CDIAC Communications

Carbon Dioxide Information Analysis Center
World Data Center for Atmospheric Trace Gases
Oak Ridge National Laboratory

My First Antarctic Cruise

by Alex Kozyr, CDIAC

March 2002
Issue No. 29

http://cdiac.ornl.gov/

Editor:
Sonja Jones

Mission accomplished! The mission of my life, that is! With pride, I can now say that I have sailed in every ocean of the world! My most recent expedition was sailing and collecting carbon dioxide (CO_2) samples in the Southern Ocean, amid blustery storms, heavy ice, and of course, the beautiful Antarctic. Although I did not actually set foot on the continent of the Antarctic (another dream of mine), I was, in reality, only a few hundred yards from its beautiful coast.

Plans for my expedition to the Antarctic actually began with a telephone call. An oceanographer colleague of mine at the Pacific Marine Environmental Laboratory (PMEL) in Seattle, Washington, telephoned one day and posed the question, "Alex, how would you like to go on a cruise, a cruise to the Antarctic?" Would I! A few short weeks after I had accepted the invitation to participate in the expedition to the Antarctic, I received a large package from the Australian Antarctic Division (AAD) containing several books about the Antarctic and the Australian National Antarctic Research Expeditions (ANARE) operations. Along with procedure books were many, many forms, including numerous medical examination forms. I have never had so many medical tests and so much blood taken from me in my life! At one point, I was convinced that I must certainly have no blood left in my body. After all the testing, I felt fit enough to fly into space (maybe later I will, but my mission at hand was to collect CO_2 samples in the Antarctic). At last my efforts were rewarded; the final page of the medical examination forms was returned to me stamped "*HEALTHY*"!

(Continued on p. 6)

Penguins, expeditioners, and the R/V *Aurora Australis* in the Antarctic

What's Inside ...

CDIAC Communications, funded by the U.S. Department of Energy's Office of Science Biological and Environmental Research Program, is published and distributed free of charge periodically by the Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory (ORNL). ORNL is managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract DE-AC05-00OR22725. *ISSN 1053-1106*

CDIAC's DOE Program Manager: Wanda Ferrell

Direct from the *Director*

I am pleased to note the concept of a centralized data management system that is developing, albeit slowly, for the network of Free-Air CO_2 Enrichment (FACE) sites around the world. In contrast to earlier CO_2 enrichment studies conducted in growth chambers and open-top chambers, FACE studies are far more realistic in terms of both permitting longer-term studies of larger individual plants and vegetation systems, and minimizing the effects of the experimental apparatus (although efforts are under way to quantify the effects of the blowers used to distribute the CO_2 in some of the designs). A few years ago, CDIAC began a FACE Web site (**http://cdiac.ornl.gov/programs/FACE/face.html**) to support the dozens of sites already conducting FACE research, or with FACE research in development or proposed. That list has now grown to more than 30 sites, studying ecosystems such as natural grasslands and tropical forests, and agricultural crops such as grapes and rice.

The kinds of data to be generated by the sites may be broadly categorized as (1) operational or system-performance data and (2) response data. The former group includes quantification of the (significant) cost of the CO_2 needed to maintain the elevated ambient levels and verification of how successful the engineered systems were in maintaining the target concentrations within the study areas. The latter group includes a host of ecological and agronomic measurements, such as biomass, species composition, growth, and yield data. Historically, users of data concerning the effects of elevated CO_2 on plants, from studies in growth chambers or open-top chambers, have assumed that the target concentrations of CO_2 were successfully maintained, and that excursions were not a significant problem. But FACE systems are far more complex, and users of effects data need to give serious attention to the environmental conditions actually experienced by the plants.

CDIAC has, to date, focused on the response data. Fortunately, George Hendrey's group at Brookhaven National Laboratory (BNL) (**http://www.face.bnl.gov/**) — which developed the engineering approach being used at many of the FACE sites — has been able to take the lead in compiling operational data for sites using their design. CDIAC and BNL are working together to develop a data management plan that will provide a secure archive for the voluminous operational data while offering users concise and understandable summaries of system performance that can be used in interpreting the response data.

Meanwhile, CDIAC will also work with the many individual FACE researchers to provide access to their data — either through holdings at CDIAC or through links to data held at the FACE sites themselves. We are pleased to note that the first of the data to be archived and distributed by CDIAC consist of data from the FACE site operated by Rich Norby and his colleagues at Oak Ridge National Laboratory. CDIAC is working with investigators at several other sites around the world to offer additional data sets.

I expect that much of the benefit from FACE research will come not from analyses of the individual data sets from individual FACE sites, but rather from syntheses (including meta-analyses) from multiple data sets. To facilitate such analyses across data sets and across sites, we have begun to work on a consistent set of variables and units, so that attempts to integrate data will not get tripped up by issues of nomenclature.

It is my hope that the data management approach being developed by CDIAC, in partnership with our colleagues at BNL, will work to the benefit of both FACE researchers and users of their data.

Bob Cushman, Director
Carbon Dioxide Information Analysis Center

Trends Online Additions and Updates

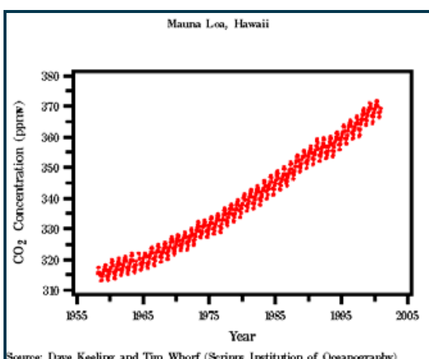
Atmospheric Trace Gas Concentrations

Carbon Dioxide and Carbon Isotopes

Atmospheric CO_2 records from sites in the SIO air sampling network *(C. D. Keeling and T. P. Whorf)*
http://cdiac.ornl.gov/trends/co2/sio-keel.htm

Ambient atmospheric CO_2 data from the Mauna Loa Observatory, Hawaii; Barrow, Alaska; Cape Matatula, American Samoa; and the South Pole have been updated with data through 2000.

The Mauna Loa atmospheric CO_2 measurements, which began in 1958, constitute the longest continuous record of atmospheric CO_2 concentrations available in the world. The Mauna Loa site is considered one of the most favorable locations for measuring undisturbed air because the possible local influences of vegetation or human activities on atmospheric CO_2 concentrations are minimal and any influences from volcanic vents may be excluded from the records. The methods and equipment used to obtain these measurements have remained essentially unchanged during the four-decade-long monitoring program.



Between 1958 and 2000, the Mauna Loa record shows a 17% increase in the mean annual concentration, from 315.98 parts per million by volume (ppmv) of dry air to 369.40 ppmv. The increase in mean annual concentration from 1999 to 2000 was 1.1 ppmv. (The largest single yearly jump in the Mauna Loa record was the 2.9 ppmv increase from 1997 to 1998.)

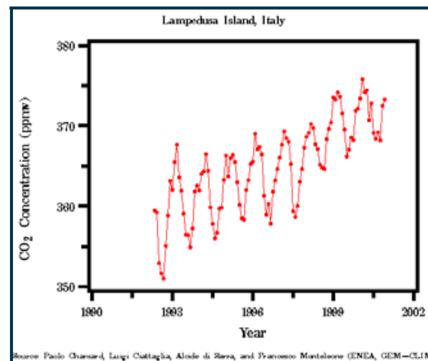
The annual CO_2 concentration at Barrow has risen from 332.8 ppmv in 1974 to 370.73 ppmv in 2000. This represents an annual increase exceeding 1.4 ppmv per year. The Barrow record is considered indicative of maritime air masses and shows the large seasonal amplitude typical of high northerly latitude sites.

At Cape Matatula, the annual average concentration of CO_2 rose from 340.6 ppmv in 1982 to 368.1 ppmv in 2000. This represents an annual growth rate of ~1.5 ppmv per year at American Samoa.

The SIO CO_2 record from the South Pole shows that annual averages of atmospheric CO_2 concentrations rose from 314.8 ppmv in 1958 to 366.9 ppmv in 2000, representing an annual increase exceeding 1.2 ppmv per year.

The Mauna Loa data are also available in NDP-001. (See page 11.)

Atmospheric CO_2 from flask measurements at Lampedusa Island *(P. Chamard et al.)*
http://cdiac.ornl.gov/trends/co2/lampis.htm

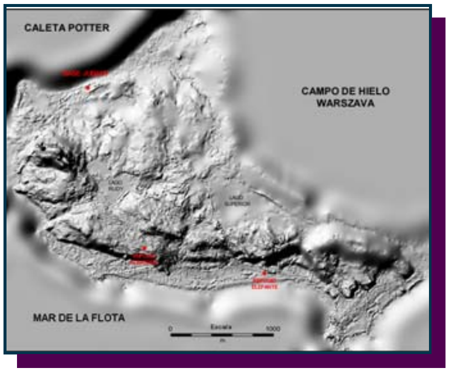


From May 1992 through December 2000, air samples were collected in glass flasks at the Lampedusa Station, on a rocky seashore on the eastern tip of Lampedusa Island, located south of Sicily in the central Mediterranean Sea.

On the basis of annual averages calculated from monthly averages, CO_2 levels at Lampedusa Island rose from 360.80 ppmv in 1993 to 371.27 ppmv in 2000. The data show an average trend of +1.5 ppmv per year. The record from Lampedusa Station exhibits a seasonal pattern, with maximum values measured during late winter or spring and minimum values recorded during the northern summer. The average annual cycle has an amplitude of about 10 ppmv. During the period of investigation, the annual growth rate varied between 0.5 and 4.0 ppmv per year, and the amplitude of the annual cycle, between 7 and 11 ppmv per year.

Atmospheric CO_2 record from continuous measurements at Jubany Station, Antarctica
(L. Ciattaglia et al.)
http://cdiac.ornl.gov/trends/co2/jubany.htm

The Italian National Research Program in Antarctica has taken continuous atmospheric CO_2 measurements at Jubany Station, Antarctica, since March 1994. Jubany Station is situated on King George Island, in the South Shetland archipelago north of the Antarctic Penisula. Based on annual averages calculated from monthly averages running from March 1994 through December 2000, CO_2 levels at Jubany have risen from 356.75 ppmv in 1994 to 366.69 ppmv in 2000.

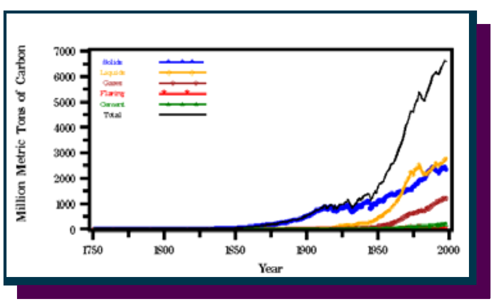


The general deceleration trend in the atmospheric CO_2 concentration first observed during 1997–1998 at Jubany and other Antarctic stations the World Meteorological Organization's (WMO's) Global Atmospheric Watch network may have been caused by several factors, such as anomalies in sea surface and air temperatures and changes in general atmospheric circulation.

Greenhouse Gas Emissions

Carbon Dioxide Emissions from Fossil-Fuel Consumption

Global, regional, and national fossil-fuel CO_2 emissions *(G. Marland et al.)*
http://cdiac.ornl.gov/trends/emis/em_cont.htm



Since 1751, roughly 270 billion tons of carbon have been released to the atmosphere from the consumption of fossil fuels and cement production. Half of these emissions have occurred since the mid-1970s. The 1998 fossil-fuel emission estimate for global CO_2 emissions—6608 million metric tons of carbon—represents a 0.3% decline from 1997. This small 1997–1998 decline is the first decline in the global record since a 1.6% decline from 1991 to 1992.

Globally, liquid and solid fuels accounted for 77.7% of the emissions from fossil-fuel burning in 1998. Combustion of gas fuels (e.g., natural gas) accounted for 18.5% (1220 million metric tons of carbon) of the total emissions from fossil fuels in 1998 and reflects a gradually increasing global utilization of natural gas. Emissions from cement production fell slightly, to 207 million metric tons of carbon, but this is still a 20-fold increase since the 1920s. Emissions from gas flaring for 1998 were estimated to be 47 million metric tons of carbon, well below the levels of the 1970s. Collectively, emissions from cement production and gas flaring comprised 4% of total emissions for 1998.

Trends Online provides data and graphics for global, regional, and national CO_2 emissions estimates from the combustion of fossil fuels, gas flaring, and the production of cement; Kyoto-related fossil-fuel CO_2 emission totals for the Annex B and non-Annex B countries from 1990 through 1998; the 1998 top 20 fossil-fuel CO_2 emitting countries; the world's countries ranked by 1998 total fossil-fuel CO_2 emissions; and the world's countries ranked by 1998 fossil-fuel CO_2 per capita emission rates.

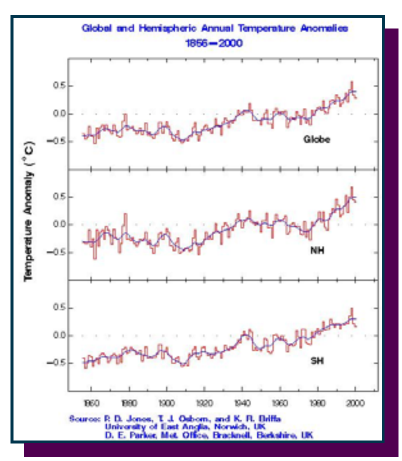
These data are also available in NDP-030. (See page 11.)

Climate

Temperature

Global and hemispheric temperature anomalies-land and marine instrumental records *(P. D. Jones et al.)*
http://cdiac.ornl.gov/trends/temp/jonescru/jones.html

These global and hemispheric temperature anomaly time series, which incorporate land and marine data, are updated and expanded annually. The land portion of the database, from which the time series are computed, consists of surface air temperature (SAT) data (land-surface meteorological data and fixed-position weather ship data) that have been corrected for nonclimatic errors, such as station shifts and/or instrument changes. The reanalysis of land surface data has resulted in the inclusion of over 1000 additional stations, a new reference period common to all stations (1961–1990; previously 1950–1979), and an increased grid-box resolution of the temperature anomalies (5° × 5°). The marine data used in the present analysis consist of sea surface temperatures (SSTs) that incorporate in situ measurements from ships and buoys. The two constituent data sets (SAT and SST) were combined, and the resulting data set has been used extensively in various Intergovernmental Panel on Climate Change (IPCC) reports. The global-mean temperature changes evident in the record have been interpreted in terms of anthropogenic forcing influences and natural variability.



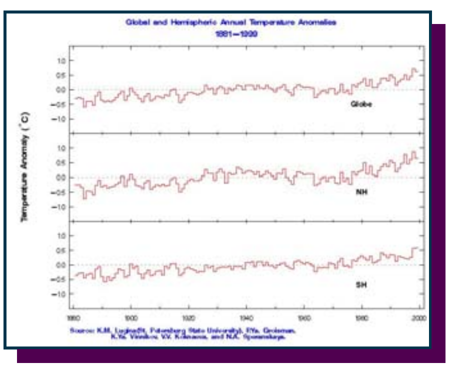
Trends in annual mean temperature anomalies for the globe show relatively stable temperatures from the beginning of the record through about 1910, with relatively rapid and steady warming through the early 1940s, followed by another period of relatively stable temperatures through the mid-1970s. From this point onward, another rapid rise similar to that in the earlier part of the century is observed. The warmest year of the global mean temperature series to date occurred in 1998, with an anomaly 0.57°C above the mean temperature of the 1961–1990 reference period. The next warmest year of the record occurred in 1997. The 1961–1990 reference period means for the globe, the Northern Hemisphere, and the Southern Hemisphere are 14.0°C, 14.6°C, and 13.4°C, respectively. The year 2000 also saw a significant positive temperature anomaly (0.29°C) but represents a cooling compared with the recent very warm years of 1997 and 1998. Still, 2000 ties 1991 for the sixth warmest year in the global record, and the eight warmest years of the global record have all occurred since 1990. These are, in descending order, 1998, 1997, 1995, 1990, 1999, 2000 and 1991 (tie), and 1994.

A good general description of the full period of record at this time indicates that the average surface air temperature of the globe has warmed ~0.5°C since the middle of the nineteenth century. In addition, with the exception of the last few years of the record, the warming has varied in extent and magnitude across the globe, and a few areas have cooled since the nineteenth century.

Monthly surface air temperature time series area-averaged over the 30-degree latitudinal belts of the globe, 1881–1999 *(K. M. Lugina et al.)*

http://cdiac.ornl.gov/trends/temp/lugina/lugina.html

Supplemented with information from different national publications, these mean monthly and annual values of surface air temperature have been taken mainly from the *World Weather Records*, *Monthly Climatic Data for the World*, and *Meteorological Data for Individual Years over the Northern Hemisphere, excluding the USSR*. This particular version of the station temperature archive (used for evaluation of the zonally averaged temperatures) was created in 1995. The total number of stations in the Northern Hemisphere and Southern Hemisphere was 384 and 301, respectively.



These show that the Northern Hemisphere has warmed at a rate of 0.6°C/100 years, and the Southern Hemisphere at a rate slightly greater than 0.5°C/100 years. The warming rate for the globe is slightly less than 0.6°C/100 years (0.58°C/100 years), a trend very close to that calculated by Jones et al. (See page 4.)

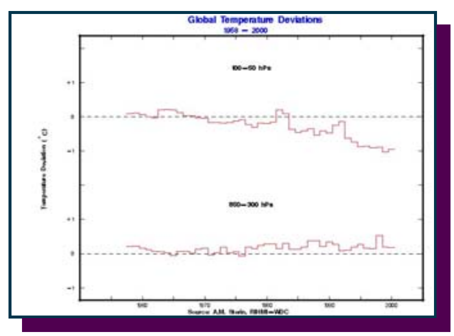
In the global records, like other records, these anomalies show that the 1980s, and particularly the 1990s, were much warmer than the years in the rest of the record. In the global record, the ten warmest years have occurred since 1981. In descending order they are 1998, 1995, 1990, 1997, 1991, 1988, 1987, 1981, 1994, and 1989. The mean temperature deviation for the 1990s is 0.42°C. The mean temperature deviation for the entire record is -0.02°C including the 1990s and -0.06°C without them. The warming in the 1990s is unprecedented.

Tropospheric and lower stratospheric temperature anomalies based on global radiosonde network data

(A. M. Sterin)

http://cdiac.ornl.gov/trends/temp/sterin/sterin.html

The observed radiosonde data from the Comprehensive Aerological Reference Data Set (CARDS) is the most complete collection of radiosonde data available, including data for more than 2,500 stations. These CARDS data were used to compute monthly mean temperature values for two atmospheric layers: the lower stratosphere (100hPa–50hPa) and the troposphere (850hPa–300hPa), over the globe, the tropics (20°N–20°S), the northern extratropics (20°N–90°N), and the southern extratropics (20°S–90°S). The series are updated on an annual basis. For the preliminary update, anomalies obtained from the Global Telecommunications System (GTS) global network radiosonde data collected at the All-Russian Research Institute of Hydrometeorological Information—World Data Center (RIHMI-WDC) were used. A more precise final update is obtained from the CARDS database when it is completed for each year. Estimates of linear trends in these temperature anomaly time series indicate strong cooling in the lower stratosphere. This cooling occurs both in the full-length time series (beginning in 1958) and in shorter time series [beginning in 1979 for comparison with the microwave sounding unit (MSU) time series].



For the globe, the temperature trends in the lower stratosphere are !0.236°C/decade for the 1961–1999 series and about !0.458°C/decade for the 1979–1999 series. The temperature trends in the troposphere for the globe are: +0.060°C/decade for the 1961–1999 series; +0.051°C/decade for the 1958–1999 series; and are about +0.010°C/decade for the 1979–1999 series. This slight warming trend is, to a large extent, a result of adding 1998 data, which reflect the very strong El Nino phenomenon of that year. However, for the tropospheric temperature trends over the globe estimated for the 1979–997 series, a slight cooling (-0.03°C/decade) is found.

My First Antarctic Cruise (Continued from p. 1)

My expedition to the Antarctic began with my departure from Oak Ridge, Tennessee, on 24 October 2001. After a brief two-day stop at PMEL to attend a training course on carbonate system equipment operations, I was really on my way. In spite of the long flight to Australia and the jet lag I suffered, as soon as I arrived in Hobart, Tasmania, on 28 October, I crawled down to the port to see the ship on which I would be sailing for the next 45 days. At first, the ice-breaking research vessel (R/V) *Aurora Australis* did not impress me as a ship capable of sailing through the heavy Antarctic ice (I still remembered the huge Russian commercial icebreaker *Ermak* on which I spent 30 days studying heavy Arctic ice in 1985). Later, however, I was most impressed by the power and comfort of the *Aurora Australis*.

The following day I boarded the ship, spent several hours exploring it, was issued clothing from AAD appropriate for the Antarctic climate, and attended a variety of safety courses (some of which included movies and pictures portraying potential hazards of the job). Promptly at 2100 hours, the *Aurora Australis* set sail from the Hobart port, and away from a noisy crowd of family and friends.

Participating in the Antarctic expedition were 70 oceanographers (or "expeditioners" as we were called) and 23 crew members from 11 countries. The expedition would take us from Hobart, Tasmania, Australia, to the Antarctic coast and back. By the early morning hours of 30 October, we were busy collecting samples at the first oceanographic station on our route.

My responsibilities during the expedition included sampling and measuring the carbon-related parameters [total carbon dioxide (TCO_2) and total alkalinity (TALK)]. Since this article is not a cruise or data report, I will not discuss the sampling and measuring of TCO_2 and TALK. However, the fact that the Southern Ocean accounts for approximately 25% of oceanic uptake of CO_2 from the atmosphere emphasizes the importance of these measurements. The CO_2 measurement group on board the *Aurora Australis* consisted of Bronte Tilbrook (our group leader), Mark Pretty, Richard Matear [all of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Holbart, Tasmania, Australia], and me (of CDIAC). Perhaps because I was a guest in Australia, or perhaps because I was born during the first International Geophysical Year (1957), I was lucky enough to be assigned by the group leader (also my shift mate) to the 12-hour day shift, which extended from 1200 hours to 0000 hours. During this 45-day expedition, I learned much from Bronte Tilbrook: not only how to take high-quality measurements, but how to speak authentic Australian. I definitely enjoyed sharing my 12-hour shift every day with such an experienced oceanographer as Dr. Tilbrook.

Each day, I learned more about the ship, the other expeditioners, and the Southern Ocean. I was surprised by the number and variety of oceanographic measurements that were performed during this expedition. Everything one might imagine was being measured in the seawater. One scientist on board the *Aurora Australis* was studying squids. At every oceanographic station we occupied after dark, this scientist could be found fishing for squids with his special squid-fishing equipment (squid fishing is conducted in the dark). All the squids he caught were measured, weighed, and frozen for further research at a laboratory on land. The squid scientist was very proud of his catch — 23 squids during the entire expedition, more than any of his colleagues had caught before!

For the first half of the expedition, every day seemed the same: station after station, samples, measurements, food (a lot of food!), high winds, heavy seas, and after each shift, a sauna and/or a beer in the bar and conversations with new friends from all over the world.

(Continued on p. 7)

Alex (second from left) during the *Ermak* Arctic Expedition, 1985

Alex during the *Aurora Australis* Antarctic Expedition, 2001

Alex inside the CO_2 laboratory

Everything changed when the ship sailed into the heavy sea ice. The expeditioners spent more of their spare time out on deck or up on the captain's bridge. First iceberg! It was a very exciting moment for those of us who were visiting the Antarctic for the first time. This iceberg was not the largest that we saw during the expedition, but it was the first! The ship circled this tiny iceberg a number of times, so that all the expeditioners had the opportunity to see it and take many pictures. We were so excited seeing everything for the first time. Our first penguin was also a big deal: maybe he was a little too far away, but he was the first penguin we saw!

Once we crossed the Antarctic Circle, darkness during the night hours ceased. We spent hours out on deck looking at everything the Antarctic had to offer. It was bitterly cold, but our clothes were appropriate for the Antarctic climate. On the cold night of 29 November, we spent more then 5 hours out on deck, as the *Aurora Australis* came within a few hundred yards of the Antarctic coast, near Buchanan Bay and Mertz Glacier, at approximately 67E00' S and 144E45' E. We threw a huge party to celebrate the crossing of the Antarctic Circle. (First-timers and even others on board were subjected to the "jests" of "King Neptune and his guards".)

The most memorable day during the expedition was on 2 December. The expeditioners were allowed to spend the entire day out on the shelf ice in the sunshine and relatively warm (~20E–25EF) temperatures. We had a lot of fun playing soccer on the ice for an audience of penguins. The highlight of the day, however, was a marriage proposal given by a young German biologist to his girlfriend. He could not have found a more romantic place on the Earth than the Antarctic shelf ice!

All too soon, it was time to return to Hobart. Due to the better-than-average weather we had experienced during the expedition, we had a few extra days and were able to revisit some of the stations on our way back. After 45 days at sea, occupying more than 130 stations, and sailing more then 3000 nautical miles, the *Aurora Australis* sailed back into the Hobart port early on the beautiful, sunny morning of 12 December 2001.

It was such a great feeling to come home after the successful completion of this expedition. With valuable, high-quality data and information stored in my computer and memories of the Antarctic stored in my head, I can say without hesitation that this was the most exciting oceanographic expedition I have taken during my career.

Photos from the R/V *Aurora Australis* Antarctic Voyage 3 can be seen at:
http://cdiac.ornl.gov/oceans/cruise.html

Focus Area Outreach

FACE Free-Air CO_2 Enrichment

http://cdiac.ornl.gov/programs/FACE/ornldata/ornldata.html

CDIAC has begun to archive and distribute data from the ORNL FACE research site. The first of the ORNL FACE databases available from the CDIAC FACE Web site includes weather-related data (air temperature, relative humidity, solar radiation, soil temperature, precipitation, wind) from 1999–2001; Future data sets will cover measured CO_2 concentrations in the experimental rings, tree basal area, and other response variables.

Additional information on CDIAC's FACE role is noted on page 2 in "Direct from the Director."

Global Change Climate Data

Dale Kaiser presented the paper "Assessing observed temperature and cloud amount trends for China over the last half of the twentieth century: What can the sunshine duration record tell us?" at the Science Team Meeting of the United State and Peoples' Republic of China Joint Agreement on Global and Regional Climate Change in Washington, D.C. (see **http://www.er.doe.gov/production/ober/doeprc.html**).

CDIAC summer student Daria Scott, representing St. Cloud State University, Minnesota, presented the paper "Evidence for a recent advance in the timing of a surface-air warming singularity in late winter over the north central United States," co-authored with CDIAC's T. J. Blasing and Dale Kaiser, at the AMS 13th Symposium on Global Change and Climate Variations in Orlando, Florida. The paper concludes that "termination of winter" tended to show up earlier in 1976–1999 than it did in 1952–1975, although it is not clear whether this is a response to global warming or part of a natural oscillation in the earth-atmosphere system.

T. J. Blasing presented "Global warming: Hot air and cold facts" at the March meeting of the AMS Smoky Mountain Chapter in Knoxville, Tennessee. The talk began with a description of the basic physical chemistry underlying the radiative properties of greenhouse gases and the observed increases in atmospheric concentrations of greenhouse gases, and proceeded to the more controversial topic of how they might be related to the observed warming of the lower atmosphere.

Ocean Data

http://cdiac.ornl.gov/oceans/home.html

Alex Kozyr attended the North Pacific Marine Science Organization (PICES) CO_2 Data Integration Test Workshop in Sidney, British Columbia, and participated in discussions on the synthesis of ocean CO_2 data from the North Pacific region. The workshop included representatives from Canada, Japan, and the United States. Among the recommendations of the workshop was the compilation of an International North Pacific Data Inventory for CO_2 and CO_2-related data. A follow-up CO_2 Data Integration Implementation Workshop is planned for Tokyo in May. Alex Kozyr was part of a multi-institution synthesis team of oceanographers presenting posters at the Oceanography Society's Biennial Scientific Meeting in Miami Beach, Florida. The posters described analyses conducted as part of the Joint Global Ocean Flux Study on a Pacific Ocean data set with over 36,000 unique sample locations.

Alex Kozyr also presented the poster "Electronic tour through the Carbon Dioxide Information Analysis Center's Ocean Web page" at the 10th annual PICES meeting in Victoria, British Columbia, Canada.

Alex Kozyr participated in a sampling cruise in the Southern Ocean on board the Australian research vessel *Aurora Australis*, part of a research crew of 70 oceanographers from 11 countries. (See "My First Antarctic Cruise" on page 1.)

Alex Kozyr was named a member of Working Group 17 (Biogeochemical Data Integration and Synthesis) of PICES, along with researchers from Canada, Japan, Korea, and Russia, and five other U.S. scientists.

Alex Kozyr also co-authored (with M. F. Lamb et al.) the paper "Consistency and synthesis of Pacific Ocean CO_2 survey data," which appeared in the journal *Deep-Sea Research II*, 49:21–58 (2002).

Other

Gregg Marland presented the paper "The Increasing Concentration of Atmospheric CO_2:How Much, When, and Why?" (co-authored with Tom Boden) at the 26th Erice International Seminar on Planetary Emergencies in Erice, Sicily. The paper examines the evidence that the observed increasing atmospheric concentrations of CO_2 have been caused by man-made emissions.

Bob Cushman presented the paper "Adding Value to Global-Change Data" at the Olga G. Nalbandov Symposium, "New Frontiers in Biocomplexity and Biodiversity," held at the University of Illinois, Urbana-Champaign (**http://www.life.uiuc.edu/plantbio/symposium/**). He stressed the importance of satisfying the needs of both data providers (especially maintaining intellectual property rights) and data users (locating, obtaining, and understanding the data) in a successful data management operation.

New and Updated Databases

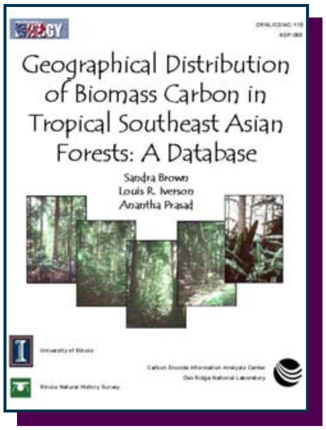
CDIAC's data holdings provide coverage in a number of areas relevant to the greenhouse effect and global climate change. Such areas include records of the concentration of CO_2 and other radiatively active gases in the atmosphere; the role of the terrestrial biosphere and the oceans in the biogeochemical cycles of greenhouse gases; emissions of CO_2 to the atmosphere; long-term climate trends; the effects of elevated CO_2 on vegetation; and the vulnerability of coastal areas to rising sea level. Data distributed by CDIAC are released as numeric data packages (NDPs), computer model packages (CMPs), and databases. Recently released data are described in this section. The data and documentation (text or HTML version) may be accessed and downloaded from CDIAC's Web site (**http://cdiac.ornl.gov/**), from CDIAC's anonymous FTP area (**cdiac.ornl.gov**), or requested directly from CDIAC on a variety of media (e.g., CD-ROM, floppy diskette). Technical questions (e.g., methodology or accuracy) should be directed to the CDIAC staff member who is responsible for preparing the individual NDP.

Geographical Distribution of Biomass Carbon in Tropical Southeast Asian Forests: A Database

http://cdiac.ornl.gov/epubs/ndp/ndp068/ndp068.html

S. Brown et al. 2001. ORNL/CDIAC-119, NDP-068.
Prepared by Tammy Beaty, Lisa Olsen, Bob Cushman, and Antoinette Brenkert, CDIAC

This database was generated from estimates of geographically referenced carbon densities of forest vegetation in tropical Southeast Asia for 1980 by providing detailed geographically eferenced information on actual and potential biomass carbon (1 g biomass = 0.5 g C). A geographic information system (GIS) was used to incorporate spatial databases of climatic,



edaphic, and geomorphological indices and vegetation to estimate potential (i.e., in the absence of human intervention and natural disturbance) carbon densities of forests in 1980. The resulting estimates were then modified to produce a map estimating actual 1980 carbon density as a function of population density and climatic zone. The database covers 13 countries: Bangladesh, Brunei, Cambodia, India, Indonesia, Laos, Malaysia, Myanmar (Burma), Nepal, the Philippines, Sri Lanka, Thailand, and Vietnam.

The 3.75-km data in this database yield an actual total carbon estimate of 42.1 Pg (1 petagram = 10^{15} grams) and a potential carbon estimate of 73.6 Pg, whereas the 0.25-degree data produced an actual total carbon estimate of 41.8 Pg and a total potential carbon estimate of 73.9 Pg.

Brown et al. (1993) compared their estimates of biomass carbon density with those of other recent assessments for the same 13-country study area. They found that estimates of biomass carbon densities derived from the U.N. Food and Agriculture Organization (FAO) Tropical Forest Resource Assessment 1990 Project were about 75% of their own, and that estimates of 1980 biomass carbon density of Flint and Richards (1994) for forests and woodlands were about 65% of their own. Although differences exist between the estimates of Brown et al. and the other two studies, the three sets of values are similar in order of magnitude despite differences in methodology, input data, and time of assessment. The general similarity of the estimates provides compelling evidence that forests of tropical Asian countries have generally low biomass carbon densities; these low densities are most likely due to the long history of human use in the region.

WDC database

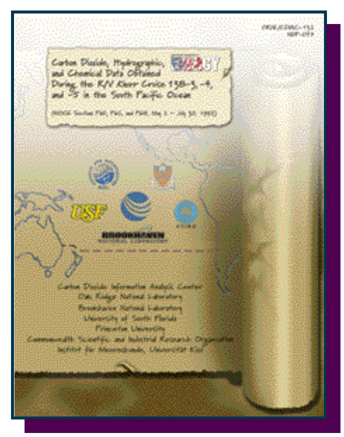
Carbon Dioxide, Hydrographic, and Chemical Data Obtained during the R/V *Knorr* Cruise 138-3, -4, and -5 in the South Pacific Ocean (WOCE Sections P6E, P6C, and P6W, May 2–July 30, 1992)

http://cdiac.ornl.gov/oceans/ndp_077/ndp077.html

K. M. Johnson et al. 2001. ORNL/CDIAC-132, NDP-077.
Prepared by Alex Kozyr and Tammy Beaty, CDIAC

CO_2-related measurements were made during the R/V *Knorr* cruise, which began in Valparaiso, Chile, on May 2, 1992, and ended 81 days later in Sydney, Australia, on July 20, 1992. The TCO_2 was measured coulometrically by use of two single-operator multiparameter metabolic analyzers (SOMMAs). The measurements made during the three legs of the *Knorr* cruise included pressure, temperature, salinity [measured by a conductivity, temperature, and depth sensor (CTD)], bottle salinity, bottle oxygen, silicate, nitrate, nitrite, phosphate, radiocarbon (14C), TCO_2, and pCO_2. The precision and accuracy of the measurements was ±1.65 µmol/kg. The pCO_2 in discrete samples was measured using a headspace-equilibration technique and gas chromatography with precision of ~1 to 2%.

The need for this experiment arose from serious concern over the rising atmospheric concentration of CO_2 and the effect on the heat balance of the global atmosphere, and as a goal to better understand the ocean's role in climate and climatic changes resulting from both natural and anthropogenic causes. The increasing concentrations of these gases may intensify the earth's natural greenhouse effect and alter the global climate in ways that are not well understood. Carbon in the oceans is unevenly distributed because of poorly characterized and complex circulation patterns and biogeochemical cycles.



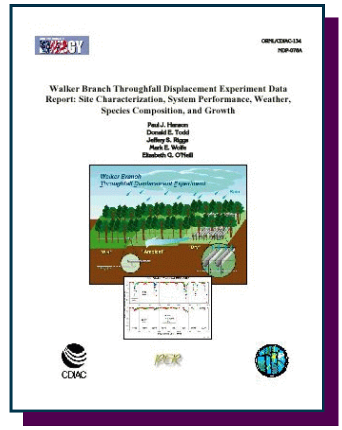
Walker Branch Throughfall Displacement Experiment Data Report: Site Characterization, System Performance, Weather, Species Composition, and Growth

http://cdiac.ornl.gov/epubs/ndp/ndp078a/ndp078a.html

P. J. Hanson et al. 2001. ORNL/CDIAC-134, NDP-078A.
Prepared by Bob Cushman, CDIAC

This numeric data package provides information on site characterization, system performance, weather, species composition, and growth for the Throughfall Displacement Experiment (TDE), which was established in the Walker Branch Watershed (WBW) of East Tennessee to provide data on the responses of forests to altered precipitation regimes. The WBW site was chosen because of its uniform slope, consistent soils, and reasonably uniform distribution of vegetation. The forest community is dominated by white oak, chestnut oak, and red maple, but it contains more than 25 tree species. The specific data includes soil water content and potential, coarse fraction of the soil profile, litter layer temperature, soil temperature, monthly weather, daily weather, hourly weather, species composition of trees and saplings, mature tree and sapling annual growth, and relative leaf area index.

Models of global climate change predict that increasing levels of greenhouse gases in the atmosphere will cause an increase in average global temperatures and alter regional levels of precipitation. It is also predicted that the incidence of drought will increase with a warming global climate. Forests throughout the southeastern United States, where evapotranspiration demand is high and is predicted to increase as temperatures rise, would be particularly vulnerable to declines in annual precipitation. Potential responses of U.S. forests to future drought associated with climate change include a reduction in net primary production and stand water use, along with increased mortality of seedlings and saplings. The past 25 years of research on the WBW provide an important reference database against which to judge the outcomes of this large-scale field experiment.



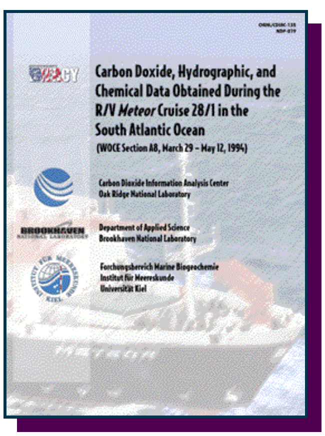
WDC database

Carbon Dioxide, Hydrographic, and Chemical Data Obtained during the R/V *Meteor* Cruise 28/1 in the South Atlantic Ocean (WOCE Section A8, March 29–May 12, 1994)

http://cdiac.ornl.gov/oceans/ndp_079/ndp079.html

K. M. Johnson et al. 2002. ORNL/CDIAC-135, NDP-079.
Prepared by Alex Kozyr and Tammy Beaty, CDIAC

The documentation in this numeric data package discusses the procedures and methods used to measure TCO_2 and the fugacity of CO_2 (fCO_2) at hydrographic stations during the R/V *Meteor* oceanographic cruise 28/1 in the South Atlantic Ocean (Section A8). Conducted as part of the World Ocean Circulation Experiment (WOCE), the cruise began in Recife, Brazil, on March 29, 1994, and ended after 35 days at sea in Walvis Bay, Namibia, on May 12, 1994. Instructions for accessing the data are provided.



TCO_2 was measured using two SOMMAs coupled to a coulometer for extracting and detecting CO_2 from seawater samples. The overall precision of the analyses was ±1.17 µmol/kg. For the second carbonate system parameter, the fCO_2 was measured in discrete samples by equilibrating a known volume of liquid phase (seawater) with a known volume of a gas phase containing a known mixture of CO_2 in gaseous nitrogen (N_2). After equilibration, the gas phase CO_2 concentration was determined by flame ionization detection following the catalytic conversion of CO_2 to methane (CH_4). The precision of these measurements was # 1.0%.

Atmospheric CO_2 Concentrations—Mauna Loa Observatory, Hawaii, 1958–2000

http://cdiac.ornl.gov/ndps/ndp001.html

C. D. Keeling and T. P. Whorf (and the Carbon Dioxide Research Group). 2001. NDP-001.
Prepared by Tom Boden, CDIAC

The ambient atmospheric CO_2 data from the Mauna Loa Observatory have been updated through 2000. The Mauna Loa measurements, which began in 1958, constitute the longest continuous record of atmospheric CO_2 concentrations available in the world, and the site is considered one of the most favorable locations for measuring undisturbed air due to the lack of local influences of vegetation. The impact of human activities on atmospheric CO_2 concentrations is minimal at this site, and any influences from volcanic vents may be excluded from the records. The methods and equipment used have remained essentially unchanged during the four-decade-long monitoring program. The Mauna Loa record shows a 17% increase in the mean annual concentration, from 315.98 parts per million by volume (ppmv) of dry air in 1959 to 369.40 ppmv in 2000. The increase in mean annual concentration from 1999 to 2000 was 1.1 ppmv. (The largest single yearly jump in the Mauna Loa record was the 2.9 ppmv increase from 1997 to 1998.) [Data are also available in *Trends Online*. (See page 3.)]

WDC database

Global, Regional, and National Annual CO_2 Emissions from Fossil-Fuel Burning, Cement Production, and Gas Flaring: 1751–1998

http://cdiac.ornl.gov/ndps/ndp030.html

G. Marland et al. 2001. NDP-030.
Prepared by Tom Boden, CDIAC

The global, regional, and national annual estimates of CO_2 emissions from fossil-fuel burning, cement production, and gas flaring include estimates from as far back as 1751 through 1998 [data also available in *Trends Online.* (See page 4.)]

WDC database

A Databank of Antarctic Surface Temperature and Pressure Data

http://cdiac.ornl.gov/epubs/ndp/ndp032/ndp032.html

P. D. Jones and P. A. Reid. 2001. ORNL/CDIAC-27, NDP-032.
Prepared by Dale Kaiser, CDIAC

An update to the Antarctic surface temperature and pressure database made available by CDIAC in 1989, this revised database includes monthly mean surface temperature and mean sea level pressure data from 29 meteorological stations within the Antarctic region through early 1999 for most stations (through 2000 for a few), and also includes all available mean monthly maximum and minimum temperature data. For many stations this means that over 40 years of data are now available, enough for many of the trends associated with recent warming to be more thoroughly examined. Much of the original version of this database was obtained from the *World Weather Records* volumes (1951–1970), *Monthly Climatic Data for the World* (since 1961), and several other sources. Of particular importance within this study are the additional data obtained from Australia, Britain, and New Zealand. Due to the prospects of a warmer climate under enhanced greenhouse conditions, there has been much study undertaken to understand the role which Antarctica may play under different climatic conditions, although recording Antarctic station data is particularly prone to errors. These errors result from climatic extremes, the difficulties of Antarctic science, and the variability of meteorological staff at Antarctic stations (high turnover and sometimes untrained meteorological staff). An increasing trend in surface temperatures has been observed over the period of record for Antarctica as a whole, with most of the warming occurring before 1970. Because a continent-wide analysis of time series masks considerable spatial detail and variability across this large region, time series of temperature and pressure trends on a local (four main regions) and monthly basis were also examined.

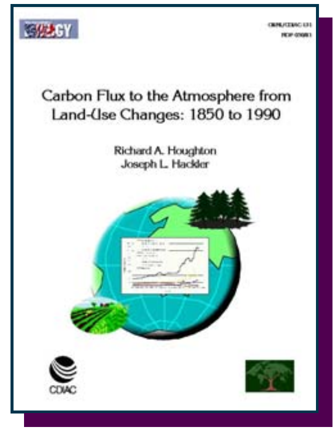
Carbon Flux to the Atmosphere from Land-Use Changes: 1850 to 1990
http://cdiac.ornl.gov/epubs/ndp/ndp050/ndp050.html

R. A. Houghton and J. L. Hackler. 2001. ORNL/CDIAC-131, NDP-050/R1.
Prepared by Bob Cushman, CDIAC

In the attempt to "balance" the global carbon cycle (that is, reconcile the known sources and sinks of carbon), two major unknowns remain: the flux between the atmosphere and the oceans and the flux between the atmosphere and terrestrial ecosystems. To address the latter, several investigators have attempted to estimate the flows of carbon between the atmosphere and both temperate and tropical ecosystems.

This database, a revision to the database originally published by CDIAC in 1995, consists of annual estimates, from 1850 through 1990, of the net flux of carbon between terrestrial ecosystems and the atmosphere resulting from deliberate changes in land cover and land use, especially forest clearing for agriculture and the harvest of wood for wood products or energy. The data are provided on a year-by-year basis for nine regions (North America, South and Central America, Europe, North Africa and the Middle East, Tropical Africa, the Former Soviet Union, China, South and Southeast Asia, and the Pacific Developed Region) and the globe. Some data begin earlier than 1850 (e.g., for six regions, areas of different ecosystems are provided for the year 1700) or extend beyond 1990 (e.g., fuelwood harvest in South and Southeast Asia, by forest type, is provided through 1995).

The estimated global total net flux of carbon from changes in land use increased from 397 Tg of carbon (1 teragram = 10^{12} gram) in 1850 to 2187 Tg, or 2.2 Pg, of carbon (1 petagram = 10^{15} gram) in 1989 and then decreased slightly to 2103 Tg, or 2.1 Pg, of carbon in 1990. The global net flux during the period 1850–1990 was 124 Pg of carbon. During this period, the greatest regional flux was from South and Southeast Asia (39 Pg of carbon), while the smallest regional flux was from North Africa and the Middle East (3 Pg of carbon). For the year 1990, the global total net flux was estimated to be 2.1 Pg of carbon.



This revised database provides estimates for all regions through 1990, whereas the original database provided estimates for only three regions (South and Central America, Tropical Africa, and South and Southeast Asia) through 1990, for one region (the Former Soviet Union) through 1985, and for the remaining five regions (North America, Europe, North Africa and the Middle East, China, and the Pacific Developed Region) through 1980. ***WDC database***

Tropical Africa: Land Use, Biomass, and Carbon Estimates for 1980
http://cdiac.ornl.gov/epubs/ndp/ndp055/ndp055.html

S. Brown and G. Gaston. 1996. ORNL/CDIAC-92, NDP-055.
Prepared by Tammy Beaty and Lisa Olsen, CDIAC.

CDIAC released an enhanced Web-based version of this numeric data package, which includes data on maximum potential aboveground biomass, land use, estimated actual biomass, and carbon in 1980. These data were collected to reduce the uncertainty associated with the possible magnitude of historical releases of carbon from land use change. The data show that in 1980 aboveground biomass averaged 209 and 67 Mg/ha in closed and open forests, respectively, compared with the corresponding maximum potential aboveground biomass of 296 and 108 Mg/ha. ***WDC database***

ALE/GAGE/AGAGE
http://cdiac.ornl.gov/ndps/alegage.html

R. Prinn, Massachusetts Institute of Technology; D. Cunnold, F. Alyea, D. Hartley, and R. H. J. Wang, Georgia Institute of Technology; P. Fraser and L. P. Steele, Commonwealth Scientific and Industrial Research Organisation; R. Weiss, Scripps Institution of Oceanography; and P. Simmonds, International Science Consultants. 2002. DB1001.
Prepared by T. J. Blasing, CDIAC

In the ALE/GAGE/AGAGE global network program, continuous high-frequency gas-chromatographic measurements of two biogenic/anthropogenic gases [methane (CH_4); and nitrous oxide (N_2O)] and six anthropogenic gases [the chlorofluorocarbons ($CFCl_3$, CF_2Cl_2, and $CF_2ClCFCl_2$); methyl chloroform (CH_3CCl_3); chloroform ($CHCl_3$); and carbon tetrachloride (CCl_4)] are carried out at five globally distributed sites. Additional important species (H_2, CO, HFC-134a, HCFC-141b, and HCFC-142b) have been added at select sites in recent years.

The program, which began in 1978, is divided into three parts associated with three changes in instrumentation: the Atmospheric Lifetime Experiment (ALE), which used Hewlett Packard HP5840 gas chromatographs; the Global Atmospheric Gases Experiment (GAGE), which used HP5880 gas chromatographs; and the present Advanced GAGE (AGAGE). AGAGE uses a new fully automated system from the Scripps Institution of Oceanography (SIO) containing a custom-designed sample module and HP5890 and Carle Instruments gas chromatographic components.

The current station locations are Cape Grim, Tasmania; Cape Head, Ireland; and Trinidad Head, California. Stations also previously existed at Cape Meares, Oregon, and Adrigole, Ireland. The current Mace Head station replaced the Adrigole station, and the station at Trinidad Head replaced the Cape Meares station.

Presently, data from all three experiments are available through March 2001 for the five existing sites. Individual measurements (generally made four times daily at each site for ALE, 12 times daily at each site for GAGE, and more than 30 times daily at each site for AGAGE) and monthly summary averages are provided for each site. All ALE and GAGE data have been recalculated according to the current AGAGE calibration standards, thus creating a unified ALE/GAGE/AGAGE data set based upon the same standards.

Proper citation of this database is dependent upon the parts of the data used; please refer to the "readme" files. ***WDC database***

CDIAC Publications

Publications, Presentations, and Awards

http://cdiac.ornl.gov/epubs/cdiac/cdiac101/pubslist.html

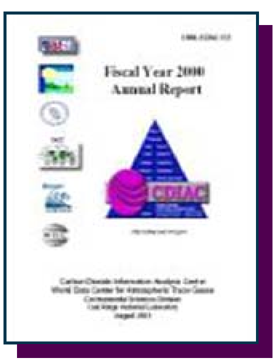
R. M. Cushman. 2001. ORNL/CDIAC-101.
Prepared by Bob Cushman, CDIAC

This online publication lists journal articles, book and proceedings chapters, numeric data packages and online databases, and other ORNL and DOE reports published by CDIAC; presentations of CDIAC staff; and awards presented to CDIAC since its inception in 1982.

Carbon Dioxide Information Analysis Center and World Data Center for Atmospheric Trace Gases Fiscal Year 2000 Annual Report

http://cdiac.ornl.gov/epubs/cdiac/cdiac133/AnnualRpt2000.html
http://cdiac.ornl.gov/epubs/cdiac/cdiac133/2000annual.pdf

R. M. Cushman et al. 2001. ORNL/CDIAC-133.
Prepared by Carolyn Householder and Sonja Jones



The fiscal year 2000 annual report represents a status report in which the previous year is reviewed, recalling new and updated data and information products, information of relevance to CDIAC Focus Areas (e.g., AmeriFlux, NARSTO, FACE, Oceans), staff presentations and awards, CDIAC citations, and request statistics for CDIAC information. The report lists publications and databases CDIAC will be working on in the coming fiscal year, plus collaborating institutions, a staff listing, and an acronym and abbreviation list.

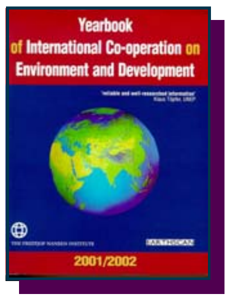
Graduate Student Theses Supported by DOE's Environmental Sciences Division: Fiscal Year 2001 Update
http://cdiac.ornl.gov/epubs/cdiac/cdiac136/cdiac136.html

R. M. Cushman. 2002. ORNL/CDIAC-136
Prepared by Bob Cushman, CDIAC

This document updates the 1995 and 2000 Graduate Student Theses reports, providing complete bibliographic citations, abstracts, and keywords for doctoral and master's theses published in late 2000 and 2001.

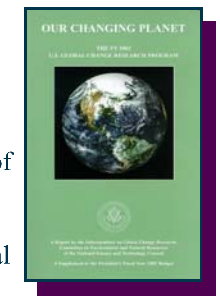
CDIAC's Bookshelf

Yearbook of International Co-operation on Environment and Development 2001/2002
O. S. Stokke and O. B. Thommessen (eds.)
http://www.greenyearbook.org/



The ninth annual edition of the *Yearbook* is an essential reference to the ever-increasing number of international agreements. The *Yearbook* covers current issues and environmental agreements in the categories of the general environment, the atmosphere, hazardous substances, the marine environment, marine living resources, nature conservation and terrestrial living resources, nuclear safety, and freshwater resources. Information provided on the various conventions include the objectives, scope, time and place of adoption, entry into force, status of participation, affiliated instruments and organizations, Secretariat, finance, special funds, rules and standards, monitoring/implementation, decision-making bodies, publications, and sources available on the Internet.

Our Changing Planet: The Fiscal Year 2002 U.S. Global Change Research Program
http://www.gcrio.org/ocp2002/



Our Changing Planet: The FY 2002 U.S. Global Change Research Program is produced annually as a report to Congress supplementing the President's fiscal year budget, and describes activities and plans of the U.S. Global Change Research Program (USGCRP). Included in this report are summaries of scientific insights from global change research, discussions of FY 2002 research in the six Research Program Elements, as well as program components and program highlights for each of the departments and agencies of the USGCRP.

Carbon Dioxide Information Analysis Center
World Data Center for Atmospheric Trace Gases

CDIAC is sponsored by the U.S. Department of Energy's Office of Science
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Oak Ridge National Laboratory is managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract No. DE-AC05-00OR22725

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