British Columbia, Canada

Elaine Matthews[1]
Columbia University, New York, New York

[1]National Aeronautics and Space Administration
Goddard Institute for Space Studies
New York, New York

Prepared by Antoinette L. Brenkert
Carbon Dioxide Information Analysis Center
Oak Ridge National Laboratory, Oak Ridge, Tennessee

Environmental Sciences Division, Publication No. 4646
Date Published: March 1997

Prepared for the
Global Change Research Program
Environmental Sciences Division
Office of Health and Environmental Research
U.S. Department of Energy
Budget Activity Number KP 12 04 01 0

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6335
managed by
LOCKHEED MARTIN ENERGY RESEARCH CORP.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-96OR22464

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Andres, R.J, G. Marland, I. Fung, E. Matthews and A.L. Brenkert. 1996. ***Geographic Patterns of Carbon Dioxide Emissions from Fossil-Fuel Burning, Hydraulic Cement Production, and Gas Flaring on a One Degree by One Degree Grid Cell Basis: 1950 to 1990.*** ORNL/CDIAC-97, NDP058. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee, U.S.A. 56 pp. doi: 10.3334/CDIAC/ffe.ndp058

Data sets of one degree latitude by one degree longitude carbon dioxide (CO_2) emissions in units of thousand metric tons of carbon (C) per year from anthropogenic sources have been produced for 1950, 1960, 1970, 1980 and 1990 (Andres et al., 1996). Detailed geographic information on CO_2 emissions can be critical in understanding the pattern of the atmospheric and biospheric response to these emissions. Global, regional and national annual estimates for 1950 through 1992 were published previously (Boden et al., 1996). Those national, annual CO_2 emission estimates were based on statistics on fossil-fuel burning, cement manufacturing and gas flaring in oil fields as well as energy production, consumption and trade data, using the methods of Marland and Rotty (1984). The national annual estimates were combined with gridded one-degree data on political units and 1984 human populations (Andres et al., 1996) to create the new gridded CO_2 emission data sets. The same population distribution was used for each of the years as proxy for the emission distribution within each country. The implied assumption for that procedure was that per capita energy use and fuel mix is uniform over a political unit. The consequence of this first-order procedure is that the spatial changes observed over time are solely due to changes in national energy consumption and nation-based fuel mix. Increases in emissions over time are apparent for most areas, e.g., from 1980 and 1990, a 63% increase in CO_2 emissions (based on 1980 emissions) occurred in mainland China and a 95% increase in India. However, actual decreases from 1980 to 1990 occurred in Western Europe, i.e., 30% in Sweden, 27% in France, and 23% in Belgium. Latitudinal summations of emissions show a slow southerly shift (in the Northern Hemisphere) in the bulk of emissions over time. The large increases, from 1950 to 1990, in China's and India's contributions to anthropogenic CO_2 emissions compared to those by the United States are, for example, very apparent at the latitudinal band around 25.5 degrees North.

The digital data sets are available without charge, on a variety of media and via the Internet from the Carbon Dioxide Information Analysis Center (CDIAC). Each decadal CO_2-emission data file requires around 1.2 megabytes of disk storage; each decadal data file that has additional country code information requires around 7.6 megabytes of disk storage, and the graphics image format (gif) map files each require around 0.02 megabytes of disk storage.

Keywords: Carbon Dioxide Emissions; Fossil Fuel; Energy Consumption; Anthropogenic Emissions; Carbon Cycle

DATA BASE DOCUMENTATION

1. NAME OF THE NUMERIC DATA PACKAGE

GEOGRAPHIC PATTERNS OF CARBON DIOXIDE EMISSIONS FROM FOSSIL-FUEL BURNING, HYDRAULIC CEMENT PRODUCTION, AND GAS FLARING ON A ONE DEGREE BY ONE DEGREE GRID CELL BASIS: 1950 TO 1990

2. CONTRIBUTORS

Robert J. Andres
Institute of Northern Engineering, School of Engineering
University of Alaska Fairbanks, Fairbanks, Alaska

Gregg Marland
Environmental Sciences Division
Oak Ridge National Laboratory, Oak Ridge, Tennessee

Inez Fung [1]
School of Earth and Ocean Sciences
University of Victoria , British Columbia, Canada

Elaine Matthews [1]
Columbia University, New York, New York

[1]National Aeronautics and Space Administration
Goddard Institute for Space Studies
New York, New York

3. KEYWORDS

Carbon Dioxide Emissions; Fossil Fuel; Energy Consumption; Anthropogenic Emissions; Carbon Cycle

4. INTRODUCTION

Annual, global carbon dioxide (CO_2) emissions from fossil-fuel burning, cement production and gas flaring show a steady increase from 1950 to 1990 (Boden et al., 1994 p. 508; Boden et al., 1996 p. 24). From 1959 through 1990 the global atmospheric CO_2 concentrations increased from 316 ppm to 354 ppm. The global, regional and national annual estimates of anthropogenic CO_2 emissions expressed in units of thousand metric tons carbon (C) per year have been documented by Boden et al. (1996). The 1992 United Nations Energy Statistics Database (U.N.,1994), the hydraulic cement production estimates compiled by the U.S. Department of Interior's Bureau of Mines (Solomon, 1993), and supplemental data on gas flaring obtained from the U.S. Department of Energy's Energy Information Administration were processed for this purpose following the methods of Marland and Rotty (1984). Estimates of anthropogenic emissions released to the atmosphere as CO_2 in 1860 amount to 93.3 million metric tons C (Keeling, 1973), in 1950 to 1638 million metric tons C and in 1990 to 6099 million metric tons C (Boden et al., 1996).

The database documented here presents decadal (1950, 1960, 1970, 1980 and 1990) estimates of gridded fossil-fuel CO_2 emissions, expressed in 1000 metric tons C per year per one degree latitude by one degree longitude. The CO_2 emissions are the summed emissions from fossil-fuel burning, hydraulic cement production and gas flaring. The national annual estimates (Boden et al., 1996) were allocated to one degree grid cells based on gridded information on national boundaries and political units, and a 1984 gridded human population map (Andres et al., 1996). Marland et al. (1985) note that using population distribution as a proxy for the distribution of CO_2 emissions within a country offers a reasonable initial approximation but carries two implied assumptions that are clearly not filled: a) that per capita energy use is uniform over a political unit, and b) that the fuel mix is constant throughout a political unit. In addition, it was assumed that the 1984 population distribution provides a useful first approximation of the within-country distribution of the CO_2 emissions for each of the years between 1950 and 1990. (Note: the national CO_2 emissions are U.N.- statistics-based). The consequence of this first-order procedure is that the spatial changes observed are solely due to changes over time in national energy consumption and the nation-based fuel mix.

The global CO_2 emissions in this database are compared with previously published estimates. Latitudinal summations are presented in a table and graph. Maps of emission patterns are added as graphics image format (gif) files. The database is part of an attempt by CDIAC to compile an integrated network of global gridded carbon flux and carbon storage information. Locally specific information on fossil-fuel emissions might aid in analyzing global sources and sinks of CO_2.

In the future we hope to have more and different information available on energy use and population density, besides the 1984 population at a one degree grid resolution, so that CO_2 emission estimates can be differently distributed over grid cells than presently. Population changes at national levels and urbanization might be incorporated to get better insight into geographical shifts in fossil-fuel consumption, such that observational data on CO_2-fertilization versus air pollution can be better analyzed. The available fossil-fuel emission data, broken down in consumption sectors, as in Boden et al. (1996), might be put in geographic context, and then analyzed for purposes of potential policy decisions for curtailing emissions. Previously, (Marland et al., 1985) estimated fossil-fuel emissions for 1980 at a 5 degree grid cell resolution. Fung et al. (1987; http://www.giss.nasa.gov) generated publicly available databases: a one degree gridded database from the 1987 fossil-fuel emissions (after Marland et al., 1985), a one degree gridded database from 1980 land-use change emissions (after Houghton et al., 1987), and a 4 by 5 degree gridded database of CO_2 exchange of the oceans (Broecker et al., 1986). The database documented here (NDP058) handles, as the previous ones, annual information. Seasonal fossil-fuel emission might be put in a geographic referencable detailed database, both for carbon flux modeling and data analysis purposes, e.g., Fung et al. (1987) used their 4 by 5 degree gridded database of monthly CO_2 exchange in their GISS 3-D global tracer transport model. Carbon isotope signatures ($^{13}C/^{12}C$ and $^{14}C/^{12}C$ data) can be incorporated as verification of fossil-fuel emission fate. Ocean isotope signature data are available, as are CO_2 concentrations; these data put in a geographic grid, and analyzed could aid in the understanding of the temporal and spatial scales of the impacts of fossil-fuel emissions.

5. DESCRIPTION OF THE DATABASE, DATA SOURCES AND GRID CELL DISTRIBUTION

This database (NDP058) consists of 33 files, 22 in ASCII text format and 11 in gif format listed in Tables 7.1, 7.2, 7.3 and 7.4. The database consists of this documentation file (the ndp058.doc or **README** file) and the files described below.

The **GRIDCAR.year** data consist of (five) single-field files for the years 1950, 1960, 1970, 1980 and 1990 with gridded CO_2 emissions from anthropogenic sources (Table 7.1). The '1992 UN revision' data (U.N., 1994) of fossil-fuel CO_2 emissions (units as 1000 metric tons C per year per one*one degree grid cell) are arranged sequentially as one record per line in bands starting with grid cells centered at 179.5 degrees West through grid cells centered at 179.5 degrees East, and from grid cells centered at 89.5 degrees North to grid cells centered at 89.5 degrees South. The FORTRAN code **READGRID.F** is provided to read the GRIDCAR.year data files and sum the emissions to global totals.

The **GRIDALL.year** data consist of (five) nine-field files for the years 1950, 1960, 1970, 1980 and 1990 (Table 7.2). Records in these files are arranged similarly from West to East and North to South. They provide the same fossil-fuel emission information but have additional location and country-code information. Grid cells are identified by the latitude and longitude coordinates of the midpoint of the grid cell and a Global Emissions Inventory Activity (GEIA)-id code. The effort to put the national annual emissions on a one degree gridded basis was a contribution to GEIA. The GEIA-id code equals [(j*1000)+i], where 'j' is a row number starting at 1 for the grid cell between 90 and 89 degrees South ('j' equals 180 for the grid cell between 89 and 90 degrees North) and 'i' is a column number starting at 1 for the grid cell between 180 and 179 degrees West ('i' equals 360 for the grid cell between 179 and 180 degrees East). In other words, latitude equals [(j-91)+0.5] and longitude equals [(i-181)+0.5]. Analogous to the national annual CO_2 emission database (Boden et al., 1996: CDIAC NDP030/R6, Table 1 and Table 2), the gridded emission database has national identifiers in the form of the United Nations recognized country's name and the United Nations 3-digit country code for each grid cell.

A gridded population data set, with population estimates for the year 1984 was used to allocate the national annual emissions over the grid cells. The population and political unit data sets were obtained from the Goddard Institute of Space Studies (GISS). The initial NASA-GISS gridded population data set (POP1X1.1984) and the initial NASA-GISS gridded political unit data set (CNTRY1X1.1993) were adjusted by Andres et al. (1996) to ensure that for each of the dates (1950, 1960, 1970, 1980, 1990) existing countries were represented, the populations were associated with the proper political units, and the available national emission estimates were properly distributed over that country's area using population.

The initial one degree gridded NASA-GISS population density data set (POP1X1.1984) describes the 1984 worldwide distribution of human population densities. It was constructed, following a method identical to Lerner et al. (1988), placing all urban centers with more than 100,000 inhabitants into the appropriate grid cells. Then, the sum of the urban populations for a political unit was subtracted from the total population for that political unit. The remaining rural and smaller urban populations were evenly distributed among cells showing human land use as defined by Matthews (1983). The aim of the NASA-GISS population density data set was to yield a geographically correct, rather than a politically correct population distribution (POP1X1.HELP). This population density data set was first converted by Andres et al. (1996) to total population per grid cell by multiplying the population density with the cell surface area. The data set was then modified by relocating 43 border urban area populations into the nearest cell identified with the correct political unit. In addition 95 coastal urban areas were reassigned from ocean to the correct political unit (but not moved to the nearest cell) (see also CNTRY1X1.HELP). Andres' modifications resulted in the **POPMOD.DAT** data file. Thus, no geographical changes of populations over time within a country or political unit were taken into account.

The initial one degree gridded NASA-GISS political unit data set (CNTRY1X1.1993) contains 186 countries, with 9 of these further subdivided into 168 provinces, states, or regions. Each grid cell was assigned to the spatially dominant political unit, with the exception that small countries and island nations were assigned a grid cell, even when not dominant. Andres et al. (1996) added 15 political units and 10 subdivisions (e.g., Bangladesh and Pakistan were the combined E&W Pakistan before 1972) that occur in the U.N. energy statistics but not in the original GISS data set. Andres' changes resulted in the **CNTYMOD.DAT** data file.

The GRIDALL.year files contain most supporting information discussed above, that is, information for each grid cell on the GEIA-id code, the latitude and longitude coordinates of the center of the grid cell, the CO_2 emissions, the date-dependent information on the U.N. country-id, the U.N. country name, the NASA-GISS country-id, the NASA-GISS country/state/province-id and the NASA-GISS country/state/province name. The gridded population data were kept as a separate available file. The FORTRAN code **READALL.F** and the SAS™ code **ALL.SAS** are provided to read the GRIDALL.year data files.

Background data sets (Table 7.3) in this database include the POPMOD.DAT data file and for the political unit information the CNTYMOD.DAT data file. Both files are arranged similarly to the GRIDCAR.year data files in that they are arranged sequentially as one record per line in bands starting with grid cells centered at 179.5 degrees West to grid cells centered at 179.5 degrees East, and from grid cells centered at 89.5 degrees North to grid cells centered at 89.5 degrees South (64800 lines). The **CNTRY1X1.COD** file identifies the NASA-GISS country/state or province names and their NASA-GISS-id country/state or province code (355 lines). The **GISSUN.COD** file translates the NASA-GISS-id country code to the UN-id/UN country name and codes (217 lines).

The remaining background files are the FORTRAN files to read the POPMOD.DAT and CNTYMOD.DAT files (**READMOD.F**), and the CNTRY1X1.COD and GISSUN.COD files (**READCODE.F**). Lastly, the FORTRAN program **INTEGRAT.F** shows how the background files (GRIDCAR.year, CNTYMOD.DAT, CNTRY1X1.COD and GISS UN.COD) were incorporated when combined with the changes over time in the political unit names. Executing the INTEGRAT.F code results in the GRIDALL.year files. The **README** file comprises this documentation.

Summary data sets (Table 7.4) in this database are (a) an ASCII file of the latitudinal summations of the gridded CO_2 emissions for the different years (**LAT.TAB**) and a graphic representation (**LAT.gif**) of the same information, and (b) world maps of the gridded CO_2 emissions for the different years in gif formats. The AMAP files (**AMAP90.gif, AMAP80.gif, AMAP70.gif, AMAP60.gif**, and **AMAP50.gif**) are very similar to the by Andres et al. (1996) published maps, but revised for the Puerto Rico and Unites States emissions (see sections 3 and 5). The AMAP maps are based on CO_2 emissions in units of million metric tons C/year/gridcell. The BMAP maps (**BMAP90.gif, BMAP80.gif, BMAP70.gif, BMAP60.gif** and **BMAP50.gif**) are based on CO_2 emissions that are standardized for grid cell area (g C/year/m^2).

6. GLOBAL TOTALS, LATITUDINAL DISTRIBUTIONS AND CHANGES OVER TIME IN CO_2 EMISSIONS

Reported estimates of global totals of CO_2 emissions and globally summed national CO_2 emissions differ (Table 6.1). Boden et al. (1996) present four reasons why the sums of the estimated emissions from all countries (columns 3 and 4, Table 6.1) are not equal to the estimates given for global total emissions (column 2, Table 6.1):

1) Global totals include emissions from bunker fuels whereas these are not included in any national totals. Bunker fuels are fuels consumed by ships and aircraft engaged in international transportation.
2) Global totals include estimates for the oxidation of non-fuel hydrocarbon products whereas national totals do not.
3) Global totals do not include annual changes in fuel stocks whereas annual changes in fuel stocks are included in national totals.
4) There are statistical anomalies in the international statistics: for example, the sum of exports from all exporters is not identical to the sum of imports for all importers.

Table 6.1 CO_2 emissions in million metric tons of C per year

YEAR	Global Totals NDP030/R6 p24	Summed National Emissions from NATIONS92.EMS file from NDP030/R6 (+Bunkers)	Summed National Emissions from Gridded Files
1950	1638[a]	1587 (+35)[a]	1589[b]
1960	2586	2505 (+65)	2505
1970	4084	3861 (+120)	3861
1980	5290	5043 (+125)	5043
1990	6099	5811 (+115)	5812[c]

With regard to Table 6.1 three more points have to be made. References to the points are marked in the table.

(a) Emissions from bunker fuels are included in the global totals (second column) and are listed within parenthesis under the summed national emissions (third column). The bunkers can be added to the summed national emissions (columns three and four) to compare those with the global totals listed in the second column. Bunker fuel consumption generally accounts for roughly half the difference between the global totals and the sum of the national emissions.

(b) The difference in 1950 for the summed national emissions (columns three and four) is because calculating national emissions for Iran yields negative numbers (export is 1.5 units more than production); this negative number is set to zero in the gridded data file.

(c) The difference in 1990 for the summed national emissions (columns three and four) is because the Netherlands Antilles exported 0.3 units more than production, resulting in a negative value that is incorporated in column three and set to zero in the gridded database.

Andres et al. (1996) summed the gridded emissions over the latitudinal bands (file 22) and noted changes in the prominent peaks (Fig. 6.1), e.g., the peak at 51.5 degrees North shows a constant increase of 40 million metric tons C per decade up to 1980, while a decrease of 10 million metric tons occurs between 1980 and 1990. Table 6.2 quantifies the shifts in the peaks over time for the major contributing countries as percent contribution of the CO_2 emissions of the summed latitudinal emissions. The figures and tables presented in this database are, however, revised for Puerto Rico's emission, which Andres et al. (1996) based on the U.S. per capita emissions while here it is based on Puerto Rico's U.N. emission estimates (Boden et al., 1996). The emission levels of the 50 states of the United States were revised accordingly.

The latitudinal CO_2 emission distribution (Fig. 6.1) shows a continuous slow shift southward towards mid-northern latitudes. The general latitudinal shift is due to different growth rates in emissions in different countries. It does not contain any changes within countries because the within-country population distribution is always based on the 1984 data. Decreasing relative contributions to the summed latitudinal CO_2 emissions (Table 6.2) are in general due to the relative slower increase in emissions of certain countries compared to other countries. Actual decreases occur between northern latitudes 54 to 47 (file 22). These actual decreases in CO_2 emissions took place between 1980 and 1990 mainly in Western Europe and Poland, and to a slight degree in Canada. In the Southern Hemisphere the only and very minor decrease (less than 4% of the latitudinal sum) took place between 13 and 15 degrees South, because of fluctuating Uruguay emissions.

It has to be noted that the changes listed for the latitudinal summations, and the changes for countries, listed in tables 6.3 and 6.4 are dependent on what years the emissions are compared. Differences might be larger or smaller for other 10-year comparisons (see Boden et al., 1996 for yearly national emissions).

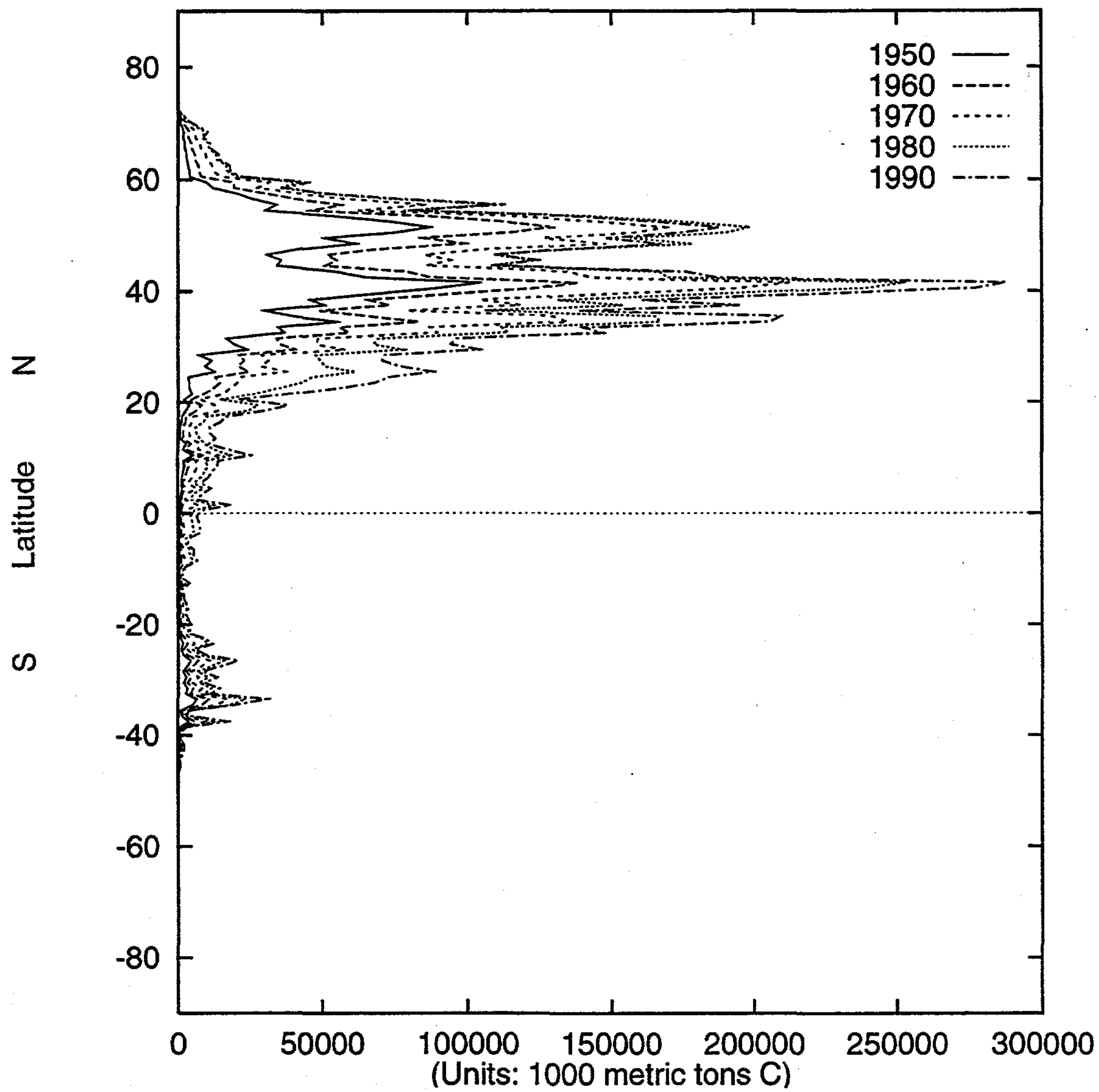

Fig. 6.1. Latitudinal distribution of decadal carbon emisions data: 1950 – 1990

Table 6.2 Latitudinal emissions in units of thousand metric tons C per year and the percent contribution by the major CO_2 emitting countries relative to the total latitudinal CO_2 emissions.

Latitude/ countries	1950	1960	1970	1980	1990
51.5 degrees N	**87276**	**129250**	**169181**	**198685**	**188591**
U.K.	39%	31%	26%	20%	20%
E. Germany	18%	20%	20%	18%	17%
W. Germany	13%	15%	12%	11%	12%
U.S.S.R.	11%	16%	19%	24%	27%
Poland	8%	10%	11%	15%	12%
41.5 degrees N	**104848**	**138532**	**212429**	**253227**	**287932**
U.S.A.	88%	77%	73%	65%	61%
U.S.S.R.	7%	9%	10%	12%	11%
China	1%	5%	4%	6%	8%
34.5 degrees N	**55068**	**83560**	**135136**	**167200**	**205633**
U.S.A.	87%	66%	59%	51%	44%
Japan	8%	13%	25%	24%	23%
China	3%	18%	11%	17%	22%
25.5 degrees N	**12673**	**24652**	**37188**	**61846**	**88474**
U.S.A.	70%	41%	40%	25%	19%
India	11%	10%	11%	12%	16%
China	7%	36%	24%	27%	31%
Mexico	5%	6%	6%	9%	8%
18.5 degrees N	**2395**	**6152**	**13973**	**24305**	**30166**
India	36%	25%	18%	18%	29%
Puerto Rico	28%	32%	23%	16%	11%
Mexico	21%	17%	12%	17%	17%
U.S. Virg.Isl.	0%	1%	19%	17%	7%
10.5 degrees N	**5291**	**8390**	**13909**	**18078**	**25188**
Venezuela	81%	77%	65%	56%	51%
India	10%	11%	11%	15%	21%
Nigeria	1%	1%	5%	12%	11%
33.5 degrees S	**6636**	**10702**	**17228**	**23607**	**30883**
Australia	51%	51%	51%	53%	53%
South Africa	30%	30%	29%	30%	31%
Chile	14%	14%	16%	13%	13%

Changes from 1980 to 1990 in total emissions of the top emitting countries are listed in Table 6.3. In addition, the increase as percent from 1980 emissions over 10 years are listed as are net per capita changes. The per capita values are obtained from Boden et al. (1996) and can not be calculated from this database. Boden et al. (1996) used annual population data provided by the United Nations, not the 1984 population database.

Table 6.3 Changes in fossil-fuel CO_2 emissions from 1980 to 1990 in the top emitting countries

Country	Emission increase in 1000 metric C per year from 1980 to 1990	% increase from 1980 to 1990 per year	Per capita change in metric tons C from 1980 to 1990 per year
China	254297	63%	+0.16
India	90640	95%	+0.08
U.S.S.R.	89982	10%	+0.02
U.S.A.	85915	7%	-0.13
Japan	40683	16%	+0.21

Major emission changes between the years 1980 and 1990 in other countries are listed in Table 6.4. These listings, ordered according to the magnitude of total change, might aid in the interpretation of the latitudinal emission distribution, and in changes that occur in the mapped emissions.

Andres et al. (1996) published maps of the gridded fossil-fuel emission rates in units of million tons C per grid cell per year. These maps, corrected for the Puerto Rico and U.S.A emissions, are available in this database (Table 7: AMAP*.*.gif) as are maps based on log transformed emission rates that are standardized for grid cell area [log (g C/m^2); BMAP*.*.gif]. Grid cell surface areas for those maps were calculated based on latitude following NASA-GISS' grid cell calculations. Because of the differences in processing and the selection of scale break-points and colors, differences over time in the maps are visualized somewhat differently. For example, a greater visual differentiation in emissions in the Southern Hemisphere occurs at the cost of less visual differentiation in emissions in the Northern Hemisphere in the second set of maps.

Table 6.4 Major changes in fossil-fuel emissions from 1980 to 1990 in other countries

Country	Change in emissions in 1000 metric tons C per year from 1980 to 1990	% change from 1980 to 1990
Dem. P. Rep. of Korea	+32847	+ 96%
Republic of Korea	+31683	+ 92%
Iran	+26125	+ 82%
South Africa	+21062	+ 36%
Turkey	+18939	+ 91%
Australia	+17260	+ 31%
Indonesia	+16574	+ 64%
Thailand	+15058	+138%
Mexico	+15910	+ 23%
France	-35527	- 27%
Poland	-30252	- 24%
Federal Rep. Germany	-23952	- 12%
Romania	- 9920	- 19%
Czechoslovakia	- 8458	- 13%
Belgium	- 8150	- 23%
Sweden	- 5857	- 30%
U.K.	- 5085	- 3%
Hungary	- 4486	- 20%
Netherlands	- 3669	- 9%
Denmark	- 3335	- 19%
Canada	- 3239	- 3%

7. FILE DESCRIPTIONS

This section describes the content and format of each of the 33 files comprising this NDP (Tables 7.1, 7.2, 7.3 and 7.4). File names and a brief description of the files are given.

7.1 GRIDDED CO_2 EMISSIONS

The five single-field **GRIDCAR.year** data files are the '1992 UN revision' (U.N., 1994) data of fossil-fuel CO_2 emissions (1000 metric tons C/one*one degree grid cell/year) arranged sequentially as one record per line in bands starting with grid cells centered at 179.5 degrees West to grid cells centered at 179.5 degrees East, and from grid cells centered at 89.5 degrees North to grid cells centered at 89.5 degrees South.

The FORTRAN 77 code (**READGRID.F**) is provided to read the GRIDCAR.year data files.

Table 7.1 Single-field CO_2 emission file names, sizes, types and format

File names and description	File size (bytes)	data type	format
1. GRIDCAR.90 1990 CO_2 emissions estimates for one degree by one degree grid cells (thousand metric tons C per year)	1231200	real	f18.6
2. GRIDCAR.80 1980 CO_2 emissions estimates (thousand metric tons C per year)	1231200	real	f18.6
3. GRIDCAR.70 1970 CO_2 emissions estimates (thousand metric tons C per year)	1231200	real	f18.6
4. GRIDCAR.60 1960 CO_2 emissions estimates (thousand metric tons C per year)	1231200	real	f18.6
5. GRIDCAR.50 1950 CO_2 emissions estimates (thousand metric tons C per year)	1231200	real	f18.6
6. READGRID.F FORTRAN 77 code to read files 1 through 5	1902		

7.2 GRID CELL INFORMATION ON CO_2 EMISSION, LOCATION AND POLITICAL UNIT

The five nine-field **GRIDALL.year** data files, provide the same information on the CO_2 emissions due to fossil-fuel burning, gas flaring and cement production as the GRIDCAR files, but also information on the grid cell with regard to the latitude and longitude coordinates, the GEIA-id code, the UN-id and accompanying country name, and the NASA-GISS country and political unit codes and name.

The FORTRAN 77 code (**READALL.F**) and SAS™ code (**ALL.SAS**) are provided to read the GRIDALL files.

Table 7.2 Nine-field CO_2 emission file names, sizes, types and format

File names and description	File size (bytes)	data type	format
7. GRIDALL.90	7646400		
Files 7 through 11 contain the following information for each grid cell:			
GEIA-cell-id		character	a6
latitude (degrees)		real	f6.1
longitude (degrees)		real	f6.1
CO_2 emissions (1000 metric tons C per year)		real	g12.6
and date-dependent information:			
U.N. country-id		integer	i3
U.N. country name		character	a40
NASA-GISS country-id		integer	i6
NASA-GISS country/state, province-id		integer	i6
NASA-GISS country/state, province name		character	a14
8. GRIDALL.80 Same content as file 7, except 1980 data	7646400		
9. GRIDALL.70 Same content as file 7, except 1970 data	7646400		
10. GRIDALL.60 Same content as file 7, except 1960 data	7646400		
11. GRIDALL.50 Same content as file 7, except 1950 data	7646400		
12. READALL.F FORTRAN code to read files 7 through 11	1487		
13. ALL.SAS[1] SAS™ code to process files 7 through 11	2770		

[1]SAS™ is a registered trademark of the SAS institute, Inc., Cary, North Carolina 27511-8000.

7.3 UNDERLYING DATABASES AND CODES TO CREATE THE EXTENDED GRIDDED CO_2 EMISSION FILES

Table 7.3 lists the files and information used to create the GRIDALL.year files from the GRIDCAR.year files. The FORTRAN 77 code **INTEGRAT.F** uses the GRIDCAR.year files, the **CNTYMOD.DAT**, the **CNTRY1X1.COD** and the **GISSUN.COD** as input and generates the GRIDALL.year files. The **POPMOD.DAT** and CNTYMOD.DAT files can be read by the **READMOD.F** FORTRAN 77 code; the CNTRY1X1.COD and GISSUN.COD files can be read by the **READCODE.F** FORTRAN 77 code. The **README** file is very similar to this document.

Table 7.3 Background file names, sizes, types and format

File names and description	File size (bytes)	data type	format
14. POPMOD.DAT	712800		
The 1984 population per grid cell		integer	i10
15. CNTYMOD.DAT	453600		
NASA-GISS country/state,province-id		integer	i6
16. CNTRY1X1.COD	28755		
NASA-GISS country-id and country/state,province-id		integer	i6
NASA-GISS country and country/state,province name		character	a14
17. GISSUN.COD	13888		
UN-id		integer	i3
NASA-GISS country-id		integer	i6
UN country name		character	a42
18. READMOD.F	569		
FORTRAN code to read files 14 and 15			
19. READCODE.F	968		
FORTRAN code to read files 16 and 17			
20. INTEGRAT.F	14171		
FORTRAN 77 code to integrate background files			
21. README = ndp058.doc			
This document			

7.4 LATITUDINAL SUMMARY AND MAPS

Table 7.4 lists the summary files in this database. The **LAT.TAB** is an ASCII file with the summed fossil-fuel emissions for 1950, 1960, 1970, 1980 and 1990 of each latitudinal band (thousand metric tons C/year/latitudinal band). The **LAT.gif** file is a visual representation of the same information. The **AMAP90.gif, AMAP80.gif, AMAP70.gif, AMAP60.gif** and **AMAP50.gif** files are Andres et al.'s (1996) gridded fossil-fuel CO_2 emission maps (million metric tons C/year/grid cell); the **BMAP90.gif, BMAP80.gif, BMAP70.gif, BMAP60.gif** and **BMAP50.gif** files are the log transformed, standardized for grid cell area emission rate maps (log(C emission/year/unit area)) which after transformation are expressed in units of grams C per square meter (g C/year/m^2).

Table 7.4 Summary file names, sizes and types

File names and description	File size (bytes)	File Type
22. LAT.TAB (thousand metric tons C/latitudinal band/yr)	11235	ASCII
23. LAT.gif (thousand metric tons C/latitudinal band/yr)	17827	gif
24. AMAP90.gif 1990 world map of gridded CO_2 emissions (million metric tons C/grid cell/yr)	19548	gif
25. AMAP80.gif 1980 world map (million metric tons C/grid cell/yr)	19534	gif
26. AMAP70.gif 1970 world map (million metric tons C/grid cell/yr)	19198	gif
27. AMAP60.gif 1960 world map (million metric tons C/grid cell/yr)	18328	gif
28. AMAP50.gif 1950 world map (million metric tons C/grid cell/yr)	17378	gif
29. BMAP90.gif 1990 world map of gridded CO_2 emissions (log (C/unit area) >> g C/m^2/yr)	16804	gif
30. BMAP80.gif 1980 world map (log (C/unit area) >> g C/m^2/yr)	16614	gif
31. BMAP70.gif 1970 world map (log (C/unit area) >> g C/m^2/yr)	16735	gif
32. BMAP60.gif 1960 world map (log (C/unit area) >> g C/m^2/yr)	16671	gif
33. BMAP50.gif 1950 world map (log (C/unit area) >> g C/m^2/yr)	16700	gif

Table 7.5 summarizes the number of countries and political units involved in the database and the number of countries and political units without information on CO_2 emissions, e.g., Namibia and Lesotho.

Table 7.5 Overview of number of countries and political units involved

	# of countries identified with a UN-id (# without CO_2 emissions)	# of political units identified with a NASA-GISS-id (# without CO_2 emissions)
1950	180 (28)	334 (33)
1960	196 (16)	360 (21)
1970	196 (5)	359 (10)
1980	195 (3)	358 (8)
1990	196 (4)	360 (8)

8. CDIAC QUALITY ASSURANCE CHECKS

An important part of the data packaging process at CDIAC involves the quality assurance (QA) of data before distribution. To guarantee data of the highest possible quality, CDIAC performs extensive QA checks, examining the data for completeness, reasonableness, and accuracy.

However, QA on the national CO_2 emissions had been performed by CDIAC (NDP030/R6) prior to processing these emissions as a gridded database. The following data checks were specifically performed for NDP058:

1) National totals were compared to reported global totals:

(a) Grid cell values of fossil-fuel emissions were summed by country name in SAS™ and the resulting national emissions were compared to a previously published database of national emissions (NDP030/R6). Summed gridded national totals check out exactly with NDP030/R6's national totals, but:

(b) Andres et al. (1996) allocated to Puerto Rico a population-based fraction of the total US emissions (UN code 840) (i.e., C emissions of 18,786 thousand metric tons for 1990), while the national emissions in NDP030/R6 had for Puerto Rico (UN code 630) a separately calculated emission of ~6-fold less than the population based fraction (i.e., 3193 thousand metric tons for 1990). This population based fraction, allocated to Puerto Rico, was in the NDP030/R6 appropriately allocated to the 50 states of the U.S.A. (total of 1,322,212 thousand metric tons for 1990). This has now been corrected, based on the NDP030/R6 data, for each of gridded database files.

(c) The national total emissions reported in NDP030/R6 had failed to replace UN code 887 by UN code 886 for 1990's cement production (113 thousand metric tons C per year (Yemen). Democratic Yemen (UN code 720) and Yemen (UN code 886) merged on 22 May, 1990 to form a single state (UN code 887). For 1990, the separation between Democratic Yemen and former Yemen should have been maintained for all emissions and UN code 887 should not have been in the database. Therefore, the 1990 cement emission allocation of Yemen was not incorporated in the gridded database of Andres et al.(1996). This has now been corrected.

2) Converting negative emission values to zero:

Fossil fuel emissions for Iran for 1950 and for the Netherlands Antilles for 1990 were set to zero. Negative emissions were calculated and reported for these two instances in NDP030/R6 because exports of fossil fuels were larger than the sum of gross production and imports.

3) Bunker Summations:

An additional QA was performed on the NDP30/R6 while collecting information for Table 6.1. Due to SAS™ not performing any calculations when missing values occur as any of the elements in an equation, the summation of bunkers could not be performed correctly using the SAS™ program in the NDP030/R6. Replacement of missing values by zeros has corrected this potential error in using the NDP030/R6 database.

9. HOW TO OBTAIN THE DATABASE AND DOCUMENTATION

This database (NDP058) and the related NDP030/R6 database are available free of charge from CDIAC. The files are available from CDIAC's anonymous FTP (file transfer protocol) area via the Internet. Obtaining the data from CDIAC's anonymous FTP area requires a computer with FTP software and access to the Internet. Commands used to obtain the database are shown below. For additional information, contact CDIAC.

>ftp cdiac.esd.ornl.gov (or >ftp 128.219.24.36)
Login: anonymous
Password: YOU@your internet address
Guest login ok, access restrictions apply.
ftp> **cd pub/ndp058**
ftp> **dir**
ftp> **mget files**
ftp> **quit**

Uncompress files on workstation, if obtained in compressed format.

CDIAC's World Wide Web home page's address: **http://cdiac.esd.ornl.gov**

For **non-FTP data acquisitions** (e.g., IBM- or MacIntosh-formatted floppy diskettes; 8200 or 8500 format 8-mm tape), users may request data from CDIAC using the following information:

Address: **Carbon Dioxide Information Analysis Center**
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, Tennessee 37831-6335, U.S.A.

Telephone: **(423) 574-3645 (Voice)**
(423) 574-2232 (FAX)
Electronic mail: **cdiac@ornl.gov**

All GEIA information is available through anonymous FTP:
>ftp ncardata.ucar.edu
ftp>cd pub/GEIA

All NASA-GISS referenced information is available through anonymous FTP:
>ftp nasagiss.giss.nasa.gov
or **http://www.giss.nasa.gov**

10. REFERENCES

Andres, R.J., G. Marland, I. Fung, and E. Matthews. 1996. A one degree by one degree distribution of carbon dioxide emissions from fossil-fuel consumption and cement manufacture, 1950-1990. Global Biogeochemical Cycles 10:3:419-429

Boden, T.A., G. Marland, and R.J. Andres, 1996. Estimates of global, regional, and national annual CO_2 emissions from fossil-fuel burning, hydraulic cement production, and gas flaring: 1950-1992, Rep. ORNL/CDIAC-90, NDP-030/R6, 600 pp., Oak Ridge Nat. Lab., Oak Ridge, Tenn.

Boden, T.A., D.P. Kaiser, R.J. Sepanski and F.W. Stoss, 1994. Trends '93, A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, World Data Center-A for Atmospheric Trace Gases. Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tenn. 37831-6335.

Broecker, W.S. et al., 1986. Isotopic versus micrometeorological ocean CO_2 fluxes: A serious conflict. J. Geophys. Res. 91:10517-10527.

Fung, I., C.J. Tucker and K.C. Prentice, 1987. Application of AVHRR vegetation index to study atmosphere-biosphere exchange of CO_2. J. Geophys. Res. 92:2999-3015.

Houghton, R.A. et al., 1987. The flux of carbon from terrestrial ecosystems to the atmosphere in 1980 due to changes in land use: geographic distribution of global flux. Tellus 39B:122-139.

Keeling, C.D., 1973. Industrial production of carbon dioxide from fossil-fuels and limestone. Tellus 25:174-198.

Lerner, J., E. Matthews and I. Fung, 1988. Methane emissions from animals: A global high-resolution database. Global Biochemical Cycles, 2:139-156.

Marland, G., and R.M. Rotty, 1984. Carbon dioxide emissions from fossil-fuels: A procedure for estimation and results for 1950-1982. Tellus 36(B):232-261.

Marland, G, R.M. Rotty and N.L. Treat, 1985. CO_2 from fossil fuel burning: Global distribution of emissions. Tellus 37(B):243-258.

Matthews, E. 1983. Global vegetation and land use: New high-resolution data bases for climate studies. J. Clim. Appl. Meteorol., 22:474-487.

Solomon, C., 1993. Cement. In Cement Minerals Yearbook-1992. U.S. Department of Interior, Bureau of Mines, Washington, D.C.

United Nations, 1994. 1992 Energy Statistics Yearbook. United Nations Statistical Division (UNSTAT), 2 United Nations Plaza, New York. N.Y. 10017

APPENDICES

APPENDIX A

A.1 LAT.TAB

YEARLY LATITUDINAL SUMMATIONS OF CO_2 EMISSIONS
(thousand metric tons C/year/latitidinal band)

Midpoint of one degree latitude bands	1950	1960	1970	1980	1990
89.5	0.0	0.0	0.0	0.0	0.0
88.5	0.0	0.0	0.0	0.0	0.0
87.5	0.0	0.0	0.0	0.0	0.0
86.5	0.0	0.0	0.0	0.0	0.0
85.5	0.0	0.0	0.0	0.0	0.0
84.5	0.0	0.0	0.0	0.0	0.0
83.5	0.0	0.0	0.0	0.0	0.0
82.5	0.0	0.0	0.0	0.0	0.0
81.5	0.0	0.0	0.0	0.0	0.0
80.5	0.0	0.0	0.0	0.0	0.0
79.5	0.0	0.0	0.0	0.0	0.0
78.5	0.0	0.0	0.0	0.0	0.0
77.5	0.0	0.0	0.0	0.0	0.0
76.5	0.0	0.0	0.0	0.0	0.0
75.5	0.0	0.0	0.0	0.0	0.0
74.5	0.0	0.0	0.0	0.0	0.0
73.5	72.6	154.8	245.6	360.9	369.0
72.5	0.0	0.0	0.0	0.0	0.0
71.5	324.6	691.9	1097.6	1612.6	1769.8
70.5	634.4	1272.9	2067.7	3062.5	3461.7
69.5	1232.7	2523.7	4064.3	5999.8	6710.8
68.5	1851.8	3872.1	6309.4	9252.4	10168.3
67.5	1700.9	3514.8	5890.1	8170.7	8679.7
66.5	2156.4	4452.4	7457.3	10325.4	10958.2
65.5	2305.9	4695.4	7809.4	10768.3	11392.1
64.5	2810.2	5686.0	9473.4	13076.9	13941.7
63.5	2850.7	5761.2	9815.8	13390.5	14213.1
62.5	3344.5	6863.1	11750.3	16411.2	17551.4
61.5	3732.9	7114.5	12099.8	16724.7	17927.2
60.5	3843.9	7890.7	14416.0	20209.1	21308.5
59.5	9601.3	19059.9	31564.5	42186.7	44991.8
58.5	11956.6	19235.0	27548.1	35043.2	37135.6
57.5	20051.0	30277.5	41635.3	49995.9	51865.6
56.5	25698.5	40471.0	58826.1	73909.6	76868.0
55.5	34194.1	56716.8	86041.0	109147.2	113091.0
54.5	30400.6	46139.8	62820.0	78571.7	80484.6
53.5	53736.6	84644.7	114385.7	141898.4	136380.1
52.5	73633.6	111701.3	145914.3	174822.6	165301.6
51.5	87276.2	129250.2	169180.8	198685.4	188591.0
50.5	75208.4	114657.2	158072.5	190278.5	174168.8

49.5	51141.5	85029.9	126823.7	156877.7	148367.7
48.5	62088.9	98952.0	148222.1	178658.6	167965.2
47.5	42088.3	69441.5	107265.0	134529.0	133514.3
46.5	30933.9	51773.5	85462.0	109076.7	110051.4
45.5	35769.3	55286.8	94250.3	122206.6	124609.2
44.5	34427.6	51030.9	86036.9	108371.0	110492.4
43.5	55050.4	79396.5	135387.0	166924.1	176423.2
42.5	65207.2	87269.2	143351.5	169720.3	186810.7
41.5	104848.2	138531.8	212428.66	253227.2	287932.4
40.5	89733.6	123853.4	194499.3	238637.1	277166.9
39.5	67138.2	93719.4	147306.9	182302.3	217777.0
38.5	45914.4	65893.6	104270.1	131578.3	160987.7
37.5	50945.6	73568.8	118396.8	154278.9	194883.1
36.5	29913.3	49146.8	79402.2	106304.0	138671.9
35.5	39478.8	65537.3	130015.7	165641.3	209520.1
34.5	55068.2	83560.1	135136.1	167200.7	205632.9
33.5	34690.7	56025.1	87177.8	1118216.6	140515.8
32.5	36952.2	59721.4	89732.3	114012.2	147067.7
31.5	16619.9	34177.4	48430.2	69412.7	96443.9
30.5	19326.4	35370.2	47930.0	67877.8	94242.7
29.5	24079.2	40690.0	58372.9	78178.2	104013.8
28.5	7156.7	20886.8	29060.8	47706.4	71359.2
27.5	11586.5	22810.8	31360.4	49263.8	70851.9
26.5	9272.1	20600.6	28661.6	50994.5	77169.3
25.5	12673.8	24652.1	37187.7	61846.0	88474.2
24.5	3378.3	12840.0	21077.2	46340.2	73221.9
23.5	3755.7	14331.2	20367.0	42975.1	68043.4
22.5	3803.8	12011.9	17551.1	34430.2	54710.8
21.5	4683.4	8696.6	15464.3	26859.8	38673.6
20.5	2074.7	4455.0	7460.0	14506.0	20595.4
19.5	3718.7	7908.0	12823.9	27634.7	38136.5
18.5	2394.5	6151.8	13972.6	24304.8	30166.5
17.5	1211.5	2628.6	5033.2	9718.4	16189.6
16.5	1075.2	2491.3	4695.2	8642.0	14580.8
15.5	702.5	1628.2	3590.6	5986.7	10804.3
14.5	690.8	1651.1	3753.3	6261.3	10967.3
13.5	726.5	1630.8	4167.5	7430.7	12961.6
12.5	2678.0	4270.6	7666.2	9068.4	10587.2
11.5	1598.3	2459.3	6774.6	12296.7	16820.7
10.5	5291.2	8389.6	13909.5	18078.3	25188.5
9.5	1977.1	3293.5	6131.5	9611.3	13987.3
8.5	2228.4	3709.5	6770.5	10301.1	13678.8
7.5	1710.6	2912.1	5858.4	9192.3	11758.3
6.5	1410.6	2392.6	4923.7	7849.7	10585.8
5.5	1040.3	2477.2	3433.7	5575.3	7916.0
4.5	1521.5	2477.2	6484.6	8740.8	11508.9
3.5	954.3	1582.7	3012.9	5345.2	8359.9
2.5	818.2	1411.6	2540.3	4399.3	6683.5
1.5	1037.5	1645.2	7218.3	12532.6	18152.7
0.5	596.5	1333.4	2232.0	5594.2	8335.6
-0.5	429.0	960.3	1660.8	4482.4	6489.7
-1.5	504.1	1142.0	1875.0	5006.8	7264.9
-2.5	537.6	1176.7	2015.6	5276.8	7667.8

-3.5	593.0	1297.4	2239.0	5333.8	7483.6
-4.5	368.4	769.2	1367.4	2730.5	3635.7
-5.5	375.1	786.9	1458.8	3858.7	3376.8
-6.5	490.2	1041.4	1877.1	4100.6	5545.6
-7.5	468.7	1014.7	1839.3	4032.9	5383.1
-8.5	602.3	1340.3	2490.5	5325.6	6678.7
-9.5	269.0	592.2	1106.3	2203.8	2590.0
-10.5	264.9	547.3	877.9	1549.8	1625.5
-11.5	270.4	552.1	866.6	1471.6	1512.0
-12.5	756.2	1475.9	2691.6	4066.9	3927.4
-13.5	332.9	651.6	974.1	1483.7	1445.3
-14.5	419.3	838.0	1222.2	2023.2	1996.5
-15.5	481.5	952.7	1316.6	2128.4	2129.9
-16.5	498.6	993.5	1749.5	2857.7	3194.8
-17.5	466.6	904.8	1816.2	2819.6	3465.7
-18.5	440.5	855.5	1593.3	2614.0	3206.7
-19.5	486.1	998.1	1862.4	3322.4	3990.0
-20.5	545.2	1035.2	1963.5	3341.6	4197.2
-21.5	498.0	1127.2	2320.6	3568.9	4128.3
-22.5	1156.5	2403.8	4265.9	8155.3	9300.0
-23.5	1620.1	3237.6	5642.7	10412.1	12095.9
-24.5	1164.4	1991.9	3240.6	4921.0	6032.4
-25.5	1819.0	3098.8	4941.0	7549.2	9618.6
-26.5	4284.1	7028.3	10956.0	15811.2	20806.4
-27.5	3137.8	5123.4	8146.0	11697.3	15005.6
-28.5	1711.0	2836.8	4459.1	6559.2	8430.9
-29.5	2773.0	4562.9	7102.2	10370.2	13588.9
-30.5	1892.8	3143.0	4941.4	7231.5	9257.5
-31.5	3147.7	5123.9	8151.4	11472.4	14396.5
-32.5	2586.6	4202.7	6605.9	9138.3	11400.1
-33.5	6636.4	10702.0	17228.4	23607.0	30883.4
-34.5	5056.4	8243.1	13363.1	17825.3	19735.9
-35.5	809.1	1291.9	2103.8	2868.7	3576.0
-36.5	1302.4	1929.8	2842.7	3687.3	4686.1
-37.5	3626.2	5796.4	9346.7	13146.2	16936.8
-38.5	745.6	1170.5	1870.6	2494.7	3034.3
-39.5	288.8	435.3	661.9	837.9	970.1
-40.5	239.0	366.0	569.6	725.2	822.0
-41.5	584.6	849.6	1206.5	1559.3	1974.7
-42.5	526.9	817.9	1278.6	1731.6	2174.1
-43.5	500.0	710.4	969.3	1232.1	1550.4
-44.5	210.6	310.9	454.8	577.8	677.4
-45.5	300.1	424.9	582.5	722.8	911.7
-46.5	144.2	214.2	317.3	401.8	470.9
-47.5	67.6	110.1	183.0	242.3	247.5
-48.5	58.4	94.8	161.0	205.5	222.6
-49.5	54.1	88.2	146.6	194.1	198.3
-50.5	42.4	69.1	114.9	152.1	155.3
-51.5	119.8	124.9	126.4	159.6	181.4
-52.5	39.1	62.9	113.9	129.8	167.4
-53.5	35.4	57.1	101.0	120.1	145.4
-54.5	29.0	47.3	78.7	104.2	106.4

-55.5	0.0	0.0	0.0	0.0	0.0
-56.5	0.0	0.0	0.0	0.0	0.0
-57.5	0.0	0.0	0.0	0.0	0.0
-58.5	0.0	0.0	0.0	0.0	0.0
-59.5	0.0	0.0	0.0	0.0	0.2
-60.5	0.0	0.0	0.0	0.0	0.2
-61.5	0.0	0.0	0.0	0.0	0.2
-62.5	0.0	0.0	0.0	0.0	0.2
-63.5	0.0	0.0	0.0	0.0	0.2
-64.5	0.0	0.0	0.0	0.0	0.2
-65.5	0.0	0.0	0.0	0.0	0.2
-66.5	0.0	0.0	0.0	0.0	0.2
-67.5	0.0	0.0	0.0	0.0	0.2
-68.5	0.0	0.0	0.0	0.0	0.1
-69.5	0.0	0.0	0.0	0.0	0.1
-70.5	0.0	0.0	0.0	0.0	0.1
-71.5	0.0	0.0	0.0	0.0	0.1
-72.5	0.0	0.0	0.0	0.0	0.1
-73.5	0.0	0.0	0.0	0.0	0.1
-74.5	0.0	0.0	0.0	0.0	0.1
-75.5	0.0	0.0	0.0	0.0	0.1
-76.5	0.0	0.0	0.0	0.0	0.0
-77.5	0.0	0.0	0.0	0.0	0.0
-78.5	0.0	0.0	0.0	0.0	0.0
-79.5	0.0	0.0	0.0	0.0	0.0
-80.5	0.0	0.0	0.0	0.0	0.0
-81.5	0.0	0.0	0.0	0.0	0.0
-82.5	0.0	0.0	0.0	0.0	0.0
-83.5	0.0	0.0	0.0	0.0	0.0
-84.5	0.0	0.0	0.0	0.0	0.0
-85.5	0.0	0.0	0.0	0.0	0.0
-86.5	0.0	0.0	0.0	0.0	0.0
-87.5	0.0	0.0	0.0	0.0	0.0
-88.5	0.0	0.0	0.0	0.0	0.0
-89.5	0.0	0.0	0.0	0.0	0.0

A.2 READGRID.F

```
C=====================================================================
C PROGRAM TO READ GRIDDED CO2 FOSSIL FUEL EMISSION DATA
C WHERE:
C  FF = CO2 EMISSION FROM FOSSIL FUELS (1000 METRIC TONS C PER YEAR)
C=====================================================================
C
      INTEGER YEAR
      REAL*8 FF(180,360)
      REAL*8 SUM
      CHARACTER*40 INFILE
      CHARACTER*40 OUTFILE
C
C GRIDCAR.YEAR = ONE DEGREE GRIDDED CO2 FOSSIL FUEL EMISSIONS
      YEAR=1950
      INFILE='GRIDCAR.50'
      OUTFILE='GRIDOUT.50'
C
      PRINT *,'PROCESSING YEAR: ',YEAR
      PRINT *,'INPUT FILE READ: ',INFILE
      PRINT *,'ECHO PRINT TO FILE: ',OUTFILE
C
      OPEN(10,FILE=INFILE,STATUS='OLD')
      OPEN(20,FILE=OUTFILE,STATUS='UNKNOWN')
C
      WRITE(20,*)'CO2 EMISSIONS (1000 METRIC TONS C) IN YEAR:', YEAR
      SUM=0.D0
C FROM NORTH > SOUTH
        DO 10 I=1,180
C FROM WEST > EAST:
          DO 10 J=1,360
            READ(10,*)FF(I,J)
            SUM=SUM+FF(I,J)
C ECHO PRINT:
C             WRITE(20,*)FF(I,J)
10      CONTINUE
      PRINT *,SUM
      CLOSE (UNIT=10)
      CLOSE (UNIT=20)
      STOP
      END
C
C 1990 ---------------------------------
C 5811613.7
C 5811272. NATIONAL TOTALS FROM NDP030.R6/NATION92.EMS
C   -341.6 == DIFF IN NETHERLANDS ANTILLES: UN CODE 530
C 1980 ---------------------------------
C 5042867.8
C 5042878. NATIONAL TOTALS FROM NDP030.R6/NATION92.EMS
C          DIFFERENCE == ROUNDOFF
C 1970---------------------------------
C 3861021.8
C 3861023. NATIONAL TOTALS FROM NDP030.R6/NATION92.EMS
C 1960---------------------------------
C 2505231.8
C 2505235. NATIONAL TOTALS FROM NDP030.R6/NATION92.EMS
C 1950---------------------------------
C 1588607.5
C 1587139. NATIONAL TOTALS FROM NDP030.R6/NATION92.EMS
C  -1471. == DIFF IN IRAN: UN CODE 364
C=====================================================================
```

A.3 READALL.F

```
C=============================================================
C PROGRAM TO READ GRIDDED CO2 FOSSIL FUEL EMISSION DATA,
C  GRID CELL LOCATIONS, COUNTRY NAMES AND COUNTRY IDENTIFICATION
C  CODES  FOR THE YEARS 1950, 1960, 1970, 1980 AND 1990.
C WHERE:
C  GEIAID = 1000*JGRID+IGRID
C  LAT(ITUDE) = [(JGRID-91)+0.5] (DEGREES)
C  LONG(ITUDE) = [(IGRID-181)+0.5] (DEGREES)
C  FF = CO2 EMISSION FROM FOSSIL FUELS (1000 METRIC TONS C PER YEAR)
C  UNID = UNITED NATIONS COUNTRY CODE
C  GNAME =  UNITED NATIONS COUNTRY NAME
C  IGIS = NASA-GISS COUNTRY NAME
C  IJCODE = NASA-GISS COUNTRY/PROVINCE-REGION CODE
C  CIJNAME = NASA-GISS COUNTRY/PROVINCE-REGION NAME
C=============================================================
C
   REAL*8 FF,SUMFF
   CHARACTER*14 CIJNAME
   CHARACTER*42 GNAME
   CHARACTER*6 GEIAID
   INTEGER UNID, IGIS,IJCODE
   REAL LAT,LONG
   INTEGER YEAR
   CHARACTER*40 INFILE
   CHARACTER*40 OUTFILE
C
   YEAR=1990
   INFILE='GRIDALL.90'
   OUTFILE='ALLOUT.90'
C
   PRINT *,'PROCESSING YEAR: ',YEAR
   PRINT *,'INPUT FILE READ: ',INFILE
   PRINT *,'ECHO PRINT TO FILE: ',OUTFILE
C
   OPEN(10,FILE=INFILE,STATUS='OLD')
   OPEN(20,FILE=OUTFILE,STATUS='UNKNOWN')
C
   SUMFF=0.D0
   DO 10 I=1,64800
    READ(10,110)GEIAID,LAT,LONG,FF,
  & UNID,GNAME,IGIS,IJCODE,CIJNAME
C ECHOPRINT
    WRITE(20,110)GEIAID,LAT,LONG,FF,
  & UNID,GNAME,IGIS,IJCODE,CIJNAME
110   FORMAT(A6,2X,F6.1,2X,F6.1,2X,G12.6,2X,
  & I3,2X,A42,2X,I6,2X,I6,2X,A14)
    SUMFF=SUMFF+FF
10  CONTINUE
   PRINT *,SUMFF
   CLOSE (UNIT=10)
   CLOSE (UNIT=20)
C
   STOP
   END
C=============================================================
```

A.4 ALL.SAS

```
*================================================================
OPTIONS LS=132 PS=32400;
*================================================================
* SAS™ CODE TO PROCESS GRIDDED CO2 FOSSIL-FUEL EMISSION DATA,
*  GRID CELL LOCATIONS, COUNTRY NAMES AND COUNTRY IDENTIFICATION
*  CODES  FOR THE YEARS 1950, 1960, 1970, 1980 AND 1990
* WHERE:
* GEIAID = 1000*JGRID+IGRID
* LAT(ITUDE) = [(JGRID-91)+0.5] (DEGREES)
* LONG(ITUDE) = [(IGRID-181)+0.5] (DEGREES)
* FF = CO2 EMISSION FROM FOSSIL FUELS (1000 METRIC TONS C PER YEAR)
* UNID = UNITED NATIONS COUNTRY CODE
* GNAME =  UNITED NATIONS COUNTRY NAME
* IGIS = NASA-GISS COUNTRY NAME
* IJCODE = NASA-GISS COUNTRY/PROVINCE-REGION CODE
* CIJNAME = NASA-GISS COUNTRY/PROVINCE-REGION NAME
**================================================================
 * 1950;
DATA NEW5;
INFILE 'GRIDALL.50';
INPUT @1 GEIAID $CHAR6. @9 LAT 6.1 @17 LONG 6.1 @25 FF5 12.6
    @39 UNID 3. @44 GNAME $CHAR42.
    @88 IGIS 6. @95 IJCODE 6. @102 CIJNAME $CHAR14.;
RUN;
;
PROC SORT DATA=NEW5;
BY UNID;
PROC MEANS NOPRINT;
BY UNID;
ID GNAME IGIS;
VAR FF5;
OUTPUT OUT=FINAL SUM=SFF;
PROC PRINT;
VAR SFF GNAME IGIS UNID;
RUN;
;
* 1960;
DATA NEW6;
INFILE 'GRIDALL.60';
INPUT @1 GEIAID $CHAR6. @9 LAT 6.1 @17 LONG 6.1 @25 FF6 12.6
    @39 UNID 3. @44 GNAME $CHAR42.
    @88 IGIS 6. @95 IJCODE 6. @102 CIJNAME $CHAR14.;
RUN;
PROC SORT DATA=NEW6;
BY UNID;
PROC MEANS NOPRINT;
BY UNID;
ID GNAME IGIS;
VAR FF6;
OUTPUT OUT=FINAL SUM=SFF;
PROC PRINT;
VAR SFF GNAME IGIS UNID;
RUN;
;
```

```
* 1970;
DATA NEW7;
INFILE 'GRIDALL.70';
INPUT @1 GEIAID $CHAR6. @9 LAT 6.1 @17 LONG 6.1 @25 FF7 12.6
   @39 UNID 3. @44 GNAME $CHAR42.
   @88 IGIS 6. @95 IJCODE 6. @102 CIJNAME $CHAR14.;
RUN;
PROC SORT DATA=NEW7;
BY UNID;
PROC MEANS NOPRINT;
BY UNID;
ID GNAME IGIS;
VAR FF7;
OUTPUT OUT=FINAL SUM=SFF;
PROC PRINT;
VAR SFF GNAME IGIS UNID;
RUN;
;
* 1980;
DATA NEW8;
INFILE 'GRIDALL.80';
INPUT @1 GEIAID $CHAR6. @9 LAT 6.1 @17 LONG 6.1 @25 FF8 12.6
   @39 UNID 3. @44 GNAME $CHAR42.
   @88 IGIS 6. @95 IJCODE 6. @102 CIJNAME $CHAR14.;
RUN;
PROC SORT DATA=NEW8;
BY UNID;
PROC MEANS NOPRINT;
BY UNID;
ID GNAME IGIS;
VAR FF8;
OUTPUT OUT=FINAL SUM=SFF;
PROC PRINT;
VAR SFF GNAME IGIS UNID;
RUN;
;
* 1990;
DATA NEW9;
INFILE 'GRIDALL.90';
INPUT @1 GEIAID $CHAR6. @9 LAT 6.1 @17 LONG 6.1 @25 FF9 12.6
   @39 UNID 3. @44 GNAME $CHAR42.
   @88 IGIS 6. @95 IJCODE 6. @102 CIJNAME $CHAR14.;
RUN;
PROC SORT DATA=NEW9;
BY UNID;
PROC MEANS NOPRINT;
BY UNID;
ID GNAME IGIS;
VAR FF9;
OUTPUT OUT=FINAL SUM=SFF;
PROC PRINT;
VAR SFF GNAME IGIS UNID;
RUN;
;
*==============================================================
```

A.5 READMOD.F

```
C==========================================================
C PROGRAM TO READ ONE DEGREE GRIDDED POPULATION DATA AND THE
C  NASA-GISS COUNTRY/REGION-PROVINCE IDENTIFICATION CODES
C==========================================================
C
   REAL*8 SUM
   INTEGER POP(180,360)
   INTEGER IJCODE(180,360)
C
   OPEN(10,FILE='POPMOD.DAT',STATUS='OLD')
   OPEN(20,FILE='CNTYMOD.DAT',STATUS='OLD')
   OPEN(30,FILE='MOD.OUT',STATUS='UNKNOWN')
C
   WRITE(30,*)'POPULATION & NASA-GISS-ID'
   SUM=0.D0
C FROM NORTH > SOUTH
   DO 10 I=1,180
C FROM WEST > EAST:
     DO 10 J=1,360
       READ(10,'(I10)')POP(I,J)
       READ(20,'(I6)')IJCODE(I,J)
       SUM=SUM+POP(I,J)
C ECHO PRINT:
       WRITE(30,*)POP(I,J),IJCODE(I,J)
10    CONTINUE
   PRINT *,SUM
   CLOSE (UNIT=10)
   CLOSE (UNIT=20)
   CLOSE (UNIT=30)
   STOP
   END
C==========================================================
```

A.6 READCODE.F

```
C=========================================================
C PROGRAM TO READ THE NASA-GISS COUNTRY/STATE-PROVINCE CODE-IDS AND
C  NAMES AND THE LINKS BETWEEN THE NASA-GISS CODE-IDS WITH THE
C  UNITED NATIONS CODE-IDS AND NAMES
C=========================================================
C
      DIMENSION ICODE(355)
      CHARACTER*14 CNAME(355)
      DIMENSION IDUN(217),IGISS(217)
      CHARACTER*42 GNAME(217)
C
C CNTRY1X1.COD IDENTIFIES THE NASA-GISS COUNTRY/STATE
C  OR PROVINCE CODE-IDS AND NAMES
      OPEN (10,FILE='CNTRY1X1.COD',STATUS='OLD')
      DO 10 K=1,355
      READ (10,'(I6,5X,A14)') ICODE(K),CNAME(K)
   10 CONTINUE
      CLOSE(UNIT=10)
C
C GISSUN.COD LINKS THE NASA-GISS CODE-IDS WITH THE
C  UNITED NATIONS CODE-IDS AND NAMES
      OPEN(20,FILE='GISSUN.COD',STATUS='OLD')
      DO 20 I=1,217
      READ(20,'(6X,I3,4X,I6,2X,A42)')
     &IDUN(I),IGISS(I),GNAME(I)
   20 CONTINUE
      CLOSE(UNIT=20)
C
      STOP
      END
C=========================================================
```

A.7 INTEGRAT.F

```
C==============================================================
C PROGRAM TO INTEGRATE ONE DEGREE GRIDDED CO2 FOSSIL FUEL
C  EMISSION DATA (GRIDCAR.YEAR FILES) WITH INFORMATION ON LOCATION,
C  COUNTRY NAMES AND COUNTRY IDENTIFICATION CODES
C  (CNTYMOD.DAT, CNTRY1X1.COD AND GISSUN.COD)
C  FOR THE YEARS 1950, 1960, 1970, 1980 AND 1990.
C  NOTE THAT COUNTRY AND POLITICAL UNIT NAMES CHANGE OVER TIME.
C
C GEIAID = 1000*JGRID+IGRID
C TLAT(ITUDE) = [(JGRID-91)+0.5] (DEGREES)
C TLONG(ITUDE) = [(IGRID-181)+0.5] (DEGREES)
C FF = CO2 EMISSION FROM FOSSIL FUELS
C       (1000 METRIC TONS C PER YEAR/GRID CELL)
C IDUN = UNITED NATIONS COUNTRY CODE
C GNAME =  UNITED NATIONS COUNTRY NAME
C IGIS = NASA-GISS COUNTRY NAME
C IJCODE = NASA-GISS COUNTRY/PROVINCE-REGION CODE
C CIJNAME = NASA-GISS COUNTRY/PROVINCE-REGION NAME
C
C==============================================================
C
    REAL*8 FF(180,360)
    INTEGER IJCODE(180,360)
    INTEGER IGIS(180,360)
    CHARACTER*40 CIJNAME(180,360)
    INTEGER IDUN(180,360)
    CHARACTER*42 GNAME(180,360)

    INTEGER ICODE(355)
    CHARACTER*14 CNAME(355)

    INTEGER IIDUN(217),IIGISS(217)
    CHARACTER*42 GINAME(217)

    CHARACTER*6 GEIAID

    INTEGER YEAR
    REAL*8 SUM
C
    OPEN(40,FILE='CNTRY1X1.COD',STATUS='OLD')
    OPEN(50,FILE='GISSUN.COD',STATUS='OLD')
C INITIATE
    DO I=1,180
     DO J=1,360
      FF(I,J)=0.D0
      IJCODE(I,J)=0
      IGIS(I,J)=0
      CIJNAME(I,J)='                                        '
      IDUN(I,J)=0
      GNAME(I,J)='                                          '
     ENDDO
    ENDDO
```

```
   DO IJ=1,5
   SUM=0.D0
   IF(IJ.EQ.1) YEAR=1950
   IF(IJ.EQ.2) YEAR=1960
   IF(IJ.EQ.3) YEAR=1970
   IF(IJ.EQ.4) YEAR=1980
   IF(IJ.EQ.5) YEAR=1990
   IF(IJ.EQ.1) OPEN(10,FILE='GRIDCAR.50',STATUS='OLD')
   IF(IJ.EQ.2) OPEN(10,FILE='GRIDCAR.60',STATUS='OLD')
   IF(IJ.EQ.3) OPEN(10,FILE='GRIDCAR.70',STATUS='OLD')
   IF(IJ.EQ.4) OPEN(10,FILE='GRIDCAR.80',STATUS='OLD')
   IF(IJ.EQ.5) OPEN(10,FILE='GRIDCAR.90',STATUS='OLD')
   IF(IJ.EQ.1) OPEN(30,FILE='GRIDALL.50',STATUS='UNKNOWN')
   IF(IJ.EQ.2) OPEN(30,FILE='GRIDALL.60',STATUS='UNKNOWN')
   IF(IJ.EQ.3) OPEN(30,FILE='GRIDALL.70',STATUS='UNKNOWN')
   IF(IJ.EQ.4) OPEN(30,FILE='GRIDALL.80',STATUS='UNKNOWN')
   IF(IJ.EQ.5) OPEN(30,FILE='GRIDALL.90',STATUS='UNKNOWN')
C
   OPEN(20,FILE='CNTYMOD.DAT',STATUS='OLD')
C
   TLONG=-179.5
   TLAT=90.5
C FROM NORTH > SOUTH
   DO 10 I=1,180
    TLAT=TLAT-1.D0
    TLONG=-179.5
C FROM WEST > EAST:
    DO 10 J=1,360
C WRITE OUT EACH GRIDCELL:
     JGRID=TLAT+91.D0-0.5D0
     IGRID=TLONG+181.D0-0.5D0
C
     GEIAID='000000'
     IF (JGRID.LE.9) THEN
      WRITE (GEIAID(3:3),'(I1)') JGRID
     ELSEIF (JGRID.LE.99) THEN
      WRITE (GEIAID(2:3),'(I2)') JGRID
     ELSEIF (JGRID.LE.999) THEN
      WRITE (GEIAID(1:3),'(I3)') JGRID
     ENDIF
     IF (IGRID.LE.9) THEN
      WRITE (GEIAID(6:6),'(I1)') IGRID
     ELSEIF (IGRID.LE.99) THEN
      WRITE (GEIAID(5:6),'(I2)') IGRID
     ELSEIF (IGRID.LE.999) THEN
      WRITE (GEIAID(4:6),'(I3)') IGRID
     ENDIF
C
     READ(10,*)FF(I,J)
C
     READ(20,'(I6)')IJCODE(I,J)
C
C PROCESS CHANGES OVER TIME:
C
C CZECHOSLOVAKIA
   IF (IJCODE(I,J).EQ.4102) IJCODE(I,J)=4100
   IF (IJCODE(I,J).EQ.4101) IJCODE(I,J)=4100
```

```
C EAST & WEST PAKISTAN SPLIT AFTER 1971 INTO BANGLADESH AND PAKISTAN
      IF ((YEAR.LT.1972).AND.(IJCODE(I,J).EQ.1200))
     1  IJCODE(I,J)=20300
      IF ((YEAR.LT.1972).AND.(IJCODE(I,J).EQ.12400))
     1  IJCODE(I,J)=20300
      IF (IJCODE(I,J).EQ.20300) CIJNAME(I,J)='E&W PAKISTAN'

C FRENCH INDO-CHINA SPLITS IN 1954 INTO CAMBODIA, LAOS, AND THE VIETNAMS
      IF ((YEAR.LT.1955).AND.(IJCODE(I,J).EQ.8600))
     1  IJCODE(I,J)=20700
      IF ((YEAR.LT.1955).AND.(IJCODE(I,J).EQ.9200))
     1  IJCODE(I,J)=20700
      IF ((YEAR.LT.1955).AND.(IJCODE(I,J).EQ.17601))
     1  IJCODE(I,J)=20700
      IF ((YEAR.LT.1955).AND.(IJCODE(I,J).EQ.17602))
     1  IJCODE(I,J)=20700
      IF (IJCODE(I,J).EQ.17601) CIJNAME(I,J)='DEM. REP.VIETNAM'
      IF (IJCODE(I,J).EQ.17602) CIJNAME(I,J)='S VIETNAM REPUBLIC'
      IF (IJCODE(I,J).EQ.20700) CIJNAME(I,J)='FR INDO-CHINA'
C VIETNAM
      IF (YEAR.GE.1970.AND.
     &IJCODE(I,J).GE.17601.AND.IJCODE(I,J).LE.17602)
     &  IJCODE(I,J)=17600

C MALAYA SINGAPORE SPLITS IN 1957 INTO SINGAPORE AND PENINSULAR MALAYSIA
      IF ((YEAR.LT.1957).AND.(IJCODE(I,J).EQ.10101))
     1  IJCODE(I,J)=21000
      IF ((YEAR.LT.1957).AND.(IJCODE(I,J).EQ.14600))
     1  IJCODE(I,J)=21000
      IF (IJCODE(I,J).EQ.21000) CIJNAME(I,J)='MALAY SINGAPORE'
      IF (YEAR.GT.1959.AND.IJCODE(I,J).EQ.10101)
     1  IJCODE(I,J)=10100
      IF (IJCODE(I,J).EQ.10101) CIJNAME(I,J)='PEN MALAYSIA'
C WAS SABAH
      IF (YEAR.GE.1970.AND.IJCODE(I,J).EQ.10102) IJCODE(I,J)=10100
      IF (IJCODE(I,J).EQ.10102) CIJNAME(I,J)='SABAH'
C WAS SARAWAK
      IF (YEAR.GE.1970.AND.IJCODE(I,J).EQ.10103) IJCODE(I,J)=10100
      IF (IJCODE(I,J).EQ.10103) CIJNAME(I,J)='SARAWAK'

C RWANDA-URUNDI SPLIT AFTER 1961 INTO RWANDA AND BURUNDI
      IF ((YEAR.LT.1962).AND.(IJCODE(I,J).EQ.2600))
     1  IJCODE(I,J)=20400
      IF ((YEAR.LT.1962) .AND.(IJCODE(I,J).EQ. 13600))
     1  IJCODE(I,J)=20400
      IF (IJCODE(I,J).EQ.20400) CIJNAME(I,J)='RWANDA-URUNDI'

C RHODESIA-NYASALAND SPLIT AFTER 1963 INTO MALAWI, ZAMBIA, ZIMBABWE
      IF ((YEAR.LT.1964).AND.(IJCODE(I,J).EQ.10000))
     1  IJCODE(I,J)=20500
      IF ((YEAR.LT.1964).AND.(IJCODE(I,J).EQ.18300))
     1  IJCODE(I,J)=20500
      IF ((YEAR.LT.1964).AND.(IJCODE(I,J).EQ.18400))
     1  IJCODE(I,J)=20500
      IF (IJCODE(I,J).EQ.20500) CIJNAME(I,J)='RHODESIA-NYASALND'
```

```
C FRENCH EQUATORIAL AFRICA SPLITS IN 1959 INTO CENTRAL AFRICAN REPUBLIC,
C  CHAD, CONGO AND GABON
     IF ((YEAR.LT.1959).AND.(IJCODE(I,J).EQ.3000))
     1    IJCODE(I,J)=20800
     IF ((YEAR.LT.1959).AND.(IJCODE(I,J).EQ.3100))
     1    IJCODE(I,J)=20800
     IF ((YEAR.LT.1959).AND.(IJCODE(I,J).EQ.3600))
     1    IJCODE(I,J)=20800
     IF ((YEAR.LT.1959).AND.(IJCODE(I,J).EQ.5800))
     1    IJCODE(I,J)=20800
     IF (IJCODE(I,J).EQ.20800) CIJNAME(I,J)='CHAD,CONGO,GABON'

C FRENCH WEST AFRICA SPLITS IN 1958 INTO BENIN, BURKINA FASO, COTE DE IVOIRE,
C  GUINEA, MALI, MAURITANIA, NIGER, SENEGAL
     IF ((YEAR.LT.1958).AND.(IJCODE(I,J).EQ.1600))
     1    IJCODE(I,J)=20900
     IF ((YEAR.LT.1958).AND.(IJCODE(I,J).EQ.2400))
     1    IJCODE(I,J)=20900
     IF ((YEAR.LT.1958).AND.(IJCODE(I,J).EQ.6700))
     1    IJCODE(I,J)=20900
     IF ((YEAR.LT.1958).AND.(IJCODE(I,J).EQ.8200))
     1    IJCODE(I,J)=20900
     IF ((YEAR.LT.1958).AND.(IJCODE(I,J).EQ.10300))
     1    IJCODE(I,J)=20900
     IF ((YEAR.LT.1958).AND.(IJCODE(I,J).EQ.10600))
     1    IJCODE(I,J)=20900
     IF ((YEAR.LT.1958).AND.(IJCODE(I,J).EQ.12000))
     1    IJCODE(I,J)=20900
     IF ((YEAR.LT.1958).AND.(IJCODE(I,J).EQ.14300))
     1    IJCODE(I,J)=20900
     IF (IJCODE(I,J).EQ.20900) CIJNAME(I,J)='FR W AFRICA '

C TANZANIA
     IF (YEAR.GE.1970.AND.
     &IJCODE(I,J).GE.15901.AND.IJCODE(I,J).LE.15902)
     &    IJCODE(I,J)=15900
     IF (IJCODE(I,J).EQ.15901) CIJNAME(I,J)='TANGANYIKA'
     IF (IJCODE(I,J).EQ.15902) CIJNAME(I,J)='ZANZIBAR'

C PANAMA
     IF (YEAR.GE.1980.AND.
     &IJCODE(I,J).GE.12601.AND.IJCODE(I,J).LE.12602)
     &    IJCODE(I,J)=12600
     IF (IJCODE(I,J).EQ.12601) CIJNAME(I,J)='PANAMA CAN Z'
     IF (IJCODE(I,J).EQ.12602) CIJNAME(I,J)='PANAMA '

C NETHERLANDS ANTILLES AND ARUBA SPLIT AFTER 1985
     IF ((YEAR.LT.1985).AND.(IJCODE(I,J).EQ.11600))
     1    IJCODE(I,J)=20200
     IF ((YEAR.LT.1985).AND.(IJCODE(I,J).EQ.18700))
     1    IJCODE(I,J)=20200
     IF (IJCODE(I,J).EQ.20200) CIJNAME(I,J)='N ANTILLES AND ARUBA'
     IF (IJCODE(I,J).EQ.18700) CIJNAME(I,J)='ARUBA'
```

```
C LEEWARD ISLANDS SPLITS IN 1957 INTO ANTIGUA & BARBUDA, BRITISH VIRGIN
C  ISLANDS, MONTSERRAT AND SAINT KITTS-NEVIS
     IF ((YEAR.LT.1957).AND.(IJCODE(I,J).EQ.600))
     1    IJCODE(I,J)=20600
     IF ((YEAR.LT.1957).AND.(IJCODE(I,J).EQ.13700))
     1    IJCODE(I,J)=20600
     IF ((YEAR.LT.1957).AND.(IJCODE(I,J).EQ.18800))
     1    IJCODE(I,J)=20600
     IF(IJCODE(I,J).EQ.18800) CIJNAME(I,J)='BRITISH V.ISLANDS'
     IF ((YEAR.LT.1957).AND.(IJCODE(I,J).EQ.19400))
     1    IJCODE(I,J)=20600
     IF (IJCODE(I,J).EQ.19400) CIJNAME(I,J)='MONTSERRAT'
     IF (IJCODE(I,J).EQ.20600) CIJNAME(I,J)='LEEWARD ISLANDS'

C ST. KITTS-NEVIS-ANGUILLA SPLITS AFTER 1980
     IF ((YEAR.LT.1981).AND.(IJCODE(I,J) .EQ.13700))
     1    IJCODE(I,J)=20100
     IF ((YEAR.LT.1981).AND.(IJCODE(I,J).EQ.500))
     1    IJCODE(I,J)=20100
C ANGUILLA (500) HAS NO UN-ID (KEEP UNID == 658 FROM BEFORE SPLIT ? )
     IF (IJCODE(I,J).EQ.500.AND.YEAR.GT.1980) IDUN(I,J)=658
     IF (IJCODE(I,J).EQ.500) GNAME(I,J)='ANGUILLA '
     IF (IJCODE(I,J).EQ.20100) CIJNAME(I,J)='ST.KITTS-NEV-ANG'

C RYUKU ISLANDS HAS DATA FOR 1950-1972, OTHERWISE INCLUDED IN JAPAN
     IF ((YEAR.GT.1972).AND.(IJCODE(I,J).EQ.19700)) THEN
        IJCODE(I,J)=8400
        IGIS(I,J)=8400
     ENDIF
     IF (IJCODE(I,J).EQ.19700) CIJNAME(I,J)='RYUKU ISLANDS'

C CHRISTMAS ISLAND HAS DATA FOR 1970-1983, OTHERWISE INCLUDED IN AUSTRALIA
     IF ((YEAR.GT.1969).AND.(YEAR.LT.1984)) THEN
     IF (IJCODE(I,J).EQ.19100) CIJNAME(I,J)='XMAS ISLAND'
        GOTO 99
     ELSE
        IF (IJCODE(I,J).EQ.19100) CIJNAME(I,J)='XMAS ISLAND'
        IF (IJCODE(I,J).EQ.19100) IJCODE(I,J)=800
C XMAS ISLAND WILL BE OVERRIDDEN BY IJCODE(I,J)>EQ.800'S  NAME AUSTRALIA
 99  ENDIF

C AUSTRALIA
     IF (IJCODE(I,J).GE.800.AND.IJCODE(I,J).LE.807) THEN
      IDUN(I,J)=36
      IGIS(I,J)=800
      GNAME(I,J)='AUSTRALIA'
     ENDIF

C BRAZIL
     IF (IJCODE(I,J).GE.2100.AND.IJCODE(I,J).LE.2125) THEN
      IDUN(I,J)=76
      IGIS(I,J)=2100
      GNAME(I,J)='BRAZIL'
     ENDIF

C CANADA
     IF (IJCODE(I,J).GE.2800.AND.IJCODE(I,J).LE.2812) THEN
      IDUN(I,J)=124
      IGIS(I,J)=2800
      GNAME(I,J)='CANADA'
     ENDIF
```

```
C CHINA
   IF (IJCODE(I,J).GE.3300.AND.IJCODE(I,J).LE.3329) THEN
    IDUN(I,J)=156
    IGIS(I,J)=3300
    GNAME(I,J)='CHINA (MAINLAND)'
   ENDIF

C INDIA
   IF (IJCODE(I,J).GE.7501.AND.IJCODE(I,J).LE.7525) THEN
    IDUN(I,J)=356
    IGIS(I,J)=7500
    GNAME(I,J)='INDIA'
   ENDIF

C USA
   IF (IJCODE(I,J).GE.17101.AND.IJCODE(I,J).LE.17151
  &.AND.IDUN(I,J).NE.630) THEN
    IDUN(I,J)=840
    IGIS(I,J)=17100
    GNAME(I,J)='UNITED STATES OF AMERICA'
   ENDIF
   IF (IJCODE(I,J).EQ.17151) GNAME(I,J)='PUERTO RICO'

C USSR
   IF (IJCODE(I,J).GE.17201.AND.IJCODE(I,J).LE.17215) THEN
    IDUN(I,J)=810
    IGIS(I,J)=17200
    GNAME(I,J)='USSR'
   ENDIF

C AMERICAN SAMOA
   IF (IJCODE(I,J).EQ.18500) CIJNAME(I,J)='AM SAMOA'
C U.S VIRGIN ISLANDS
   IF (IJCODE(I,J).EQ.18900) CIJNAME(I,J)='US V ISLANDS'
C CAYMAN ISLANDS
   IF (IJCODE(I,J).EQ.19000) CIJNAME(I,J)='CAYMAN ISLANDS'
C GIBRALTAR
   IF (IJCODE(I,J).EQ.19200) CIJNAME(I,J)='GIBRALTAR'
C MACAU
   IF (IJCODE(I,J).EQ.19300) CIJNAME(I,J)='MACAU'
C NIUE
   IF (IJCODE(I,J).EQ.19500) CIJNAME(I,J)='NIUE'
C PACIFIC ISLANDS
   IF (IJCODE(I,J).EQ.19600) CIJNAME(I,J)='PAC ISLANDS'
C SAINT HELENA
   IF (IJCODE(I,J).EQ.19800) CIJNAME(I,J)='ST HELENA'
C ST PIERRE
   IF (IJCODE(I,J).EQ.19900) CIJNAME(I,J)='ST PIERRE'
C WAKE ISLAND
   IF (IJCODE(I,J).EQ.20000) CIJNAME(I,J)='WAKE ISLAND'
C ANTARCTICA
   IF (IJCODE(I,J).EQ.25300) CIJNAME(I,J)='ANTARCTICA'
C ANTARCTIC FISHERIES
   IF (IJCODE(I,J).EQ.18600) CIJNAME(I,J)='ANTARCTIC FISH'
C
C LESOTHO  (9400) HAS NO FOSSIL FUEL EMISSION DATA
C    IF (IJCODE(I,J).EQ.9400) IDUN(I,J)=426
C NAMIBIA (11200) HAS NO FOSSIL FUEL EMISSION DATA
C    IF (IJCODE(I,J).EQ.11200) IDUN(I,J)=516
C TUVALU (16700)  HAS NO FOSSIL FUEL EMISSION DATA AND NO UN-ID
C ANTARCTICA (25300) HAS NO FF EMISSION DATA NOR UN-ID
C KERGUELEN  (25500) HAS NO FF EMISSION DATA NOR UN-ID
C ANGUILLA (500) HAS NO IGIS-CODE NOR UN-ID
```

```
C
      DO K=1,355
       IF(I.EQ.1.AND.J.EQ.1.AND.IJ.EQ.1)
     & READ (40,'(I6,5X,A14)') ICODE(K),CNAME(K)
      ENDDO

      DO K=1,355
       IF (ICODE(K).EQ.IJCODE(I,J)) THEN
        CIJNAME(I,J)=CNAME(K)
        GOTO 911
       ENDIF
      ENDDO
911   CONTINUE

      DO K=1,217
       IF(I.EQ.1.AND.J.EQ.1.AND.IJ.EQ.1)
     & READ(50,'(6X,I3,4X,I6,2X,A42)')
     & IIDUN(K),IIGISS(K),GINAME(K)
      ENDDO

      DO K=1,217
       IF (IIGISS(K).EQ.IJCODE(I,J)) THEN
        GNAME(I,J)=GINAME(K)
        IDUN(I,J)=IIDUN(K)
        IGIS(I,J)=IIGISS(K)
        GOTO 912
       ENDIF
      ENDDO
912   CONTINUE

      IF(I.EQ.1.AND.J.EQ.1.AND.IJ.EQ.1) CLOSE(UNIT=40)
      IF(I.EQ.1.AND.J.EQ.1.AND.IJ.EQ.1) CLOSE(UNIT=50)

      WRITE(30,'(A6,2X,2(F6.1,2X),G12.6,2X,
     &I3,2X,A42,2X,
     &I6,2X,I6,2X,A14)')
     &GEIAID,TLAT,TLONG,FF(I,J),
     &IDUN(I,J),GNAME(I,J),
     &IGIS(I,J),IJCODE(I,J),CIJNAME(I,J)
C
      SUM=SUM+FF(I,J)
      TLONG=TLONG+1.D0
10    CONTINUE
C
      PRINT *,'IN YEAR:',YEAR,' CO2 EMISSIONS=',SUM,
     &' IN 1000 METRIC TONS C'
C IN YEAR:     1950 CO2 EMISSIONS=  1588607.5  IN 1000 METRIC TONS C
C IN YEAR:     1960 CO2 EMISSIONS=  2505231.8  IN 1000 METRIC TONS C
C IN YEAR:     1970 CO2 EMISSIONS=  3861021.8  IN 1000 METRIC TONS C
C IN YEAR:     1980 CO2 EMISSIONS=  5042867.8  IN 1000 METRIC TONS C
C IN YEAR:     1990 CO2 EMISSIONS=  5811613.7  IN 1000 METRIC TONS C
C
      CLOSE (UNIT=10)
      CLOSE (UNIT=20)
      CLOSE (UNIT=30)

      REWIND 10
      REWIND 20
      REWIND 30
```

```
C CLEAN:
   DO I=1,180
    DO J=1,360
     FF(I,J)=0.D0
     IJCODE(I,J)=0
     IGIS(I,J)=0
     CIJNAME(I,J)='                    '
     IDUN(I,J)=0
     GNAME(I,J)='                     '
    ENDDO
   ENDDO

   ENDDO

   STOP
   END
C=================================================================
```

INTERNAL DISTRIBUTION

1. T. A. Boden
2. A. L. Brenkert
3. M. D. Burtis
4. R. M. Cushman
5. S. G. Hildebrand
6. S. V. Jennings
7. S. B. Jones
8. D. P. Kaiser
9. P. Kanciruk
10. A. W. King
11. A. Kozyr
12. G. Marland
13. W. M. Post III
14 D. E. Shepherd
15. D. S. Shriner
16. L. D. Voorhees
17. Central Research Library
18-32. ESD Library
33-34. Laboratory Records Department
35. Laboratory Records Department ORNL- RC
36. ORNL Patent Section
37. Y-12 Technical Library

EXTERNAL DISTRIBUTION

38. Robert J. Andres, University of Alaska, Institute of Northern Engineering, School of Engineering, Fairbanks, AK 99775

39. Shelton S. Alexander, Pennsylvania State University, Department of Geosciences, 537 Deike Building, State College, PA 16802

40. William E. Asher, University of Washington, Joint Inst. for the Study of the Atmos. & the Ocean, Box 354235, Seattle, WA 98195

41. Jeff Banasek, UIC, Inc., P.O. Box 83, 1225 Channahon Road, Joliet, IL 60434

42. Robert Bidigare, University of Hawaii, Department of Oceanography, 1000 Pope Road, Honolulu, HI 96822

43. Harry L. Boston, Director, Environmental Restoration Program, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee 37831-6402

44. Peter G. Brewer, Monterey Bay Aquarium Res. Inst., P.O. Box 628, 7700 Sandholt Rd., Moss Landing, CA 95039

45. Michelle Broido, US Department of Energy, Environmental Sciences Div., ER-74, 19901 Germantown Road, Germantown, MD 20874

46. O. B. Brown, University of Miami, 4500 Rickenbacker Causeway, Miami, FL 33149

47. L. Brugmann, Stockhom University, Dept. of Geology and Geochemistry, S-106 91 Stockholm, Sweden

48. Robert H. Byrne, University of South Florida, Department of Marine Science, 140 Seventh Avenue, S, Saint Petersburg, FL 33701

49. Patrick A. Crowley, US Department of Energy, Environmental Sciences Div., ER-74, 19901 Germantown Rd., Germantown, MD 20874

50. E. G. Cumesty, ORNL Site Manager, Department of Energy, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831-6269

51. G. Cutter, Old Dominion University, Dept. of Oceanography, Norfolk, VA 23529

52. Roger C. Dahlman, US Department of Energy, Environmental Sciences Div., ER-74, 19901 Germantown Rd., Germantown, MD 20874

53. Giovanni Daneri, CEA Universidad del Mar, Dept. de Oceanografia y, Biologia Pesquera, Amunaategui 1838, Vina Del Mar, Chile

54. Database Section, Natl. Inst. for Envir. Studies, Center for Global Envir. Research, 16-2 Onogawa, Tsukuba, Ibaraki 305, Japan

55. Fred A. Donath, Institute for Environmental Education, Geological Society of America, 1006 Las Posas, San Clemente, California 92673

56. Jerry W. Elwood, US Department of Energy, Office of Energy Research, ER-74, 19901 Germantown Rd., Germantown, MD 20874

57. William R. Emanuel, Environmental Sciences Department, University of Virginia, Clark Hall, Charlottesville, VA 22903

58. Gerd Esser, Justus-Liebig-University, Inst. for Plant Ecology, Heinrich-Buff-Ring 38, D-35392 Giessen, Germany

59. Wanda Ferrell, US Department of Energy, Environmental Sciences Division, ER-74, 19901 Germantown Rd., Germantown, MD 20874

60. Diana W. Freckman, College of Natural Resources, 101 Natural Resources Building, Colorado State University, Fort Collins, Colorado 80523

61. Inez Y. S. Fung, University of Victoria, School of Earth & Ocean Sciences, P.O. Box 1700, MS 4015, Victoria, B.C. V8W 2Y2, Canada

62. Richard H. Gammon, University of Washington, Chemistry Department, Box 351700, Seattle, WA 98195

63. Jean-Pierre Gattuso, Observatoire Oceanologique Europeen, Avenue Saint-Martin, MC-98000, Monaco

64. Catherine M. Goyet, Woods Hole Oceanographic Inst., Marine Chemistry & Geochemistry Dept., 360 Woods Hole Road, MS #25, Woods Hole, MA 02543

65. David O. Hall, University of London, Div. of Biosphere Sciences, Kings's College Longon, Campden Hill Road, London W8 7AH, United Kingdom

66. A. Hittelman, WDC-A for Solid Earth Geophysics, NOAA Code E/GC1, 325 Broadway, Boulder, CO 80303

67. H. Hodgson, British Library, Boston Spa, DSC, Special Acquisitions, Wetherby, West Yorkshire, LS23 7BQ, United Kingdom

68. Huasheng Hong, Xiamen University, Environmental Science Res. Centre, Post Code 361005, Mail Box 1085, Xiamen, Fujian, People's Rep China

69. Carroll A. Hood, GCRIO, 2250 Pierce Road, Bay City, MI 48710

70. John C. Houghton, US Department of Energy, Environmental Sciences Div., ER-74, 19901 Germantown Rd., Germantown, MD 20874

71. David M. Karl, University of Hawaii, Dept. of Oceanography, 1000 Pope Road, Honolulu, HI 96822

72. Thomas R. Karl, National Climatic Data Center, 151 Patton Ave., Federal Bldg., Rm. 516E, Asheville, NC 28801

73. Charles D. Keeling, Scripps Inst. of Oceanography, University of California-San Diego, Mail Code 0220, 9500 Gilman Drive, 2314 Ritter Hall, La Jolla, CA 92093

74. Stephan Kempe, Schnittspahnstr. 9, D-64287 Darmstadt, Germany

75. K.-R. Kim, Seoul National University, Dept. of Oceanology, Seoul 151-7442, Korea

76. John C. Klink, Miami University, Department of Geography, 217 Shideler Hall, Oxford, OH 45056

77. E. Lewis, Brookhaven National Laboratory, Oceanographic Sci. Div., Upton, NY 11973

78. Jonathan J. Lloyd, Australian National University, Res. School of Biological Sciences, GPO Box 475, Canberra, ACT 2601, Australia

79. Jennifer A. Logan, Harvard University, Center for Earth & Planetary, Physics 108 Pierce Hall, 29 Oxford Street, Cambridge, MA 02138

80. Peter Lunn, US Department of Energy, Environmental Sciences Div., ER-74, 19901 Germantown Rd., Germantown, MD 20874

81. Thomas H. Mace, USEPA/Natl. Data Processing Div., MD-34, 79 TW Alexander Drive, Bldg. 4201, Durham, NC 27711

82. Elaine Matthews, NASA, Goddard Institute for Space Studies, 2880 Broadway, New York, NY 10025

83. James J. McCarthy, Harvard University, Museum of Comparative Zoology, 26 Oxford Street, Cambridge, MA 02138

84. P. Middleton, Science & Policy Assoc., Inc., 3445 Penrose Place, Suite 140, Boulder, CO 80301

85. Frank J. Millero, University of Miami, RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33149

86. R. E. Munn, University of Toronto, Inst. for Environmental Studies, Haultain Bldg. 170 College St., Toronto, Ontario M5S 1A4, Canada

87. Shohei Murayama, Natl. Inst. for Resources & Envir., Environmental Assessment Dept., 16-3 Onogawa, Tsukuba, Ibaraki 305, Japan

88. Shuzo Nishioka, Natl. Inst. for Envir. Studies, Global Environment Research Division, 16-2 Onogawa, Tsukuba, Ibaraki 305, Japan

89-90. Office of Scientific and Technical Information, P. O. Box 62, Oak Ridge, Tennessee 37831

91. Office of Assistant Manager for Energy Research and Development, U.S. Department of Energy, Oak Ridge Operations, P. O. Box 2001, Oak Ridge, Tennessee 37831-8600

92. Jao Ryoung Oh, Korea Ocean Research, & Development Inst., Chemical Oceanography Div., An San P.O. Box 29, Seoul 4325-600, Korea

93. Jos G.J. Olivier, RIVM, Lab for Waste Materials & Emissions, P.O. Box 1, NL-3720 BA Bilthoven, Netherlands

94. Bobbi Parra, US Department of Energy, Environmental Sciences Division, ER-74, 19901 Germantown Rd., Germantown, MD 20874

95. William Parton, Colorado State University, Natural Resource Ecology Lab, Fort Collins, CO 80523

96. Ari Patrinos, US Department of Energy, ER-74, 19901 Germantown Rd., Germantown, MD 20874

97. Tsung-Hung Peng, NOAA/AOML, Ocean Chemistry Division, 4301 Rickenbacker Causeway, Miami, FL 33149

98. B. Preselin, University of California, Dept. of Biological Sciences, Santa Barbara, CA 93106

99. Paul D. Quay, University of Washington, School of Oceanography, Box 357940, Seattle, WA 98195

100. Roberta Y. Rand, USDA, Global Change Data & Info. Management, 10301 Baltimore Blvd., Beltsville, MD 20705

101. S. Ichtiaque Rasool, 52 Blvd. de Sebastopol, 5th Floor, 75003 Paris, France

102. Joachim Ribbe, University of Washington, Joint Institute for the Study of the Atmosphere and Oceans, Box # 35425, Seattle, WA 98195

103. Michael R. Riches, US Department of Energy, OHER, ER-74, 19901 Germantown Rd., Germantown, MD 20874

104. Jorge L. Sarmiento, Princeton University, Atmospheric and Oceanic, Sciences Program, P.O. Box CN710, Sayre Hall, Princeton, NJ 08544

105. G. S. Sayler, Director, Center for Environmental Biotechnology, The University of Tennessee, 1015 Research Drive, Suite 100, Knoxville, Tennessee 37932-2567

106. Alan M. Shiller, Univ. of Southern Mississippi, Center for Marine Science, Stennis Space Center, Bay Saint Louis, MS 39529

107. Kiminori Shitashima, Central Research Institute of Electric Power Industry, Marine Science Group, 1646, Abiko, Abiko-city, Chiba, 270-11, Japan

108-207. Timmothy W. Stamm, CDIAC, University of Tennessee, EERC, 10521 Research Drive, Suite 100, Knoxville, TN 37932

208. Michel H. C. Stoll, Netherlands Inst. for Sea Research, Dept. MCG, P. O. Box 59, 1790 Abden Burg-Texel, Netherlands

209. Eric T. Sundquist, US Geological Survey, Quissett Campus, Branch of Atlantic Marine Geology, Woods Hole, MA 02543

210. Taro Takahashi, Columbia University, Lamont-Doherty Earth Obs., Climate/Environment/Ocean Div., Rt. 9W, Palisades, NY 10964

211. Pieter P. Tans, Natl. Oceanic & Atm. Adm., CMDL, Maincode R/E/CG1, 325 Broadway, Boulder, CO 80303

212. John A. Taylor, Australian Natl. University, CRES, GPO Box 4, Canberra, ACT 0200, Australia

213. John R. G. Townshend, University of Maryland, Dept. of Geography, 1113 Lefrak Hall, College Park, MD 20742

214. J. Tucker, Marine Biological Lab, Woods Hole, MA 02543

215. Douglas W. R. Wallace, Brookhaven National Lab, Oceanographic & Atmos. Sciences Div., P.O. Box 5000, Upton, NY 11973

216. Carol Watts, Natl. Oceanic & Atm. Adm., Central Library, 1315 East-West Hwy., 2nd Floor, SSMC 3, Silver Spring, MD 20910

217. Ray F. Weiss, Scripps Inst. of Oceanography, University of California, Mail Code A-020, Room 2271, Ritter Hall, La Jolla, CA 92093

218. Chi Shing Wong, Government of Canada, Institute of Ocean Sciences, P.O. Box 6000, 9860 West Saanich Road, Sidney, BC V8L 4B2, Canada

219. L. Xu, Xiamen University, Environmental Science, Research Center, Xiamen, Fujian, People's Rep China

220. Yoshifumi Yosuoka, Natl. Inst. for Envir. Studies, Center Global Environment Research, 16-2 Onogawa, Tsukuba, Ibaraki 305, Japan