

Carbon Dioxide and Climate

A Bibliography

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CARBON DIOXIDE AND CLIMATE

A Bibliography

ABOUT THIS BIBLIOGRAPHY

Since the onset of the industrial revolution, atmospheric concentrations of carbon dioxide have been steadily increasing. Indications are that the global level of carbon dioxide will double by the end of the 21st century. The major sources of this input are the combustion of fossil fuels; deforestation, particularly in the underdeveloped areas of the world; and land modifications such as erosion, desertification, and urbanization. A growing number of people are becoming concerned that this increasing carbon dioxide concentration will adversely affect the global climate. The mechanism of action is popularly known as the "greenhouse effect" and is based on the ability of carbon dioxide to transmit visible and ultraviolet radiation but to absorb and scatter infrared radiation, thereby upsetting the global radiation balance and raising global temperatures. The effects of this temperature rise are in considerable dispute but will probably favor some regions while others will suffer.

This bibliography with abstracts presents citations selected from the Department of Energy's computerized Energy Data Base (EDB) using the RECON on-line retrieval system. The data base is maintained by the DOE Technical Information Center (TIC) and covers all aspects of energy.

The bibliography contains additions to the data base from July 1, 1976, to September 14, 1980. The citations are arranged in reverse chronological order by date of publication. Each bibliographic citation is followed by either an abstract or the subject descriptors used in indexing the publication; in some cases a phrase or sentence augments the descriptors to elaborate on the title.

Indexes for corporate author, personal author, subject, contract number, and report number are included.

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The principal elements of abstract entries for a typical research and development report and a typical technical journal article are illustrated below.

Date of publication	Report number	Contract number	Title	Availability	Corporate
84	(ORAU/IEA-79-6(0))		Uncertainties associated with global effects of atmospheric carbon dioxide.	Rotty, R.M. (Oak Ridge Associated Universities, Inc., TN (USA). Inst. for Energy Analysis).	Mar 1979. Contract EY-76-C-05-0033. 29p. Dep. NTIS, PC A03/MF A01.

Abstract Although the evidence is quite clear that the increase in atmospheric CO₂ is at least to a large degree a result of fossil fuel burning, and it is equally clear that this increase will result in some change in the global climate, there are quantitative uncertainties that require additional understanding before full assessments can be made. There are also quantitative uncertainties regarding the natural carbon cycle, the behavior of the various reservoirs when perturbed by man, the terrestrial biosphere, and the rate at which the oceans can assimilate and store carbon. There are uncertainties in regard to the climate change that can result from increased atmospheric CO₂. Progress in modeling the atmosphere must continue to narrow these uncertainties before the impacts of climate change on man can be adequately determined. The future demands for fossil fuels are uncertain. The growth of the developing world will be closely linked to fossil energy for the next five to eight decades. Only the observed increase in the atmospheric concentration and the present (and recent past) rate of production of CO₂ from fossil fuels provide data without uncertainties.

Abstract number	Date of publication	Title	Author(s)	Journal citation
30		CO ₂ Climate sensitivity study with a mathematical model of the global climate.	Manabe, S.; Stouffer, R.J. (NOAA Geophysical Fluid Dynamics Lab, NJ).	Nature (London), 282: No. 5738, 491-493 (29 Nov 1979).

Abstract A mathematical model was developed to evaluate the climatic effects of an atmospheric carbon dioxide increase. The model consists of a general circulation model of the atmosphere and a simple mixed layer model of the ocean. The functions of the two component models are discussed. Results of two time-integration simulations of the mathematical model are reported. In general, it is suggested that the warming of the atmosphere in response to an increase in CO₂ will have significant seasonal and interhemispheric impacts. Area mean temperature changes and changes in mean thickness of sea ice that could occur as a result of increased CO₂ levels are tabulated. (4 graphs, 10 references, 1 table)

INDEXES

Five indexes are provided. Each index is preceded by an introduction that details the organization of the index and the principles by which it was compiled. The reader is referred to these introductions for information not found in the index examples that follow.

•Corporate Index

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is indexed as:

Oak Ridge Associated Universities, Inc., TN (USA). Inst. for Energy Analysis

Uncertainties associated with global effects of atmospheric carbon dioxide, 84 (ORAU/IEA-79-6(0))

•Author Index

Individual author names are indexed alphabetically in the form appearing on the document abstracted, with the exception that given names are reduced to initials:

Rotty, R.M., Uncertainties associated with global effects of atmospheric carbon dioxide, 84 (ORAU/IEA-79-6(0))

Rust, B.W., Inferences drawn from atmospheric CO₂ data, 59

•Subject Index

The subject index which consists of entries naming specific materials, objects, and processes is arranged alphabetically. Document titles or informative phrases (or both) specific to these entries are arranged alphabetically under the entries. For example:

CALIFORNIA/FOSSIL-FUEL POWER PLANTS

Coal or nuclear: the unintended consequences of electricity generation (Accounting for social costs), 349

CARBON CYCLE

Uncertainties associated with global effects of atmospheric carbon dioxide, 84 (ORAU/IEA-79-6(0))

•Contract Number Index

The Department of Energy's technical report literature is indexed alphanumerically by using contract numbers. This index lists the contract number with its corresponding corporate entry and the abstract and report numbers. For example:

EY-76-C-02-0016	Brookhaven National Lab., Upton, NY (USA)
21	BNL-27406
EY-76-C-05-0033	Oak Ridge Associated Universities, Inc., TN (USA). Inst. for Energy Analysis
62	ORAU/IEA-79-10(R)
84	ORAU/IEA-79-6(0)

•Report Number Index

Technical report literature is also indexed alphanumerically by using report numbers. This index includes information on where individual reports may be obtained. Patents and conference papers are indexed here as a matter of convenience.

ORAU/IEA-		
78-24(M)	115	Dep. NTIS, PC A03/MF A01
79-6(0)	84	Dep. NTIS, PC A03/MF A01
ORNL-		
5194	319	Dep. NTIS \$5.00

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ABSTRACT

This bibliography with abstracts presents 394 citations retrieved from the Energy Data Base of the Department of Energy Technical Information Center, Oak Ridge, Tennessee. The citations cover all aspects of the climatic effects of carbon dioxide emissions to the atmosphere. These include carbon cycling, temperature effects, carbon dioxide control technologies, paleoclimatology, carbon dioxide sources and sinks, mathematical models, energy policies, greenhouse effect, and the role of the oceans and terrestrial forests.

ABSTRACTS

- 1 (DOE/EV--0087) SYNTHETIC FUELS AND THE ENVIRONMENT: AN ENVIRONMENTAL AND REGULATORY IMPACTS ANALYSIS. (Department of Energy, Washington, DC (USA). Office of Technology Impacts). Jun 1980. 652p. NTIS, PC A99/MF A01.

Since July 1979 when DOE/EV-0044 report Environmental Analysis of Synthetic Liquid fuels was published the synthetic fuels program proposals of the Administration have undergone significant modifications. The program year for which the development goal of 3.5 million barrels per day is to be reached has been changed from 1990 to 1995. The program plan is now proposed to have two stages to ensure, among other things, better environmental protection: an initial stage emphasizing applied research and development (R and D), including environmental research, followed by a second stage that would accelerate deployment of those synthetic fuel technologies then judged most ready for rapid deployment and economic operation within the environmental protection requirements. These program changes have significantly expanded the scope of technologies to be considered in this environmental analysis and have increased the likelihood that accelerated environmental R and D efforts will be successful in solving principal environmental and worker safety concerns for most technologies prior to the initiation of the second stage of the accelerated deployment plan. Information is presented under the following section headings: summary; study description; the technologies and their environmental concerns (including, coal liquefaction and gasification, oil shale production, biomass and urban waste conversion); regulatory and institutional analyses; and environmental impacts analysis (including air and water quality analyses, impacts of carbon dioxide and acid rain, water availability, solid and hazardous wastes, coal mining environmental impacts, transportation issues, community growth and change, and regional impacts). Additional information is presented in seventeen appendixes. (JGB)

- 2 (DOE/EV/10281--1) CONSEQUENCES OF A HYPOTHETICAL WORLD CLIMATE CHANGE PRODUCED BY INCREASED ATMOSPHERIC CARBON DIOXIDE. PROGRESS REPORT, 1 SEPTEMBER 1979-31 APRIL 1980. Roberts, W.O. (Aspen Inst. for Humanistic Studies, Boulder, CO (USA)). May 1980. Contract AC02-79EV10281. 8p. Dep. NTIS, PC A02/MF A01.

Progress is reported on a research program seeking to understand the effects of increased global levels of atmospheric CO₂ as a result of human activities. An outline of the major social, economic, geopolitical and ethical issues to be faced as a result of global

warming is being attempted. Groundwork is being laid for a longer-term effort to delineate possible strategies to meet the predicted challenges. (ACR)

- 3 (ORNL/EIS--108/V1) CARBON CYCLES AND CLIMATE: A SELECTED BIBLIOGRAPHY. Olson, J.S.; Allison, L.J.; Collier, B.N. (Oak Ridge National Lab., TN (USA)). May 1980. Contract W-7405-ENG-26. 42p. NTIS, PC A03/MF A01.

This partially annotated bibliography contains the first 1000 references from a computerized file of literature on the global ecological implications of carbon cycles and climatic changes. Many early citations originated from the Biogeochemical Ecological Information Center established at Oak Ridge National Laboratory in 1968 and from profiles of computerized files such as Government Research Abstracts (GRA) and Biological Abstracts (BA). Later citations have been extracted from the open literature through 1978 and early 1979, from government reports and impact statements, and from profiles of GRA, BA, and the Energy Data Base of the Department of Energy Technical Information Center, Oak Ridge, Tennessee. The subject categories covered by this bibliography may be divided into two main topics: carbon cycling and climate system analysis. Volume I contains an introduction and overview.

- 4 (ORNL/EIS--108/V2) CARBON CYCLES AND CLIMATE: A SELECTED BIBLIOGRAPHY. Olson, J.S.; Allison, L.J.; Collier, B.N. (Oak Ridge National Lab., TN (USA)). May 1980. Contract W-7405-ENG-26. 256p. NTIS, PC A12/MF A01.

This partially annotated bibliography contains the first 1000 references from a computerized file of literature on the global ecological implications of carbon cycles and climatic changes. Many early citations originated from the Biogeochemical Ecological Information Center established at Oak Ridge National Laboratory in 1968 and from profiles of computerized files such as Government Research Abstracts (GRA) and Biological Abstracts (BA). Later citations have been extracted from the open literature through 1978 and early 1979, from government reports and impact statements, and from profiles of GRA, BA, and the Energy Data Base of the Department of Energy Technical Information Center, Oak Ridge, Tennessee. The subject categories covered by this bibliography may be divided into two main topics: carbon cycling and climate system analysis. Volume 2 contains an alphabetical (by author) listing of citations.

- 5 (ORNL/EIS--108/V3) CARBON CYCLES AND CLIMATE: A SELECTED BIBLIOGRAPHY. Olson, J.S.; Allison, L.J.; Collier, E.N. (Oak Ridge National Lab., TN (USA)). May 1980. Contract W-7405-ENG-26. 184p. NTIS, PC A09/MF A01.

This partially annotated bibliography contains the first 1000 references from a computerized file of literature on the global ecological implications of carbon cycles and climatic changes. Many early citations originated from the Biogeochemical Ecological Information Center established at Oak Ridge National Laboratory in 1968 and from profiles of computerized files such as Government Research Abstracts (GRA) and Biological Abstracts (BA). Later citations have been extracted from the open literature through 1978 and early 1979, from government reports and impact statements, and from profiles of GRA, BA, and the Energy Data Base of the Department of Energy Technical Information Center, Oak Ridge, Tennessee. The subject categories covered by this bibliography may be divided into two main topics: carbon cycling and climate system analysis. Volume 3 provides indexes for author, organization (corporate authority), keywords (or free index terms), taxonomic category, subject category, Chemical Abstracts codes, Biological Abstracts codes (crosscode), and COSATI/Weekly Government Abstracts codes concentrated with permuted title words.

- 6 (ORAU/IEA--80-9(M)) CONSTRAINTS ON CARBON DIOXIDE PRODUCTION FROM FOSSIL FUEL USE. Rotty, R.M.; Marland, G. (Oak Ridge Associated Universities, Inc., TN (USA). Inst. for Energy Analysis). May 1980. Contract AC05-76OR00033. 37p. NTIS, PC A93/MF A01.

The exponential growth of fossil fuel use over recent decades has resulted in a 4.3% annual increase in the carbon dioxide emitted to the atmosphere. The question addressed here is, when (and to what extent) will constraints limit the use of fossil fuels and the subsequent production of CO₂. Three types of possible constraints are discussed: resource constraints, fuel-demand constraints, and environmental constraints. An analysis of the next 50 years suggests that resource constraints will not provide severe limits. Fuel-demand constraints will probably limit the use of fossil fuels to levels that keep the atmospheric carbon dioxide concentration below 450 ppm(v) for the next 50 years, so that the impacts of atmospheric carbon dioxide will not cause mankind to take action soon. In spite of this conclusion a continuing, long-term problem is foreseen and full efforts to understand and continually monitor the CO₂ problem should be made and alertness to any changes that may require action should be maintained.

- 7 (CONF-800474--1) MODELING THE PROSPECTS FOR CLIMATIC CHANGE: CURRENT STATE-OF-THE-ART AND IMPLICATIONS. Kellogg, W.M. (Aspen Inst. for Humanistic Studies, Boulder, CO (USA); National Center for Atmospheric Research, Boulder, CO (USA)). 4 Apr 1980. Contract AC02-79EV10281. 43p. NTIS, PC A03/MF A01.

From Economic methodologies for climate change; Ft Lauderdale, FL, USA (24 Apr 1980).

It has been increasingly suggested that the world's climate is going to change in the next several decades, primarily as a result of anthropogenic perturbations to the global carbon cycle brought about by fossil fuel burning and large-scale deforestation. In order to cope with these future climatic changes, it is necessary that tools be developed to predict how complex systems respond to a given change

of conditions. This report summarizes the status of our ability to model the planetary system that determines the climate. (ACR)

- 8 (DOE/EV--0071) CARBON DIOXIDE EFFECTS RESEARCH AND ASSESSMENT PROGRAM. CARBON DIOXIDE RESEARCH PROGRESS REPORT, FISCAL YEAR 1979. Dahlman, R.C.; Gross, T.; Machta, L.; Elliott, W.; MacCracken, M. (Department of Energy, Washington, DC (USA). Office of Health and Environmental Research; National Oceanic and Atmospheric Administration, Silver Spring, MD (USA). Environmental Research Labs.; California Univ., Livermore (USA). Lawrence Livermore Lab.). Apr 1980. 88p. Dep. NTIS, PC A05/MF A01.

Research on the global carbon cycle and the effects of increased carbon dioxide on the global climate system is reported. Environmental and societal effects related to CO₂ and environmental control technology for CO₂ are also discussed. Lists of research projects and reports and publications of the Carbon Dioxide and Climate Research Program are included. An expanded CO₂ monitoring network is providing increased coverage for interpretation of patterns of sources and sinks seasonal variability, and documentation of the global growth of CO₂. Modeling studies emphasized that knowledge of the transport and mixing of surface ocean waters is important in understanding deep oceanic circulation. Initial studies in the equatorial Pacific are helping quantify estimates of the amount of outgassing CO₂ from tropical waters. During fiscal year 1979, there was a substantial increase in appreciation of the role of the ocean in controlling not only atmospheric CO₂ concentrations but also the climatic response to changes in concentration. Model simulations of the effect of doubled CO₂ concentration carried out with fixed ocean temperatures a situation that is possible during perhaps the next 20 years, showed relatively small summer heating over land areas. On the other hand, simulations in which the oceanic temperatures could come into instantaneous equilibrium with atmospheric conditions continued to show global temperature increases of 3 ± 1.5°C, accentuated at high latitudes. To improve understanding of possible regional climate changes, there were increased efforts to reconstruct regional climatic patterns prevailing during past warm periods that might serve as analogs of future climatic conditions. Particular attention was directed to the climates of the United States and other countries bordering the North Atlantic Ocean during the warm period 5000 to 7000 years ago.

- 9 CLIMATOLOGICAL SIGNIFICANCE OF A DOUBLING OF EARTH'S ATMOSPHERIC CARBON DIOXIDE CONCENTRATION. Science; 207: 1462-1463(28 Mar 1980).

The mean global increase in thermal radiation received at the surface of the earth as a consequence of a doubling of the atmospheric carbon dioxide content is calculated to be 2.28 watts per square meter. Multiplying this forcing function by the atmosphere's surface air temperature response function, which has recently been determined by three independent experimental analyses to have a mean global value of 0.113 K per watt per square meter, yields a value of less than or equal to 0.26 K for the resultant change in the mean global surface air temperature. This result is about one order of magnitude less than those obtained from most theoretical numerical models, but it is virtually identical to the result of a fourth experimental approach to the problem described by Newell and

Dopplnick. There thus appears to be a major discrepancy between current theory and experiment relative to the effects of carbon dioxide on climate. Until this discrepancy is resolved, options in the selection of future energy alternatives should not be limited.

- 10 (ORNL--5620, pp 1-20) TERRESTRIAL ECOLOGY SECTION. Harris, W.F. Mar 1980. Environmental Sciences Division. Annual progress report for period ending September 30, 1979.

The Terrestrial Ecology Section provides expertise in terrestrial environmental sciences to both basic and applied research problems. Several research projects serve to maintain technical ability in selected areas of terrestrial ecology. These research projects anticipate future programmatic directions, undertake development of new technical requirements, and promote new research in terrestrial ecology. Four broad areas comprise the general framework of current section research interests: ecological effects (principally of gaseous air pollutants on plants), fate and transport (with continued emphasis on carbon and sulfur cycles), ecosystem studies (with emphasis on physiological processes), and environmental resources (encompassing forest management for the Oak Ridge Reservation and environmental research park activities on selected portions of the Reservation).

- 11 (ORNL--5620, pp 98-112) ECOSYSTEM STUDIES PROGRAM. Van Hook, R.I. Mar 1980. Environmental Sciences Division. Annual progress report for period ending September 30, 1979.

The Ecosystem Studies Program consists of National Science Foundation-supported research designed to increase our understanding of both aquatic and terrestrial ecosystem function, and Department of Energy-supported research which addresses issues associated with successful utilization of fuels from biomass. National Science Foundation-supported activities currently include work in systems analysis, spiraling of nutrients in stream ecosystems, and global carbon inventories and cycling. Fuels from biomass activities deal with production and harvest of wood for fuel and environmental constraints associated with utilizing agricultural and forest residues for fuel. Strong emphasis is placed on interaction and collaboration with outside institutions as evidenced by the number of universities and federal agencies involved in our efforts. Educational aspects of the program include support of undergraduate and pre- and post-doctoral candidates who are actively involved in one of our five major research areas.

- 12 STAFF FINDINGS. Washington, DC; President's Commission on Coal (Mar 1980). 66p. (NP--24389). GPO \$3.75.

In the 1980s, coal can contribute to the national effort to reduce oil imports by serving as a replacement fuel for oil (either alone or in coal-oil mixtures) and natural gas in electrical utility and large industrial boilers. More than 5.5 million barrels (mmbbl) of oil and natural gas are consumed each day in these units. For the most part, that oil is residual oil; a byproduct of the refining process. This oil presently sells for \$25 to \$35 per barrel and represents a significant dollar outflow. Today, the delivered price of coal is approximately 20 to 50 percent that of oil. Because of its rapidly increasing price, much of the oil consumed in industrial and

utility boilers could be replaced economically by coal, despite the substantial capital costs associated with conversion or new construction and the pollution control equipment to comply with existing Clean Air laws. Federal legislation has been in effect since 1974 to require the conversion of utility and industrial boilers to coal use. Despite this, few industrial and utility conversions have taken place. Numerous exemptions contained in the statutes (the Energy Supply and Environmental Coordination Act and the Powerplant and Industrial Fuel Use Act) have combined with a lengthy administrative procedure to tie up the conversion program in litigation and delay. The environmental effects of increased use of coal are discussed. Problems of coal mine safety, labor relations and coal miners' living conditions are evaluated.

- 13 (CONF-800309--6) COSTS OF CLIMATE IMPACTS. Roberts, W.D. (Aspen Inst. for Humanistic Studies, Boulder, CO (USA)). Mar 1980. Contract AC02-79EV10281. 9p. NTIS, PC A02/MF A01.

From International workshop on the energy/climate interactions; Munster, F.R. Germany (3 Mar 1980).

The surest prospect for future world climate patterns is that they will differ from present ones. What is uncertain is how much, and exactly in what way in different geographical regions. The anthropogenic CO₂ increase will probably exceed the unknown forcing functions of natural climate change within 30 to 60 years. It is not unlikely that by AD 2040 the world's climate, driven by the CO₂ increase, will enter a domain warmer than any within the past few million years. The costs of averting this climate change or of absorbing its impact are likely to be huge, even though today imponderable. Not least among these are intangible and unquantifiable costs associated with changes in human values and the quality of everyday life for future generations.

- 14 (DOE/EV/10206--1) GEOCHEMICAL DETERMINATION OF BIOSPHERIC CO₂ FLUXES TO THE ATMOSPHERE. ANNUAL PROGRESS REPORT. Stuiver, M. (Washington Univ., Seattle (USA)). 27 Feb 1980. Contract AT06-79EV10206. 4p. Dep. NTIS, PC A02/MF A01.

A research program has been initiated to increase the knowledge of past biospheric carbon reservoir changes that have resulted in increases, or reductions, of atmospheric CO₂ levels. The research program was approved in July 1979. This progress report covers 7 months of work. The research has been mainly developmental; initial steps taken in measurements of ¹³C/¹²C ratios in tree rings are summarized briefly.

- 15 ENERGY: A SUMMARY OF THE CONAES REPORT. Brooks, H. (Harvard Univ., Cambridge, MA). Bull. At. Sci.; 36: No. 2, 23-30 (Feb 1980).

Two decisions must be crystallized in the near future: the selection of a mix of sustainable energy sources that can be developed and relied upon for a long term; and a viable plan for marshaling resources for a transitional period leading from present technology and primary fuels to those of the future (past 2010). The National Academy Committee on Nuclear and Alternative Energy Systems (CONAES) sees this transitional period as lasting from 30 to 60 years. CONAES deliberated many energy policy issues and Dr. Brooks, as committee chairman, interprets concluding views of CONAES on conservation

- potential; pricing policy; rapidity and extent of expansion of coal use, nuclear power solar energy use; breeders vs advanced converters; seriousness, timing, and response to the carbon dioxide problem; air pollution regulations for coal; water as a constraint on the expansion of coal and electric power; electrification vs fluid fuels; proliferation and nuclear power; and energy policy and the Third World. For the full CONAES report, see CCNS-3784-T1. (MCW)
- 16 (CONF-7903105--) CARBON DIOXIDE EFFECTS RESEARCH AND ASSESSMENT PROGRAM. THE ROLE OF TEMPERATE ZONE FORESTS IN THE WORLD CARBON CYCLE: PROBLEM DEFINITION AND RESEARCH NEEDS. Amentano, T.V.; Hett, J. (ed.). (Institute of Ecology, Indianapolis, IN (USA)). Feb 1980. Contract AC02-79EV10040. 76p. Dep. NTIS, PC A05/MF A01.
- From Conference on the role of temperate zone force in the world carbon cycle; Indianapolis, IN, USA (21 Mar 1979).
- The continuing rise in the CO₂ content of the atmosphere has produced concern that in the next half-century, climatic, ecological and societal effects may occur throughout the world which will not easily be reversed. This prospect has encouraged a critical assessment of the many elements of the global carbon cycle and the influence of man on it. The role of the terrestrial biosphere has been underscored by recent evidence that reduction of the world's biota may be adding as much or more carbon to the atmosphere as combustion of fossil fuels. The diversity of world ecosystems, and the lack of data on carbon content in many of them, have led to different interpretations of how much the terrestrial biosphere contributes to carbon accumulation in the atmosphere. A detailed review is needed of the principal elements of biospheric influence on the carbon cycle, of where the accumulating atmospheric carbon is originating, and of the options there may be to control it. The Office of Carbon Dioxide Effects Research and Assessment of the US Department of Energy has funded The Institute of Ecology to evaluate three terrestrial biospheric components which may be important in the world carbon cycle. These components are: the temperate zone forest, particularly over the past 100 years; organic soils of the world; and freshwater systems subject to eutrophication. From 10 to 12 researchers have participated in each panel. Data review, problem definition and recommendations for research have been the focus in each workshop. The results reported here cover the temperate forest component.
- 17 SCENARIO FOR A WARM, HIGH-CO₂ WORLD. Wigley, T.M.L.; Jones, P.D.; Kelly, P.M. (Univ of East Anglia, UK). Nature (London); 283: No. 5742, 17-21(3 Jan 1980).
- To assess the impact of global changes in temperature, precipitation, and winds that might occur as a result of increased carbon dioxide levels in the atmosphere, a meteorologically and climatologically realistic scenario of global warming was developed. The patterns of climatic changes that could result from a large increase in atmospheric CO₂ were determined by comparing the five warmest years from 1925-74 with the five coldest years in the same period. Results indicate that increased atmospheric CO₂ will cause temperature increases in most regions of the world, with maximum temperature increases occurring in northern Asia. A few isolated regions, however, will be cooler. Precipitation will increase over India and decrease in regions of the U.S., Europe, and the USSR. The social, political, and economic impacts of these changes are briefly considered. (2 maps, 34 references)
- 18 (DOE/EV--0062/1) CLIMATE PROGRAM PLAN. VOLUME 1 OF 2. (California Univ., Livermore (USA). Lawrence Livermore Lab.; Department of Energy, Washington, DC (USA). Office of Health and Environmental Research). Jan 1980. Contract W-7405-ENG-48. 90p. Dep. NTIS, PC A05/MF A01.
- As part of the United States Climate Program Plan developed by the Interdepartmental Committee for Atmospheric Sciences, DOE is responsible for developing an understanding of and assessment capabilities for the effects of climate and climate fluctuations on man's generation of power, the effects of power generation and its various fuel processes and/or control technologies on climate, and development of blends of power generation and distribution modes that minimize adverse environmental and climatic effects. The DOE Climate Program Plan focuses on these three major roles in basic and applied research. The purpose of this document is to present background information relevant to these roles, to identify the perceived and potential effects of energy technologies on climate that now merit assessment, to define the need for research on the prediction of weather and climate variations and assessment of their effects on power production, and to outline research goals appropriate to the DOE mission. This report focuses on the need for assessing the cycles and budgets of the entire range of substances emitted in power production by the many technologies now in use. Emissions include but are not limited to ⁸⁵Kr, particles, sulfur, and nitrogen oxides, waste heat, and hydrocarbons. To provide the basis for assessing the impacts of these emissions, this plan calls for specialized, mission-oriented research to improve understanding of processes that determine how these emissions are transported, transformed, and scavenged in the atmosphere, and of the natural processes that can be affected by energy activities. This latter category includes potential modification of surface properties caused, for example, by large arrays of solar collectors, extensive biomass production, and wind power modification of the boundary layer. (JGB)
- 19 (DOE/ER--0050) CLIMATE AND ENERGY: A COMPARATIVE ASSESSMENT OF THE SATELLITE POWER SYSTEM (SPS) AND ALTERNATIVE ENERGY TECHNOLOGIES. Kellermeyer, D.A. (Argonne National Lab., IL (USA)). Jan 1980. Contract W-31-109-ENG-38. 69p. Dep. NTIS, PC A04/MF A01.
- The potential effects of five energy technologies on global, regional, and local climate were assessed. The energy technologies examined were coal combustion, light water nuclear reactors, satellite power systems, terrestrial photovoltaics, and fusion. The assessment focused on waste heat rejection, production of particulate aerosols, and emissions of carbon dioxide. The current state of climate modeling and long-range climate prediction introduces considerable uncertainty into the assessment, but it may be concluded that waste heat will not produce detectable changes in global climate until world energy use increases 100-fold, although minor effects on local weather may occur now; that primary particulate emissions from coal combustion constitute a small percentage of total atmospheric particulates; that carbon dioxide from coal combustion in the US alone accounts for about 30% of the current increase in global atmospheric CO₂, which may, by about 2050, increase world temperature 2 to 3°C, with

pronounced effects on world climate; that rocket exhaust from numerous launches during construction of an SPS may affect the upper atmosphere, with uncertain consequences; and that much research in climatology is needed before potential effects can be quantitatively predicted with any confidence. Although climatic impact is an appropriate concern in formulating long-term energy policy, the level of uncertainty about it suggests that it is not currently useful as a decision criterion. 88 references.

20 EXPANDED USE OF FOSSIL FUELS BY THE U.S. AND THE GLOBAL CARBON DIOXIDE PROBLEM.

Emanuel, W.R.; Olson, J.S.; Killough, G.G. (Oak Ridge National Lab., TN). Contract W-7405-ENG-26. J. Environ. Manage.; 10: No. 1, 37-49 (Jan 1980).

Continued combustion of fossil fuels contributes to a steady increase of carbon dioxide concentration in the atmosphere. Projecting present increases in rates of fossil-fuel utilization, a doubling of CO₂ concentration in the atmosphere may be expected within the next 75 years. Based on preliminary calculations, coal utilization by the U.S. to the year 2020 accounts for between 9 and 14% of the increase in CO₂ concentration. Carbon dioxide in the atmosphere absorbs infrared radiation, causing an increase in the surface temperature of the earth. The most recent climatic models indicate that each doubling in atmospheric CO₂ concentration will result in a temperature increase of approximately 3 ± 1°C, depending on the model used. Changes in average rates of precipitation and evaporation may follow, leading to higher probabilities of drought in the mid-latitudes (including the U.S.). Manabe and Wetherald (J. Atmos. Sci., 32: 3-15 (1975)) have estimated the temperature increase at high latitudes to be three times the increase in the global average surface temperature. Large-scale melting of the polar ice caps and a subsequent increase in the surface area of the oceans may follow on a timetable that is not yet clear. The distribution of vegetation and agricultural activities can be expected to change in response to the temperature increase and associated with the analysis of the CO₂/climate problem mandate the initiation of an immediate global-scale interdisciplinary research effort to determine more clearly the components and connections of the problem and to develop strategies for reducing the impacts, i.e., contingency plans that could be helpful regardless of impact details which remain to be determined. 26 references.

21 (BNL-27406) SHELF-SEA ECOSYSTEMS.

Walsh, J.J. (Brookhaven National Lab., Upton, NY (USA)). 1980. Contract EY-76-C-02-0016. 75p. NTIS, PC A04/MF A01.

An analysis of the food chain dynamics of the Oregon, Alaskan, and New York shelves is made with respect to differences in physical forcing of these ecosystems. The world's shelves are 10% of the area of the ocean, yield 99% of the world's fish catch, and may be a major sink in the global CO₂ budget.

22 (CONF-800475-1) TOWARD A POLITICAL ANALYSIS OF THE CONSEQUENCES OF A WORLD CLIMATE CHANGE PRODUCED BY INCREASING ATMOSPHERIC CARBON DIOXIDE.

Schwartz, R. (Aspen Inst. for Humanistic Studies, Boulder, CO (USA)). 1980. Contract AC02-79-DE-10281. 25p. NTIS, PC A02/MF A01.

From Southwestern Political Science Association annual meeting; Houston, TX, USA

(2 Apr 1980).

It was Hegel's extraordinarily deep and perceptive insight that mankind is caught up in a drama that cannot be fully understood until it has been played out. The owl of Minerva spreads its wings only with the falling of the dusk. On the more hopeful side is the fact that, although we cannot know the consequences of future interactions between climate and society, we can begin to work toward political solutions and gird ourselves for ominous trends that are now coming into view. The purpose of this paper is to identify one such trend, namely the increase of atmospheric temperatures due to increased carbon dioxide (CO₂) and lay some initial groundwork for political research related to climate-societal interactions.

23 EXPANDED USE OF FOSSIL FUELS BY THE US AND THE GLOBAL CARBON DIOXIDE PROBLEM. Emanuel, W.R.; Olson, J.S.; Gillough, G.G. (Oak Ridge National Lab., TN). Contract W-7405-ENG-26.

J. Environ. Manage.; 10: 37-49 (1980).

Projecting present increases in rates of fossil fuel utilization, a doubling of CO₂ concentration in the atmosphere may be expected within the next 75 years. Based on preliminary calculations, coal utilization by the United States to the year 2020 accounts for between 9 and 15% of the increase in CO₂ concentration. Carbon dioxide in the atmosphere absorbs infrared radiation, causing an increase in the surface temperature of the earth. The most recent climatic models indicate that each doubling in atmospheric CO₂ concentration will result in a temperature increase of approximately 3 ± 1°C, depending on the model used. Changes in average rates of precipitation and evaporation may follow, leading to higher probabilities of drought in the mid-latitudes (including the United States). Manabe and Wetherald (1975) have estimated the temperature increase at high latitudes to be three times the increase in the global average surface temperature. Large-scale melting of the polar ice caps and a subsequent increase in the surface area of the oceans may follow on a timetable that is not yet clear. The distribution of vegetation and agricultural activities can be expected to change in response to the temperature increase and associated changes in precipitation and evaporation. The many uncertainties associated with the analysis of the carbon dioxide/climate problem mandate the initiation of an immediate global-scale interdisciplinary research effort to determine more clearly the components and connections of the problem and to develop strategies for reducing the impacts, i.e., contingency plans that could be helpful regardless of impact details which remain to be determined.

24 (CONF-800549-3) MODELING THE ROLE OF TERRESTRIAL ECOSYSTEMS IN THE GLOBAL CARBON CYCLE. Emanuel, W.R.; Post, W.M.; Shugart, H.H. Jr. (Oak Ridge National Lab., TN (USA)).

1980. Contract W-7405-ENG-26. 16p. NTIS, PC A02/MF A01.

From 11. annual modeling and simulation conference; Pittsburgh, PA, USA (1 May 1980).

A model for the global biogeochemical cycle of carbon which includes a five-compartment submodel for circulation in terrestrial ecosystems of the world is presented. Although this terrestrial submodel divides carbon into compartments with more functional detail than previous models, the variability in carbon dynamics among ecosystem types and in different climatic zones is not adequately treated. A new model construct which specifically treats this variability by modeling the distribution of

- ecosystem types as a function of climate on a 0.5° latitude by 0.5° longitude scale of resolution is proposed.
- 25 (DOE/EV/10281--T1) GLOBAL POLITICAL SYSTEM'S PERSPECTIVE TO CLIMATE-SOCIETY INTERACTIONS. Schwere, R. (Aspen Inst. for Humanistic Studies, Boulder, CO (USA)). 1980. Contract AC02-79EV10281. 23p. NTIS, PC A02/MF A01.
The purpose of this paper is to suggest some of the principal elements that might be useful in the development of a general theory of the climate-society interaction, to point out some of the pathways and linkages among political components involved in coping with climatic impacts, and to identify some obstacles, strategies, and incentives that apply to making policy choices related to climate.
- 26 (CONF-7809197--) PROCEEDINGS OF THE WORKSHOP ON STRATOSPHERIC AND MESOSPHERIC IMPACTS OF SATELLITE POWER SYSTEMS (SPS). (Argonne National Lab., IL (USA)). Dec 1979. Contract W-31-109-ENG-38. 120p. Dep. NTIS, PC A06/MF A01.
From Workshop on stratospheric and mesospheric impacts of satellite power systems; Rosemont, IL, USA (6 Sep 1978).
Three general issues were identified as potentially significant and deserving of consideration. These general issues are summarized as follows: (1) Composition perturbations due to: (a) rocket exhaust emissions, and (b) reentry effects; (2) Climatic effects due to: (a) increased noctilucent cloud formation, and (b) composition perturbations; and (3) Effects of localized energy injection: (a) rocket exhaust thermal energy and (b) microwave absorption. The conclusions and recommendations of the workshop participants are summarized for each individual issue. The basis for these conclusions is contained in the participants' discussion as summarized in the preceding section and in the written contributions prepared by individual participants and collected together in Appendix B. The recommendations for further research also in general follow from the discussion, but are also based upon the assumption that two years would be available from the date of the workshop in which to carry them out before the final environmental impact assessment would be due. Finally, a list of general recommendations made by workshop participants is given. (WHK)
- 27 (UCRL--S1444-79) PROGRAM REPORT FOR FY 1979: ATMOSPHERIC AND GEOPHYSICAL SCIENCES DIVISION OF THE PHYSICS DEPARTMENT. Knox, J.B.; Orphan, R.C. (eds.). (California Univ., Livermore (USA). Lawrence Livermore Lab.). Dec 1979. Contract W-7405-ENG-48. 81p. NTIS, PC A05/MF A01.
The Atmospheric and Geophysical Sciences (G) Division continues to develop and validate modeling techniques for air quality assessments. The data developed by G Division are used by government officials to help them plan and implement energy programs. Our research includes the following varied areas: regional and local effects of atmospheric releases of toxic or radioactive materials; global climatic effects of accumulated atmospheric carbon dioxide resulting mainly from the increased use of fossil fuels; behavior of pollutants in areas of complex terrain or complex meteorological processes; evaluation of hazards from LNG spills; impact of fossil-fuel emissions, particularly sulfates and acid rain. These studies help the DOE to fulfill its goal of meeting our energy needs while at the same time ensuring public health, safety, and an acceptable environment quality.
- 28 ENVIRONMENTAL IMPLICATIONS OF FOSSIL-FUELLED POWER STATIONS. Robson, A. (Central Electricity Generating Board, London (UK)). R. Soc. Health J.; 99: No. 6, 247-255 (Dec 1979).
The public health and environmental implications of electricity generation by fossil-fuelled power stations are discussed with respect to pollutant emission and the disposal of waste products. The following conclusions were deduced. The policy of using tall chimney stacks has ensured that acceptable concentrations of potential pollutants are observed in the vicinity of power stations. Large scale carbon dioxide emission may represent a problem in the future due to its effect on the climate. The effects of sulphur dioxide and the oxides of nitrogen need to be kept under review but it is likely that sources other than power stations will be of greater importance in this context. Pulverised fuel ash is a safe and useful by product of power production. Finally the radiation dose to man caused by the release of naturally occurring radioisotopes is negligible compared to the natural background levels.
- 29 CO₂-CLIMATE SENSITIVITY STUDY WITH A MATHEMATICAL MODEL OF THE GLOBAL CLIMATE. Manabe, S.; Stouffer, R.J. (Princeton Univ., NJ). Nature (London); 282: No. 5738, 491-493 (29 Nov 1979).
An increase in the CO₂-content of the atmosphere resulting from man's activity could have a significant effect on the climate in the near future. Some new results from a study of the response of a mathematical model of the climate to an increase in the CO₂-content of the air are described. The mathematical model consists of (1) a general circulation model of the atmosphere and (2) a simple mixed layer ocean model with uniform thickness. The atmospheric model predicts the changes of the vertical component of vorticity, divergence, temperature, moisture and surface pressure based on the equations of motion, the thermodynamical equation, and the continuity equations of moisture and mass.
- 30 CO₂-CLIMATE SENSITIVITY STUDY WITH A MATHEMATICAL MODEL OF THE GLOBAL CLIMATE. Manabe, S.; Stouffer, R.J. (NOAA Geophysical Fluid Dynamics Lab, NJ). Nature (London); 282: No. 5738, 491-493 (29 Nov 1979).
A mathematical model was developed to evaluate the climatic effects of an atmospheric carbon dioxide increase. The model consists of a general circulation model of the atmosphere and a simple mixed layer model of the ocean. The functions of the two component models are discussed. Results of two time-integration simulations of the mathematical model are reported. In general, it is suggested that the warming of the atmosphere in response to an increase in CO₂ will have significant seasonal and interhemispheric impacts. Area mean temperature changes and changes in mean thickness of sea ice that could occur as a result of increased CO₂ levels are tabulated. (4 graphs, 10 references, 1 table)
- 31 AN EMPIRICAL DETERMINATION OF THE HEATING OF THE EARTH BY THE CARBON DIOXIDE GREENHOUSE EFFECT. Hoyt, D.V. (Cooperative Inst for Research on Env Sciences, Colo). Nature (London); 282: No. 5737, 388-390 (22 Nov 1979).

Models that were developed to describe global warming trends caused by increased concentrations of atmospheric carbon dioxide are reviewed. Described is a new model that permits empirical determination of temperature increases caused by the greenhouse effect. The model is used to evaluate atmospheric CO₂ data for 1880-1970. According to the new technique, the global temperature increase caused by the greenhouse effect was 1 m gr 1x0.40°C during that period. (3 graphs, 33 references)

Rotty, R.M. (Institute for Energy Analysis, Oak Ridge Associated Universities, Oak Ridge, Tennessee). Rev. Geophys. Space Phys.; 17: No. 4, 1813-1824 (Oct 1979).

Literature on the possible impact of carbon dioxide emissions on global climate is reviewed. The aspects covered are the following: Man's impact on carbon cycle, natural carbon cycle and perturbations, climatic response to carbon dioxide and human responses to climate change.

- 32 SPECULATIONS ABOUT THE UPPER MIOCENE CHANGE IN ABYSSAL PACIFIC DISSOLVED BICARBONATE DELTA¹³C. Bender, M.L.; Keigwin, L.D. Jr (Rhode Island Univ., Kingston (USA). Graduate School of Oceanography). Earth Planet. Sci. Lett.; 45: No. 2, 383-393 (Nov 1979).

New data from three Tasman Sea cores support Keigwin's observation that the delta¹³C of Pacific benthic foraminifera (and by inference bottom-water TCO₂) decreased by 0.7 per thousand at about 6.5 Myr B.P. Simple box models are developed and used to test several hypotheses about the cause of the delta¹³C decrease. The authors favor the idea that the delta¹³C shift was due to a rapid change in TCO₂ cycling within the oceans (such as would result from either a decrease in upwelling rate, or an increase in the fraction of PO₄³⁻ reaching the deep oceans in particulate organic matter and a corresponding drop in the performed PO₄³⁻ concentration). The delta¹³C decrease across the shift might reflect either a global decrease in upwelling rate, or a different abyssal circulation pattern before the shift.

- 33 FATE OF FOSSIL FUEL CARBON DIOXIDE AND THE GLOBAL CARBON BUDGET. Broecker, W.S.; Takahashi, T.; Simpson, H.J.; Peng, T.H. (Columbia Univ., Palisades, NY). Science; 206: 409-418 (26 Oct 1979).

The fate of fossil fuel carbon dioxide released into the atmosphere depends on the exchange rates of carbon between the atmosphere and three major carbon reservoirs, namely, the oceans, shallow-water sediments, and the terrestrial biosphere. Various assumptions and models used to estimate the global carbon budget for the last 20 years are reviewed and evaluated. Several versions of recent atmosphere-ocean models appear to give reliable and mutually consistent estimates for carbon dioxide uptake by the oceans. On the other hand, there is no compelling evidence which establishes that the terrestrial biomass has decreased at a rate comparable to that of fossil fuel combustion over the last two decades, as has been recently claimed.

- 34 FATE OF FOSSIL FUEL CARBON DIOXIDE AND THE GLOBAL CARBON BUDGET. Broecker, W.S.; Takahashi, T.; Simpson, H.J.; Peng, T.H. Science; 206: No. 4417, 409-418 (26 Oct 1979).

The fate of fossil fuel carbon dioxide released into the atmosphere depends on the exchange rates of carbon between the atmosphere and the oceans, shallow-water sediments and the terrestrial biosphere. Models and assumptions used to estimate the global carbon budget for the last 20 years are reviewed and evaluated. Several atmosphere-ocean models agree with estimates for carbon dioxide uptake by the oceans. There is no evidence to establish that terrestrial biomass has decreased at a rate comparable to that of fossil fuel combustion over the last two decades.

- 36 COMING ENERGY CRUNCH. Agenda; 2: No. 4, 7-13 (Aut 1979).

Roads to Energy Self-Reliance: The Necessary National Demonstrations, Science Council Report No. 30, outlines a 25-year, \$3.8 billion program of energy research, development, and demonstration designed to make Canada energy self-reliant. Energy supply is tied to economic, social, and political sovereignty, and it is noted that more than 90% self-sufficiency can be achieved by the end of the century, and Canada can become totally self-sufficient by 2025 if the recommended demonstration programs are undertaken. Programs on oil and gas, coal, nuclear energy, renewable energy sources, and conversion technologies are described. Press comments on the Report No. 30 are presented. The impact of massive use of coal and synthetic fuels on the climate of Canada is discussed in a section entitled, Carbon Dioxide: Pandora's Emissary. In a section entitled, Reflections on Canada's Energy Options, it is stated that the Report No. 30 left too many eggs in the basket of the Western provinces and their oil industry. It is concluded that it is important to develop all resources.

- 37 (DOE/EV--0046(Vol.1)) PROCEEDINGS OF THE US DEPARTMENT OF ENERGY ENVIRONMENTAL CONTROL SYMPOSIUM. VOLUME 1. PLENARY SESSION AND FOSSIL FUELS. (Department of Energy, Washington, DC (USA). Div. of Environmental Control Technology; Argonne National Lab., IL (USA)). Sep 1979. Contract W-31-109-ENG-38. 655p. (CONF-781109--(Vol.1)). Dep. NTIS, PC A99/MF A01.

From Environmental control symposium; Washington, DC, USA (28 Nov 1978).

Volume one of the proceedings (Plenary Session and Fossil Fuels) contains papers on environmental pollution control which resulted mainly from US DOE's research programs in coal (preparation, desulfurization, gasification, liquefaction, combustion, fluidized-bed combustion, and pollution control methods with respect to SO₂, NO_x, and CO₂ (global effects and feasibility studies)); a few papers deal with oil shale operations and the enhanced recovery of petroleum. Papers have been entered individually into EDB and ERA, with 3 also into EAPA; six papers had been entered previously from other sources. (LTN)

- 38 (BNL--51116) ENVIRONMENTAL CONTROL TECHNOLOGY FOR ATMOSPHERIC CARBON DIOXIDE. FINAL REPORT. Albanese, A.S.; Steinberg, M. (Brookhaven National Lab., Upton, NY (USA)). Sep 1979. Contract EY-76-C-02-0016. 58p. Dep. NTIS, PC A04/MF A01.

The impact of fossil fuel use in the United States on worldwide CO₂ emissions and the impact of increased coal utilization on CO₂ emission rates are assessed. The aspects of CO₂ control are discussed as well as the available CO₂ control points (CO₂ removal sites). The primary factor affecting the practicability of a CO₂ control system is the energy required by the control system. Of the three potential CO₂ control points, removal from the stacks of

- 35 CARBON DIOXIDE AND CLIMATE. Marland, G.;

- fossil fuel power plants appears to require the least amount of energy. Estimates of the energy required to capture and recover CO₂ from coal-fired power plant stacks by various processes are presented. Although capture and recovery of CO₂ is an important consideration in the overall scheme of CO₂ control, disposal or reuse of recovered CO₂ may be the weakest link in the CO₂ control chain. Of the several options considered, deep ocean storage appears to be the most promising. Two control scenarios are evaluated, one based on the absorption of CO₂ contained in power plant flue gas by seawater; the other, based on absorption of CO₂ by monoethanolamine (MEA). Captured CO₂ is injected into the deep ocean in both cases. Analyses indicate that capture and disposal by seawater is not feasible, whereas capture and disposal using MEA is a possibility. However, the economic penalties of CO₂ control are significant; for example, at a CO₂ removal efficiency of 50%, it is estimated that the power generation efficiency of a conventional coal fired power plant would be reduced from 34 to about 25%. The cost of power generation would be expected to double. For 90% CO₂ removal, power generation efficiency is reduced to between 15 and 6% and the cost of power generation increases by a factor of from 4 to 7.
- 39 ORGANIC CARBON EXPORT FROM UPLAND AND FORESTED WETLAND WATERSHEDS. Mulholland, P.J.; Kuenzler, E.J. (Univ. of North Carolina, Chapel Hill). *Limnol. Oceanogr.*; 24: No. 5, 960-966(Sep 1979).
Export of organic carbon per unit runoff from five small, eastern North Carolina watersheds with considerable swamp drainage was severalfold higher than the export rates from upland watersheds reported in the literature. This reflects the higher concentrations of organic carbon, especially dissolved forms, in swamp waters and is probably attributable to increased contact time between water and organic debris as well as to concentration effects of high evapotranspiration in swamps.
- 40 CARBON DIOXIDE AND PLANT GROWTH UNDER WATER AND LIGHT STRESS: IMPLICATIONS FOR BALANCING THE GLOBAL CARBON BUDGET. Gifford, R.M. (Commonwealth Scientific and Industrial Research Org, Australia). *Search*; 10: No. 9, 316-318(Sep 1979).
To accommodate upward revisions of the magnitude of carbon dioxide emissions due to deforestation, new sinks have to be postulated to balance the global carbon budget. Carbon fixation by the remaining intact biosphere may be more responsive to stimulation by increasing atmospheric concentration than was previously assumed. The response of plant growth to carbon dioxide concentrations under conditions of water-limited growth and light-limited growth is discussed. CO₂ caused a greater improvement in water use efficiency when water availability was most limited. Results also indicated a positive response of plant growth to CO₂ enrichment under low light conditions. (9 references, 2 tables)
- 41 (DOE/EV--0046(Vol.1), pp 237-259) ENVIRONMENTAL CONTROL TECHNOLOGY FOR CARBON DIOXIDE. Steinberg, M.; Albanese, A.S.; Dang, V.D. (Brookhaven National Lab., Upton, NY). Sep 1979.
From Environmental control symposium; Washington, DC, USA (28 Nov 1978).
The possible adverse global environmental effects of CO₂ buildup due to fossil fuel energy utilization have prompted an investigation of possible methods for its control. A systematic overview is presented for various routes for removal, recovery, disposal and use of CO₂ from various control points in the global system. The effect of substitute alternative non-fossil energy sources on the global CO₂ problem is evaluated. The energy and mass balances for a number of removal and recovery routes are used as evaluation criteria. Flow sheets are presented for conversion of CO₂ from various sources to synthetic carbonaceous fuels with the use of non-fossil energy. Several unique CO₂ disposal alternatives are presented and discussed. Many of the feasibility studies considered are treated in more detail than in other papers in the system. (LTN)
- 42 (DOE/EV--0046(Vol.1), pp 260-271) OPTIONS FOR COLLECTION AND DISPOSAL OF CARBON DIOXIDE FROM CONCENTRATED SOURCES. Baes, C.F. Jr. (Oak Ridge National Lab., TN); Beall, S.E.; Marland, G. Sep 1979.
From Environmental control symposium; Washington, DC, USA (28 Nov 1978).
The cost of recovery of carbon dioxide from the stack gas of fossil-fuel power plants and its disposal in the ocean are considered. It is concluded that: the cost of CO₂ recovery from flue gas will be high; combustion of fuel in pure oxygen may permit a more efficient recovery of CO₂ (and SO₂), partly because of improvement in overall efficiency of the plant, lower heat losses, less combustion air power, etc.; deep ocean disposal would give a long retention time; fresh water is not a suitable medium for disposal; seawater could be used because dissolving CO₂ should increase the density of seawater; the cooling water flow from a fossil fuel plant is more than adequate to accommodate the CO₂ output of the plant, but the plant must be sited to permit ocean disposal; we need more data on the density effect of introducing CO₂ into seawater as a function of temperature and pressure; we need to know more of the rate of descent and spreading of the vertical plume formed by a CO₂ disposal stream; other forms of CO₂ suitable for disposal may include the hydrate and dry ice; and liquid CO₂ might be used for ocean disposal, but the depth of injection would be over 3,000 m.
- 43 IMPACT OF CARBON DIOXIDE ON CLIMATE. MacDonald, G.J. (The MITRE, Corporation 1820 Dolley Madison Boulevard, McLean, Virginia 22102). *Phys. Teach.*; 17: No. 6, 367-373(Sep 1979).
Statistics concerning the amount of CO₂ released into the atmosphere by fossil fuel burning are presented and discussed. Despite unknown factors in the carbon cycle, changes in climate are seen as very likely to occur. (AIP)
- 44 (DOE/EV--0046(Vol.1)) PROCEEDINGS OF THE US DEPARTMENT OF ENERGY ENVIRONMENTAL CONTROL SYMPOSIUM. VOLUME 1. PLENARY SESSION AND FOSSIL FUELS. (Department of Energy, Washington, DC (USA). Div. of Environmental Control Technology; Argonne National Lab., IL (USA)). Sep 1979. Contract W-31-109-ENG-38. 655p. (CONF-781109--(Vol.1)). Dep. NTIS, PC A99/MF A01.
From Environmental control symposium; Washington, DC, USA (28 Nov 1978).
Volume one of the proceedings (Plenary Session and Fossil Fuels) contains papers on environmental pollution control which resulted mainly from US DOE's research programs in coal (preparation, desulfurization, gasification, liquefaction, combustion, fluidized-bed

- combustion, and pollution control methods with respect to SO_2 , NO_x , and CO_2 (global effects and feasibility studies); a few papers deal with oil shale operations and the enhanced recovery of petroleum. Papers have been entered individually into EDB and ERA, with 3 also into EAP; six papers had been entered previously from other sources. (LTN)
- 45 (UCID--18332) INTERNATIONAL SCIENTIFIC INTEREST IN THE QUESTION OF CO_2 INDUCED CLIMATE CHANGE. Potter, G.L. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Sep 1979. Contract W-7405-ENG-48. 10p. Dep. NTIS, PC A02/MF A01.
- International scientific interest in the CO_2 climate question has been increasing recently. A survey of researchers shows that West Germany, Canada, USSR, and Great Britain are the most active in investigating various aspects of the CO_2 climate question. In addition, numerous individual scientists are very active in the assessment of the carbon balance and climatic effects of increased CO_2 . Industrialized countries have shown the greatest concern while developing countries have very little interest in the problem.
- 46 MARKET PENETRATION CHARACTERISTICS FOR ENERGY PRODUCTION AND ATMOSPHERIC CARBON DIOXIDE GROWTH. Laurmann, J.A. (Stanford Univ., CA). Science; 205: 896-898 (31 Aug 1979).
- Estimates are given for the maximum rate at which fossil-fuel consumption can be reduced by introducing non-carbon-based energy sources, using the market-penetration-time concept. These estimates indicate an immediate need to implement a revised energy policy, if major climatic changes due to increased amounts of carbon dioxide are to be avoided in the next century. The application of market-penetration ideas to energy consumption is new, however, and may not be valid for the prediction of future trends. 11 references.
- 47 INCREASED ATMOSPHERIC CO_2 : ZONAL AND SEASONAL ESTIMATES OF THE EFFECT ON THE RADIATION ENERGY BALANCE AND SURFACE TEMPERATURE. Ramanathan, V.; Lian, M.S.; Cess, R.D. (National Center for Atmospheric Research, Boulder, Colorado 80307). J. Geophys. Res.; 84: No. C8, 4949-4958 (20 Aug 1979).
- The climatic effects of increased atmospheric CO_2 are discussed in the context of the effect upon two basic components of the climate system, namely, (1) latitudinal and seasonal radiative heating of the surface-troposphere system and (2) the enhancement of latitudinal and seasonal surface temperatures. Radiative transfer model calculations show that the radiative heating of the surface-troposphere system (caused by increased CO_2) undergoes substantial latitudinal and seasonal variations. The seasonal variations are most pronounced at high latitudes. The increased CO_2 heating of the surface and troposphere is significantly different for clear sky and overcast sky conditions. These CO_2 heating calculations were then incorporated within a seasonal energy balance climate model for the northern hemisphere. Despite the significant seasonal variations in surface-troposphere heating due to increased CO_2 , the seasonal model results, when annually averaged over all latitudes, yield essentially the same CO_2 -induced increase in hemispherical mean surface temperature as does an annual energy balance model. The seasonal model, however, shows a strong seasonal variation at high latitudes for
- the increase in zonal surface temperature due to increased atmospheric CO_2 . For example, the CO_2 -induced enhancement in the zonal surface temperature for 80°N - 90°N is more than 3 times as great in the summer as in the winter.
- 48 (UCID--18248) HEALTH AND RELATED ENVIRONMENTAL EFFECTS OF GREATLY INCREASED COAL USE. Ramsey, W.J.; Thornton, R.L. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 17 Aug 1979. Contract W-7405-ENG-48. 29p. Dep. NTIS, PC A03/MF A01.
- There is a wealth of information already published on the health and related environmental effects of coal use. However, thus far such information does not lead to rigorous conclusions regarding those effects. Uncertainty still exists as to which emissions pose the greatest hazards. A recent book summarizes well what is known about air pollution and human health. Several attempts have been made to assess injuries and deaths attributable to the coal utilization system from mining through electrical power generation. Environmental assessments of emerging coal conversion technologies are also being carried out. The high degree of uncertainty in these evaluations justifies concern about future health effects of greatly increased coal use. Neither can we be sanguine about the increasing levels of carbon dioxide in the atmosphere due to increasing fossil fuel combustion and their potential effects on climate. Large-scale changes in climate could lead to, among other effects, civil and international disorder because of a redistribution of areas of agricultural productivity and thus to considerable human suffering.
- 49 DESIGN FOR A TECHNOLOGY ASSESSMENT OF COAL. Kawamura, K. and others. Futures; 11: No. 4, 299-311 (Aug 1979).
- The objective of the assessment was to compare the environmental, social, economic, and institutional consequences that may arise from development of various mixes of coal based energy technologies to 2030. The assumptions behind the method, experience from two U.S. public forum discussions, the three scenarios constructed and the results of analysis of the effects of global carbon dioxide build-up from coal combustion are presented.
- 50 DESIGN FOR A TECHNOLOGY ASSESSMENT OF COAL. Kawamura, K.; Boroush, M.; Chen, K.; Christakis, A.N. (Battelle, Columbus Lab, Ohio). Futures; 11: No. 4, 299-311 (Aug 1979).
- The objective of the coal technology assessment is to compare the environmental, social, economic, and institutional consequences that may arise from development of various mixes of coal-based energy technologies to the year 2030. This article presents the assumptions behind the method, the experience from two forums with interested parties, the three scenarios constructed for the study, and the result of one issue analysis, namely the effects of global carbon-dioxide buildup from coal combustion. Refs.
- 51 (UCRL--82556) MAN'S EFFECT ON STRATOSPHERIC OZONE. Ellsaesser, H.W. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Aug 1979. Contract W-7405-ENG-48. 23p. (CONF-790858--2). Dep. NTIS, PC A02/MF A01.
- From 4. international symposium on environmental biogeochemistry; Canberra,

Australia (27 Aug 1979).

Since McDonald, at the beginning of this decade, first proposed that water vapor from SST exhaust would lead to increases in skin cancer, about a dozen man-induced mechanisms have been suggested as threatening to modify our stratospheric ozone uv-shield. Possible thinning of the ozone layer has been attributed to one or more of the catalytic ozone destroyers, water vapor ($\text{HO}/\text{sub } x/$), oxides of nitrogen ($\text{NO}/\text{sub } x/$), chlorine (ClX); or bromine (BrX). The original catalyst, $\text{HO}/\text{sub } x/$, rather quickly lost its role to $\text{NO}/\text{sub } x/$. In an almost unique evolution, computed sensitivity of stratospheric ozone to $\text{NO}/\text{sub } x/$ progressively declined until a reversal of effect occurred. Models now compute a thickening of the ozone layer for any but high level or very massive injections of $\text{NO}/\text{sub } x/$. Meanwhile, computed sensitivity to ClX has fluctuated widely and in 1978 models increased to the point where comparisons with observations were becoming an embarrassment. The potential role of BrX has also increased but awaits a credible source of stratospheric bromine to bring it center stage. More recently the atmospheric build-up of carbon dioxide, by cooling the stratosphere and increasing the chemical equilibrium level of ozone, has also been recognized as a potential modifier of the ozone layer.

- 52 ARE WE HEATING UP OUR EARTH. Degens, E.T.; Kempe, S. Bild Wiss.; 16: No. 8, 52-58 (Aug 1979). (In German).

The CO_2 climatological thermometer is visibly rising - we are about to enter into a warm period. But anyone who thinks this heating up, which is expected on a world-wide scale, is going to be something pleasant and agreeable is making a mistake. We know from the geological history of the earth that a global rise in temperature of as little as 2°C crucially affects the climatic belt and, in its turn, the plant world. A change in climate which previously took thousands of years is thus taking place in a few decades. The reason for this is the increase in the CO_2 content of the air caused by human activities. If we fail to restrict the combustion of fossil fuels the earth will turn into a hot house.

- 53 (DOE/ET/10040--1) ROLE OF TEMPERATE ZONE FORESTS IN THE WORLD CARBON CYCLE: PROBLEM DEFINITION AND RESEARCH NEEDS. Armentano, T.V.; Hett, J. (eds.). (Institute of Ecology, Indianapolis; IN (USA)). Aug 1979. Contract AC02-79EV10040. 69p. Dep. NTIS, PC A04/MF A01.

The proceedings of a workshop on carbon uptake and losses from temperate zone forests are reported. Total standing stock and growth recovery transients were examined for most of the temperate region over a period from pre-settlement times to the present, with emphasis on the last three decades. Because of data availability, certain regions and topics were covered more in detail than others. The forest inventory data reviewed here suggests the temperate zone forests could have functioned for the past several decades as a net sink for 10^9 tons of carbon annually. This is nearly one-half of the total annual rise in carbon concentration of the atmosphere. However, due to the limited data on non-commercial timberlands, nonmerchantable tree components, and soil organic matter changes, the precision of this estimate of temperate zone C retention may be only within one-quarter to one-half of the true value. Despite this limitation, the available data suggests strongly that temperate zone forests probably are not a source of

carbon as implied by the 2.2×10^9 tons annual release postulated by Woodwell et al (1978). The principal areas for which new information would reduce uncertainties in estimates of carbon uptake and losses from temperate zone forests are discussed, and recommendations are made for a series of research initiatives to increase resolution of the problem areas. (JGB)

- 54 (CONF-790202--; pp 235-250) DIFFERENT CONSTRAINT ON ENERGY SYSTEMS. Rotty, R. (Inst. for Energy Analysis, Oak Ridge, TN). Jul 1979.

From 6. annual energy conference and exhibition energy and the public; Knoxville, TN, USA (21 Feb 1979).

The environmental effects of global energy demand and global energy use are examined in respect to the release of carbon dioxide (CO_2) over time. Data from 1948 show a steady increase in CO_2 concentrations in the atmosphere and reflect the presence of an annual cycle which has a biological basis. Measurements of the CO_2 buildup and its impact on climate indicate that there are temperature increases for the lower latitudes and a significant change in the temperature gradient from the equator to the pole. The implications that changing weather and food production patterns will have for socio-economic and political structures are examined in terms of the energy needed for a growing world population and the economic development of Third World countries.

- 55 (DOE/ET/2880--1) POSSIBLE FUTURE ENVIRONMENTAL ISSUES FOR FOSSIL FUEL TECHNOLOGIES. FINAL REPORT. Attaway, L.D. (Flow Resources Corp., San Rafael, CA (USA)). Jul 1979. Contract ET-78-C-01-2880. 245p. Dep. NTIS, PC A11/MF A01.

The work reported here was carried out for the Department of Energy's Office of Fossil Energy to identify and assess 15 to 20 major environmental issues likely to affect the implementation of fossil energy technologies between 1985 and 2000. The energy technologies specifically addressed are: oil recovery and processing; gas recovery and processing; coal liquefaction; coal gasification (surface); in situ coal gasification; direct coal combustion; advanced power systems; magnetohydrodynamics; surface oil shale retorting; and true and modified in situ oil shale retorting. Environmental analysis of these technologies included, in addition to the main processing steps, the complete fuel cycle from resource extraction to end use. The 16 environmental issues identified as those most likely for future regulatory actions and the main features of, and the possible regulatory actions associated with, each are as follows: disposal of solid waste from coal conversion and combustion technologies; water consumption by coal and oil shale conversion technologies; siting of coal conversion facilities; the carbon dioxide greenhouse effect; emission of polycyclic organic matter (POM); impacts of outer continental shelf (OCS) oil development; emission of trace elements; groundwater contamination; liquefied natural gas (LNG), safety and environmental factors; underground coal mining - health and safety; fugitive emissions from coal gasification and liquefaction - health and safety; boomtown effects; emission of fine particulates from coal, oil and oil shale technologies; emission of radioactivity from the mining and conversion of coal; emission of nitrogen oxides; and land disturbance from surface mining. (LTN)

- 56 (CONF-790202-- pp 235-256) DIFFERENT CONSTRAINT ON ENERGY SYSTEMS. Rotty, R. (Inst. for Energy Analysis, Oak Ridge, TN). Jul 1979.

From 6. annual energy conference and exhibition energy and the public; Knoxville, TN, USA (21 Feb 1979).

The environmental effects of global energy demand and global energy use are examined in respect to the release of carbon dioxide (CO_2) over time. Data from 1948 show a steady increase in CO_2 concentrations in the atmosphere and reflect the presence of an annual cycle which has a biological basis. Measurements of the CO_2 buildup and its impact on climate indicate that there are temperature increases for the lower latitudes and a significant change in the temperature gradient from the equator to the pole. The implications that changing weather and food production patterns will have for socio-economic and political structures are examined in terms of the energy needed for a growing world population and the economic development of Third World countries.

- 57 STUDIES OF DIFFERENT ENERGY STRATEGIES IN TERMS OF THEIR EFFECTS ON THE ATMOSPHERIC CO_2 CONCENTRATION. Niehaus, F.; Williams, J. (Energy Systems Program, International Institute for Applied Systems Analysis A-2361 Laxenburg, Austria). J. Geophys. Res.; 84: No. C6, 3123-3130(20 Jun 1979).
- EARTH ATMOSPHERE; CARBON DIOXIDE; QUANTITY RATIO; INERT ATMOSPHERE; TEMPERATURE EFFECTS; AMBIENT TEMPERATURE; CARBON CYCLE; ENERGY DEMAND; FOSSIL FUELS; WASTE HEAT; NATIONAL ENERGY PLAN; ENERGY MANAGEMENT; CHEMICAL COMPOSITION

- 58 DIP IN THE ATMOSPHERIC CO_2 LEVEL DURING THE MID-1960'S. Bacastow, R. (Scripps Institution of Oceanography, La Jolla, California 92093). J. Geophys. Res.; 84: No. C6, 3108-3114(20 Jun 1979).

Removal of the southern oscillation effect from the CO_2 records at Mauna Loa, Hawaii, and the South Pole reveals corresponding decreases following the Agung eruption in 1963. The period of the decreases roughly corresponds to the period of reduced solar transmittance, as measured at Mauna Loa. It is suggested that the decrease in CO_2 level is due to reduced sea surface temperatures, for which there is some direct evidence. The temperature anomaly required to produce the CO_2 level dip is calculated on the basis of several simple models and found to be close to that observed.

- 59 INFERENCES DRAWN FROM ATMOSPHERIC CO_2 DATA. Rust, B.W.; Rotty, R.M.; Marland, G. (Institute for Energy Analysis, Oak Ridge Associated Universities, Oak Ridge, Tennessee 37830). J. Geophys. Res.; 84: No. C6, 3115-3122(20 Jun 1979).

Detailed analyses of the atmospheric carbon dioxide concentration measurements from Mauna Loa Observatory have produced a model which describes most of the variability in the data. The final model is $y(t) = a + \frac{de}{\sup at + \frac{E}{\sub i}} - \frac{1}{2} \frac{A}{\sub i} \sin \left[\left(\frac{2\pi}{T} \sub i \right) (t + \phi_1) \right] + \frac{E}{\sub j} - \frac{1}{2} \frac{F}{\sub j} \sin \left[\left(\frac{2\pi}{\tau} \sub j \right) (t + \theta) \right]$, where a is the preindustrial value, α is the exponential long-term growth rate, i represents the annual cycle and its harmonics, and j represents longer-term periodicities. The exponential growth rate is nearly identical to that calculated for the production of CO_2 from fossil fuel burning. A long-period component of about 44 months correlates with the southern oscillation index. Another long-period oscillation--about 142 months--has tentatively

been identified with the solar activity cycle and complicates the determination of α because the two sources of curvature interact in the fitting procedure, and the data record is not long enough to specify both of them independently. The generality of the model has been demonstrated by testing it against shorter data sequences from the South Pole and Australia.

- 60 (COO--2195-32) GLOBAL TRANSPORT PROCESSES AND INTERACTIONS WITH TRACE CONSTITUENTS. ANNUAL PROGRESS REPORT, 1 OCTOBER 1978-30 SEPTEMBER 1979. Newell, R.E. (Massachusetts Inst. of Tech., Cambridge (USA). Dept. of Meteorology). 18 Jun 1979. Contract EY-76-S-02-2195. 20p. Dep. NTIS, PC A02/MF A01.

Technical progress made in the period 1 October 1976 to 15 June 1978 is summarized. It was found that tropical Pacific sea temperature can be used to predict tropical air temperature several months ahead. Either Indian Ocean sea temperatures or volcanic aerosol may be used as a second predictor. Atmospheric CO_2 concentration also depends on tropical Pacific sea temperature, although whether the relationship occurs through the solubility effect or through the influence of the oceanic biosphere is not shown. A simple model for the temperature change accompanying a CO_2 doubling yields a temperature rise of less than 0.25°C , which is not in accord with other models.

- 61 CARBON DIOXIDE IN THE OCEAN SURFACE: THE HOMOGENEOUS BUFFER FACTOR. Sundquist, E.T. (Geological Survey, Reston, VA); Plummer, L.N.; Wigley, T.M.L. Science; 204: 1203-1205(15 Jun 1979).

The amount of carbon dioxide that can be dissolved in surface seawater depends at least partially on the homogeneous buffer factor, which is a mathematical function of the chemical equilibrium conditions among the various dissolved inorganic species. Because these equilibria are well known, the homogeneous buffer factor is well known. Natural spatial variations depend very systematically on sea surface temperatures, and do not contribute significantly to uncertainties in the present or future carbon dioxide budget.

- 62 (ORAU/IEA--79-10(R)) CARBON-13 FROM TREE RINGS AS A TRACER IN THE CARBON DIOXIDE PROBLEM. Bell, P.R. (Oak Ridge Associated Universities, Inc., TN (USA). Inst. for Energy Analysis). Jun 1979. Contract EY-76-C-05-0033. 30p. Dep. NTIS, PC A03/MF A01.

This report is concerned with the current state of the analysis of the $^{13}\text{C}/^{12}\text{C}$ ratio in the wood of trees. The aim of such research is to provide an historical record of the $^{13}\text{C}/^{12}\text{C}$ ratio in the atmosphere. The $\delta^{13}\text{C}$ of the atmosphere is about -7‰ (departure of the $^{13}\text{C}/^{12}\text{C}$ ratio in parts per thousand from the PDB standard), while the $\delta^{13}\text{C}$ of coal and wood is about -25‰ , petroleum is about -28‰ , and natural gas is still more negative. The dilution of atmospheric CO_2 by CO_2 from these sources is expected to have already changed the atmospheric value by about 1‰ . It is hoped that the isotopic record in the trees will allow a better estimate of the effects of deforestation and industrial CO_2 input. There are many complicating effects in the tree isotopic record, and rather large differences are found between trees. If it is possible to obtain the past record of the $^{13}\text{C}/^{12}\text{C}$ ratio in the atmosphere by this method, it will require extensive and careful effort.

- 63 QUESTIONS CONCERNING THE POSSIBLE INFLUENCE OF ANTHROPOGENIC CO₂ ON ATMOSPHERIC TEMPERATURE. Newell, R.E.; Dopplick, T.G. (Department of Meteorology, Massachusetts Institute of Technology, Cambridge 02139). J. Appl. Meteorol.; 18: No. 6, 822-825 (Jun 1979). Estimates of the atmospheric temperature changes due to a doubling of CO₂ concentrations have been with a static radiative flux model. They yield temperature changes >0.25 K. It appears that the much larger changes predicted by other models arise from additional water vapor evaporated into the atmosphere and not from CO₂ itself.
- 64 RADON EVASION RATES IN THE ATLANTIC AND PACIFIC OCEANS AS DETERMINED DURING THE GEOSecs PROGRAM. Peng, T.; Broecker, W.S.; Mathieu, G.G.; Li, Y.; Bainbridge, A.E. (Lamont-Doherty Geological Observatory and Department of Geological Sciences, Columbia University, Palisades, New York 10964). J. Geophys. Res.; 84: No. C5, 2471-2487 (20 May 1979). During the Geosecs expedition in the Atlantic and the Pacific oceans, more than 100 stations were occupied for the measurement of surface radon profiles. The radon deficiency in these profiles gives estimates of the gas transfer rate across the sea-air interface. The global mean transfer rate is estimated to be 2.9 m/d (at 20° C) which is corresponding to a hypothetical stagnant films thickness of about 36 microns. No clear relationship can be found between the gas exchange rate and wind speed. The CO₂ exchange rate as determined by the radon method is 80% of that given by the distributions of natural and of bomb-produced radiocarbon. One possible explanation may be that the Geosecs radon measurements were made during periods of lower than average wind speed. Another is that the conversion of CO₂ to HCO₃⁻ is catalyzed within the sea.
- 65 PROBLEMS IN INTERPRETING TREE-RING Δ¹³C RECORDS. Farmer, J.G. (Woods Hole Oceanographic Inst., MA). Nature (London); 279: No. 5710, 229-231 (17 May 1979). The trend in whole wood delta ¹³C from 1883 to 1968 for tree rings of an American elm, grown in a non-forest environment at sea level in Falmouth, Cape Cod, Massachusetts (41°34'N, 70°38'W) on the northeastern coast of the US is reported. Examination of the delta ¹³C trends in the light of various potential influences demonstrates the difficulty of attributing fluctuations in ¹³C/¹²C ratios to a unique cause and suggests that comparison of pre-1850 ratios with temperature records could aid resolution of perturbatory parameters in the twentieth century. (JGB)
- 66 TWO-DIMENSIONAL CALCULATION INCLUDING ATMOSPHERIC CARBON DIOXIDE AND STRATOSPHERIC OZONE. Haigh, J.D.; Fyle, J.A. (Clarendon Lab., Oxford, England). Nature (London); 279: 222-224 (17 May 1979). It has been predicted that increased use of fossil fuels and deforestation will result in the doubling of CO₂ levels in the atmosphere in less than a hundred years. A description is given of the calculation of the subsequent effect of increased CO₂ on stratospheric ozone, using a two-dimensional model of the atmosphere including radiative and photochemical processes. The calculation includes the feedback of changes in temperature on the mean circulation, but not on eddy transport, and allows latitudinal and seasonal effects to be studied. The total global increase in ozone for a doubling of CO₂ is calculated to be about 7%. Advantages of the use of a two-dimensional model over previously reported results from one-dimensional model calculations are discussed. (JGB)
- 67 PROBLEMS IN INTERPRETING TREE-RING DELTA¹³C RECORDS. Farmer, J.G. (Woods Hole Oceanographic Institution, MA (USA)). Nature (London); 279: No. 5710, 229-231 (17 May 1979). It is stated that the studies reported could be of considerable use both in historical climatology and for an understanding of the effects of the impingement of human activities on the carbon cycle.
- 68 (CONF-770385--) CARBON DIOXIDE EFFECTS: RESEARCH AND ASSESSMENT PROGRAM. Elliott, W.P.; Machta, L. (eds.). (National Oceanic and Atmospheric Administration, Boulder, CO (USA). Air Resources Lab.). May 1979. 127p. Dep. NTIS, PC A07/MF A01. From Workshop on the global effects of carbon dioxide from fossil fuels; Miami Beach, FL, USA (7 Mar 1977). Current knowledge of the CO₂ cycle and the consequences of increases in CO₂ content of the atmosphere are discussed. Significant gaps in our understanding are identified and actions to fill these gaps are recommended. Reports on panel discussions on the following topics are presented: atmospheric CO₂, biological effects, ocean geochemistry, and climate effects. Each invited paper has been abstracted and indexed for ERA/EDB. (JGB)
- 69 (CONF-770385--, pp 51-62) CO₂ AND THE BIOSPHERE. Loomis, R.S. (Univ. of California, Davis). May 1979. From Workshop on the global effects of carbon dioxide from fossil fuels; Miami Beach, FL, USA (7 Mar 1977). Two major areas of concern are evident in assessments of the interactions between atmospheric CO₂ and the biosphere. The first of these, the biosphere as a source and sink for gaseous CO₂, involves biosphere pool sizes and transfer processes such as photosynthesis and respiration. The second concerns changes in the character and activity of the biosphere that may result from changes in CO₂ concentration and climate. The principal lines of evidence and argument as presented in the literature are discussed.
- 70 (CONF-770385--, pp 63-71) CARBON DIOXIDE CHEMISTRY IN OCEAN WATER. Takahashi, T. (Columbia Univ., Palisades, NY). May 1979. From Workshop on the global effects of carbon dioxide from fossil fuels; Miami Beach, FL, USA (7 Mar 1977). The Revelle factor, the ratio of the fractional change in p/sub CO₂/ exerted by seawater to that in total CO₂ dissolved in seawater, is an important parameter in the air/sea CO₂ exchange study. In an oceanic alkalinity range of 2.2 to 2.4 meq/kg, it passes a maximum at a total CO₂ value 10 to 20% greater than the mean total CO₂ value of 2.00 millimoles/kg in the surface ocean water. For oceanic alkalinity and total CO₂ range, the Revelle factor increases from 10 to 18 as the p/sub CO₂/ increases from 330 to 900 x 10⁻⁶ atm. This fact indicates that the surface ocean water tends to absorb proportionally less CO₂ from the atmosphere until the atmospheric CO₂ concentration is raised to three times the present value. Data obtained in the Atlantic and Pacific during the GEOSecs expeditions (1972 to 1974) identify the northern North

Atlantic as the active sink area for atmospheric CO₂. A comparison of the Atlantic surface water p/sub CO₂/ data obtained during the IGY (1957 to 1958) and the GEOSECS expeditions shows that, during the 15-year period, the surface water p/sub CO₂/ in the Atlantic increased at an average rate of 1.8 (+0.4) x 10⁻⁶ atm/year. This rate is comparable to the atmospheric CO₂ increase rate of 1.2 to 1.4 ppm (by volume) per year observed at the Mauna Loa Observatory. It appears the oceanic p/sub CO₂/ increases at a similar rate as the atmospheric CO₂. The box diffusion model of CO₂ distribution in the atmosphere/ocean system yields the observed atmospheric CO₂ increase rate and the Suess effect. It may be used reliably for short-term forecasting of atmospheric CO₂ concentration. However, for a reliable longer-term forecasting method, more oceanographic features, such as regional differences in the vertical eddy diffusivity, the effect of fossil fuel CO₂ neutralization by marine carbonates, particulate carbon flux, and vertical flow velocity should be incorporated into the model.

- 71 (CONF-770385-- , pp 91-99) SOME CONSIDERATIONS OF CLIMATIC VARIABILITY IN THE CONTEXT OF FUTURE CO₂ EFFECTS ON GLOBAL-SCALE CLIMATE. Mitchell, J.M. Jr. (National Oceanic and Atmospheric Administration, Silver Spring, MD). May 1979.

From Workshop on the global effects of carbon dioxide from fossil fuels; Miami Beach, FL, USA (7 Mar 1977).

Various aspects of past variations of planetary-scale temperature conditions on the earth that may be helpful in assessing the importance of future temperature changes possibly related to atmospheric CO₂ increases are considered. Discussion is presented under the following section headings: past fluctuations of planetary-scale mean temperature; update of the recent global cooling; changes of climate variability; and a look to the future. (JGB)

- 72 (CONF-770385-- , pp 100-101) EFFECT OF INCREASING THE CO₂ CONCENTRATION ON THE CLIMATE OF A GENERAL CIRCULATION MODEL. Manabe, S. (Princeton Univ., NJ). May 1979.

From Workshop on the global effects of carbon dioxide from fossil fuels; Miami Beach, FL, USA (7 Mar 1977).

The climatic influence of the change of CO₂ concentration in air is discussed based upon the results from a simplified general circulation model of the atmosphere (Manabe and Wetherald, 1975). The model consists of the equation of motion, thermodynamical equation, equation of radiative transfer, and the prognostic equation of water vapor. The temperature of the earth's surface is determined by the balance condition that no heat is stored there. The depth of snow cover and the amount of soil moisture is determined from the budget of snow and liquid water respectively. One of the main characteristics of the model is the estimation of heat transport by large-scale eddies through explicit computation rather than parameterization. On the other hand, the model contains the following simplifications; a limited computational domain, a idealized topography, no heat transport by ocean currents, and fixed cloudiness.

- 73 (CONF-770385-- , pp 102-110) CRYOSPHERIC RESPONSES TO A GLOBAL TEMPERATURE INCREASE. Barry, R.G. (Univ. of Colorado, Boulder). May 1979.

From Workshop on the global effects of carbon dioxide from fossil fuels; Miami Beach, FL, USA (7 Mar 1977).

The term cryosphere embraces all terrestrial manifestations of ice in snow cover, glaciers, ice sheets, seawater and freshwater ice, and ground ice or permafrost. Since snow and ice are persistent only with subzero temperatures, global warming induced by an increase in the atmospheric content of carbon dioxide will lead to changes in the cryosphere. The likely nature and possible magnitude of such effects are reviewed here in the context of existing literature studies. The effects of global warming on snowfall and snow cover, sea ice, permafrost, and ice sheets are considered.

- 74 (CONF-770385-- , pp 111-118) TECHNICAL FIXES FOR THE CLIMATIC EFFECTS OF CO₂. Dyson, F.J. (Inst. for Advanced Study, Princeton, NJ); Marland, G. May 1979.

From Workshop on the global effects of carbon dioxide from fossil fuels; Miami Beach, FL, USA (7 Mar 1977).

The possibility of disastrous long-term ecological effects caused by an increase in production of CO₂ by fossil-fuel plants is considered. Order-of-magnitude estimates of the feasibility and size of emergency plans that might be proposed are given. Possibilities discussed are the physical transfer of CO₂ to the deep ocean, transfer of CO₂ to the long-term biosphere, biological transfer of CO₂ to the deep ocean, physical extraction of CO₂ from the air, and the balancing of the CO₂-induced heat retention with artificial alteration of the earth's albedo. (JGB)

- 75 (CONF-770385-- , pp 36-43) PRESENT AND FUTURE PRODUCTION OF CO₂ FROM FOSSIL FUELS: A GLOBAL APPRAISAL. Rotty, R.M. (Oak Ridge Associated Univ., TN). May 1979.

From Workshop on the global effects of carbon dioxide from fossil fuels; Miami Beach, FL, USA (7 Mar 1977).

The level of carbon dioxide in the atmosphere is a problem of worldwide proportions. Unilateral action by any one nation in planning alternatives to fossil fuel use will most likely be ineffective in controlling carbon dioxide. Energy growth in the past has been largely based on fossil fuels, and consequently annual carbon dioxide production has increased steadily at a rate of 4.3%. In 1976, global carbon dioxide production contained more than 5 billion metric tons of carbon. Of this, 27% was a result of activity in the United States. By 2025 the total will have grown more than fivefold, and the developing countries and communist Asia will be producing over half the global total. The challenge to the United States is to develop energy supply systems not based on fossil fuels which can and will be used by developing nations.

- 76 (CONF-770385-- , pp 44-50) ATMOSPHERIC MEASUREMENTS OF CARBON DIOXIDE. Machta, L. May 1979.

From Workshop on the global effects of carbon dioxide from fossil fuels; Miami Beach, FL, USA (7 Mar 1977).

Perhaps the most relevant piece of information pertaining to the CO₂ problem is the long record of atmospheric measurements obtained at Mauna Loa, Hawaii. Two types of variations are immediately obvious: first, the upward growth of CO₂ concentration over the 18 years on record; second, the annual cycle displaying a drop during the summer growing season. Evidence for a long-term upward trend

of about the same magnitude as determined for Mauna Loa appears in all other records at background stations.

- 77 (CONF-770385-- pp 72-90) MODELS TO PREDICT FUTURE ATMOSPHERIC CO₂ CONCENTRATIONS. Bacastow, R.B.; Keeling, C.D. (Univ. of California at San Diego, La Jolla). May 1979.

From Workshop on the global effects of carbon dioxide from fossil fuels; Miami Beach, FL, USA (7 Mar 1977).

From current knowledge of the geochemical reservoirs that store and transfer carbon on a global basis, future concentrations of atmospheric CO₂ for various assumed patterns of fossil fuel consumption are predicted. To carry out these predictions, use was made of simple nondimensional chemical tracer reservoir or box models, but comparisons were made with a model in which the ocean is assumed to mix tracers vertically by diffusion.

- 78 (ORNL--5508, pp 24-35) ECOSYSTEM STUDIES PROGRAM. Van Hook, R.I.; Allen, T.; Allison, L.J. Apr 1979.

Environmental Sciences Division annual progress report for period ending September 30, 1978.

Research activities of the systems analysis project consisted of the following: succession modeling; error analysis of nonlinear systems; and spatial heterogeneity. Fuels from woody biomass were studied with regard to the following: species selection; stand establishment; silvicultural treatment; and harvesting. Progress is also reported on the following: material spiralling in stream ecosystems, and global carbon dioxide. (HLW)

- 79 (UCRL--82540) ZONAL MODEL CALCULATION OF THE CLIMATIC EFFECT OF INCREASED CO₂. Potter, G.L. (California Univ., Livermore (USA)). Lawrence Livermore Lab.). Apr 1979. Contract W-7405-ENG-48. 24p. (CONF-790458--1). Dep. NTIS, PC A02/MF A01.

From Symposium on environmental and climatic impact of coal utilization; Williamsburg, VA, USA (17 Apr 1979).

This study was a preliminary numerical experiment to test the effect of changing atmospheric CO₂ concentrations on the climate simulated by a zonal atmospheric model including numerous feedback mechanisms. The main results of this analysis may be summarized as follows: (1) increased CO₂ concentrations warm the troposphere and reduce the intensity of the polar surface inversions. This effect caused the magnification of the temperature response with latitude; (In the case of the zonal model, polar temperatures were very cold, and the warming associated with the increased CO₂ and water vapor only partially compensated for the intense sub-freezing temperatures. Consequently, no snow or ice melted even though the surface temperatures increased); (2) The magnitude of the stratospheric temperature difference increased with altitude as CO₂ concentrations were increased; (3) Precipitation, evaporation, and the total atmospheric water content increased with increasing CO₂ concentrations, (The Bowen ratio (H/LE) decreased with increasing CO₂).

- 80 (SRI--5793) JASON. LONG TERM IMPACT OF ATMOSPHERIC CARBON DIOXIDE ON CLIMATE. TECHNICAL REPORT. MacDonald, G.; Abarbanel, H.; Carruthers, P. (SRI International, Arlington, VA (USA)). Apr 1979. Contract EY-76-C-03-0115-136. 197p. (JSR--78-07). Dep. NTIS, PC A09/MF A01.

The questions of the sources of atmospheric carbon dioxide are addressed; distribution of the present carbon dioxide among the atmospheric, oceanic, and biospheric reservoirs is considered; and the impact on climate as reflected by the average ground temperature at each latitude of significant increases in atmospheric carbon dioxide is assessed. A new model for the mixing of carbon dioxide in the oceans is proposed. The proposed model explicitly takes into account the flow of colder and/or saltier water to great depths. We have constructed two models for the case of radiative equilibrium treating the atmosphere as gray and dividing the infrared emission region into nine bands. The gray atmosphere model predicts an increase of average surface temperature of 2.8°K for a doubling of CO₂, a result about a degree less than the nine band model. An analytic model of the atmosphere was constructed (JASON Climate Model). Calculation with this zonally averaged model shows an increase of average surface temperature of 2.4° for a doubling of CO₂. The equatorial temperature increases by 0.7°K while the poles warm up by 10 to 12°K. The JASON climate model suffers from a number of fundamental weaknesses. The role of clouds in determining the albedo is not adequately taken into account nor are the asymmetries between the northern and southern hemisphere. (JGB)

- 81 (SAN--115/136-2) LONG TERM IMPACT OF ATMOSPHERIC CARBON DIOXIDE ON CLIMATE. TECHNICAL REPORT JSR-78-07. MacDonald, G.; Abarbanel, H.; Carruthers, P. (SRI International, Arlington, VA (USA)). Apr 1979. Contract EY-76-C-03-0115 P.A. 136. 184p. Dep. NTIS, PC A09/MF A01.

If the current growth rate in the use of fossil fuels continues at 4.3% per year, then the CO₂ concentration in the atmosphere can be expected to double by about 2035 provided the current partition of CO₂ between the atmosphere, biosphere, and oceans is maintained as is the current mix of fuels. Slower rates of anticipated growth of energy use lead to a doubling of the carbon content of the atmosphere sometime in the period 2040 to 2060. This report addresses the questions of the sources of atmospheric CO₂; considers distribution of the present CO₂ among the atmospheric, oceanic, and biospheric reservoir; and assesses the impact on climate as reflected by the average ground temperature at each latitude of significant increases in atmospheric CO₂. An analytic model of the atmosphere was constructed (JASON Climate Model). Calculation with this zonally averaged model shows an increase of average surface temperature of 2.4° for a doubling of CO₂. The equatorial temperature increases by 0.7°K, while the poles warm up by 10 to 12°K. The warming of climate will not necessarily lead to improved living conditions everywhere. Changes in sea level, in agricultural productivity, and in water availability can be anticipated, but the dimensions of their economic, political, or social consequences can not.

- 82 ¹³C/¹²C RATIO IN ATMOSPHERIC CO₂. Nachr. Chem., Tech. Lab.; 27: No. 4, -177(Apr 1979). (In German).

CARBON DIOXIDE; CARBON 12; CARBON 13; ISOTOPE RATIO; EARTH ATMOSPHERE; CALIBRATION STANDARDS; BIOSPHERE; SEAS; COMPARATIVE EVALUATIONS

- 83 AIR POLLUTION ABATEMENT: ENERGY POLICY AND THE CO₂ PROBLEM. Seeliger, J.; Zimmermeyer, G. (Gesamtverband des Deutscher Steinkohlenbergbaus, Essen (Germany, F.R.)).

Umwelt; No. 2, 126-129(Apr 1979). (In German).

The problems connected with increasing CO₂ emissions are delicate as according to present theories anything may happen or nothing at all. The consequences to be drawn with regard to energy supply are investigated.

- 84 (ORAU/IEA--79-6(0)) UNCERTAINTIES ASSOCIATED WITH GLOBAL EFFECTS OF ATMOSPHERIC CARBON DIOXIDE. Rotty, R.M. (Oak Ridge Associated Universities, Inc., TN (USA). Inst. for Energy Analysis). Mar 1979. Contract EY-76-C-05-0033. 29p. Dep. NTIS, PC A03/MF A03.

Although the evidence is quite clear that the increase in atmospheric CO₂ is at least to a large degree a result of fossil fuel burning, and it is equally clear that this increase will result in some change in the global climate, there are quantitative uncertainties that require additional understanding before full assessments can be made. There are also quantitative uncertainties regarding the natural carbon cycle, the behavior of the various reservoirs when perturbed by man, the terrestrial biosphere, and the rate at which the oceans can assimilate and store carbon. There are uncertainties in regard to the climate change that can result from increased atmospheric CO₂. Progress in modeling the atmosphere must continue to narrow these uncertainties before the impacts of climate change on man can be adequately determined. The future demands for fossil fuels are uncertain. The growth of the developing world will be closely linked to fossil energy for the next five to eight decades. Only the observed increase in the atmospheric concentration and the present (and recent past) rate of production of CO₂ from fossil fuels provide data without uncertainties.

- 85 (UCRL--E2576) TRENDS IN OTHER SPECIES. Penner, J.E. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Mar 1979. Contract W-7405-ENG-48. 35p. Dep. NTIS, PC A03/MF A01.

Predicted and measured trends in trace species other than ozone are compared and current knowledge regarding man's role in the budget for several species is discussed. Possible trends in stratospheric species caused by long-term solar uv variability are compared to trends detected to date or to predicted trends caused by anthropogenic emissions. Halocarbons, CO, and CO₂ are considered first. Then current thinking is reviewed on possible trends in N₂O, CH₄, and H₂O whose concentrations may have increased in the past. Finally, the trends expected for species (other than ozone) from solar flux variations are discussed. The predicted changes from uv flux variations appear to dominate the other trends discussed herein at high altitude.

- 86 ASSESSMENT OF THE POSSIBLE FUTURE CLIMATIC IMPACT OF CARBON DIOXIDE INCREASES BASED ON A COUPLED ONE-DIMENSIONAL ATMOSPHERIC-OCEANIC MODEL. Hunt, B.G.; Wells, N.C. (Australian Numerical Meteorology Research Centre, P. O. Box 5089AA, Melbourne, Australia 3001). J. Geophys. Res.; 84: No. C2, 787-791(20 Feb 1979).

A radiative-convective equilibrium model of the atmosphere has been coupled with a mixed layer model of the ocean to investigate the response of this one-dimensional system to increasing carbon dioxide amounts in the atmosphere. For global mean conditions a surface temperature rise of about 2° K was

obtained for a doubling of the carbon dioxide amount, in reasonable agreement with the commonly accepted results of Manabe and Wetherald. This temperature rise was essentially invariant with season and indicates that including a shallow (300 m) ocean slab in this problem does not basically alter previous assessments. While the mixed layer depth of the ocean was only very slightly changed by the temperature increase, which extended throughout the depth of the mixed layer, the impact of this increase on the overall behavior of the ocean warrants further study. A calculation was also made of the temporal variation of the sea surface temperature for three possible carbon dioxide growth rates starting from an initial carbon dioxide content of 300 ppm. This indicated that the thermal inertia of the slab ocean provides a time lag of 8 years in the sea surface temperature response compared to a land situation. This is not considered to be of great significance as regards the likely future climatic impact of carbon dioxide increase.

- 87 GREENHOUSE EFFECTS OF SOME ATMOSPHERIC CONSTITUENTS. Houghton, J.T. (Clarendon Lab, UK). Int. At. Energy Agency Bull.; 290: No. 1376, 515-521(9 Feb 1979).

The greenhouse effect can accelerate if the concentration of constituents that absorb in the infrared is increased. Carbon dioxide, such minor constituents as chlorofluoromethanes, and aerosols are discussed. Limitations of atmospheric models used to predict changes in the greenhouse effect are identified. Current models predict about a 2K rise in surface temperature if the atmospheric CO₂ concentration were doubled, and a 6K rise if the CO₂ burden were increased eight-fold. (1 diagram, 5 graphs, 23 references)

- 88 EFFECT OF CLIMATIC WARMING ON THE WEST ANTARCTIC ICE SHEET. Thomas, R.H. (Univ. of Maine, Orono); Sanderson, T.J.O.; Rose, K.E. Nature (London); 277: No. 5695, 355-358(1 Feb 1979).

Climatic warming could cause increased melting from Antarctic ice shelves. Continued weakening of the ice shelves in this way would result in the ultimate collapse of most of the West Antarctic ice sheet. For complete removal of the ice shelves collapse of the ice sheet and a 5 m rise in world sea level could occur in < 100 yr. More realistically, ice-shelf deterioration is likely to be a rather slow process, and even for a major and sustained warming trend ice-sheet collapse would take several hundred years, with most of the associated rise in sea level occurring during the final century. However, little is known about the glaciers that drain the northern part of the ice sheet. These glaciers have little or no protective fringe of ice shelf and, unless they flow over sufficiently high bedrock sills, they may show a more rapid response to increased temperatures.

- 89 (PB--297384) EFFECTS OF INCREASES IN CARBON DIOXIDE IN THE EARTH'S ATMOSPHERE: A SYNTHESIS. Smith, S. (Biospherics Inc., Rockville, MD (USA)). Feb 1979. Contract NOAA-41-USC-252C(3). 17p. NTIS, PC A02/MF A01.

If left unchecked, increasing levels of CO₂ may eventually have far-reaching consequences on a global scale. Many scientists forecast a CO₂-dependent increase in temperature, with concomitant effects on weather, climate, terrestrial and marine ecology, and other dimensions of the environment. These changes may have serious implications for human

- industrial activities such as agriculture, fishing, and energy production and use. More research is needed to define the problem and to pinpoint the decisionmaking time frame before the problem becomes unsolvable. To reduce uncertainties and to assess the seriousness of the matter, scientists point to the need for a well-coordinated, interdisciplinary, international program. Practical ways of reducing the CO₂ content of the air, either by direct removal from the air or by 'scrubbing' the effluent of powerplants, should also be investigated. The effects of continued increases in atmospheric CO₂ may have implications for many diverse aspects of national and international policy. If the issue is ignored, CO₂, until now a seemingly harmless trace component of the atmosphere, could eventually exert profound influences.
- 90 THE PROBLEM OF CARBON DIOXIDE. Niehaus, F. (IAEA/Intl Inst for Applied Systems Analysis). Int. At. Energy Agency Bull.; 21: No. 1, 2-10(Feb 1979).
Technical feature: Carbon dioxide emissions from fossil fuel combustion pose a long-term global threat. The principal danger may be the impact of increased atmospheric CO₂ on the radiation balance in the atmosphere ('the greenhouse effect'). Data on increasing atmospheric CO₂ concentrations, temperature effects, and vertical temperature profiles for different CO₂ concentrations are presented. Discussed are the causes of the increase in atmospheric CO₂, the effects of climatic changes, and future levels of atmospheric CO₂. A 50 terawatt fossil fuel strategy and a 50 terawatt energy strategy employing solar and nuclear power to monitor CO₂ levels in the atmosphere are assessed. The feasibility of removing CO₂ from the atmosphere is determined. (1 diagram, 7 graphs)
- 91 (PNL--2850(Pt.3), pp 1.45-1.46) SPECTROSCOPIC TECHNIQUE FOR MEASURING ATMOSPHERIC CO₂. Stokes, G.M.; Stokes, R.A. Feb 1979.
Pacific Northwest Laboratory annual report for 1978 to the DOE Assistant Secretary for Environment. Part 3. Atmospheric sciences.
As part of a continuing effort to identify areas in which astronomical techniques and data may be profitably applied to atmospheric problems, both new and archival solar spectra have been collected to prepare for an analysis of their use for studying the changes of the atmospheric CO₂ burden. This analysis has resulted in the initiation of an observing program using the Fourier Transform Spectrometer (FTS) of the McMath Solar Telescope at Kitt Peak National Observatory (KPNO). This program is generating spectra, the quality of which should not only aid the archival CO₂ study but also lead to analyses of other trace gases.
- 92 CLIMATIC CHANGES DUE TO ENERGY GROWTH. Bach, W. (Muenster Univ. (Germany, F.R.)). Forschungsstelle fuer Angewandte Klimatologie und Umweltstudien). Brennst.-Waerme-Kraft; 31: No. 2, 49-56(Feb 1979). (In German).
The article tries to show the difficulties of predicting climatic changes due to energy growth. The mechanism of the climatic system, the possible reasons of climatic fluctuations, the problems of climatic forecasting by model calculations; the future world energy developments and the possible options for covering the energy demand are described. The influence of different energy supply strategies on the climatic are investigated.
- 93 (PB--297384) EFFECTS OF INCREASES IN CARBON DIOXIDE IN THE EARTH'S ATMOSPHERE: A SYNTHESIS. Smith, S. (Biospherics Inc., Rockville, MD (USA)). Feb 1979. Contract NOAA-41-USC-252C(3). 17p. NTIS, PC A02/MF A01.
If left unchecked, increasing levels of CO₂ may eventually have far-reaching consequences on a global scale. Many scientists forecast a CO₂-dependent increase in temperature, with concomitant effects on weather, climate, terrestrial and marine ecology, and other dimensions of the environment. These changes may have serious implications for human industrial activities such as agriculture, fishing, and energy production and use. More research is needed to define the problem and to pinpoint the decisionmaking time frame before the problem becomes unsolvable. To reduce uncertainties and to assess the seriousness of the matter, scientists point to the need for a well-coordinated, interdisciplinary, international program. Practical ways of reducing the CO₂ content of the air, either by direct removal from the air or by 'scrubbing' the effluent of powerplants, should also be investigated. The effects of continued increases in atmospheric CO₂ may have implications for many diverse aspects of national and international policy. If the issue is ignored, CO₂, until now a seemingly harmless trace component of the atmosphere, could eventually exert profound influences.
- 94 GRADUAL INCREASE OF OCEANIC CO₂. Chen, G.T. (Oregon State Univ., Corvallis); Millero, F.J. Nature (London); 277: No. 5693, 205-206(18 Jan 1979).
Since 1850, human activities, mainly the burning of fossil fuels and the clearing of forests, have increased the amount of CO₂ in the atmosphere by approx. 50 ppm. Although it is generally believed that the oceanic CO₂ has increased correspondingly, only very limited data have shown the increase quantitatively. A computational calculation is presented of the variation of the preformed total CO₂ at the time of its last contact with the atmosphere. The result for the Atlantic Ocean reveals that the older water masses have invariably smaller preformed CO₂ as compared to the more recently formed waters.
- 95 RECENT TRENDS IN THE ¹³C/¹²C RATIO OF ATMOSPHERIC CARBON DIOXIDE. Keeling, C.D. (Scripps Institution of Oceanography, La Jolla, CA (USA)); Mook, W.G.; Tans, P.P. Nature (London); 277: No. 5692, 121-123(11 Jan 1979).
BIOSPHERE; CARBON DIOXIDE; CARBON 12; CARBON 13; EARTH ATMOSPHERE; EXPERIMENTAL DATA; GRAPHS; ISOTOPE RATIO; TIME DEPENDENCE; TREES
- 96 HASA WORKSHOP, CARBON DIOXIDE, CLIMATE AND SOCIETY. Williams, J.; von Winterfeldt, D. (International Inst. for Applied Systems Analysis, Laxenburg, Austria). Nat. Resour. Forum; 3: No. 2, 187-191(Jan 1979).
The International Institute for Applied Systems Analysis Energy Systems Programme is studying global aspects of energy systems, concentrating on a time period 15 to 50 years from now. A recent workshop addressed the questions associated with carbon dioxide produced by combustion of fossil fuels, its impact on climate and environment, and the implications of present knowledge on these questions for energy strategies. Three working groups considered three major aspects of the CO₂ problem: (1) the bio-geochemical carbon

cycle as a background for predicting future atmospheric concentrations of CO₂; (2) the present state of knowledge regarding the impacts of increased atmospheric CO₂ concentrations on climate and environment; and (3) the implications of present knowledge of CO₂ with regard to decision-making on energy strategies. This review summarizes the reports of the three groups. The major conclusions are stated in five policy statements that attempt to address the problem of supplying energy in sufficient quantities to assure global economic, political, and social well-being yet remain within acceptable bounds of CO₂ emission. (SAC)

- 97 (ORNL/TM--6651) SIMULATION OF LAND-USE PATTERNS AFFECTING THE GLOBAL CARBON CYCLE. Chan, Y.H.; Olson, J.S.; Emanuel, W.R. (Oak Ridge National Lab., TN (USA)). Jan 1979. Contract W-7405-ENG-26. 183p. Dep. NTIS, PC A09/MF A31.

Past increase of atmospheric CO₂ involves significant contributions from both fossil and nonfossil (biospheric) sources. A simulation model was used to reconstruct changes since 1860 and project four hypothetical future scenarios of CO₂ injection to 2460. Nineteen compartments and their exchanges of carbon were considered. Areal extent of tropical forests, other wooded ecosystems, and nonforests were incorporated into the model. Rapidly and slowly exchanging pools of carbon per unit area, and net primary production for each pool and ecosystem group, were projected by integrating income-loss differential equations numerically using CSMP programming language. Estimated cumulative releases of CO₂ from fossil fuels (plus cement) near 120 Gtons of carbon (1 Gton = 10⁹ metric tons) from 1860 to 1970 were assumed to equal prompt and delayed releases from forest clearing. Limits of exploitable forest area and biomass were evaluated and found to contribute much less future CO₂ than the usable coal, oil, gas, and oil shale. Ultimate release from the latter (7500 ± 2500 × 10⁹ tons of C) could increase atmospheric CO₂ manyfold: doubling the assumed 1860 levels as early as (1) year 2025 for assumed nominal scenario (expanding releases slightly less rapidly than at present), (2) year 2033 for a delayed expansion scenario that would prolong use of fossil reserves (lowering peak carbon release rate from approx. 43 to approx. 28 Gtons/year), (3) year 2087 for a slow burner scenario (increasing very slowly from present levels), and (4) year 2299 for a combination scenario (which assumes low fossil-fuel use, high carbon storage, and high net primary production of forested exosystems).

- 98 MAN'S GLOBAL REDISTRIBUTION OF CARBON. Bjorkstrom, A. Ambio; 8: No. 6, 254-259(1979).

Combustion of fossil fuels, forest clearing, and other human activities add vast amounts of carbon to the atmosphere as CO₂. The natural cycling of carbon carries some of this input into the ocean and perhaps another part is taken up by the world's organic material. The known reserves of fossil fuels are large enough so that their combustion could cause the atmospheric carbon dioxide concentration to increase by more than a factor of five. This article surveys the major sources of uncertainty regarding the inputs, reservoirs, and outputs in the process of global carbon redistribution.

- 99 (CONF-790468--2) FLEXIBLE ROLE FOR SIMULATION MODELING IN ENVIRONMENTAL DECISIONS:

MODELS OF THE GLOBAL CARBON CYCLE AS AN EXAMPLE. Emanuel, W.R. (Oak Ridge National Lab., TN (USA)). 1979. Contract W-7405-ENG-26. 21p. Dep. NTIS, PC A02/MF A01.

From Institute of ecology workshop on information needs in environmental assessment; Indianapolis, IN, USA (8 Apr 1979).

The progression of models developed to analyze the global carbon cycle in resolving the CO₂/climate issue serves as an example of the changing character of models, depending on the immediate role they play in environmental decision making. The dominant and successful role served by models in the carbon cycle problem demonstrates to some degree the desirability of this flexible approach. The pattern of model development will be different for each application of modeling to environmental decision making; however, some general similarities frequently emerge. Simple models, heavily based in measurements, are often the most useful in assisting decision makers to establish priorities among a set of environmental issues. When the decision to allocate resources to the analysis of an environmental problem has been reached, structurally detailed models which are not necessarily sophisticated in the representation of each process are useful in establishing the relative importance of system interactions. Models in which structure is condensed but sophistication in representing processes is emphasized are used in actually developing policy. Finally, the design of management practices to mitigate an environmental impact requires the most complex models which usually can only be developed when the insight from earlier stages of analysis has been gained.

- 100 MAN'S GLOBAL REDISTRIBUTION OF CARBON. Bjorkstrom, A. (Univ of Stockholm, Sweden). Ambio; 8: No. 6, 254-259(1979).

At present, the combustion of fossil fuels leads to the emission of nearly 20 gigaton/yr of carbon dioxide into the earth's atmosphere. The impacts of these emissions on the global carbon cycle are discussed. Sinks for the atmospheric carbon include ocean waters and forest ecosystems. Gross inputs to the global carbon cycle are expected to cause climatic changes in the future. (12 photos, 22 references)

- 101 FUTURE COAL SUPPLY FOR THE WORLD ENERGY BALANCE. Grenon, M. (ed.). Oxford, England; Pergamon Press (1979). 732p. (CONF-7711140--).

From 3. IISA conference on energy resources; Moscow, USSR (23 Nov 1977).

The conference covered aspects of coal resources, exploration and mine planning; mining technology, hydraulic mining, and underground coal gasification; coal transport; evaluation of coal deposits; use of models in developing fuel and energy systems; short-term future of coal, future coal supply and demand; coal conversion; coal and atmosphere CO₂; analytical approaches to coal-related systems, coal data systems. The papers have been abstracted separately.

- 102 MAN'S GLOBAL REDISTRIBUTION OF CARBON. Bjorkstrom, A. (Univ of Stockholm, Sweden). Ambio; 8: No. 6, 254-259(1979).

Combustion of fossil fuels, forest clearing and other human activities add vast amounts of carbon to the atmosphere as CO₂. The natural cycling of carbon carries some of this input into the ocean and perhaps another part is taken up by the world's organic material. The known reserves of fossil fuels are large

enough so that their combustion could cause the atmospheric carbon dioxide concentration to increase by more than a factor of five. This article surveys the major sources of uncertainty regarding the inputs, reservoirs and outputs in the process of global carbon redistribution. Refs.

- 103 (CONF-7910158--1) PROSPECT OF A GLOBAL WARMING AND STUDIES OF ITS SOCIETAL IMPACTS. Kellogg, W.W. (Aspen Inst. for Humanistic Studies, Boulder, CO (USA)); National Center for Atmospheric Research, Boulder, CO (USA)). 1979. Contract AC02-79EV10281. 16p. NTIS, PC A02/MF A01.

From 7. global modeling conference; Laxenburg, Austria (2 Oct 1979).

It is now generally accepted in the climatological community that a significant climate change will take place in the near future as a result of the continued burning of fossil fuel. This paper attempts to outline the major components of the program that will need to be undertaken to assess the economic and societal adjustments resulting from climatic change. (ACR)

- 104 EFFICIENT USE OF ENERGY RESOURCES. Nordhaus, W.D. New Haven, CT; Yale University Press (1979). 183p.

Few problems facing mankind today rival the importance of using the earth's exhaustible energy resources efficiently. The fundamental economic question is: how fast should we consume our low-cost resources, which, most efficiently, should be used before our more expensive resources. A set of forecasts and evaluations of the market - determined the economically efficient paths of energy production and consumption over time is presented. Quantitative estimates are developed through the use of a model, describing the efficient and market-determined allocations of energy resources over time under a number of scenarios. Scenarios are also structured to evaluate issues related to the environmental costs of energy use, particularly the buildup of atmospheric carbon dioxide, which could lead to major climatic changes over the next 200 years if market forces are unchecked. The basic theory of markets for depletable resources precedes the discussions of the findings from the model and the analysis of alternative energy technology development decisions. 64 reference, 24 figures, 40 tables.

- 105 (DOE/EV/10040--1) ROLE OF TEMPERATE ZONE FORESTS IN THE WORLD CARBON CYCLE: PROBLEM DEFINITION AND RESEARCH NEEDS. Armentano, T.V.; Hett, J. (eds.). (Institute of Ecology, Indianapolis, IN (USA)). 1979. Contract AC02-79EV10040. 77p. NTIS, PC A05/MF A01.

The proceedings of a workshop on carbon uptake and losses from temperate zone forests are presented. The goals of the workshop were to analyze existing data on growth and utilization of the temperate zone forest carbon pool and to identify further research needs in relation to the role of temperate forests in the global carbon cycle. Total standing stock and growth recovery transients were examined for most of the temperate region over a period from pre-settlement times to the present, with emphasis on the last three decades. Because of data availability, certain regions and topics were covered more in detail than others. Forest inventory data from most of the commercial timberlands of the north temperate zone suggest these forests have functioned over the past several decades as an annual sink for about 10

metric tons of carbon. Thus, net growth of these forests has withdrawn carbon from the atmosphere at a rate equivalent, approximately, to 50% of the annual rise in atmospheric carbon. Various data inadequacies make this estimate probably no more precise than plus or minus half of the value. Analysis of growth and vegetation changes in New England and the southeastern United States shows that forest biomass has partly recovered since extensive clearing took place in the 18th and 19th centuries. This regrowth represents a net withdrawal of carbon (carbon sink) from the atmosphere in recent decades, although the difference in pool size between present and original forests means that, in the longer term, the two regions have functioned as carbon sources.

- 106 (CONF-791204--39) ASSESSMENT OF THE ATMOSPHERIC EFFECTS OF A SATELLITE POWER SYSTEM. Rote, D.M.; Brubaker, K.L.; Lee, J.; Valentino, A.R. (Argonne National Lab., IL (USA)). 1979. Contract W-31-109-ENG-38. 30p. NTIS, PC A03/MF A01.

From 2. Miami international conference on alternative energy sources; Miami Beach, FL, USA (10 Dec 1979).

The satellite power system has been proposed as an alternative, renewable energy source for the early part of the next century. The present paper focuses on a pertinent reference system that has been the focal point of a Concept Development and Evaluation Program (CDEP). In addition, one aspect of the CDEP program, namely, the Atmospheric Effects Assessment, is detailed. Starting with the troposphere, potential atmospheric effects and the present understanding of them are summarized as a function of altitude. The main source of disturbance is described as the space transportation system, which would include a heavy lift launch vehicle (HLLV) approximately five times larger than the Saturn V rocket. To transport the necessary materials into space, HLLVs would have to be launched once or twice per day for thirty years. Essentially all levels of the atmosphere will be affected. However, as the altitude increases, the atmosphere becomes increasingly rarified, the possible degree of modification increases, and the state of our knowledge regarding such modifications decreases. Hence, the results presented here are, in most cases, only preliminary.

- 107 (DOE/EV/10040--2) ROLE OF ORGANIC SOILS IN THE WORLD CARBON CYCLE: PROBLEM DEFINITION AND RESEARCH NEEDS. Armentano, T.V. (ed.). (Institute of Ecology, Indianapolis, IN (USA)). 1979. Contract AC02-79EV10040. 43p. NTIS, PC A03/MF A01.

The following goals were addressed in the workshop: review and analysis of available data on carbon in organic soils from the past century to the present; assessment of the probable flux of carbon to and from organic soils in the near future; identification of major data inadequacies which preclude reliable analysis of the principal processes influencing carbon flux in organic soils; and proposal of research initiatives which could improve understanding of organic deposits in relation to the carbon cycle within a time frame of two to four years. The major finding of the workshop is that the organic soils are important in the overall carbon budget. Histosols and gleysols, the major organic soil deposits of the world, normally sequester organic carbon fixed by plants. They may now be releasing enough carbon to account for nearly 10% of the annual rise in atmospheric content

of CO₂. Current annual release of carbon from organic soils is estimated to fall within the range of 0.03 to 0.37 x 10⁹ t, a release equivalent to 1.3% to 16% of the annual increase of carbon in the atmosphere. Present annual releases of carbon from the Everglades Agricultural Area in Florida and the Sacramento-San Joaquin Valley in California are estimated at 0.017 x 10⁹ tons. Annual sequestering of carbon by undrained organic soils has been estimated at about 0.045 x 10⁹ tons. Several strategies for peatland management are available, including creation, preservation, functional designation, and use of wetlands for agriculture and energy supply.

- 108 (CONF-790468--1) WHAT ROLE CAN SIMULATION MODEL PREDICTIONS PLAY IN ENVIRONMENTAL DECISIONS: CARBON DIOXIDE AS AN EXAMPLE. Emanuel, W.R. (Oak Ridge National Lab., TN (USA)). 1979. Contract W-7405-ENG-26. 10p. Dep. NTIS, PC A02/MF A01.

From Institute of ecology workshop on information needs in environmental assessment; Indianapolis, IN, USA (8 Apr 1979).

Frequently, when an environmental issue requiring quantitative analysis surfaces, the development of a model synthesizing all aspects of the problem and applicable at each stage of the decision process is proposed. A more desirable alternative is to generate models specifically designed to meet the requirements of each level in decision making and which can be adapted in response to the changing status of the environmental issue. Various models of the global carbon cycle constructed to predict levels of CO₂ in the atmosphere as a result of man's activities are described to illustrate this point. In summary, the progression of models developed to analyze the global carbon cycle in resolving the CO₂/climate issue indicates the changing character of models depending on the immediate role they play in environmental decision making. The dominant and successful role served by models in the carbon cycle problem points to the desirability of this flexible approach.

- 109 (CONF-790631--11) OTEC PHYSICAL AND CLIMATIC ENVIRONMENTAL IMPACTS. Ditmars, J.D.; Paddock, R.A. (Argonne National Lab., IL (USA)). 1979. Contract W-31-109-ENG-38. 10p. Dep. NTIS, PC A02/MF A01.

From 6. OTEC conference; Washington, DC, USA (19 Jun 1979).

Assessment of Ocean Thermal Energy Conversion (OTEC) environmental impacts and resource utilization requires an understanding of the physical processes underlying the interactions between an OTEC plant or plants and the ocean. An overview of the US Department of Energy program for the development and application of analyses and models for the prediction of the physical aspects of OTEC impacts is presented. Predictive tools are necessary to address problems at different site areas, scales of OTEC deployment, and time horizons. The effects of intake/discharge designs and of ambient ocean conditions on recirculation and near-field effluent plume behavior have been investigated by means of physical models. Further study of the intake flow fields may be necessary to make estimates of intake impingement and entrainment effects. Mathematical analysis of intermediate-field mixing of plant effluents has shown that effluent plumes may have vertical dimensions on the order of meters and lateral dimensions on the order of kilometers. Models of oceanic regional and island coastal circulation are required to investigate far-field effects on the scale of tens of kilometers. Basin-wide

resource renewal and physical environmental effects are being studied by means of a numerical model of the Gulf of Mexico with detailed vertical resolution. Concerns regarding climatic impacts presently are focused on atmospheric CO₂ loading and modification of air-sea heat exchange processes due to OTEC operation.

- 110 (DOE/TIC--10293) MODELING THE CIRCULATION OF CARBON IN THE WORLD'S TERRESTRIAL ECOSYSTEMS. Emanuel, W.R.; Killough, G.G.; Olson, J.S. (Oak Ridge National Lab., TN (USA)). 1979. Contract W-7405-ENG-26. 40p. Dep. NTIS, PC A03/MF A01.

A mathematical model for the circulation of carbon in the world terrestrial ecosystems is proposed. A five-compartment representation is developed which corresponds to the functional components studied by field ecologists. Rate coefficients for this linear dynamic model are calculated from estimates of the 1970 standing crops and compartment exchanges of carbon. The model is analyzed in terms of response to a unit impulse, thereby displaying a transient time distribution. The response to a hypothetical pulse input through gross primary production is also simulated, illustrating the efficiency of the terrestrial carbon system in transferring carbon into longer storage components. Finally, the concept of CO₂ fertilization is examined by allowing gross primary production to increase in response to higher atmospheric concentrations. Although the standing crop of carbon in photosynthesizing compartments is induced to grow from a hypothetical preindustrial level to a specified 1970 level, the accompanying increase in other compartments is not as large as obtained in earlier model formulations which incorporate an input from the atmosphere directly to compartments containing carbon in woody material or soil.

- 111 (OTA-E--86) DIRECT USE OF COAL: PROSPECTS AND PROBLEMS OF PRODUCTION AND COMBUSTION. (Office of Technology Assessment (U.S. Congress), Washington, DC). 1979. 427p. GPO.

Coal production in the United States will more than double by the year 2000, to as much as 2 billion tons per year. The investments in facilities, man-power, and technologies for the mining, transportation, and use of such vast quantities of coal will be immense. This report assesses the benefits and risks of such a massive shift to coal and away from other fuels. It deals with the social, economic, physical, and biological impacts of such a shift. It examines the complete coal system, from extraction to combustion, including the key steps and institutions that policy can influence. The environmental impacts and possible effects on the public health are documented. Occupational and community impacts are examined. Technologies under development that might reduce costs, increase convenience of use, or mitigate negative impacts are reviewed.

- 112 (DOE/ET/10040--1(Summ.)) ROLE OF ORGANIC SOILS IN THE WORLD CARBON CYCLE: PROBLEM DEFINITION AND RESEARCH NEEDS. Armentano, T.V. (ed.). (Institute of Ecology, Indianapolis, IN (USA)). 1979. Contract AC02-79EV10040. 37p. Dep. NTIS, PC A03/MF A01.

Findings and recommendations of the workshop on organic soils are summarized. The major finding of the workshop is that organic soils are important in the overall carbon budget.

Histosols and gleysols, the major organic soil deposits of the world, normally sequester organic carbon fixed by plants. They may now be releasing enough carbon to account for nearly 10% of the annual rise in atmospheric content of CO_2 . Current annual release of carbon from organic soils is estimated to fall within the range of 0.03 to 0.37×10^9 t, a release equivalent to 1.3% to 16% of the annual increase of carbon in the atmosphere. If half of the released carbon remains airborne, organic soils contribute 0.6% to 8.0% of the annual rise in CO_2 . Uncertainties in data suggest the actual release could lie outside the range. Present annual releases of carbon from the Everglades Agricultural Area in Florida and the Sacramento-San Joaquin Valley in California are estimated at 0.017×10^9 tons. When combined with additional carbon release from other known drainage programs and the possibility of major drainage activity in the tropics, this figure suggests that the lower limit of the world estimate of carbon release from organic soils is too low. Annual sequestering of carbon by undrained organic soils has been estimated at about 0.045×10^9 tons. This estimate is based on only a few studies, however, and precision is probably no better than an order of magnitude. Several strategies for peatland management are available, including creation, preservation, functional designation, and use of wetlands for agriculture and energy supply.

- 113 Problema uglekisljega gaza. (PROBLEM OF CARBON DIOXIDE). Budyko, M.I. Leningrad, USSR; Gidrometeoizdat (1979). 58p.

The booklet deals with changes in the atmospheric carbon dioxide concentration of the present epoch and of the geological past. The effect of the atmospheric carbon dioxide on climate and on the production of plant cover is discussed. Estimates of the climatic conditions of the future are given.

- 114 CARBON DIOXIDE AND CLIMATE: TOO MUCH HEAT CLOUDS DEBATE. Gribbin, J. (Univ of Sussex, UK). Energy Policy; 6: No. 4, 314-319 (Dec 1978).

Technical feature: The possibility of a significant global warming as a result of increased atmospheric carbon dioxide from the burning of fossil fuels (the greenhouse effect) has recently received attention from climatologists and energy policy planners. The greenhouse effect has been used by the pro-nuclear lobby as an argument in favor of a massive commitment to nuclear power generation. While the CO_2 problem is real, the solution does not lie in an energy strategy based on nuclear power, which involves as yet unsolved problems of radioactive waste disposal. The economic feasibility of processes for removing CO_2 from waste gases should be investigated. (4 graphs, 10 references)

- 115 (ORAU/IEA--78-24(M)) CLIMATE MODELS AND THE PREDICTION OF CO_2 -INDUCED CLIMATIC CHANGES. Watts, R.G. (Institute for Energy Analysis, Oak Ridge, TN (USA)). Dec 1978. Contract EY-76-C-05-0033. 41p. Dep. NTIS, PC A03/MF A01.

The carbon dioxide (CO_2) content of the atmosphere has shown a systematic increase each year since regular measurements began in 1958. A major source of CO_2 is the combustion of fossil fuels. A number of studies of the sensitivity of climate to increases in the CO_2 content of the atmosphere have been published. This report is an assimilation of the results of some of these studies. The climate

sensitivity problem is introduced through a discussion of the various atmospheric feedbacks and the ice albedo feedback. The most recent estimates of the various feedbacks are used to estimate upper and lower bounds of the globally averaged temperature increase that would accompany a doubling of atmospheric CO_2 content. The results of a CO_2 doubling experiment using a general circulation model are presented, and the possible response of the cryosphere is discussed.

- 116 CARBON DIOXIDE AND CLIMATE. TOO MUCH HEAT CLOUDS DEBATE. Gribbin, J. (Sussex Univ., Brighton (UK)). Energy Policy; 6: No. 4, 314-319 (Dec 1978).

The growing awareness of the possibility of a carbon dioxide 'greenhouse effect' acting to warm the Earth unpleasantly which is being used as an argument against increased use of fossil fuels and, by implication, in support of a massive nuclear programme, is examined. Using as a basis the mixed energy strategy suggested by the IAEA/IIASA study ('Studies of different energy strategies in terms of their effects on the atmospheric CO_2 concentration'. Niehaus and Williams. Carbon Dioxide Cycle of the joint IAGA/IAMAP Assembly, Seattle, Washington (1977)), the times it would take for a doubling of the present reservoir of carbon dioxide to occur with different fuel mixes and different assessments of world energy needs over the years and decades to come, are estimated. The alternative problems of dealing with carbon dioxide as a waste from fossil fuel as against that of dealing with wastes from nuclear power stations are discussed.

- 117 (IMMR--40-RRR5-78, pp 27-30) ECONOMIC AND SOCIAL IMPLICATIONS OF THE COAL INDUSTRY. Newman, M. (Pennsylvania State Univ., University Park). Dec 1978.

From 4. Kentucky coal refuse disposal and utilization seminar; Pineville, KY, USA (6 Jun 1978).

In summary, the Committee recommended that attention be directed toward six major areas of uncertainty and concern in addition to the need for an improved data, monitoring and projection system. (1) Air pollution health effects: concern focuses on respirable acid particles and on the atmospheric transformation and transport of stack emissions. (2) Coal mine worker health and safety: concern focuses on monitoring the enforcement and health effects of the 1977 law and on the effects of new equipment (particularly diesel) in the mines. Training of new miners was of concern as well. (3) Global effects of atmospheric carbon dioxide: concern was expressed for the possibility of substantial climate changes within 50 years that could be disruptive of worldwide socio-political systems. (4) Trace elements: coal use releases, and environmental protection devices concentrate, toxic elements that can leach into water or enter the food chain. (6) Reclamation of arid land: mining by surface methods in arid areas may create areas that cannot be restored.

- 118 RADIOCARBON IN ANNUAL CORAL RINGS OF FLORIDA. Druffel, E.M.; Linick, T.W. (Mount Soledad Radiocarbon Laboratory, Department of Chemistry, University of California, San Diego, La Jolla, California 92093). Geophys. Res. Lett.; 5: No. 11, 913-916 (Nov 1978).

Radiocarbon measurements on a 175-year (A.D. 1800 to 1974) growth of the coral *Montastrea annularis* from The Rocks reef off the Florida Keys reveal the rate of local uptake of fossil fuel CO_2 and bomb ^{14}C by surface ocean waters

of the Gulf Stream. In the nineteenth century, the pre-bomb, pre-industrial $\Delta^{14}\text{C}$ value of surface ocean waters as seen in these corals of the Gulf Stream in the Florida Straits was -51 ± 20 /infinity. By 1955, uptake of industrial CO_2 by these waters had lowered the $\Delta^{14}\text{C}$ values to about -610 /infinity. The results can be used to make predictions regarding anthropogenic CO_2 that can be expected to enter the oceans in future decades. Bomb-produced ^{14}C is found to be present in the corals in comparable concentrations to that found in the dissolved inorganic carbon (DIC) of the North Pacific and North Atlantic Oceans.

- 119 (UCRL--81575) PRELIMINARY ZONAL MODEL ANALYSIS OF THE CLIMATIC CHANGE RESULTING FROM INCREASED ATMOSPHERIC CARBON DIOXIDE. Potter, G.L. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Nov 1978. Contract W-7405-ENG-48. 31p. (CONF-7810151--1). Dep. NTIS, PC A03/MF A01.

From US/USSR symposium of the effects of carbon dioxide on climate; Dushanbe, USSR (10 Oct 1978).

The increase in atmospheric carbon dioxide expected in the next few decades may result in a general increase in global surface temperatures. It is the purpose of this presentation to demonstrate how a two-dimensional zonal atmospheric model can be used to test the possible atmospheric response to various carbon dioxide concentrations. The response of a more complex three-dimensional general circulation model is well documented (Manabe and Wetherald, 1975) but to date, no experiments have been attempted with a comprehensive two-dimensional model. I present only the preliminary results that have provided a basis for future improvement of the model and better understanding of the feedback mechanisms that prevail given different atmospheric carbon dioxide concentrations.

- 120 ATMOSPHERIC CARBON DIOXIDE: POSSIBLE CONSEQUENCES OF FUTURE FOSSIL FUEL USE. Rotty, R.M. (Inst. for Energy Analysis, Oak Ridge, TN). Contract ZY-65-C-06-0033. Resour. Energy; 1: No. 3, 231-249 (Nov 1978).
Accurate and regular measurements of the concentration of CO_2 in the atmosphere during the past 20 years show an accelerating increase. Although clearing of tropical forests has released large amounts of carbon to the atmosphere, evidence is strong that a major contributor is the combustion of fossil fuels. Future energy demands of the world will require extensive further exploitation of fossil fuels, and projections show that without major development of nonfossil fuel alternatives, the atmospheric concentration will double within the next 75 years. Four issues require serious attention: (1) the developing countries will require vastly increased amounts of energy. Major efforts to develop suitable (inexpensive) non-fossil energy sources to meet at least a portion of this demand are required; (2) the distribution of carbon released from fossil fuels and from other anthropogenic sources among the reservoirs of the carbon cycle must be better defined; (3) uncertainties regarding the effect of the increased concentration of CO_2 in the atmosphere on global climate must be reduced; (4) possible political and social responses to a substantial climate change must be studied in order to more fully understand all of the implication of increased atmospheric CO_2 .

- 121 CARBON DIOXIDE GAS IN THE EARTH'S ATMOSPHERE. Smirnov, B.M. (I. V. Kurchatov

Institute of Atomic Energy). Sov. Phys. - Usp. (Engl. Transl.); 21: No. 11, 978-980 (Nov 1978).

On the basis of forecasts of extraction of fossil fuels during the next fifty years an analysis is made of the accumulation in the Earth's atmosphere of carbon dioxide released in industrial processes. The effect of such changes on the Earth's climate and on harvests is discussed.

- 122 ENERGY FROM BIOMASS AND WASTES: AN OVERVIEW. Klass, D.L. Energy Top.; 1-6 (23 Oct 1978).

Forecasters have proposed seven different ways to estimate potential energy that the U.S. can derive from biomass, but no one method has been agreed upon. Economic factors will determine biomass developments in the near term, while a major energy source role can be anticipated in the long term. The large-scale use of biomass will require extensive monitoring and modeling to determine the effect on carbon dioxide balance from forest cutting and combustion. Over 130 research and demonstration programs have included a feasibility study from Hawaii, production techniques, and conversion methods, such as anaerobic digestion, thermochemical gasification or liquefaction, and alcohol fuels. Economic feasibility for biomass and waste energy sources will improve as fossil-fuel costs increase and will ultimately make a significant contribution.

- 123 CARBON DIOXIDE A GLOBAL ENVIRONMENT PROBLEM INTO THE FUTURE. Wong, C.S. (Inst of Ocean Sciences, Canada). Mar. Pollut. Bull.; 9: No. 10, 257-264 (Oct 1978).

Feature article: carbon dioxide is discussed with respect to the greenhouse effect. The extent and behavior of CO_2 in the atmosphere is reasonably well known. The behavior of CO_2 in land phytomass and detritus is difficult to investigate because of the heterogeneous nature of these systems. Research efforts should concentrate on understanding CO_2 behavior in the oceans. Ocean sampling problems are less severe because oceans are relatively homogeneous systems in the liquid phase. Oceanic CO_2 studies should concentrate on: improving techniques of observing oceanic partial pressure of CO_2 and other carbonate chemistry parameters; intensifying efforts to investigate, from available open ocean platforms and weatherships, oceanic CO_2 increase and the transfer of CO_2 between the surface layers and the deep ocean; intensifying efforts to understand oceanic processes of CO_2 uptake and release through controlled experiments; and intensifying studies on the circulation of CO_2 in the ocean. (1 diagram, 4 graphs, 25 references, 1 table)

- 124 200 YEAR RECORD OF CARBON-13 AND CARBON-14 VARIATIONS IN A BERMUDA CORAL. Nozak, Y.; Rye, D.M.; Turekian, K.K.; Dodge, R.E. (Department of Geology and Geophysics, Yale University, New Haven, Connecticut 06520). Geophys. Res. Lett.; 5: No. 10, 825-828 (Oct 1978).

A 200 year old brain coral, captured in Bermuda in 1976 was slabbed and x-rayed. Using the annual growth bands sequential, dated samples were taken over the entire growth period of the coral and analyzed for $\Delta^{14}\text{C}$, $\sigma^{13}\text{C}$ and $\delta^{18}\text{O}$. During the past 80 years atmospheric variations in $\Delta^{14}\text{C}$ and $\delta^{13}\text{C}$ due to human effects, such as release of bomb C-14 and dilution of both C-14 and C-13 by fossil fuel burning, are closely tracked by the coral.

Prior to 1900 divergences between the coral and tree $\Delta^{14}\text{C}$ and $\Delta^{13}\text{C}$ can be related to world-wide changes in plant production and possibly oceanic upwelling rates.

- 125 WILL AN INCREASE IN CARBON DIOXIDE REALLY NOT MEAN HIGHER TEMPERATURES. AGAINST THE SPECULATIONS ON A CLIMATIC DISASTER. Panzram, H. Glueckauf; 114: No. 19, 866-868 (Oct 1978). (In German).

The report deals with assumptions that predict a climatic catastrophe. Apart from this, the relationship between the carbon dioxide content and the earth's climate, the removal of secular heat-up, and the inexactness of climatic prognoses are reported on.

- 126 CLIMATIC CHANGE. Aware; No. 97, 9-11 (Oct 1978).

Reprinted from IAEA Bulletin, Agency Bulletin, Volume 19, Number 1, February 1977.

Excerpts from a meteorological panel of experts' report address the problems of recent climatic extremes and concern that a major global climatic change is taking place. In spite of a warming trend during the 20th Century, it is not certain that the Little Ice Age is complete, as evidenced by severe temperature drops and changes in atmospheric circulation in the northern hemisphere. While the committee found no conclusive evidence that either natural disturbances or human activities have caused more than local effect, it recommends monitoring those processes which cause variability: carbon dioxide, aerosol particles of volcanic origin in the stratosphere, reflectivity of snow and ice, and changes in reflectivity caused by land use and sea development. Data acquired from these studies will help in short-term climate forecasting and in planning to moderate man's impact on the environment. (DCK)

- 127 CARBON DIOXIDE CONTROVERSY. Environment; 20: No. 8, 24 (Oct 1978).

The carbon dioxide controversy was discussed at a conference of climatologists at York University, Ontario, according to reports in the Montreal Gazette (6/17/78) and the Ottawa Citizen (6/9/78). According to M. Mitchell (National Oceanic and Atmospheric Administration), the world cannot wait for proof that air pollution is warming the earth's atmosphere, because by then it will be too late to avoid the drastic consequences of climatic change. The world is already warmer than it has been for 120,000 yr and the greenhouse effect created by pouring the equivalent of 5 trillion tons of carbon into the air every year through the burning of fossil fuels could raise the temperatures permanently as much as 2.5°C. Such a temperature change could cause melting of the polar ice cap, flooding, and vast changes in rainfall and agricultural patterns. According to R. Bryson (Univ. Wisconsin) carbon dioxide is not a problem for the short term, and possibly for the longer term. According to Bryson, particles in the atmosphere screen us from the sun and produce a cooling effect. The cooling influence of the particles produced by the burning of fossil fuels would counterbalance the warming effect of carbon dioxide in the atmosphere.

- 128 CARBON DIOXIDE AND THE 'GREENHOUSE EFFECT': AN UNRESOLVED PROBLEM. Smith, I. Aware; No. 96, 11-15 (Sep 1978).

Presents chapters 4, 5, 6 from the April 1978 report, London, the International Energy Agency (IEA) Coal Research.

The concentration of CO_2 in the atmosphere had risen to 330 ppmv in 1974 as compared to an assumed value of 290 ppmv from 1870 to 1900. Models predict a doubling of the concentration within the next century due to burning fossil fuel for all energy strategies, assuming that 50% of the CO_2 emitted actually remains in the atmosphere. Fossil-fuel combustion is not the only cause of the increasing amount of CO_2 in the atmosphere. In fact the contributions of CO_2 in the atmosphere from deforestation and other land modifications are estimated to be half or up to twice the amount due to fossil-fuel combustion. The effect of doubling the concentration of atmospheric CO_2 will be to reduce the net global heat loss, but the extent to which the earth's surface will be warmed as a result is still a matter for conjecture. At present concentrations, no global temperature rise has been detected above the noise level of natural variations. The most reliable estimates of temperature rise for a doubling of the concentration are 2°C in the tropics and 1°C at the poles, with an uncertainty factor of at least two either way. Four thousand to 8000 years ago, when the world was several degrees warmer than at present, the climate was more favorable to some areas than it is now. The question of a rise in sea level is equally unresolved. At present the only confirmed fact is that the concentration of CO_2 in the atmosphere is increasing. There is little evidence to support either a complacent or an alarmist attitude, so that it is most desirable that various aspects of the CO_2 cycle should be monitored to reduce uncertainties and give a firmer basis for energy policy during the next decade.

- 129 (BNL-24999) ENVIRONMENTAL CONTROL TECHNOLOGY FOR CARBON DIOXIDE. Steinberg, M.; Albanese, A.S.; Dang, V.D. (Brookhaven National Lab., Upton, NY (USA)). Sep 1978. Contract EY-76-C-02-0016. 36p. (CONF-781110-30). Dep. NTIS, PC A03/MF A01.

From 71st meeting of the AICHE; Miami, FL, USA (12 Nov 1978).

The possible adverse global environmental effects of CO_2 buildup in the atmosphere due to emissions from increasing fossil fuel combustion operations, have prompted an investigation of a number of possible methods and systems for controlling CO_2 emissions and buildup. A systematic overview is presented of a number of routes for removal, recovery, disposal, and reuse of CO_2 from various control points in the global system. The energy and mass balances for various routes are used as a criteria for evaluation. An assessment of the value of alternative energy sources as a means of CO_2 control is made.

- 130 FOSSIL FUEL: FUTURE SHOCK. Gribbin, J. (Univ. of Sussex, Brighton, Eng.). New Sci.; 79: No. 1117, 541-543 (24 Aug 1978).

The author reviews the arguments over long-range effects of carbon dioxide (CO_2) concentrations from burning fossil fuels. The atmosphere and biomass reservoirs for storing CO_2 appear to be full, but the oceans may offer the possibility of long-term storage even though some feel they are also reaching saturation levels. It is possible to scrub and store CO_2 if it were first declared a pollutant. More information on climate changes is needed and will require better climate models to handle the large timescales. At issue, too, are questions of whether a slightly warmer climate will be beneficial or detrimental. Studies of the Climatic Optimum period of 4000 to 8000 years ago indicate that a warmer climate will allow increased food

production. The author concludes that a flexible mix of fuels must be ready so that when the environmental evidence has been collected and analyzed, the best mix can be selected.

- 131 TERMINAL MESOZOIC GREENHOUSE: LESSONS FROM THE PAST. McLean, D.M. (Virginia Polytechnic Inst. and State Univ., Blacksburg). Science; 201: No. 4354, 401-406 (4 Aug 1978).

The late Mesozoic rock and life records implicate short-term (up to 10^5 to 10^6 years) global warming resulting from carbon dioxide--induced "greenhouse" conditions in the late Maestrichtian extinctions that terminated the Mesozoic Era. Oxygen isotope data from marine microfossils suggest late Mesozoic climatic cooling into middle Maestrichtian, and warming thereafter into the Cenozoic. Animals adapting to climatic cooling could not adapt to sudden warming. Small calcareous marine organisms would have suffered solution effects of carbon dioxide--enriched waters; animals dependent upon them for food would also have been affected. The widespread terrestrial tropical floras would likely not have reflected effects of a slight climatic warming. In late Mesozoic, the deep oceanic waters may have been triggered into releasing vast amounts of carbon dioxide into the atmosphere in a chain reaction of climatic warming and carbon dioxide expulsion. These conditions may be duplicated by human combustion of the fossil fuels and by forest clearing.

- 132 (ANU-P--727) POLLUTION, ENVIRONMENTAL AND HEALTH HAZARDS OF FOSSIL FUELS. Titterton, E.J. (Australian National Univ., Canberra. Research School of Physical Sciences). Aug 1978. 8p. Dep. NTIS (US Sales Only), PC A02/MF A01.

Toxic emissions from fossil-fuelled power stations and the greenhouse effect, are discussed, along with a comparison of pollution and health effects of fossil-fuelled and nuclear power stations.

- 133 RESEARCH CHALLENGE: CLEAN ENERGY FROM COAL. Cooper, B.R. (West Virginia Univ., Morgantown). Phys. Today; 31: No. 8, 32-39 (Aug 1978).

A physicist suggests areas in which physical research might aid in producing clean energy from coal: Instrumental means for coal classification (reflectivity), methods of measuring thermoplastic properties, instruments for monitoring ventilation, measuring CO, remote sensing, control devices, etc.; removing and measuring impurities, such as pyrite and other iron-sulfur compounds (Moesbauer effect, magnetic susceptibility and magnetic separation are emphasized); trace element measurement (and removal if needed); coal-fired MHD generators (plasma, superconducting magnets, electrodes, materials, and combined-cycle power plants); erosion and corrosion in coal conversion plants, including the metallurgical effects of hydrogen (embrittlement and attack); needed improvements in catalysts, including understanding the catalytic effects of minerals; problems of climatic changes due to increased carbon dioxide in the atmosphere (capacity of oceans to absorb CO₂, theoretical models of atmosphere); new methods of mining (especially instrumentation for monitoring and controlling ventilation); and in-situ gasification. (LTN)

- 134 GLOBAL ENERGY STRATEGIES. THE IMPLICATIONS OF CO₂. Williams, J. (Int Inst

for Appl Syst Anal, Laxenburg, Austria). Futures; 10: No. 4, 293-302 (Aug 1978).

The paper discusses the uncertainties and shortcomings that surround the current models of the carbon cycle, climatic change, and energy consumption; all are required in predicting the effect of carbon dioxide (CO₂ sub 2%) on climate. Using estimates of energy consumption in 2025 the paper defines the boundaries of the problem: a global warming (preponderantly at the poles), and unpredictable (at present) regional climatic variations. The implications for energy policy are discussed, and it is concluded that all options must be kept open at present. 27 refs.

- 135 CARBON DIOXIDE AND THE 'GREENHOUSE EFFECT'--AN UNRESOLVED PROBLEM. Smith, I. (Int Energy Agency). Energy Dig. (London); 7: No. 4, 11-16 (Aug 1978).

The radiation balance of the earth could be disturbed if heat were prevented from escaping due to the blanketing action of greater amounts of carbon dioxide in the atmosphere. This radiation trap is known as the "greenhouse effect". Fossil fuel combustion is not only the cause of the increasing amount of carbon dioxide in the atmosphere. In fact the contributions of carbon dioxide to the atmosphere from deforestation and other land modifications are estimated to be half or up to twice the amount due to fossil fuel combustion. Finally, it should be stressed that at present the only confirmed fact is that the concentration of carbon dioxide in the atmosphere is increasing. There is little evidence to support either a complacent or an alarmist attitude, so that it is most desirable that various aspects of the carbon dioxide cycle should be monitored to reduce uncertainties and give a firmer basis for energy policy during the next decade.

- 136 MUCH ADD ABOUT DIOXIDES AND PARTICULATES. Doane, F.P. PIMA Mag.; 60: No. 7, 27-30 (Jul 1978).

Refuted are environmentalist assertions that sulfur dioxide particulates, and carbon dioxide by-products from human fossil fuel burning are a threat. Natural pollution from volcanoes, forest fires, sea salts, oxidation of soil humus and bogs, and other phenomena create more CO₂, SO₂, and particulates than humans create. The function of CO₂ in plant growth is evaluated. (17 references, 2 tables)

- 137 (ORNL/EIS--109) CHANGES IN THE GLOBAL CARBON CYCLE AND THE BIOSPHERE. Olson, J.S.; Pfuderer, H.A.; Chan, Y.H. (Oak Ridge National Lab., TN (USA)). Jul 1978. Contract W-7405-ENG-26. 176p. Dep. NTIS, PC A09/MF A01.

Increases in atmospheric CO₂, risks of climatic change, and impacts from such change are reviewed. Needs for closer scrutiny of changes in organic carbon and in the patterns of the biosphere are explained. The organic carbon pool is considered here as a moderate source of CO₂, perhaps 1 to 3 Gtons/yr in recent years. The biosphere could become a net sink for CO₂ if it were managed optimally to minimize the future peak of atmospheric CO₂ and to maximize storage as well as production rates of organic carbon. A preliminary global computer model explores the implications of tropical and subtropical forest clearing as a nonfossil source of CO₂ as well as some limits on the biosphere's role as a potential sink. Because of these limits and the oceanic factors of carbonate buffering, slow physical circulation, and limited net sedimentation of

carbon, models confirm that 4- to 7-fold increases of CO_2 could occur if projections of high fossil energy consumption were to materialize. Review of climatic changes does not support beliefs that cooling would become great enough to counteract the mean surface temperature rise of 2 to 9°C in 100 years. Changes in climate pattern, temperature, drought, and waterlevel, and in their varied biological effects, would interact to change success of crops, other ecosystems, and many social institutions.

- 138 INCREASED ATMOSPHERIC CARBON DIOXIDE AND STRATOSPHERIC OZONE. Groves, K.S.; Mattingly, S.R.; Tuck, A.F. *Nature* (London); 273: No. 5665, 711-715(29 Jun 1978).

A column model in which atmospheric photochemistry and radiative transfer have been coupled together, and with vertical transport represented by eddy exchange coefficients, has been used to calculate the effect on stratospheric ozone of increasing carbon dioxide amounts due to fossil fuel combustion and possibly deforestation.

- 139 (DOE/TIC--11161) COMPREHENSIVE PLAN FOR CARBON DIOXIDE EFFECTS RESEARCH AND ASSESSMENT. PART I: THE GLOBAL CARBON CYCLE AND CLIMATIC EFFECTS OF INCREASING CARBON DIOXIDE. (Department of Energy, Washington, DC (USA). Office of Carbon Dioxide Research and Assessment). May 1978. 68p. Dep. NTIS, PC A04/MF A01.

The well-documented increase of carbon dioxide in the atmosphere has led to concern about the impact on the world's climate. To obtain answers to the many questions raised by this issue requires a research program of considerable magnitude and scope conducted over at least a decade. Presented here is an outline of some of the specific research needed to attack the problems. These problems are: (1) What will be the future atmospheric concentrations of CO_2 , (2) What will be the climatic effect of these concentrations, (3) What will be the effect on the biological and physical environment of these climate changes coupled with the increases of CO_2 , (4) What, if any, will be the effects of these changes on human societies, and (5) In the event that these changes are undesirable, what actions can be taken to prevent them. The research outlined in this document addresses mainly the first two questions because there are the first steps in defining the problems.

- 140 ATMOSPHERIC INPUT OF CARBON DIOXIDE FROM BURNING WOOD. Wong, C.S. (Inst. of Ocean Sciences, Sidney, B.C.). *Science*; 200: No. 4338, 197-199(14 Apr 1978).

The atmospheric input of carbon dioxide from burning wood, in particular from forest fires in boreal and temperate regions resulting from both natural and man-made causes and predominantly from forest fires in tropical regions caused by shifting cultivation, is estimated to be 5.7×10^{15} grams of carbon per year as gross input and 1.5×10^{15} grams of carbon per year as net input. This is a significant amount as compared to the fossil-fuel carbon dioxide produced from the utilization of oil, gas, coal, and limestone, and bears on the hypothesis of the enhanced sedimentation of marine detritus as a removal mechanism of excess atmospheric carbon dioxide.

- 141 WHAT MIGHT MAN-INDUCED CLIMATE CHANGE MEAN. Cooper, C.F. (San Diego State Univ., CA). *Foreign Aff.*; 56: No. 3, 500-520(Apr

1978).

The impacts of global climatic change are examined and the conclusion reached that an international multi-disciplinary effort is needed to reach understanding and a global consensus. More research is needed to assess the short- and long-range effects of climatic shifts on agriculture and animals and the effects of both on social and political institutions. Current information on carbon dioxide (CO_2) effects can be compared with past observations and used in climatic-simulation models to project future effects and illustrate their wide distribution. Besides CO_2 , heat emission and particulate matter released by fossil fuel and nuclear power plants are felt to have measurable impact. Technological solutions will be helpful, but the need for serious social and economic adjustments is foreseen.

- 142 (BNL--50877) ENVIRONMENTAL CONTROL TECHNOLOGY FOR ATMOSPHERIC CARBON DIOXIDE. PROGRESS REPORT NO. 2, OCTOBER 1, 1977--MARCH 31, 1978. (Brookhaven National Lab., Upton, NY (USA)). Apr 1978. Contract EY-76-C-02-0016. 27p. Dep. NTIS, PC A03/MF A01.

A methodology for systematically constructing and evaluating scenarios for controlling atmospheric carbon dioxide is described. Based on fundamental principles and a search of the literature a number of alternative processes (building blocks), ranging from conventional technologies to advanced concepts, are presented for consideration in the construction of these scenarios. Since there are several key factors to consider in evaluating alternative control strategies, such as energy requirements, disposal options, and process inefficiencies, each of which could render a particular alternative impracticable, a reasonably thorough analysis of each candidate scenario is required before meaningful conclusions can be reached. In this report, information is presented on (1) a logic structure for constructing scenarios, (2) process options for CO_2 capture, reuse, and disposal, (3) a methodology for evaluating scenarios, (4) an assessment of the energy requirements for capturing CO_2 from the atmosphere, and (5) an evaluation of a control system for removing CO_2 from power plant stack gases by adsorption with seawater, followed by deep ocean disposal.

- 143 EFFECTS OF CLIMATE ON ENERGY POLICY. Williams, J. (International Institute for Applied Systems Analysis, Laxenburg, Austria). *Electron. Power*; 24: No. 4, 261-268(Apr 1978).

The global climate system consists of five subsystems: the atmosphere, oceans, cryosphere (ice and snow), biosphere, and land. These components interact with each other through a wide variety of processes, such that the total climate system is highly complex and nonlinear. Despite the inability to understand all aspects of the climate system and to predict climatic changes, it is possible to make preliminary estimates of the impacts of energy conversion and consumption on the system. These estimates can be made on the basis of observed responses of the system to perturbations and on the basis of results from climate models. Although many uncertainties about the impacts remain, as is illustrated in this article, it is nevertheless clear that human activities could become an important climate regulating force in the near future. 53 refs.

- 144 CARBON DIOXIDE, CLIMATE, AND SOCIETY. Williams, J. *Options* (IIASA); 1-2(Spr 1978).

Questions raised at a recent workshop on the effects of carbon dioxide produced by burning fossil fuels reflect concerns for its impact on climate and society as atmospheric concentrations of CO₂ increase. Three groups were formed to apply systems analysis to these problems. The first group, studying the mechanics and prediction of CO₂ concentration levels, concluded that 20 to 30-year forecasts are possible with present models and that a significant new source of CO₂ is caused by tropical deforestation projects. The second group examined the use of models to study the effects on climate and environment. Their conclusions call for shifting patterns of rainfall and an overall increase in rainfall. The implications of these conclusions were examined by the third group, which recommended a 5 to 10-year research and planning program and outlined five policy statements on the use of fossil fuels. Their recommendations emphasize the assessment of energy strategies on the basis of their environmental and socio-economic impacts.

strong temperature dependence. This paper presents one-dimensional model results for the steady state ozone behavior when the CO₂ concentration is twice its ambient level which account for coupling between chemistry and temperature. When the CO₂ level doubled, the total ozone burden increased in relation to the ambient burden by 1.2--2.5%, depending on the vertical diffusion coefficient used. Above 30 km. In this region the relation variations were insensitive to the choice of diffusion coefficient. Below 30 km, ozone concentrations were smaller than the unperturbed values and were sensitive to the vertical diffusion profile in this region (10--30 km). Ozone decreases in the lower stratosphere because of a reduction in ozone-producing solar radiation, which results in smaller downward ozone fluxes from the region at 25--30 km relative to the flux values for the ambient atmosphere. These offsetting changes occurring in the upper and lower stratosphere act to minimize the variation in total ozone.

- 145 (CONF-780611--3) RELATIONSHIPS BETWEEN REMOVAL PROCESSES AND RESIDENCE TIMES FOR ATMOSPHERIC POLLUTANTS. Slinn, W.G.N. (Oregon State Univ., Corvallis (USA)). 24 Mar 1978. Contract EY-77-S-09-0980. 50p. Dep. NTIS, PC A03/MF A01.

From AIChE symposium; Philadelphia, PA, USA (4 Jun 1978):

This report is concerned with improving estimates for the residence times of atmospheric trace constituents in various atmospheric reservoirs. Residence times are defined only for steady-state conditions; i.e., when the net growth rate vanishes. The most useful case of vanishing net growth rate is when the total growth rate is equal to the decay rate. It is demonstrated that the most important advance towards improving estimates of pollutant residence times is through proper choices of reservoirs. Chosen reservoirs should possess the following features: steady-state conditions, uniform mixing ratio throughout or throughout specified subreservoirs, and subreservoirs chosen in which removal rates can be treated as approximate constants. An example of a poorly mixed reservoir, the stratosphere, is discussed. In another example, it is suggested that commonly used reservoirs for atmospheric CO₂ have been chosen poorly and that a substantial portion of the anthropogenic CO₂ released during the past 50 years may still be mixing into the stratosphere. In another example, it is suggested that determination of the dry deposition velocity for accumulation-mode aerosol particles may not be so important as previously thought. To improve estimates for the atmospheric residence times of these particles, it is important to increase knowledge of what is called the ascension velocity.

- 146 EFFECT OF INCREASED CARBON DIOXIDE CONCENTRATIONS ON STRATOSPHERIC OZONE. Boughner, R.E. (NASA Langley Research Center, Hampton, Virginia 23665). J. Geophys. Res.; 83: No. C3, 1326-1332 (20 Mar 1978).

During the past several years, much attention has been focused on the destruction of ozone by anthropogenic pollutants such as the nitrogen oxides and chlorofluoromethane. Little or no attention has been given to the influence on ozone of an increased carbon dioxide concentration for which a measurable growth has been observed. Increased carbon dioxide can directly affect ozone by perturbing atmospheric temperatures, which will alter ozone production, whose rate displays a fairly

- 147 WHAT A DIFFERENCE A DEGREE MAKES¹. Schneider, S.H. (US Natl Center for Atmospheric Research, Colo). CHEMTECH; 8: No. 3, 143-145 (Mar 1978).

Slight changes in climate, such as temperature changes or changes in the amount of precipitation, cause large responses in marginal regions. This impact in turn affects food production. Such climate changes in the arctic region have recently caused the shifting of glaciers. Energy generation resulting in increased levels of atmospheric carbon dioxide has caused a worldwide temperature rise of a few tenths of a degree Celsius. The nature of exponentials is such that the first increment of growth cannot be discerned clearly. The effects of increased CO₂ in the atmosphere should become large sometime after the year 2000. (4 graphs, 2 photos)

- 148 (ORNL--5365, pp 156-175) TERRESTRIAL ECOLOGY SECTION. Harris, W.F. Mar 1978. Environmental Sciences Division annual progress report for period ending September 30, 1977.

Studies on ecological effects of coal combustion included the following: episodic air pollution stress; interaction of gaseous pollutants and acid precipitation; and brimstone: preliminary results from SO₂ effects on forest growth. Studies on fate and transport of contaminants included deposition of aerosol-associated trace elements to a deciduous forest; hydrologic source areas; and environmental behavior of mercury. The environmental research park is described and forest resource management is discussed. Ecosystem analysis studies included hydrology of Walker branch; water budget of an oak-hickory forest; nutrient release from decaying wood; transpiration of the tulip poplar; and atmospheric CO₂ and its interaction with biospheric changes. (HLW)

- 149 (KFK--2621) MATHEMATICAL TREATMENT OF FIRST ORDER KINETICS SYSTEMS WITH RESPECT TO THE CARBON DIOXIDE CYCLE OF THE EARTH. Fenyi, S.; Frick, H. (Kernforschungszentrum Karlsruhe G.m.b.H. (Germany, F.R.)). Inst. fuer Datenverarbeitung in der Technik 2). Mar 1978. 132p. Dep. NTIS (US Sales Only), PC A07/MF A03.

The CO₂-cycle of the earth is conceived as a 'first order kinetics' system. This leads to a system of coupled first order differential equations. Differential equations systems of general 'first order kinetics' systems are analyzed with respect to equilibrium states and

asymptotic behaviour of the solutions. The second part of the report treats the thermodynamic aspect of the first order kinetics systems. According to the idea of J. Meixner the problem was transformed in an analogous problem of electrical networks. Methods for the numerical treatment are presented.

- 150 CARBON DIOXIDE PROBLEM: SOLUTION BY TECHNICAL COUNTERMEASURES. Bach, W. Umsch. Wiss. Tech.; 78: No. 4, 117-118 (15 Feb 1978). (In German).

A rough assessment indicates that anthropogenic influences might raise the mean global surface temperature by 0.8 to 1.2 C in 2000 AD and by 2 to 4 C in 2050 AD. The rapidly increasing levels of atmospheric carbon dioxide are largely responsible for this warming trend. A variety of measures for the reduction of carbon dioxide emissions is presented. One promising approach is to work out a world-wide energy mix that can counteract a temperature increase. (In German)

- 151 QUESTION MARK OVER COAL. POLLUTION, POLITICS, AND CO. Marland, G.; Rotty, R.M. (Oak Ridge Assoc Univ, Inst for Energy Anal, Tenn). Futures; 10: No. 1, 21-30 (Feb 1978).

The increasing concentration of carbon dioxide (CO₂) in the atmosphere is now well-documented, and although the evidence of actual or potential climate changes is not conclusive, the growth in energy consumption magnifies the importance of the possible dangers. The CO₂ increase will be mainly produced by coal, and the indications are that many countries will be contributing to the increase in atmospheric CO₂ early in the next century. Using world energy resource estimates and projections of the global production of CO₂ from fossil-fuel burning in the year 2025, the paper argues that it will be difficult to achieve an international consensus and commitment to deal with the issue. This is because of the relationship between economic growth, industrialization, and the production of CO₂, and because of the distribution of the beneficial and harmful effects of any climatic change. 28 refs.

- 152 (CONF-7608116-- pp 91-114) PANEL III: PLANTS AS SOURCES OF AIRBORNE MATERIALS. Benninghoff, W.S.; Carson, J.L.; Dawson, G.A. Feb 1978.

From Ecologists/Metrologists workshop; Douglas Lake, MI, USA (16 Aug 1976).

Studies were conducted on the contribution of plants to the gaseous composition and particle loads of the atmosphere. The role of plants in contributing CO, CO₂, methane, and nitrogen oxides is discussed. The importance of ammonia as the only alkaline gaseous component of the atmosphere is discussed. Geophysical consequences of the presence in the air of small particles resulting from gas-to-particle conversion are discussed. Products released to the atmosphere from unconfined burning of plant materials are described. Other solids contributed to the air by plants are sulfur compounds, microorganisms, spores, pollen, plant fragments, and detritus. It was concluded that plant materials in the air are significant to human health, environmental quality, and climatic change. Recommendations are given with regard to various aspects of plant materials in the air. (HLW)

- Rotty, R.M. Futures; 10: No. 1, 21-30 (Feb 1978).

There is a growing concern about the effect of fossil-fuel burning, and the consequent increase in carbon dioxide concentration in the atmosphere. This increasing concentration is now well-documented, and although the evidence of actual or potential climate changes is not conclusive, the growth in energy consumption magnifies the importance of the possible dangers. The carbon dioxide increase will be mainly produced by coal. Whereas the increase in atmospheric carbon dioxide is now being imposed upon the world principally by the USA, the USSR, and Western Europe, the developing countries will probably be important contributors by early in the next century.

- 154 CO₂ PROBLEM: POSSIBLE SOLUTIONS BY TECHNICAL COUNTERMEASURES. Bach, W. (Muenster Univ. (Germany, F.R.). Forschungsstelle fuer Angewandte Klimatologie und Umweltstudien). Umsch. Wiss. Tech.; 78: No. 4, 117-118 (Feb 1978). (In German).

If we continue to burn fossil fuels, a global temperature rise of 10C must be reckoned with for the year 2000; in 2050, it will be 3 to 40C. Preventive measures are discussed, e.g.: Reducing the combustion of fossil fuels, removing CO₂ before emission, establishing a carbon bank, discharging CO₂ into the deep sea. Model calculations indicate that it might be possible to prevent the expected temperature rise by a world-wide energy mix.

- 155 IS MANKIND WARMING THE EARTH. Kellogg, W.W. (Natl Center for Atmospheric Research, Colo). B Atomic Scientists; 34: No. 2, 10-19 (Feb 1978).

Technical feature: Ways in which human activity affect climate changes are examined. The release of radioactive krypton-85 from nuclear reactors and fuel reprocessing plants, release of aerosols, and release of heat through thermal pollution are all major influences on climate. The buildup of carbon dioxide from fossil fuel combustion is the largest single factor that contributes to warming trends in climate. By the end of the century, the earth's average surface temperature will be warmer than at any time in the past 1000 years or more and will still be rising. The implications of a warmer earth and the effect warmer climate will have on ice masses are discussed. (1 diagram, 1 graph, 1 map, 1 photo, 21 references, 1 table)

- 156 PREDICTING FUTURE ATMOSPHERIC CARBON DIOXIDE LEVELS. Siegenthaler, U.; Deschger, H. (Univ., Bern). Science; 199: No. 4327, 388-395 (27 Jan 1978).

Results from different models for the natural carbon dioxide cycle are compared. Special emphasis is given to the type of ocean modeling (diffusive deepsea or two-box ocean), behavior of the biosphere, and value of the oceanic buffer factor against carbon dioxide uptake. According to the most probable models, the fraction of the cumulative production remaining airborne will be between 46 and 80% 100 years from now for any realistic assumptions concerning future carbon dioxide production. For a prescribed maximum increase of 50% above the preindustrial carbon dioxide level, the production could grow by about 50% until the beginning of the next century, but should then decrease rapidly.

- 153 QUESTION MARK OVER COAL: POLLUTION, POLITICS, AND CARBON DIOXIDE. Marland, G.;

- 157 WEST ANTARCTIC ICE SHEET AND CARBON DIOXIDE GREENHOUSE EFFECT: A THREAT OF

DISASTER. Mercer, J.H. Nature (London); 271: No. 5643, 321-325(26 Jan 1978).

If the global consumption of fossil fuels continues to grow at its present rate, atmospheric carbon dioxide content will double in about 50 years. Present models of climatic effects of this doubling yield a rise in temperature that could cause rapid deglaciation of West Antarctica, leading to a 5 m rise in sea level. The models, which are discussed, are known to be crude and oversimplified, so climatic changes which occur could easily differ from the estimates, although there is as yet no way of knowing whether the models err on the pessimistic or optimistic side.

- 158 WEST ANTARCTIC ICE SHEET AND CO₂ GREENHOUSE EFFECT: A THREAT OF DISASTER. Mercer, J.H. (Ohio State Univ., Columbus). Nature (London); 271: No. 5643, 321-325(26 Jan 1978).

If the global consumption of fossil fuels continues to grow at its present rate, atmospheric CO₂ content will double in about 50 years. Climatic models suggest that the resultant greenhouse-warming effect will be greatly magnified in high latitudes. The computed temperature rise at lat 80°S could start rapid deglaciation of West Antarctica, leading to a 5 m rise in sea level.

- 159 ATMOSPHERIC CARBON DIOXIDE AND CARBON RESERVOIR CHANGES. Stuiver, M. (Univ. of Washington, Seattle). Science; 199: No. 4326, 253-258(20 Jan 1978).

The net release of CO₂ from the biosphere to the atmosphere between 1850 and 1950 is estimated to amount to 1.2×10^9 tons of carbon per year. During this interval, changes in land use reduced the total terrestrial biomass by 7%. There has been a smaller reduction in biomass over the last few decades. In the middle 19th century the air had a CO₂ content of approximately 268 parts per million, and the total increase in atmospheric CO₂ content since 1850 has been 18%. Major sinks for fossil fuel CO₂ are the thermocline regions of large oceanic gyres. About 34% of the excess CO₂ generated so far is stored in surface and thermocline gyre waters, and 13% has been advected into the deep sea. This leaves an airborne fraction of 53%.

- 160 BIOTA AND THE WORLD CARBON BUDGET. Woodwell, G.M. (Ecosystems Center, Woods Hole, MA); Whittaker, R.H.; Reiners, W.A.; Likens, G.E.; Delwiche, C.C.; Botkin, D.B. Science; 199: 141-145(13 Jan 1978).

This article reviews briefly current knowledge of the world carbon budget with special emphasis on the question of whether the biota is now a source or a sink for CO₂. The analysis shows through convergent lines of evidence that the biota is not a sink and may be a source of CO₂ as large as or larger than the fossil fuel source. The issue is important because of the potential that changes in the CO₂ content of air have for changing climate worldwide.

- 161 BIOTA AND THE WORLD CARBON BUDGET. Woodwell, G.M. (Marine Biological Lab., Woods Hole, MA); Whittaker, R.H.; Reiners, W.A.; Likens, G.E.; Delwiche, C.C.; Botkin, D.B. Science; 199: No. 4325, 141-146(13 Jan 1978).

Current knowledge of the world carbon budget is reviewed with special emphasis on the question of whether the biota is a source or a sink for CO₂. The analysis shows through convergent lines of evidence that the biota is

not a sink and may be a source of CO₂ as large or larger than the fossil fuel source. The issue is important because of the potential that changes in the CO₂ content of air have for changing climate worldwide. Various analyses suggest that human activities in the near future could release large additional amounts of CO₂ into the atmosphere with results that are substantially unpredictable.

- 162 GEOPHYSICAL CONSEQUENCES OF CARBON DIOXIDE GENERATION BY FOSSIL FUELS. Fong, P. (Emory Univ., Atlanta). Ga. J. Sci.; 36: No. 1, 34-41(Jan 1978).

The recent National Academy of Sciences Report "Energy and Climate" asserts that the greenhouse effect of CO₂ generated by the burning of fossil fuels would increase the temperature of the earth by 11°F. It is argued and calculations have been carried out to show that the principal effect is the complete melting of the polar icecaps in a few centuries; the resulting inundation of the populated land areas and the coastal cities of the world is even more disastrous. The calculated increase of temperature is only 1.4°C.

- 163 GLOBAL AIR POLLUTION AND CLIMATE CHANGE. Kellogg, W.W.; Schneider, S.H. (National Center for Atmospheric Research, Boulder, CO). IEEE Trans. Geosci. Electron.; GE-16: No. 1, 44-50(Jan 1978).

Mankind has now demonstrated that it can change the composition of the atmosphere on a global scale. Those consequences of global air pollution which may have the greatest impact on society in the decades ahead are the associated changes in the radiation balance of the earth and atmosphere and the resulting change of climate. Carbon dioxide increase from the burning of fossil fuels at a continuously increasing rate can cause a 1°C rise in mean surface temperatures by 2000 A.D., and 2-3°C rise by the middle of the next century. There are uncertainties in this projection of mean temperature rise of perhaps a factor of two; and the polar regions are expected to experience an increase several times larger. Other anthropogenic influences, such as the addition to the atmosphere of chlorofluoromethanes, nitrous oxide, and possibly aerosols, may contribute still further to this global warming. The mean surface temperature of the earth by 2000 A.D., if our projection is correct, will be warmer than at any time in the past 1000 years or more. Accompanying such a climate change there will be shifts in the large scale atmospheric circulation patterns and significant alterations of regional temperature and precipitation distributions--favorable for some regions, unfavorable for others, although we cannot predict the details of these changes. This prospect, based on theoretical model calculations that scientists cannot prove to be fully credible ahead of time, challenges the decision makers of the world to decide whether to act together to avert the climate change, to wait for more research on the climate system to verify our theoretical models, or to do nothing at all. We must ask, How much proof is enough. Such major strategy decisions must, of course, be based on value judgments of the potential risks and benefits of a given course of action as well as on the scientific and technological factors involved.

- 164 CLIMATIC CHANGE: VOLCANOES, MAN-MADE POLLUTION, AND CARBON DIOXIDE. Dittberner, G.J. (Univ. of Wisconsin, Madison). IEEE Trans. Geosci. Electron.; GE-16: No. 1, 50-

61(Jan 1978):

The causes of climatic change are summarized with emphasis on what appear to be the three most important factors external to atmospheric processes controlling climate on the scale of decades. These are (1) high level stratospheric particles injected by volcanic eruptions, (2) the increase in carbon dioxide due to an increase in industrial activity, and (3) generation of lower atmospheric particles directly caused by man. A historical perspective on each of these begins with the earliest discoveries and ends with current state of the art knowledge. The impact of these factors on climate is examined using the model of Eryson and Dittberner. Results show that these three factors can indeed simulate, remarkably well, the past behavior of hemispheric climate as best we know it. The most important implication to emerge from this study is that climate is affected not only by nature, but also by man through the burning of fossil fuels and the subsequent production of carbon dioxide and particulates.

- 165 UNDERSTANDING ANTHROPOGENIC EFFECTS ON ULTRAVIOLET RADIATION AND CLIMATE. Hidalgo, H. (Institute for Defense Analyses, Arlington, VA). IEEE Trans. Geosci. Electron.; GE-16: No. 1, 4-22(Jan 1978).

This paper describes recent efforts to assess the risk of anthropogenic increases of UV-B radiation and changes of climate at the earth's surface. The main intent of the paper is to provide the reader with a grasp of the basic methodology applied to both problems. The application of the methodology is illustrated by (1) recent changes in our understanding of the risk of increases in UV-B radiation from the use of chlorofluoromethanes and operation of high-altitude aircraft and (2) the limited available results for changes of climate from the burning of fossil fuels.

- 166 CARBON DIOXIDE QUESTION. Woodwell, G.M. Sci. Am.; 238: No. 1, 34-43(Jan 1978).

The present concentration of carbon dioxide in the atmosphere is slightly more than 330 ppm, compared with 280 ppm in 1850, and if present trends continue it could be nearly double today's value by 2000. The rapid increase was originally thought to be caused by burning of fossil fuels, but it is now thought that it may be due in an equal degree to worldwide destruction of forests. Discusses recent studies on the carbon dioxide content and balance of the ocean, atmosphere and biota, and concludes that if the world's oceans and forests cannot store enough carbon dioxide there will be a major climatic change.

- 167 NATURAL AND PERTURBED TROPOSPHERE.

Stewart, R.W.; Hammed, S.; Pinto, J. (NASA Inst for Space Stud, Goddard Space Flight Cent, New York, NY). IEEE Trans. Geosci. Electron.; GE-16: No. 1, 30-44(Jan 1978).

It is now generally accepted that the troposphere is a region of chemical complexity and that many human activities may alter the chemical structure of the region. A prerequisite to any realistic assessment of human impacts on pollution and climate is an understanding of the natural budgets of atmospheric gases. This requires a knowledge of physical, chemical, and biological processes within the various reservoirs which are involved in the cycles of these gases. The processes important in establishing the concentrations of a number of tropospheric species and gaps in current understanding of these processes are discussed. The points at

which man may intervene in the major cycles of atmospheric gases are identified. The possible consequence of such interventions are described. Pollutants released into the troposphere may adversely affect the environment by virtue of their chemical interactions with other atmospheric species, their radiative properties, or both. Problems discussed include the growth of atmospheric CO₂ resulting from the burning of fossil fuels and its possible climatic effects, the consequences of increased levels of CO emission on the self-cleansing ability of the troposphere and on the radiation budget, and possible changes in the stratospheric odd nitrogen and ozone amounts due to increased use of fertilizers in agriculture. The magnitude of the perturbations predicted by various model studies are reviewed with particular attention to uncertainties which may affect the results. 90 refs.

- 168 EFFECTS OF HUMAN ACTIVITIES ON GLOBAL CLIMATE. PART II. Kellogg, W.W. (National Center for Atmospheric Research, Boulder, CO). WMO (World Meteorol. Organ.) Bull.; 27: No. 1, 3-9(Jan 1978).

The implications of a warmer earth are discussed in regard to length of the growing season, precipitation patterns, and the fate of the ice masses. Other topics of discussion are the value of a long range climate forecast, and areas of immediate and urgent concern, including climate modelling, carbon dioxide sources and sinks, the Arctic ice pack, ice sheets, changing patterns of temperature and precipitation, and aerosols. (JGB)

- 169 LOOKING INTO THE COAL OPTION. Grenon, M. Options (IIASA); 5-6(Win 1978).

A report on the 1977 Energy Resources Conference held in Moscow focuses on the technical and economic aspects of coal as they relate to global resource policy problems. Estimates of untouched reserves continue to rise, including those in developing countries, although the Soviet Union, China and the U.S. continue to dominate. Underground mining will be applied, with new approaches in hydraulic bore hole mining, robots, microbiological attack, in-situ liquefaction, underground gasification, and others being explored and developed. Surface mining is expected to account for most of the increased production in the near term with equipment that tends toward gigantism. The major issue with coal, however, is its dependence on inexpensive transportation and the possibility of using pipelines. The conference reviewed the role of coal in meeting increasing energy demand and concluded that power generation and metallurgical applications will absorb the increase in production. Combustion products and their effects on global climatic and atmospheric conditions were discussed with the consensus that more work is needed to quantify carbon dioxide risk.

- 170 ENERGY USE AND CLIMATIC CHANGES.

Williams, J.; Hafele, W. (Intl Inst for Applied Systems Analysis, Austria). Acta Astronaut.; 5: No. 7-8, 589-600(1978).

Survey report: The potential impacts of the three major energy options (nuclear, fossil fuel, and solar) on local and global climate are modeled and evaluated in terms of resources, demands, options, strategies, and constraints. All three systems produce waste heat. Fossil fuel usage also leads to increased atmospheric carbon dioxide. Solar energy systems, if employed on a large scale, could modify climate because of changes in land or

ocean surface characteristics. Space observations will be important for future evaluations of climatic flux resulting from different energy options.

- 171 **ATMOSPHERIC CO₂ CONSEQUENCES OF BURNING FOSSIL FUELS.** Rotty, R.M. (Oak Ridge Associated Universities, TN). pp 523-540 of Nuclear energy and alternatives. Kadiroglu, O.K.; Perlmutter, A.; Scott, L. (eds.). Cambridge, MA; Ballinger Publishing Company (1978).

From International scientific forum on an acceptable nuclear energy future of the world; Fort Lauderdale, FL, USA (7 Nov 1977).

Increases in the atmospheric concentration of CO₂ cause concern only when the quantities become large, for example, 600 billion tons (or so) of additional carbon. The direct contribution from emphasis on United States coal use through 1985, as called for in the National Energy plan, is of minor consequences. On the other hand, if such a policy continues into the next century and serves as a model for major segments of the world, then the quantity of the resulting CO₂ could have serious consequences early in the next century. Further, if coal is used on a large scale as the base for liquid and/or gaseous synthetic fuels as the oil and natural gas reserves are depleted, the inefficiencies of conversion serve to increase the CO₂ produced per unit of delivered energy and further aggravate the problem. If we are to continue to prove world leadership, then it becomes vitally important that we set the proper example with regard to exploitation of coal reserves in the next century. Of prime importance is the development of other energy options, not only for the United States, but all the world - especially the developing world. Such options should be inexpensive, dependable, easily deployable, relatively safe, and socially acceptable - characteristics enjoyed by the fossil fuels for the past one hundred years. During the most critical period of the next fifty years, we will have to shift to a system that obtains a major supply of energy from another source (or sources) that has most of the desirable characteristics of fossil fuels, but does not produce CO₂. Prime candidates are solar, with its children (wind, hydro, OTEC); nuclear; and perhaps fusion; but each of these has its albatross.

- 172 **WHERE WE AGREE: REPORT OF THE NATIONAL COAL POLICY PROJECT. VOLUME 1.** Murray, F.X. (ed.). Boulder, CO; Westview Press, Inc. (1978). 347p.

The report of the National Coal Policy Project is entitled Where We Agree to focus attention on the broad areas of agreement reached by the project participants. This one-year project brought together leading individuals from environmental and industry groups to seek consensus on important national policy issues related to the use of coal in an environmentally and economically acceptable manner. Task forces were responsible for exploring specific areas of interest: transportation, air pollution, fuel utilization and conservation, energy pricing, and emission charges. Volume 1 contains the full task force reports on transportation, air pollution, fuel utilization and conservation, energy pricing, and emission charges. Because of its length and technical nature, the mining task force report makes up all of Volume 2. The mining report defines--on a regional and national basis--the technical, social, legal, and administrative requirements for ensuring that coal is mined in an environmentally sound manner. A summary of

the project, available from the Center for Strategic and International Studies (CSIS), provides a synthesis of the project's findings and individual summaries of each task force report. Consensus was reached on more than 150 recommendations related to such issues as locations and patterns of coal development, coal reserve quality and quantity, reclamation, the effects of development on water resources, and the socioeconomic impacts of coal development.

- 173 **CO₂ AND SPACESHIP EARTH.** Terra, S. EPRI J.; 3: No. 6, 22-27(1978).

Atmospheric CO₂ concentrations have increased so rapidly since the start of the industrial revolution that the threat of climatic and economic disruptions may require limitations on future fossil-energy production. The greenhouse effect by which longwave radiation is absorbed by CO₂ and reradiated back to earth, will raise the earth's temperature. Other factors can be traced to a warming trend caused by an increase in nitrous oxides from agricultural activity and a cooling tendency as the added warmth increases evaporation and cloud formation. Several national and international studies of CO₂ effects are underway and legislation for further data and research has been proposed in Congress. While scientists agree that CO₂ levels are increasing, they disagree on the nature of the long-term effects on climate, crop production, deglaciation, and the impact of forest and other biological matter. Simulation models for projecting future conditions need to include transients to predict the effects of CO₂ level changes.

- 174 **CARBON DIOXIDE AND THE 'GREENHOUSE EFFECT': AN UNRESOLVED PROBLEM.** Smith, I. London; IEA Coal Research (1978). 40p. (ICTIS/ER--01).

This executive review evaluates current scientific literature concerned with the accumulation of carbon dioxide in the atmosphere. The extent and possible causes of natural variations in global climate are outlined as a background to potential variations due to human activity. Estimates are given on relative contributions of carbon dioxide to the atmosphere due to fossil fuel combustion, deforestation and other land modifications. The possibility of a rise in global temperature as a result of increasing the amount of carbon dioxide in the atmosphere is discussed including model predictions, natural factors which could compensate for or emphasize a warming effect, and the implications if extensive warming actually occurred. Carbon dioxide disposal is discussed, but there appears to be no practicable long-term means of accomplishing this. It is concluded that there is no evidence of a rise in global temperature due to carbon dioxide at present. Predictions, which involve a high degree of uncertainty, indicate that the global temperature could rise appreciably in the next century. An increase in precipitation rate is also expected. If these changes result in a redistribution of climatic zones, there may be problems in adapting agricultural belts in some regions. Complete melting of all the ice sheets would take several millennia. A partial melting of continental ice sheets would not necessarily occur in view of the increase in precipitation rates, but if it did, there would be a rise in sea level of a few metres. Melting of the Arctic sea ice would affect climate, but not sea level.

- 175 MODELS FOR OCEAN UPTAKE OF FOSSIL FUEL CO₂. Broecker, W.S. (Columbia Univ., Palisades, NY). Trans. Am. Nucl. Soc.: 30: 85(1978). (CONF-7811109--).
From 1978 winter meeting of American Nuclear Society; Washington, DC, USA (12 Nov 1978).
CARBON DIOXIDE;FOSSIL-FUEL POWER PLANTS;SEAS; UPTAKE;SOLUBILITY;FOSSIL-FUEL POWER PLANTS; FORESTS;ENVIRONMENTAL EFFECTS;BIOMASS; BIODEGRADATION
- 176 GLOBAL CO₂ PROBLEM, DEPARTMENT OF ENERGY RESEARCH OBJECTIVES. Slade, D. (Dept. of Energy, Washington, DC). Trans. Am. Nucl. Soc.: 30: 85(1978). (CONF-7811109--).
From 1978 winter meeting of American Nuclear Society; Washington, DC, USA (12 Nov 1978).
CARBON DIOXIDE;GLOBAL ASPECTS;US DOE; GREENHOUSE EFFECT;CLIMATES;GOVERNMENT POLICIES; ENVIRONMENTAL EFFECTS
- 177 UNCERTAINTIES ASSOCIATED WITH EFFECTS OF GLOBAL ATMOSPHERIC CO₂. Rotty, R.M. (Oak Ridge Associated Universities, TN). Trans. Am. Nucl. Soc.: 30: 84(1978). (CONF-7811109--).
From 1978 winter meeting of American Nuclear Society; Washington, DC, USA (12 Nov 1978).
CARBON DIOXIDE;EARTH ATMOSPHERE;GLOBAL ASPECTS;CLIMATES;FOSSIL-FUEL POWER PLANTS; FORECASTING;TERRESTRIAL ECOSYSTEMS;GREENHOUSE EFFECT;ENVIRONMENTAL EFFECTS
- 178 EFFECTS OF INCREASING ATMOSPHERIC CO₂ ON CLIMATE. Mitchell, J.M. Jr. (EDS/NOAA, Silver Spring, MD). Trans. Am. Nucl. Soc.: 30: 84(1978). (CONF-7811109--).
From 1978 winter meeting of American Nuclear Society; Washington, DC, USA (12 Nov 1978).
CARBON DIOXIDE;EARTH ATMOSPHERE;GLOBAL ASPECTS;CLIMATES;FOSSIL-FUEL POWER PLANTS; GREENHOUSE EFFECT;ENVIRONMENTAL EFFECTS
- 179 BIOSPHERE AS A SOURCE AND/OR A SINK FOR CARBON DIOXIDE. Olson, J.S.; Killough, G.G. (Oak Ridge National Lab., TN). Trans. Am. Nucl. Soc.: 30: 85(1978). (CONF-7811109--).
From 1978 winter meeting of American Nuclear Society; Washington, DC, USA (12 Nov 1978).
CARBON DIOXIDE;ECOSYSTEMS;UPTAKE;PLANTS; ANIMALS;METABOLISM;CARBON 12;CARBON 13;ISOTOPE RATIO;BIOCHEMISTRY;ENVIRONMENTAL EFFECTS; GREENHOUSE EFFECT
- 180 HEAT RELEASES OF POWER PLANTS. Styrikovich, M.A. (USSR Academy of Sciences, Moscow). pp 311-346 of Thermal effluent disposal from power generation. Zaric, Z.P. (ed.). Washington, DC; Hemisphere Publishing Corporation (1978).
From International advanced course on heat disposal from power generation; Dubrovnik, Yugoslavia (23 Aug 1976).
The effects of increased world energy demands on the environment and, in particular, climate, are discussed. Increases in emissions of CO₂ and SO₂ into the atmosphere are projected, and their effects on climate are discussed. Specific heat releases into water basins and the atmosphere from power plants of different types are tabulated. Various steam condensation heat withdrawal systems are considered, and factors involved in the utilization of waste heat from power plants are discussed. (JGB)
- 181 POWER PRODUCTION AND ITS POTENTIAL INFLUENCE ON THE GLOBAL CLIMATE. Berkovskii, B. pp 347-364 of Thermal effluent disposal from power generation. Zaric, Z.P. (ed.). Washington, DC; Hemisphere Publishing Corporation (1978).
From International advanced course on heat disposal from power generation; Dubrovnik, Yugoslavia (23 Aug 1976).
The influence that the fuel-power complex may have on the global climate is discussed. An attempt has been made to estimate the degree of this influence as well as the restrictions on the increase and methods of energy production which will prevent catastrophic changes in the climate. It is shown that the most important influence of the fuel-power complex on the global climate can be made by the following anthropogenic factors: increase in energy production which, through thermal pollution, increases the temperature of the atmosphere at the earth's surface; CO₂ pollution of the atmosphere, decreasing the long wave radiation of the earth; the increase in the concentration of the atmospheric aerosols which reduce the incoming solar radiation. A quantitative estimate of the restrictions on energy production related to thermal, CO₂, and aerosol pollution of the atmosphere is given. First, the main notions of climatology and primary factors of climate formation are exposed, followed by a discussion of the interaction of the fuel-power complex with the biosphere. Attention is then concentrated on the main potential influence of the fuel-power complex on the global climate. A detailed analysis of the restrictions on future energy production and utilization is presented.
- 182 ENVIRONMENTAL ISSUES IN COAL USE--A FUTURE PERSPECTIVE. Greenway, A.R.; Rogers, J.A. (Fred C. Hart Assoc, Inc, New York, NY). Proc. Air Pollut. Control Assoc.: 1: 1-16(1978).
The study of Environmental Issues in Future Coal Use performed for ERDA (now DOE) that had as its objective to identify environmental constraints that should be considered in the planning for inexhaustible versus exhaustible energy resource development is described. The study was conducted over a short time period, used broad assumptions and generalizations and was based on readily available data and reports. 15 refs.
- 183 (CONF-7808112--1) MINERAL CYCLING IN TROPICAL FORESTS. ENVIRONMENTAL SCIENCES DIVISION PUBLICATION NO. 1269. Cole, D.W.; Johnson, D.W. (Oak Ridge National Lab., TN (USA); Washington Univ., Seattle (USA)). 1978. Contract W-7405-ENG-26. 29p. Dep. NTIS, PC A03/MF A01.
From 5. North American forest soils conference; Ft Collins, CO, USA (6 Aug 1978).
Generalizations concerning the cycling of nutrients in the tropics are difficult because tropical forests have not been extensively studied and tropical systems are more diverse than temperate zones. Several conclusions can be made regarding nutrient dynamics in tropical forests. Selective storage of nutrients within the vegetative component of the ecosystem is not a universal means of nutrient conservation in tropical areas. There is appreciably more leaf turnover expressed as litterfall in lowland tropical forests than any other forest type. High rate of turnover is also found in the forest floor due to high temperature and humid conditions of these sites. This high rate of decomposition has an impact on the storage of carbon, affecting in turn the capacity of these systems to store nitrogen. The implication of such difference could potentially be felt in several ways.

Ecologically we should expect to see plant species capable of nitrogen fixation. Management practices which exclude nitrogen fixers or cause a decrease in soil organic matter could detrimentally affect the nitrogen status and thus the productivity of these ecosystems. The rapid rate of organic turnover, both foliar and soil, also suggests that these forests have some mechanism of rapidly recapturing critical nutrients prior to leaf fall. In general, the most serious effects of site clearing and burning seem to relate to N losses and erosion. Burning releases cation nutrients from vegetation and must result in some N loss. However, cations so released are retained on soil exchange sites and N losses are generally quickly compensated for by N fixation. It appears that N conservation is very tightly linked to C conservation in tropical soils. Clearing, burning, and cultivation all result in carbon losses from the soil which in turn cause a release of N. If sites are reforested, soil C contents build up and N losses from site disturbances are recovered fairly quickly by fixation.

- 184 (CGC-4287-13, pp 53-63) ENERGY, CO₂, AND CLIMATE: PLANNING A PROGRAM OF RESEARCH AND ANALYSIS. Hendricks, J.W. 1978.

Social science energy review. Volume 1, No. 4, Fall 1978.

Energy supply plans that call for burning large amounts of coal, oil, and gas will create large amounts of carbon dioxide and is a matter of concern for energy planning. Burning fossil fuels may substantially raise the CO₂ levels in the earth's atmosphere. This could reduce the earth's radiation of energy, resulting in a global warming trend and other climatic changes which would affect agriculture and other important human activities. A simplified summary of the linkage between energy policies and possible CO₂ problems is given and reveals the importance of uncertainties about such things as: the responses of complex natural systems to additional CO₂ emissions, and the feasibility of systems to decide upon and implement CO₂ control strategies. The DOE has formed an Office of Carbon Dioxide Effects Research and Assessment to direct a CO₂ research program. Along with a brief description of this program, the Mapping Group on Energy and the Social Sciences reviews the appropriate role for the social sciences in a research program on the energy-CO₂-climate linkages.

- 185 INTRODUCTION TO THE CLIMATE/ENVIRONMENT ASPECTS OF CO₂ (A PESSIMISTIC VIEW). Williams, J. (International Inst. for Applied Systems Analysis, Laxenburg, Austria). pp 131-139 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

The problems that arise when estimates are made of the effect on climate of increasing the atmospheric CO₂ concentration. The climate system is highly complex and nonlinear and the understanding of (and ability to predict) climatic variations is poor. Observational studies and the use of models have helped in understanding some of the processes and mechanisms of climatic variations, but predictions still cannot be made.

Office, Bracknell, England). pp 181-191 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

A single column radiative-convective equilibrium model was used to investigate the dependence of the effects of doubling CO₂ on the assumptions made for the temperature and humidity structure. It is found that, relative to a convective parameterization which generates a moist adiabatic lapse rate, a convective adjustment to a fixed lapse rate exaggerates the effect of doubling CO₂ for surface temperatures above about 280°K, but makes little difference at lower temperatures. The results are quite sensitive to the assumptions made for relative humidity, indicating the need for a realistic parameterization of convection in CO₂ experiments.

- 187 POTENTIAL CONSEQUENCES OF INCREASING CO₂ LEVELS IN THE ATMOSPHERE. Bach, W. (Center for Applied Climatology and Environmental Studies, Muenster, Germany). pp 141-167 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

The potential consequences for agricultural productivity and world food supply of increasing atmospheric CO₂ levels and the resulting climate variations are reviewed. Above all, increasing CO₂ raises the surface air temperature and changes the distribution of precipitation. The combined effects of these elements may already be adversely influencing food production in some regions. There is a high probability that the adverse effect will become more frequent and more widespread as the CO₂ concentration in the atmosphere continues to increase over the next decades.

- 188 CRYOSPHERIC RESPONSES TO A GLOBAL TEMPERATURE INCREASE. Barry, R.G. (Univ. of Colorado, Boulder). pp 169-180 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

The likely nature of possible changes in the cryosphere that would follow a global warming induced by an increase in the atmospheric content of CO₂ is discussed. It is concluded that warming effects would be negligible on the century time-scale for major ice sheets and ground ice. Changes in seasonal snowfall in high latitude or in Arctic pack ice may also be minimal for an initial doubling of CO₂. Any increase in winter snowfall would probably be offset by increased summer melt. For the pack ice, it is possible that greater melt, by leading to more pools and open water, would increase the stratus cover and reduce the solar radiation input. The critical factor here could be an increase in meridional advection in the atmosphere and the ocean. In both cases, however, negative feedbacks are a possibility for a limited warming.

- 186 EFFECTS OF DOUBLING THE CO₂ CONCENTRATION ON RADIATIVE-CONVECTIVE EQUILIBRIUM. Rowntree, P.B.; Walker, J. (Meteorological

- 189 GLOBAL TEMPERATURE CHANGES: RELATIVE IMPORTANCE OF DIFFERENT PARAMETERS AS CALCULATED WITH A RADIATIVE-CONVECTIVE MODEL. Reck, R.A. (General Motors Corp., Warren,

MI). pp 193-200 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

A radiative-convective model was used to calculate the response of the calculated temperature profile to a variety of changes in atmospheric constituents, CO_2 , H_2O , O_3 , and airborne particles as well as to changes in surface albedo and Rayleigh scattering. In the troposphere the response decreases with altitude at about the same rate as the temperature, reaching 80% of its surface value at 8.3 km (336 mb). In the stratosphere the response increases as the calculated temperature increases. When airborne particles are present the response to other parameters is reduced. It is concluded that these results illustrate the difficult nature of attempting to make predictions of the climatic consequences due to changes in any one global parameter since many are of significant size.

190 FACTORS OF THE GREENHOUSE EFFECT OF THE ATMOSPHERE AND THEIR INFLUENCE ON CLIMATE.

Kondratyev, K.Ya.; Bunakova, A.M. (Leningrad Univ., USSR). pp 201-207 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

The contribution of freons and other minor gaseous constituents to the atmospheric greenhouse effect is considered, and possible relevant climatic consequences are discussed. Previous studies indicate that atmospheric pollution caused by freons and by a change in the radiation balance of the earth-atmosphere system may influence climate more than other anthropogenic factors such as an increase in the concentration of CO_2 and aerosols. It is concluded that the role of various atmospheric constituents should be taken into account in planning a system for monitoring parameters important to climatic changes. (JGB)

191 CLIMATIC LIMITS TO GROWTH: HOW SOON; HOW SERIOUS. Schneider, S.H. (National Center for Atmospheric Research, Boulder, CO). pp 219-225 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

The effects of an increase in atmospheric CO_2 , $\text{NO}/\text{sub x/}$, and other trace gases with strong infrared absorptions on global climate are reviewed. Several steps to minimize society's vulnerability to such changes are suggested. They include: learn the range of possibilities so that facts and values can be more easily disentangled; focus current energy debate on growth rate issues, particularly for Third World countries; conserve energy and develop viable solar or other renewable resources; and, begin now to minimize our economic dependence on energy growth. It is concluded that weighing the risks of possible climatic changes against the benefits of continued and increased fossil fuel consumption is a process long overdue. (JGB)

192 EFFECTS OF DIFFERENT ENERGY STRATEGIES ON THE ATMOSPHERIC CO_2 CONCENTRATION AND CLIMATE. Williams, J. (International Inst. for Applied Systems Analysis, Laxenburg, Austria). pp 239-247 of Carbon dioxide, climate, and society.

Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

In order to assess the future atmospheric CO_2 concentration and its implications, three models are required. An energy model is used to estimate the future use of fossil fuels, and thus to estimate the input of fossil fuel CO_2 into the atmosphere. The amount of the fossil fuel CO_2 that remains in the atmosphere can then be given by a model of the carbon cycle, which considers the reservoirs of carbon and the transfers between them. The effects of the atmospheric CO_2 concentration on climate can then be assessed using a climate model. To the results of each of these models must be attached an uncertainty such that the future use of fossil fuels and the implications thereof cannot be predicted. The model results can only be used at the present time to assess the magnitude of the problem. The results of three scenarios are discussed; limitations of the results are pointed out.

193 FOSSIL FUEL UTILIZATION POLICY ASSESSMENT AND CO_2 INDUCED CLIMATIC CHANGE. Laurmann, J.A. (Stanford Univ., CA). pp 253-261 of Carbon dioxide, climate, and society.

Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

In order to assess the policy implications of the growing acceptance of the reality of this CO_2 threat to the environment, a judgment is required as to the likelihood not only of the occurrence of the environmental insult but also of governmental actions that might be taken to avoid it. In developing the arguments presented, it was found that considerations are dominated by uncertainties, the sources of which range from the strictly scientific to the geopolitical. A summary of an attempt to quantify the former is presented, thereby leading to recommendations for steps needed to prepare for the succeeding evaluation of the interregional social and political problems that will have to be addressed if global remedial measures are indeed found to be necessary. The analysis is formulated in terms of projections that assume continuity of present energy resource usages. The importance of the various sources of prediction uncertainty need to be reconsidered when evaluating strategies of amended fossil fuel use.

194 ATMOSPHERIC CO_2 CONSEQUENCES OF HEAVY DEPENDENCE ON COAL. Rotty, R.M. (Oak Ridge Associated Universities, Inc., TN). pp 263-273 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

The energy demands of various segments of the world as they are now and could be in 50 years are assessed. Annual fossil fuel CO_2 releases were calculated to contain 23×10^9 t of carbon for this period. It is concluded that the problem of avoiding a CO_2 -triggered climate change becomes that of providing fuel for the developing countries to assure their progress without heavy dependence on fossil fuels. It is recommended that the following areas of inquiry receive serious consideration: rate of fossil fuel use; distribution of CO_2 produced from fossil fuel combustion and from other

anthropogenic sources among the several reservoirs in the carbon cycle; effects of concentration of CO_2 on climate; and, global response of a CO_2 -induced climate change. (JGB)

195 STANDARD SETTING FOR CARBON DIOXIDE.

Hoepfinger, E. (International Inst. for Applied Systems Analysis, Laxenburg, Austria). pp 279-282 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

Since the effects of increased shares of CO_2 in the atmosphere are not well known, there exist rather contradictory conjectures. A continuous increase of CO_2 in the atmosphere from fossil fuel combustion beyond an unknown critical value will lead to irreversible large-scale changes in the earth's climate. A model is presented for the decision problem, taking into account different interest groups. The problem of how to determine and adapt an emission standard for CO_2 is treated within the framework of a three-person infinite-stage game; the players are called regulator, producer, and impactee.

196 CARBON DIOXIDE DISPOSAL IN THE OCEAN.

Mustacchi, C. (Analysis and Development of Energy Systems, Rome, Italy); Armenante, P.; Cena, V. pp 283-289 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

Basically, CO_2 can be disposed of into the ocean in three alternative ways: by bubbling and dissolution of untreated flue gases; by dissolution of separated CO_2 in the gaseous or liquid phase; and by abatement with sea water of CO_2 in the power plant and return of the solution to the ocean. Each of the methods is considered as to benefits and disadvantages. It is concluded that if and when it is acknowledged that CO_2 cumulation in the troposphere can be dangerous, no major difficulty and only moderate cost will be involved in its removal. The processes to be preferred are those involving a separation of CO_2 by absorption stripping in the plant. By optimizing the process detail, and the additional cost per electric kWh is expected to be not higher than 20%. The equipment is conventional chemical engineering process units, operated in very conservative design conditions. If anything, our estimates are oversafe inasmuch as they are based upon a detailed design for a 1 GW(e) power station. Assuming a one-order-of-magnitude increase in the unit size of power stations, a sizeable economy of scale is in order, and removing the CO_2 to the ocean can entail an increase price per kWh of barely 12 to 15%. Some small verification effort should be devoted to the dissolution aspects where most of the uncertainties lie. Sinking a number of CO_2 bottles at depth 150 to 200 m and monitoring pH at various distances and times is a minor undertaking for oceanographers and should be considered at this time.

197 DEEP SEAS: CLIMATE AND ECONOMIC

DEVELOPMENT. Gibrat, R. pp 291-299 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb

1978).

Studies on oceanographic mechanisms are reviewed. The importance of greater understanding of these mechanisms is important, especially with serious consideration being given to using the oceans for CO_2 and thermal discharges, as well as the thermal gradients as an energy source. (JGB)

198 NONLINEAR INTERACTION MODEL BETWEEN LAND

BIOTA AND THE ATMOSPHERE. Kohlmaier, G.H. (Institut fuer Physikalische Chemie, Frankfurt, Germany); Fischbach, U.; Kratz, G.; Sire, E.O. pp 111-119 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

Assuming the most probable values for inventories and fluxes of the global carbon cycle it was possible to reproduce past and present values of atmospheric carbon by adding to the relatively well-known fossil fuel carbon flux the current man-made biogenic flux of about $2 \text{ to } 4 \times 10^9 \text{ t C/a}$. Larger biogenic carbon fluxes have a very sensitive effect on the stability of the atmosphere; for this reason it is concluded that the biosphere must be conserved as much as possible. Under the condition of an intact biosphere adopting a 3.3% growth in fossil fuel use annually, the increase of CO_2 is less than predicted on the average (in 2025, between $850 \text{ and } 900 \times 10^9 \text{ t C}$).

199 MATHEMATICAL TREATMENT OF BOX MODELS FOR

THE CO_2 -CYCLE OF THE EARTH. Avenhaus, R.; Fenyi, S.; Frick, H. (Kernforschungszentrum, Karlsruhe, Germany). pp 121-127 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

The CO_2 -cycle of the earth is described by a system of coupled first order differential equations. Equilibrium states of the undisturbed cycle and the dynamic behavior of the disturbed cycle are analyzed. The results are illustrated with some numerical calculations.

200 CARBON DIOXIDE, CLIMATE AND SOCIETY.

Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978). 342p. (CONF-780287-).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

Conference papers are divided into the following categories: the carbon cycle; the impact on climate and environment of increasing atmospheric CO_2 concentrations; and the interaction between energy strategies and the CO_2 question. Papers in scope for ERA/EDB were abstracted and indexed individually. (JGB)

201 PRELIMINARY EVALUATION OF PAST CO_2

INCREASE AS DERIVED FROM ^{13}C MEASUREMENTS IN TREE RINGS. Freyer, H.D. (Kernforschungsanlage, Juelich, Germany). pp 69-77 of Carbon dioxide, climate and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).

From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).

Carbon-13 data (in the cellulose fraction) from different trees of the northern hemisphere

- are presented, covering the last 150 years. These data were taken for preliminary model evaluation of the past atmospheric CO₂ increase and total anthropogenic CO₂ production since industrialization. Preindustrial atmospheric CO₂ concentration was 295 ± 1 ppm. The biospheric CO₂ source from the beginning of industrialization to the middle of this century has been larger than the fossil one. The ratio of the cumulative input of fossil to nonfossil CO₂ into the atmosphere from the beginning of industrialization up to 1974 is 2:1 (136 x 10⁹ t C of fossil and 70 x 10⁹ t C of nonfossil CO₂). The present input rates are 5 x 10⁹ t C/a of fossil and 3 ± 2 x 10⁹ t C/a of nonfossil CO₂, based on an airborne fraction of (58 ± 14)% and 36% for fossil and total CO₂ input, respectively. (JGB)
- 202 MODEL RESPONSES OF THE ATMOSPHERIC CO₂ INPUT. Siegenthaler, U.; Heimann, M.; Gesshger, H. (Univ., Bern, Switzerland). pp 79-87 of Carbon dioxide, climate and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).
From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).
The responses of the atmospheric CO₂ and ¹³C levels were computed for a combined fossil and biogenic input by means of a box-diffusion model. In order to demonstrate the effect of different biospheric input histories (in addition to the fossil input), model responses for the following cases are presented: zero biogenic input, only fossil CO₂; biogenic flux always equal to one half and fossil flux, i.e., both increase in an approximately exponential way; biogenic production rate according to a Gaussian curve, with maximum in 1890 and width delta = 20 years, cumulative input from biota equal to 65 x 10⁹ t of C, or one half the fossil input until 1974. After 1950, the biogenic production is essentially zero for case 3, which has been included for analyzing the effect of a past input on the present situation. For all three cases, no fertilizing effect of the additional CO₂ is assumed (biota growth factor epsilon = 0). (JGB)
- 203 SOURCE FUNCTIONS FOR CO₂ IN THE ATMOSPHERE. Zimen, K.E. (Hahn-Meitner Inst. fuer Kernforschung, Berlin, Germany). pp 89-102 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).
From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).
Input of CO₂ into the atmosphere from fossil fuels and changing biomass is evaluated. It is necessary to find a new sink or sinks for CO₂. Perhaps one of these sinks could be the carbonates on land. The sediments on the continents constitute roughly 5 x 10¹⁸ km³. The fraction of limestone in the sediments is about 8%, but with regard to the fraction on the surface exposed to the air it may be about 29%. If the 5 x 10¹⁸ km³ sediments are distributed evenly all over the land area of 136 x 10⁶ km², a layer of 3.7 km is formed. It is assumed that on the average a layer of 1 m is in contact with the CO₂ in the air. Then, with a density of CaCO₃ of 2.7 t/m³, the amount of limestone in this surface layer is (0.29 x 5 x 10¹⁷ m³ x 1 m/3700 m) x (2.7 x 10⁶ g/m³) approx. = 1 x 10²⁰ g = 1 x 10¹⁸ mols. Thus the carbon reservoir in contact with the atmosphere is about 2 orders of magnitude larger than the carbon reservoirs in the atmosphere, the biosphere, and the mixed surface sea.
- 204 VEGETATION AND CO₂ CHANGES. Lieth, H. (Univ. Osnabrueck, Germany). pp 103-109 of Carbon dioxide, climate, and society. Williams, J. (ed.). Elmsford, NY; Pergamon Press Inc. (1978).
From IIASA carbon dioxide, climate and society workshop; Laxenburg, Austria (21 Feb 1978).
The potential of global vegetation as a source of CO₂ concentration in the atmosphere is discussed. A model was constructed for gross primary productivity, net primary productivity, and dark respiration. Results are tabulated. (JGB)
- 205 (ORAU/IEA(M)--77-27) ATMOSPHERIC CO₂ CONSEQUENCES OF HEAVY DEPENDENCE ON COAL. Rotty, R.M. (Institute for Energy Analysis, Oak Ridge, TN (USA)). Dec 1977. Contract EY-76-S-05-033. 39p. Dep. NTIS, PC A03/MF A01.
It must be conceded that great uncertainty pervades the estimates of the effect of increased CO₂ concentration in the atmosphere. It is of the highest importance that these uncertainties be resolved as expeditiously as possible, say by 1985. This will require a worldwide commitment of considerable scale. Only such aggressive effort is likely to lead to an estimate of the effect of CO₂ sufficiently robust to warrant the political, social, and economic measures that might be required to deal with unprecedented changes in the world's climate. Increases in the atmospheric concentration of CO₂ cause concern only when the quantities become large--i.e., several hundred billion tons of additional carbon. The direct contribution from emphasis on coal use through 1985, as called for in the U.S. National Energy Plan, is of minor consequence. On the other hand, if such a policy continues into the next century, or if it serves as a model for major segments of the world, then the quantity of resulting CO₂ could have serious consequences early in the next century. Further, if coal is used on a large scale as the base for liquid and/or gaseous synthetic fuels as the oil and natural gas reserves are depleted, the inefficiencies of conversion would serve to increase the CO₂ produced per unit of delivered energy and further aggravate the problem.
- 206 HOW MUCH MORE CO₂ CAN WE TAKE. Panrath, J. (Umweltbundesamt, Berlin (Germany, F.R.)). Umsch. Wiss. Tech.; 77: No. 24, 811(Dec 1977). (In German).
AIR POLLUTION; CARBON DIOXIDE; EARTH ATMOSPHERE; CLIMATES; RESEARCH PROGRAMS; CORRELATIONS; COMPARATIVE EVALUATIONS; ENVIRONMENTAL EFFECTS
- 207 ROLE OF INCREASING CO₂ CONCENTRATIONS IN THE ATMOSPHERE. Umwelt (Inf. Bundesminist. Intern); No. 59, 47-48(Dec 1977). (In German).
Short communication only.
AIR POLLUTION; CARBON DIOXIDE; EARTH ATMOSPHERE; QUANTITY RATIO; CLIMATES; RESEARCH PROGRAMS; ENVIRONMENTAL EFFECTS
- 208 SOURCE FUNCTIONS OF CO₂ AND FUTURE CO₂ BURDEN IN THE ATMOSPHERE. Zimen, K.E.; Offermann, P.; Hartmann, G. (Hahn-Meitner-Institut fuer Kernforschung Berlin G.m.b.H. (Germany, F.R.)). Z. Naturforsch., a; 32: No. 12, 1544-1554(Dec 1977).
A logistic source function for CO₂ was derived which takes into account the input arising from the burning of fossil fuels, the

stimulation of photosynthesis by the increasing partial pressure of CO_2 and the decrease of biomass through deforestation etc. The parameters in a 5-box-model for the kinetics of CO_2 were adjusted to fit the new Mauna Loa data on CO_2 concentrations in air. Using these parameters and a buffer factor for the absorption of CO_2 into the sea, the future CO_2 burden was calculated for status quo conditions and for different values of the growth coefficient of fossil fuel consumption. The results show that one can change the deforestation factor in rather wide limits without changing very much the future CO_2 concentration in air during the next 80 years or so. On the other hand, the future CO_2 burden depends strongly on the growth rate of fossil fuel consumption and will double under status quo conditions early in the next century.

- 209 MODELING THE EFFECT OF ATMOSPHERIC CARBON DIOXIDE ON THE GLOBAL RADIATIVE HEAT BALANCE. Mulholland, R.J.; Hole, C.L.; Gowdy, C.M. IEEE Trans. Syst., Man, Cybern.; 7: 803-805 (Nov 1977).

Because of fossil fuel combustion, the amount of atmospheric carbon dioxide is increasing, and thereby raising the earth's average temperature through the greenhouse effect. Results of a radiative heat balance simulation of the future dynamic behavior of the average global temperature are reported. Based on projected fuel usage patterns, a 6xK temperature rise within the next 200 years is forecast. Such a temperature rise would be significant and would add weight to the theory that fossil fuel combustion will change climate. (2 graphs, 13 references)

- 210 TEMPERATURE FEEDBACK IN A STRATOSPHERIC MODEL. Luther, F.M.; Wuebbles, D.J.; Chang, J.S. (Lawrence Livermore Laboratory, University of California, Livermore, California 94550). J. Geophys. Res.; 82: No. 31, 4935-4942 (20 Oct 1977).

Perturbing the stratospheric composition affects the stratospheric temperature profile via the radiation balance. Changes in temperature affect chemical reaction rates, which in turn feed back on stratospheric composition. The effect of temperature feedback on ozone concentration has been investigated for three types of perturbations: (1) stratospheric injection of $\text{NO}/\text{sub } x/$, (2) release of fluorocarbons, and (3) doubling CO_2 . Temperature feedback had approximately a 10% restoring effect on ozone for small ozone reductions because of either stratospheric $\text{NO}/\text{sub } x/$ injection or release of fluorocarbons. Doubling CO_2 concentrations increased total ozone by 2.9%. Calculations of ozone reduction including temperature feedback were as much as 20% less than fixed temperature calculations using the U.S. Standard Atmosphere temperature profile.

- 211 (UCRL--50044-76-1) IMPERIAL VALLEY ENVIRONMENTAL PROJECT: PROGRESS REPORT. Phelps, P.L.; Anspaugh, L.R. (eds.). (California Univ., Livermore (USA). Lawrence Livermore Lab.). 19 Oct 1977. Contract W-7405-ENG-48. 198p. Dep. NTIS, PC A09/MF A01.

Progress is reported in six areas of research: air quality, water quality, ecosystem quality, subsidence and seismicity, socioeconomic effects, and integrated assessment. A major goal of the air quality element is to evaluate the rate of emission of H_2S , CO_2 , H_2 , N_2 , CH_4 , and C_2H_6 from the operation of the geothermal loop experimental

facility at Niland. Concentrations of H_2S were found to vary between 1500 to 4900 ppm by volume at the Niland facility. To distinguish between geothermal fluids and other waters, extensive sampling networks were established. A major accomplishment was the installation of a high-resolution subsidence-detection network in the Salton Sea geothermal field area, centered on the test facility at Niland. A major effort went into establishing a background of data needed for subsequent impact assessments related to socioeconomic issues raised by geothermal developments. Underway are a set of geothermal energy scenarios that include power development schedules, technology characterizations, and considerations of power-plant-siting criteria. A Gaussian air-pollution model was modified for use in preliminary air-quality assessments. A crop-growth model was developed to evaluate impacts of gases released from geothermal operations on various agricultural crops. Work is also reported on the legal analysis of geothermal legislation and the legal aspects of water-supply utilization. Remote sensing was directed primarily at the Salton Sea, Heber, Brawley, and East Mesa KGRAs. However, large-format photography of the entire Salton Trough was completed. Thermal and multispectral imaging was done for several selected sites in the Salton Sea KGRA. (JGB)

- 212 CARBON DIOXIDE: A PROBLEM OF PRODUCING USABLE DATA. Lepkowski, W. Chem. Eng. News (Wash., D.C.); 55: No. 42, 26-30 (17 Oct 1977).

On Oct. 4, 1977, the 20th anniversary of man's first orbital view of spaceship Earth, a press release issued by the Commerce Department's National Oceanic and Atmospheric Administration went into the mails carrying the headline, "NOAA's Atmospheric Carbon Dioxide Monitors Show Global Increase, Raise Questions." NOAA reported that carbon dioxide readings taken at a measuring station at Mauna Loa, Hawaii, showed a 5% rise--from 314 ppm to 330 ppm--between 1958, when measurements began, and 1976. Readings at four other NOAA sites around the world show the same trends. NOAA's news is part of a drama now beginning to unfold as perhaps the fundamental science policy issue for the next decade. For if what many scientists fear is correct--that atmospheric carbon dioxide generated by the burning of fossil fuels is growing and accelerating--then the world could be in for drastic climatic shifts and thus changes not only in the balance of military and economic power but in billions of individual lives.

- 213 CO_2 PROBLEM. PROBLEMS OF THE LONG-TERM GLOBAL EFFECTS OF THE COMBUSTION OF FOSSIL FUELS. Zimen, K.E. (Hahn-Meitner-Institut fuer Kernforschung Berlin G.m.b.H. (Germany, F.R.). Bereich Kernchemie und Reaktor). Atomwirtsch., Atomtech.; 22: No. 10, 516-518 (Oct 1977). (In German).

Problems of the long term global effects of manmade radioactivity play a major role in the controversy about nuclear power. It is surprising to note that another global problem goes almost unnoticed which unavoidably accompanies the combustion of coal, oil and natural gas, i.e., the ejection of large amounts of CO_2 into the atmosphere. The worldwide irreversible climatic consequences of rising CO_2 concentrations in the atmosphere should be made the subject of urgent international study to allow the necessary technical and political decisions to be taken.

- 214 ACID RAIN, ZOOPLANKTON FECAL PELLETS AND

THE GLOBAL CARBON BUDGET. Hall, C.A.S.; Rce, G.; Ryther, J.H.; Woodwell, G.M. Biol. Bull.; 153: No. 2, 427-428 (Oct 1977).

Some five to seven billion metric tons (BMT) of carbon dioxide are produced each year from fossil fuel burning and forest cutting. Of this, one to several BMT are unaccounted for in the increases in carbon dioxide observed in the atmosphere and dissolved in the sea. Any additional sink for this "missing" carbon must be large-scale, increasing and not balanced by feedbacks. Biotic processes of the sea could account for this "missing" carbon. One billion metric tons of carbon divided by the area of the sea means that about 2.8 g (new) C must be removed in some way from the surface waters of the sea each year, an amount equal to about 4 percent of the primary production of the open sea. The proposed causal train is: increased nitrogen in rainwater + increased summertime primary production in stratified, nitrogen-limited, nutrient-poor oceanic waters + increased zooplankton feeding rates + increased zooplankton fecal pellet production + increased sequestering of carbon below the permanent thermocline via fecal pellet sinking. There is no doubt that this process is working to some extent, but are the rates sufficient to increase the zooplankton fecal pellet production by 2.8 g/(m²·yr). About 100 to 200 mg N/m² enter the sea surface each year in rain (an amount equal to all the dissolved nitrate in the upper 100 m of stratified Sargasso Sea water; both quantities are small compared to the amount annually incorporated as primary production). Analysis of the limited data available indicate that the nitrogen concentration of rain has approximately doubled in recent decades. The increase is caused by fixation of nitrogen during fossil fuel burning, which, with increased sulfur emission, causes acid rain.

215 FUTURE OF THE WORLD ENERGY SYSTEM.

GLOBAL ENERGY SCENARIOS: 1. STATUS QVO. 2. NUCLEAR POWER UTILIZATION. 3. EQUILIBRIUM STRATEGIES. Voss, A. (Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.)); Niehaus, F. (International Atomic Energy Agency, Vienna (Austria)). Umsch. Wiss. Tech.; 77: No. 19, 625-632 (Oct 1977). (In German).

In scenarios with several options, the possible ways for future energy supply (up to 2100) are discussed. Especially the effects of the CO₂ emissions from combustion processes, mainly an increase of the average temperatures, set limits to the possible use of fossil fuels. A transition to the practically unlimited energy sources nuclear and solar energy thus enforced can make a sufficient energy supply possible in a stationary state expected for the second half of the next century. The CO₂ loads and the temperature changes associated with it can be held below a reasonable limit only in this scenario.

216 (BNL-60794) ENVIRONMENTAL CONTROL TECHNOLOGY FOR ATMOSPHERIC CARBON DIOXIDE. QUARTERLY PROGRESS REPORT NO. 1, JUNE 20, 1977--SEPTEMBER 30, 1977. Steinberg, M.; Albanese, A.S.; Dang, V.D. (Brookhaven National Lab., Upton, NY (USA)). Oct 1977. Contract EY-76-C-02-0016. 18p. Dep. NTIS, PC A02/MF A01.

The primary objective of the subject program is to assess the potential options for controlling atmospheric CO₂. Accordingly, CO₂ control scenarios based on conventional technology and applied to the larger industrial emitters will be prepared. The studies will include preliminary cost estimates of selected processes, to identify fruitful areas for environmental control technology (ECT)

programmatic development as related to CO₂ release control. BNL's prior experience in this area includes the development and evaluation of a number of processes for removing CO₂ from the atmosphere for the purpose of producing synthetic carbonaceous fuels including methanol, gasoline, and methane. Background information from other DOE programs will be used to determine the limitations for the control studies. This progress report presents background information on: (1) the concentration levels of CO₂ in the atmosphere during the last one hundred years; (2) the possible effects of rising CO₂ levels; (3) the impact of fossil fuel use in the United States on overall worldwide CO₂ emissions; (4) the impact of increased coal utilization on CO₂ emissions; and (5) process considerations for controlling CO₂.

217 EFFECTS OF HUMAN ACTIVITIES ON GLOBAL CLIMATE. PART I. Kellogg, W.W. (National Center for Atmospheric Research, Boulder, CO). WMO (World Meteorol. Organ.) Bull.; 26: No. 4, 229-240 (Oct 1977).

Various influences of mankind on the climate and the time scale for the corresponding changes to take place are discussed. A number of anthropogenic causes of climate change are described in terms of their effects on mean surface temperature, and in some cases their effects on precipitation as well. It can be seen that, even given the uncertainties about our understanding of the behaviour of the climate system and the factors that determine climate, the effect of the atmospheric carbon dioxide increase emerges as by far the dominant one. Furthermore, many of the other factors (notably direct generation of heat and possible additions of chlorofluoromethanes and nitrous oxide) also contribute to a temperature change in the same direction--a warming.

218 CARBON DIOXIDE AND CLIMATE. HOW FAST CAN WE SAFELY BURN COAL. Krause, C. Oak Ridge Natl. Lab. Rev.; 10: No. 4, 40-47 (Feb 1977).

If the increase in combustion of fossil fuels continues to grow, the atmospheric CO₂ concentration could double in 60 yrs, resulting in an increase in global temperature. The Oak Ridge study group is concerned with the need to predict more accurately the climatic effects of increasing atmospheric CO₂ and the need to learn more about the carbon cycle. With increased temperature, rates of plant respiration and decay could exceed photosynthesis resulting in release of additional CO₂. Other adverse impacts of a warming trend are listed. The following remedial measures are suggested: reduction of coal combustion by increasing energy conservation, and establishment of a worldwide food reserve in the event of a decline in agricultural production. There has been a cooling trend in the earth's surface temperature in recent years. Opposing influences on climate may have been cancelling each other's effects, giving rise to a controversy over whether the net effects of man's future activities will be a cooling or warming trend. (HLW)

219 CARBON DIOXIDE AND CLIMATE: CARBON BUDGET STILL UNBALANCED. Kerr, R.A. Science; 197: No. 4326, 1352-1353 (30 Sep 1977).

The problem of the possibility of global climatic changes induced by carbon dioxide from fossil fuel combustion is discussed with special emphasis on the carbon cycle. Estimates of the contribution to atmospheric carbon dioxide from deforestation are quoted. The

mechanisms of ocean circulation and chemistry which influence the absorption of carbon dioxide are described.

- 220 (BNL--50867) WORKSHOP REPORT ON QUANTIFYING ENVIRONMENTAL DAMAGE FROM ENERGY ACTIVITIES. Moskowitz, P.D.; Rowe, M.D.; Morris, S.C.; Hamilton, L.D. (Brookhaven National Lab., Upton, NY (USA)). 11 Sep 1977. Contract EY-76-C-02-0016. 71p. Dep. NTIS, PC A04/MF A01.

Data and methods for quantifying environmental damage from energy activities were evaluated. Specifically, discussions were designed to identify the types and amounts of pollutants emitted by energy technologies that may affect the environment adversely, methods of estimating spatial and temporal changes in air and water quality resulting from these emissions, spatial and temporal distributions of ecosystems at risk, dose-response functions for pollutants and ecosystems at risk, and environmental and economic variables to be used to measure damage. Emphasis was on available data and on several methods for quantitative estimation of effects of energy on the environment. Damage functions that could be used to quantitate effects of ozone and sulfur oxide on agricultural crops and trees, effects of altered stream depth and velocity patterns on river fish species, and sensitivities of lake chemistry and biology to acid rainfall are listed. Also described are methods for estimating effects of carbon dioxide, sulfur dioxide, ozone, and several other atmospheric pollutants on selected terrestrial communities by using computer modeling techniques. With these techniques, quantitative estimates of the effects of energy on the environment could be developed within one to two years. Brief discussions about effects of nutrient and trace metal discharges on terrestrial ecosystems and about impacts of petroleum hydrocarbon, heat, biocides, and entrainment on aquatic ecosystems are also included.

- 221 EISENBUD: ENERGY VERSUS THE ENVIRONMENT. EPRI J.; 2: No. 7, 19-23(Sep 1977).

An EPRI interview.

In this interview Merrill Eisenbud, advisor to the Electric Power Research Institute (EPRI), reveals his philosophy of balancing the costs and benefits of energy production and environmental protection through a public understanding of both the positive and negative implications of all options. As head of the New York City Environmental Protection Administration, he expresses concern for the widespread misinformation about the environment. The public, for example, doesn't understand that the refinement of measuring instruments allows better detection of pollutants, although environmental quality may have improved. He feels that electrical energy benefits, both obvious and subtle, have enhanced our environment far more than they have damaged it. Continued public education on nuclear energy is also needed. He advocates international control of fuel reprocessing and continuation of the breeder reactor program. Environmental research programs must choose their issues carefully if they are to have any long-range effect. He considers the long-range effects of CO₂ emissions from coal-fired power plants to be an appropriate task for EPRI to undertake. (DCK)

- 222 NOAA CARBON DIOXIDE MEASUREMENTS AT MAUNA LOA OBSERVATORY, 1974-1976. Peterson, J.T.; Komhyr, W.D.; Harris, T.B.; Chin, J.F.S. (Air Resources Laboratories, National Oceanic and

Atmospheric Administration, Boulder, Colorado 80302). Geophys. Res. Lett.; 4: No. 9, 354-356(Sep 1977).

The Geophysical Monitoring for Climatic Change program of NOAA's Environmental Research Laboratories has measured atmospheric carbon dioxide concentrations at Mauna Loa Observatory, Hawaii, continuously since June 1974. The measurements through 1976 have been analyzed for recent secular concentration changes and show a continuing increase of about 0.9 ppm/year.

- 223 ARE WE AT THE BRINK OF A CLIMATIC CATASTROPHE. WILL THE MACROCLIMATE REMAIN STABLE. NATURAL PROCESSES AND HUMAN INFLUENCE AS CLIMATIC FACTORS. Flohn, H. (Bonn Univ. (Germany, F.R.). Meteorologisches Inst.). Umsch. Wiss. Tech.; 77: No. 17, 561-569(Sep 1977). (In German).

The risk of using fossil fuels is at least as high as the risk of nuclear power plant operation. This is the conclusion at which the present paper arrives. Our knowledge of the climatic changes during the last 20,000 years is rather clear, but unfortunately it is not a suitable basis for prognoses: Just as sure as the natural processes will bring about a new ice age sooner or later, man's influence may create a new 'hot age'. If the CO₂ content in the atmosphere increases at the present rate, the decisive climatic turnover may occur within the very next 30-50 years. The results may be catastrophic.

- 224 CO₂ RISK. CHANGE IN CLIMATE BY INCREASING COMBUSTION WITHIN THE NEXT DECADES. Hampicke, U. (Essen Univ. (Gesamthochschule) (Germany, F.R.). Arbeitsgruppe Umwelt, Gesellschaft, Energie). Umsch. Wiss. Tech.; 77: No. 18, 599-606(Sep 1977). (In German).

Carbon dioxide, CO₂, develops in all combustion processes. The CO₂ content in the atmosphere has increased by almost 14% during the past hundred years. The greenhouse effect has long been known: The more CO₂ in the atmosphere, the more the earth surface is to heat up. Within the next 50 years doubling of the CO₂ content in the atmosphere can be possible. Will the enormous ice quantities at the north and south pole melt. Will countries in moderate climates be changed into deserts. Or would such change in climate lead to increased rainfalls so that the world nutrition situation would improve. Many test results now available indicate that a doubling of the CO₂ content in the atmosphere would be an adventurous climatic test, the results of which nobody can predict. However, indications exist which say that the increase of CO₂ content in the atmosphere will not take place as fast as was often predicted.

- 225 CAN WE CONTROL THE CARBON DIOXIDE IN THE ATMOSPHERE. Dyson, F.J. (Inst. for Energy Analysis, Oak Ridge, TN). Energy (Oxford); 2: No. 3, 287-291(Sep 1977).

The carbon dioxide generated by burning fossil fuels can theoretically be controlled by growing trees. Quantitative estimates are made of the size and cost of a plant-growing program designed to halt the increase of carbon dioxide in the atmosphere. 21 references.

- 226 (ORAU/IEA(O)--77-22) SOME LONG-RANGE SPECULATIONS ABOUT COAL. Weinberg, A.M.; Marland, G.H. (Institute for Energy Analysis, Oak Ridge, TN (USA)). Aug 1977. Contract EY-76-C-05-0033. 18p. Dep. NTIS, PC A02/MF A01.

Should the world demand for energy increase sixfold within the next 50 years, largely because the underdeveloped countries industrialize, and if half this demand is met by coal, then the estimated world recoverable resource of coal of 4×10^{12} metric tons would last at this asymptotic level about 140 years. The carbon dioxide concentration in the atmosphere is then estimated to increase about threefold. These two eventualities may place limits on our ultimate use of coal. The risk of a CO_2 accumulation inherent in the widespread use of coal is in a sense analogous to the risk of nuclear proliferation: both problems are global, uncertain, and could pose profound challenges to man's future.

- 227 CARBON DIOXIDE CORRELATION WITH OXIDANT AIR POLLUTION IN THE SAN BERNARDINO MOUNTAINS OF CALIFORNIA. Coyne, P.I.; Bingham, G.E. (Univ. of California, Livermore). J. Air Pollut. Control Assoc.; 27: No. 8, 782-784 (Aug 1977).

Ambient CO_2 concentrations in the San Bernardino Mountains fluctuate directly with the level of air pollution and are generally highest when O_3 levels are highest. Published laboratory studies employing unstressed plants and plants stressed by nitrogen and sulfur oxides have shown that CO_2 concentrations above normal ambient levels do have a stimulatory effect on net photosynthesis. This stimulatory effect can wholly or partially offset pollutant injury, depending on CO_2 and pollutant levels as well as other environmental conditions. Clearly this potential amelioration of pollutant effects must be taken into account in any attempt to understand and predict the effects of pollutants on plants.

- 228 CARBON: THE REAL LIMIT TO GROWTH. Kelly, P. Futures; 9: No. 4, 324-334 (Aug 1977).

The biomass and free carbon dioxide on the earth have increased since the industrial revolution and will continue to increase until and beyond the cessation of hydrocarbon-based technology. This hypothesis is discussed in terms of the equilibrium carbon cycle, the industrial revolution, the role of synthetic fertilizers, and the nutrient limit. The carbon cycle and how its responses to disturbances might be treated mathematically are surveyed. (1 diagram, 3 references)

- 229 ATMOSPHERIC CARBON DIOXIDE AND FOREST CLEARANCE. Moore, P.D. (King's College, London). Nature (London); 268: 296-297 (28 Jul 1977).

The use of fast-growing forest species as a carbon sink for increasing atmospheric CO_2 is considered. It is pointed out that although forests represent a major carbon reservoir, it would be wrong to assume them all to be efficient carbon sinks. Most natural forest vegetation is at or near a climax or equilibrium state. The loss in CO_2 consumption resulting from replacement of low grade forest, as well as the energy expenditure necessary for the establishment, management, fertilization, harvest, and storage of such a crop, must also be considered in any attempt at biological control of CO_2 . (JGB)

- 230 ASSESSING THE GREENHOUSE EFFECT. Norman, C. Nature (London); 268: No. 5618, 289-290 (28 Jul 1977).

A report on the climatic effects of energy production and consumption is reviewed. The study, which constitutes the first major

attempt to assess the validity and potential consequences of the greenhouse effect, was conducted by the National Academy of Sciences. Though the report is hedged with uncertainties and qualifications, it is concluded that if the use of fossil fuels continues to increase at present rates, the average global temperature could rise by about 6°C over the next 200 years, with potentially dire consequences for agriculture and fisheries. (JGB)

- 231 YET ANOTHER CONSTRAINT: ARE WE ALTERING THE EARTH'S CLIMATE. Williams, J. Options (IIASA); 4-5 (Sum 1977).

The impact of man's energy conversion activities on the earth's climate will put a constraint on how energy options are chosen. It is vital to project the effects of present and future technologies in order to select those causing the least changes in temperature, composition of the atmosphere, or character of the land surface. The nuclear, fossil fuel, and solar options are examined in this context. Computer simulation studies of nuclear power parks indicate atmospheric effects will extend beyond the vicinity of the parks. Carbon dioxide (CO_2) studies show that continued burning of fossil fuels will double the CO_2 content and cause a one-to-three-degree rise in temperature. Solar energy will involve the use of vast amounts of land, with a subsequent impact on local climates as surface reflectivity, texture, and hydrology are altered. (DCK)

- 232 (COO-2195-29) GLOBAL TRANSPORT PROCESSES AND INTERACTIONS WITH TRACE CONSTITUENTS. ANNUAL PROGRESS REPORT, 1 JULY 1976-30 SEPTEMBER 1977. Newell, R.E. (Massachusetts Inst. of Tech., Cambridge (USA). Dept. of Metallurgy). 15 Jun 1977. Contract EY-76-S-02-2195. 16p. Dep. NTIS, PC A02/MF A01.

Technical progress made in the period 1 July 1976 to 30 September 1977 is summarized. A detailed analysis of monthly mean sea surface temperature has been made for the Pacific and Atlantic down to 30°S and is in progress for the Indian Ocean. It has been found that oceanic temperature changes precede tropical air temperature changes by about six months, opening the prospect of predicting tropical mean temperature. It has also been found that fossil fuel CO_2 changes in the atmosphere are related to equatorial Pacific sea surface temperature in the sense that colder water is followed by smaller rates of increase in atmospheric CO_2 . It is suggested that the physical reason for the observed relationship is that cold water, produced by upwelling, is accompanied by more nutrients which encourage photosynthesis in the surface layers and lead to a greater take-up of atmospheric CO_2 .

- 233 CAN WE DO WITHOUT URANIUM. Weinberg, A.M. (Oak Ridge Associated Universities, TN). Combustion; 48: No. 12, 12-18 (Jun 1977).

From Conference on future strategies for energy development; Oak Ridge, TN, USA (21 Oct 1976).

The results of a study by the Institute of Energy Analysis: "Economic and Environmental Implications of a U.S. Nuclear Moratorium, 1985-2010" are discussed. The energy demand to 2010 is estimated. Alternative energy sources are discussed for the hypothetical case in which nuclear power is rejected and fossil fuel is gone or foresworn because of excess carbon dioxide production. An estimate is made of the energy obtainable from each of the renewable resources: geothermal, hydro, wind,

waves and tides, sun, biomass, and solar electric systems. Factors effecting the plausibility of using breeder reactors are detailed. (DIA)

- 234 (ORAU/IEA(O)--77-16) UNCERTAINTIES ASSOCIATED WITH FUTURE ATMOSPHERIC CO₂ LEVELS. Rotty, R.M. (Institute for Energy Analysis, Oak Ridge, TN (USA)). Jun 1977. Contract EY-76-C-05-0033. 19p. Dep. NTIS, PC A02/MF A01.

The need for inexhaustible energy supply systems is clearly demonstrated by the problems associated with the use of fossil fuels. Atmospheric carbon dioxide increases can lead to significant climate changes, but evaluating the changes that might result from fossil fuel use in the future is fraught with uncertainties. This paper discusses and weighs the relative importance of answering the following questions: what activities of man contribute to atmospheric carbon dioxide and what portion of this is attributable to fossil fuel combustion; where else can the carbon dioxide go; what climate changes result from atmospheric carbon dioxide changes; what are the future global energy needs and what fraction must be supplied by fossil fuel; and what is the confidence in our answers to the above questions.

- 235 WIDE RANGE INFLUENCES ON CLIMATE BY HUMAN INTERVENTION. HISTORICAL SURVEY AND FUTURE PROSPECTS. Flohn, H. (Bonn Univ. (Germany, F.R.). Meteorologisches Inst.). pp vp. of Energie und Umwelt. Essen, Germany, F.R.; Vulkan-Verl. (Jun 1977). (In German)

From 2. international fair and congress on techniques in environmental protection; Duesseldorf, F.R. Germany (8 Feb 1977).

A survey of the postglacial-period climate history is followed by a discussion of the influencing factors of nature and man as the cause for climatic variations. The green house effect and air pollution as well as the role of the Arctic Ocean are dealt with. The contribution concludes with perspectives for the 21st century.

- 236 (ORNL/TM--5924) AUTOMATIC GAS ANALYSIS SYSTEM FOR CONTINUOUS MONITORING OF OXYGEN AND CARBON DIOXIDE EXCHANGE IN TERRESTRIAL ECOSYSTEMS. Randolph, J.C.; Rau, F.M. (Oak Ridge National Lab., TN (USA)). Jun 1977. Contract W-7405-ENG-26. 25p. Dep. NTIS, PC A03/MF A01.

An automatic, continuous flow, gas analysis system was designed to monitor metabolic rates of terrestrial vertebrates over relatively long periods of time, such as daily cycles, under field conditions in the absence of the investigator. The gas analysis system described in this report used an infrared absorption analyzer for carbon dioxide and a paramagnetic analyzer for oxygen. The simultaneous measurement of CO₂ production and O₂ consumption by an organism permitted the direct calculation of the respiratory quotient (RQ), an important index in determining metabolic rates. This gas analysis system was used to examine the daily metabolic rates of three species of small mammals (chipmunks, field mice, and shrews) under natural seasonal temperature regimes at the Walker Branch Watershed study site of Oak Ridge National Laboratory. The system was also designed and used in conjunction with the D₂¹⁸O isotope turnover method of measuring metabolism of free-living animals.

- 237 (ORAU/IEA(O)--77-15) PRESENT AND FUTURE PRODUCTION OF CO₂ FROM FOSSIL FUELS: A GLOBAL APPRAISAL. Rotty, R.M. (Institute for Energy Analysis, Oak Ridge, TN (USA)). Jun 1977. Contract EY-76-C-05-0033. 22p. Dep. NTIS, PC A02/MF A01.

Levels of atmospheric carbon dioxide is a question of worldwide proportions. Unilateral action by any one nation in planning alternatives to fossil-fuel use will most likely be ineffective in controlling carbon dioxide. Energy growth in the past has been largely based on fossil fuels and, consequently, the annual carbon dioxide production has increased steadily at 4.3%. In 1976 the global carbon dioxide production contained more than 5 billion metric tons of carbon. Of this, 27% was a result of activity in the United States, but by 2025 the total will have grown more than fivefold with the developing countries and communist Asia producing over half the global total. The challenge to the United States is to develop energy supply systems not based on fossil fuels which can and will be used by developing nations.

- 238 CHANGES OF LAND BIOTA AND THEIR IMPORTANCE FOR THE CARBON CYCLE. Bolin, B. Science; 196: No. 4290, 613-615(6 May 1977).

The report compares the increase in atmospheric carbon dioxide due to the expansion of forestry and agriculture with that due to fossil fuel combustion. Tables show the net primary production and biomass of land biota for different types of vegetation, the production of wood and the input of carbon dioxide into the atmosphere due to land modifications. The author concludes that the input of carbon to the atmosphere from this cause since the early 19th century is 50 plus or minus 25% of the amount due to fossil fuel combustion; the present annual input being 10 to 35% of the present emission from the use of fossil fuels. The atmospheric carbon dioxide concentration has increased since the early 19th century by 35 to 50 ppm. If 40 +/-5% of the net output of carbon dioxide due to human activities has remained airborne instead of 50% as assumed previously, then future increases might be delayed provided depletion of the world's forests is stopped.

- 239 CARBON DIOXIDE-CLIMATE PROBLEM: RECENT DEVELOPMENTS. Pearman, G.I. Clean Air (Brighton, Engl.); 11: 21-26(May 1977).

The causes of observed increases in carbon dioxide concentration in the atmosphere, and the possible climatic consequences if the trend is sustained, have direct relevance to the debate on future energy requirements and their environmental effects. On the basis of the recent literature and two international carbon dioxide-climate meetings scheduled for this year, several aspects of the global carbon cycle are discussed and the areas of uncertainty emphasized.

- 240 (ORNL--5269) DIFFUSION-TYPE MODEL OF THE GLOBAL CARBON CYCLE FOR THE ESTIMATION OF DOSE TO THE WORLD POPULATION FROM RELEASES OF CARBON-14 TO THE ATMOSPHERE. Killough, G.G. (Oak Ridge National Lab., TN (USA)). May 1977. Contract W-7405-ENG-26. 96p. Dep. NTIS, PC A05/MF A01.

A nonlinear dynamic model of the exchange of carbon among the atmosphere, terrestrial biosphere, and ocean is described and applied to estimating the radiation dose to the world's population from the release of ¹⁴C to the atmosphere from the nuclear power industry. A

computer implementation of the model, written in the IBM Continuous System Modeling Program III (CSMP III) simulation language, is presented. The model treats the ocean as a diffusive medium with respect to vertical transport of carbon, and the nonlinear variation of CO₂ partial pressure with the total inorganic carbon concentration in surface waters is taken into account in calculating the transfer rate from ocean to atmosphere. Transfers between the atmosphere and terrestrial biosphere are represented by nonlinear equations which consider CO₂ fertilization and impose a constraint on the ultimate total carbon mass in the biosphere.

- 241 WOOD VERSUS FOSSIL FUEL AS A SOURCE OF EXCESS CARBON DIOXIDE IN THE ATMOSPHERE: A PRELIMINARY REPORT. Adams, J.A.S. (Univ., Sao Paulo, Brazil); Mantovani, M.S.M.; Lundell, L.L. Science; 196: No. 4285, 54-56(1 Apr 1977).

If the amounts of wood consumed in deforestation to increase agricultural land and as firewood in underindustrialized countries are added to the amount consumed by the money economies as forest products, the estimates of the net amount of wood removed from the biosphere in this century should be revised upward. The per capita ratio of the weight of carbon from net wood burned to the weight of carbon from fossil fuel burned in this century has been at least 0.1 and may have approached 1.0.

- 242 (CONF-760744--), pp 81-93) GLOBAL ENERGY DEMAND AND RELATED CLIMATE CHANGE. Rotty, R.M. (Oak Ridge Associated Universities, TN). Apr 1977.

From Conference on energy sources of the future; Oak Ridge, TN, USA (5 Jul 1976).

Because climate is the result of energy exchange between the Sun and the Earth, the Earth and outer space, and of the interchanges of energy between parts of the Earth, it is necessary to understand how anthropogenic releases of energy from long-term storage might influence and alter the natural exchanges in sufficient magnitude to cause an observable change in climate. It is believed that there are four ways that the natural energy transfer system can be perturbed and thus initiate climate changes. These are: a change in the total amount of energy being exchanged--either that coming from the Sun (probably not controllable by man) or that leaving the Earth (which is augmented by man); a change in the albedo resulting from changes in atmospheric aerosols and particulate loading; a change in the albedo resulting from changes in cloud cover; and a change in the optical properties of the atmosphere with change in carbon dioxide. A discussion and calculations are given for each factor. It is then concluded that the increase in concentration of atmospheric carbon dioxide is the most crucial factor for all of mankind. It is suggested that the time when the atmospheric CO₂ concentration will become critical is early in the twenty-first century. (MCW)

- 243 ENERGY TECHNOLOGY ASSESSMENT: CONSIDERATIONS OF GEOGRAPHICAL SCALE. Palsedo, P.F. (Brookhaven National Lab., Upton, NY). J. Energy Dev.; 2: No. 2, 207-217(Spr 1977).

Energy technology assessment must encompass the broader considerations of political boundaries and geographical scale if it is to avoid irrelevancy. As a tool for solving energy problems, technology assessment can serve to

identify regional and international areas where appropriate institutions are needed. A shortcoming of technology assessment as it currently functions is that it treats environmental impacts in terms of technology effects rather than as specific emissions with a geographic distribution. The addition of the effects on population distribution and the interrelations of energy, economics, climate, and perceptions will make assessment more sensitive to human and regional differences. There is a global dimension to such phenomena as nuclear safeguards and carbon dioxide emissions which underscores the importance of including geographical scale and political institutions in any assessment. (DCK)

- 244 CLIMATE AND ENERGY: A SCENARIO TO A 21ST CENTURY PROBLEM. Flohn, H. (Univ Bonn, Ger). Clim. Change; 1: No. 1, 5-20(Mar 1977).

The energy contribution of anthropogenic climatic fluctuations has been estimated to a gain of 15-20 TW, in comparison with a gain or deficit of 100-300 TW from natural processes responsible for the observed climatic fluctuations of the last 200 years. A dominant role of an increase of CO₂ by a factor 2-5 in the next century, accompanied by side effects acting in the same direction, seems to be most likely. Under the assumption of constant natural factors, anthropogenic warming and its effects on the Arctic sea-ice may successively lead to climatic states as in 1931-60, in the early Middle Age (900-1200) and in the climatic optimum period ca. 5000 BP. Finally it may result in a complete destruction of the Arctic sea-ice with a drastic shift of all climatic belts towards north. The implications of these trends for present energy policy and selection of energy sources is discussed briefly. 50 refs.

- 245 HOW LONG IS COAL'S FUTURE. Rotty, R.M.; Weinberg, A.M. (Oak Ridge Assoc Univ, Tenn). Clim. Change; 1: No. 1, vp(Mar 1977).

Nearly all scenarios for future U.S. energy supply systems show heavy dependence on coal. However, potential climate change resulting from increasing atmospheric carbon dioxide concentrations may prevent coal from playing a major role. Observed atmospheric CO₂ concentrations have increased from 315 ppm in 1958 to 330 ppm in 1974--in 1900, before much fossil fuel was burned, it was about 290-295 ppm. Slightly over one-half the CO₂ released from fossil fuels is accounted for by the increase observed in the atmosphere; at present growth rates the quantities are doubling every 15-18 years. Atmospheric models suggest a global warming of about 2 K if the concentration were to rise to two times its pre-1900 value. 20 refs.

- 246 ON GEOENGINEERING AND THE CO₂ PROBLEM. Marchetti, C. (Int Inst for Appl Syst Anal, Laxenburg, Austria). Clim. Change; 1: No. 1, 59-68(Mar 1977).

The problem of CO₂ control in the atmosphere is tackled by proposing a kind of 'fuel cycle' for fossil fuels where CO₂ is partially or totally collected at certain transformation points and properly disposed of. CO₂ is disposed of by injection into suitable sinking thermohaline currents that carry and spread into the deep ocean that has a very large equilibrium capacity. The Mediterranean undercurrent entering the Atlantic at Gibraltar has been identified as one such current; it would have sufficient capacity to deal with all CO₂ produced in

Europe even in the year 2100. 18 refs.

- 247 HOW LONG IS COAL'S FUTURE. Rotty, R.M.; Weinberg, A.M. *Clim. Change*; 1: No. 1, 45-57(Mar 1977).

Nearly all scenarios for future U.S. energy supply systems show heavy dependence on coal ranging from 700 million tons to 3300 million tons per year. However, potential climate change resulting from increasing atmospheric carbon dioxide concentrations may prevent coal from playing a major role. The carbon in the carbon dioxide produced from fossil fuels each year is about 1/10 the net primary production by terrestrial plants, but the fossil fuel production has been growing exponentially at 4.3% per year. Observed atmospheric carbon dioxide concentrations have increased from 315 ppm in 1958 to 330 ppm in 1974--in 1900, before much fossil fuel was burned, it was about 290-295 ppm. Atmospheric models suggest a global warming of about 2 K if the concentration were to rise to two times its pre-1900 value--enough to change the global climate in major (but largely unknown) ways. With the current rate of increase in fossil fuel use, the atmospheric concentration should reach these levels by about 2030--earlier if coal replaces oil and gas.

- 248 GEOENGINEERING AND THE CARBON DIOXIDE PROBLEM. Marchetti, C. *Clim. Change*; 1: No. 1, 59-68(Mar 1977).

The problem of carbon dioxide control in the atmosphere is tackled by proposing a kind of fuel cycle for fossil fuels where carbon dioxide is partially or totally collected at certain transformation points and properly disposed of. Carbon dioxide is disposed of by injection into suitable sinking thermohaline currents that carry and spread it into the deep ocean that has a very large equilibrium capacity. The Mediterranean undercurrent entering the Atlantic at Gibraltar has been identified as one such current: it would have sufficient capacity to deal with all carbon dioxide produced in Europe even in the year 2100.

- 249 CLIMATE AND ENERGY: A SCENARIO TO A 21ST CENTURY PROBLEM. Flohn, C.H. *Clim. Change*; 1: No. 1, 5-20(Mar 1977).

The energy contribution of anthropogenic climatic fluctuations has been estimated to a gain of 15-20 TW, in comparison with a gain or deficit of 100-300 TW from natural processes responsible for the observed climatic fluctuations of the last 200 years. A dominant role of an increase of carbon dioxide by a factor 2-5 in the next century, accompanied by side effects acting in the same direction, seems to be most likely. Under the assumption of constant natural factors anthropogenic warming and its effects on the Arctic sea-ice may successively lead to climatic states as in 1031-60, in the early Middle Age (900-1200) and in the climatic optimum period ca 5000 BP. Finally it may result in a complete destruction of the Arctic sea-ice with a drastic shift of all climatic belts towards north, extending even to the interior tropics.

- 250 CARBON DIOXIDE AND FUTURE CLIMATE. Mitchell, J.M. *Environ. Data Serv.*; 3-9(Mar 1977).

The addition of carbon dioxide to the atmosphere due to burning fossil fuel is discussed. The release rate of carbon dioxide has been growing since at least 1950 at an average rate of 4.3% per year. If all known

fossil fuel reserves in the world are consumed, a total of between 5 and 14 times the present amount of carbon dioxide in the atmosphere will be released. The oceans would then be unlikely to withdraw the proportion of perhaps 40% which they are believed to have withdrawn up to the present. The increase in the atmosphere would be in excess of 3 times or conceivably ten times the present amount. If the reserves are used up within a few hundred years, more than half the excess carbon dioxide would remain in the atmosphere after a thousand years. The "greenhouse" effect of carbon dioxide is explained. The simulation with numerical models of the effects of carbon dioxide on atmospheric radiation fluxes is discussed. An estimated increase in the average annual temperature of the earth of 2.4 to 2.9C is given for doubling the carbon dioxide content; also a 7% increase in global average precipitation. The effect of increasing carbon dioxide on global mean temperature is viewed in the perspective of the glacial-interglacial cycles. The warming effect of carbon dioxide may induce a "super-interglacial" on the present interglacial which is expected to decline toward a new ice age in the next several thousand years. Finally it is proposed that it may be necessary to phase out the use of fossil fuels before all the knowledge is acquired which would necessitate such an action.

- 251 RADIATIVE-CONVECTIVE MODEL STUDY OF THE CARBON DIOXIDE CLIMATE PROBLEM. Augustsson, T.; Ramanathan, V. *J. Atmos. Sci.*; 34: No. 3, 448-451(Mar 1977).

A radiative-convective model study of the increase in global surface temperature due to an increase in the carbon dioxide concentration is presented. The model considers several weak bands of carbon dioxide which contribute about 30% to the temperature increase. A comparison study of the various published results with the present analysis indicates that, for the carbon dioxide bands in the 12 to 18 micrometer region, the best estimate of temperature increase for the constant cloud top radiative-convective model is about 1.9K for a doubling of the carbon dioxide concentration. The inclusion of the carbon dioxide bands in the 10 and 7.6 micrometer regions increases the temperature to about 2K. The computed temperature increase is very sensitive to the radiative-convective model assumptions regarding cloud top and relative humidity. Because of this sensitivity the estimated value of temperature increase with concentration ranges from 1.98 to 3.2K.

- 252 (UCRL--52221) CONCEPT STUDY FOR A MINIATURIZED RAPID-RESPONSE INFRARED SENSOR FOR LOW CARBON DIOXIDE CONCENTRATIONS. Bingham, G.E.; McQuaid, J.H. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 7 Feb 1977. Contract W-7405-ENG-48. 38p. Dep. NTIS, PC A03/MF A01.

The feasibility was studied of developing a miniature carbon dioxide sensor that would accurately detect fluctuations in ambient CO₂ concentrations of less than 1 ppm (v/v). The sensor would have a frequency response of 100 Hz. The sensor element envelope would have a total volume of less than 100 cm³ with an instrument input power drain of less than 3 W. The principle of measurement would be that of a dual-wavelength infrared monochromator spectrometer measurement with 3.9- and 4.25-μm center frequencies and a 0.1-μm bandwidth. The sample area would be an open-sided, multiple-path cell of 4 cm³ volume (2 x 2 x 1 cm) protruding from one end of the sensor package. This CO₂ sensor would have direct and immediate

applicability to several areas of basic scientific research, including (but not limited to) plant physiology (photosynthesis, respiration), aerodynamic transfer processes, and ecological stress analyses.

- 253 DEVELOPMENT OF THE FUEL AND ENERGETIC BASIS AND ITS IMPACT ON WEATHER AND CLIMATE. Borisenkov, E.P. Meteorol. Gidrol.; No. 2, 3-14(Feb 1977). (In Russian).

Data on effect of thermal emissions into the atmosphere upon climate have been analyzed. Estimations of the effect of thermal emissions on the mean global temperature are performed. It is demonstrated that in the planned rate of increase of the fuel and energetic basis and thermal emissions during the nearest 100 to 150 years sensible changes in the mean temperature will not occur. However, much earlier effects of thermal emissions are expected on the dynamics of atmospheric processes and probably on the variability of meteorological fields.

- 254 ECONOMIC GROWTH AND CLIMATE: THE CARBON DIOXIDE PROBLEM. Nordhaus, W.D. Am. Econ. Rev.; 67: No. 1, 341-346(Feb 1977).

A brief overview of the climatic implications of economic activity is presented, with special reference to CO_2 . It is thought that the economic activities that most affect climate are agriculture and energy. Of these, the latter is probably more significant and is certainly more easily analyzed. In the energy sector, emissions of CO_2 , particulate matter, and heat are of significance for the global climate. A brief overview of the interaction between CO_2 and the climate is as follows: combustion of fossil fuels leads to emissions of CO_2 into the atmosphere. Once in the atmosphere, the residence time appears to be very long, with approximately one-half of all industrial CO_2 still airborne. Because of the selective absorption of radiation, the increased atmospheric concentration is thought to lead to increased surface temperatures. The most careful study to date (S. Manabe and R. T. Wetherald, Atmospheric Sci., 32: 3-15 (1975)) predicts that a doubling of atmospheric concentrations of CO_2 would eventually lead to a global mean temperature increase of 3°C . The predicted temperature increase by latitude indicates that there is considerable amplification at high latitudes. This outcome is the effect of an uncontrolled economy-climate system. Two aspects of atmospheric CO_2 control are investigated, namely: (1) reduce emissions of CO_2 by substituting noncarbon-based fuels for carbon-based fuels; and (2) either offset the effects of emissions of CO_2 or use natural or industrial processes to clean the CO_2 from the air. The first strategy is examined in detail. The author then concludes that meeting CO_2 standards appears feasible and requires little change in energy allocation for 20 to 40 years. (MCW)

- 255 APPLICATION OF GAS-LIQUID CHROMATOGRAPHY TO ANALYSIS OF ATMOSPHERE POLLUTION. Rudenko, B.A.; Smirnova, G.I. (Inst. of Organic Chemistry, Moscow). Zh. Anal. Khim.; 32: No. 2, 367-382(Feb 1977). (In Russian).

The analytical applications of gas-liquid chromatography to the analysis of air pollution are discussed on the basis of an extensive bibliographic review. Techniques for carrying out the analysis are discussed with a consideration of the condensation of microimpurities in cold traps, passing air through liquid sorbents, chemical trapping of the components, and trapping by various sorbents. The determination of the atmospheric

pollution by different chemical species such as inorganic gases, CO_2 , methane, light hydrocarbons, automobile exhaust gases, polycyclic aromatic hydrocarbons, organic compounds containing S, and various other classes of compounds are reviewed. 323 references. (J8R)

- 256 RELATIONSHIP BETWEEN ATMOSPHERIC CARBON DIOXIDE AND PACIFIC SEA SURFACE TEMPERATURE. Newell, R.E.; Weare, B.C. (Massachusetts Inst. of Tech., Cambridge). Geophys. Res. Lett.; 4: No. 1, 1-2(Jan 1977).

There is a spatial and a temporal correspondence between changes in Pacific sea surface temperature and changes in atmospheric carbon dioxide, after seasonal trends have been removed.

- 257 INFLUENCE OF CO_2 ON THE EFFECTS OF SO_2 AND NO_2 ON ALFALFA. Hou, L.Y.; Hill, A.C.; Soleimani, A. (Univ. of Utah, Salt Lake City). Environ. Pollut. (London); 12: No. 1, 7-16(Jan 1977).

Studies were conducted to determine the effects of CO_2 concentrations on leaf injury and inhibition of the apparent photosynthetic rate of alfalfa (*Medicago sativa* L. Ranger) caused by fumigations with SO_2 or SO_2 and NO_2 . Alfalfa plants were exposed to high concentrations of SO_2 under two CO_2 concentrations for 3 h and percentage of leaf injury was measured. The higher CO_2 concentration reduced the amount of injury caused by SO_2 . Approximately two-and-a-half times as much injury developed on plants fumigated under ambient CO_2 (315 ppm) than under high CO_2 (645 ppm) concentrations. The latter CO_2 concentration was calculated to occur downwind from a coal-fired power plant using Western coal when the SO_2 concentration was 1 ppm. Alfalfa plants were also fumigated with a 3:1 mixture of SO_2 and NO_2 under two CO_2 concentrations for 2 h. CO_2 uptake rates were calculated during exposures. The inhibition of the apparent photosynthetic rate caused by treatment with combined SO_2 and NO_2 was less than half at high CO_2 pressure than that observed under ambient concentration. The depression of CO_2 uptake rate was slow under high CO_2 concentration in comparison with the immediate response obtained at ambient levels. Fumigation with combined SO_2 and NO_2 reduced the photosynthetic rate of alfalfa. However, the admixing of CO_2 in a high enough concentration immediately increased the photosynthetic rate. Thus, high CO_2 concentration could both increase CO_2 uptake by the plant and protect it from the adverse effects of SO_2 and NO_2 mixtures.

- 258 EARLY EVOLUTION OF THE TERRESTRIAL ATMOSPHERE AND HYDROSPHERE. Mukhin, L.M.; Moroz, V.I. (Institute for Space Research, USSR Academy of Sciences, Moscow). Sov. Astron. Lett. (Engl. Transl.); 3: No. 1, 39-41(Jan 1977).

A possible picture is outlined for the evolution of the primitive atmosphere and hydrosphere of the earth: the surface temperature would have been below 0°C initially (since the solar constant was lower than today), and the injection of CO_2 into the atmosphere would not have been balanced by Urey equilibrium processes because of the lack of contact with liquid water. The greenhouse effect in the primitive atmosphere would have melted the ice in the equatorial zone after a time interval of order 10^8 yr, when the CO_2 pressure had risen to 1 atm.

- 259 ENVIRONMENTAL BIOGEOCHEMISTRY. VOLUME 1. CARBON, NITROGEN, PHOSPHORUS, SULFUR, AND SELENIUM CYCLES. Nriagu, J.O. (ed.). Ann Arbor, MI; Ann Arbor Science Publishers, Inc. (1977). 435p. (CONF-750454--P1).

From 2. international symposium on environmental biogeochemistry; Burlington, Ontario, Canada (8 Apr 1975).

Volume 1 of the two-volume series contains papers on various aspects of the environmental biogeochemistry of carbon, nitrogen, phosphorus, sulfur, and selenium cycles. Nine of the papers were abstracted and indexed individually for EDB. (JGB)

- 260 VARIATIONS OF THE CARBON CYCLE AT PRESENT AND IN THE GEOLOGICAL PAST. Galimov, E.M. (Inst. of Geochemistry and Analytical Chemistry, Moscow, USSR). pp 3-11 of Environmental biogeochemistry. Vol. 1. Nriagu, J.O. (ed.). Ann Arbor, MI; Ann Arbor Science Publishers, Inc. (1977).

From 2. international symposium on environmental biogeochemistry; Burlington, Ontario, Canada (8 Apr 1975).

The variation of atmospheric CO₂ concentration was studied by measuring carbon isotope ratios in the tree rings of two spruce trees of ages 100 and 50 years. No appreciable influence of the technogenic CO₂ on the carbon cycle was found. In order to evaluate the effects of man's activities on the geochemical cycle of carbon, carbonate samples from strata of sedimentary beds were examined for carbon isotopic variations. It is concluded that occurrence of heavy carbonates corresponds with the periods of high tectonic activity. (JGB)

- 261 MAN'S IMPACT ON THE ATMOSPHERIC CARBON MONOXIDE CYCLE. Seiler, W.; Zankl, H. (Max-Planck Inst. for Chemistry, Mainz, Germany). pp 25-37 of Environmental biogeochemistry. Vol. 1. Nriagu, J.O. (ed.). Ann Arbor, MI; Ann Arbor Science Publishers, Inc. (1977).

From 2. international symposium on environmental biogeochemistry; Burlington, Ontario, Canada (8 Apr 1975).

Major sources and sinks of the atmospheric CO cycle that could be significantly altered by man are reviewed. Problems encountered in estimating the amount produced by anthropogenic sources are discussed in detail. Measurements of the rate of anthropogenic production of CO in Munich are reported. (JGB)

- 262 IMPACT OF PRODUCTION AND USE OF ENERGY ON THE GLOBAL CLIMATE. Bolin, B. (Univ. of Stockholm). Annu. Rev. Energy; 2: 157-226(1977).

Based on study by author, entitled "Energy and climate", carried out under auspices of Secretariat for Future Studies, Stockholm.

The increasing production of energy by man has begun to modify significantly the environment that the earth naturally offers man. At first the environmental effects were local, limited to cities and industrial zones. In recent years, however, cities and industries have grown rapidly and they extend now over considerable areas, so that man's influence on the environment has become regional. This review of possible global climatic changes has included the effect of direct heat emissions into the atmosphere as a result of man's increasing energy production and the importance of carbon dioxide and particles in the atmosphere. There are, however, many other ways in which man may influence the climate, which are presented in both the scientific literature and the popular press. A closer study of the

literature shows, however, that scientists at present do not agree on the correctness of most of these theories; some of them may be correct in principle, but massive research efforts are required to clarify this and above all to estimate their quantitative importance. Thus, the statements about clear interrelations between man's activities and climatic changes that have occurred lately cannot at present be accepted as sufficiently well documented. Only through global cooperation between governments and the scientific community can we hope to understand gradually the interplay between the many mechanisms at work in the climatic system. The very possibility that significant changes will take place within 100 years, maybe within 50 years, is an exceedingly important fact. Within another decade or two, reality will most likely show how relevant this fact is. Even now we must pay due regard to the possibility of change when planning our future energy supply, above all by retaining the utmost degree of flexibility. 3 tables, 11 figures, 34 references.

- 263 ALTERNATIVE LONG-RANGE ENERGY STRATEGIES. Weinberg, A.M.; Rotty, R.M. (Oak Ridge Associated Universities, TN). pp 225-239 of Global chemical cycles and their alterations by man. Stumm, W. (ed.). Berlin; Abakon Verlagsgesellschaft (1977).

From Workshop on global chemical cycles and their alterations by man; Berlin, F.R. Germany (15 Nov 1976).

See CONF-761184--.

Each of the energy modes is beset with limitations that become apparent when viewed in the long run. Fossil fuels may be limited by CO₂. Geothermal is probably a small source. Fusion may not be feasible. Fission in the long run may pose unacceptable risk. Solar may be extremely expensive. With world energy demand increasing, possibly tenfold, it seems prudent to pursue all alternatives. Though some argue that centralized energy poses a threat to human freedom, the authors point out that there may be no credible alternative to such modes of production unless population stabilizes at a relatively low value.

- 264 BIOLOGICAL RESPONSE TO FOSSIL FUEL COMBUSTION PRODUCTS. Delwiche, C.C.; Likens, G.E. (Univ. of California, Davis). pp 73-88 of Global chemical cycles and their alterations by man. Stumm, W. (ed.). Berlin; Abakon Verlagsgesellschaft (1977).

From Workshop on global chemical cycles and their alterations by man; Berlin, F.R. Germany (15 Nov 1976).

See CONF-761184--.

The combustion of fossil fuels can influence biological processes both by the injection into the atmosphere of foreign substances not otherwise found in the atmosphere and by altering the concentrations of other atmospheric constituents. Present rates of fossil fuel use are sufficient to have altered considerably the cycles of carbon, nitrogen, sulfur, and phosphorus.

- 265 FOSSIL FUEL BURNING: ITS EFFECTS ON THE BIOSPHERE AND BIOGEOCHEMICAL CYCLES. GROUP REPORT. Lerman, A.; Bernhard, M.; Bolin, B.; Delwiche, C.C.; Ehhalt, D.H.; Gessel, S.P.; Kester, D.R.; Krumbein, W.E.; Likens, G.E.; Mackenzie, F.T.; Reiners, W.A.; Stumm, W.; Woodwell, G.M.; Zinke, P.J. pp 275-289 of Global chemical cycles and their alterations by man. Stumm, W. (ed.). Berlin; Abakon Verlagsgesellschaft (1977).

From Workshop on global chemical cycles and

- their alterations by man; Berlin, F.R. Germany (15 Nov 1976).
See CCNF-761184--.
- The burning of fossil fuels (peat, coal, petroleum) and wood produces a variety of gaseous oxides of carbon, nitrogen, hydrogen, and sulfur, compounds of heavy metals, and solid particles (ash). Their redistribution among the hydrosphere, lithosphere, and biosphere is to a large extent mediated by their residence times in the atmosphere, long or short as the case may be. Addition of carbon dioxide and other gases to the atmosphere may affect the climate of the earth. Climatic changes of such an origin would potentially affect the life on earth in the broadest sense, from changes in the structure of ecological systems to the mental state of the earth's human inhabitants. The relationships between biological productivity and fuel burning are discussed.
- 266 SOURCE FUNCTIONS: FOSSIL FUEL COMBUSTION PRODUCTS, RADIONUCLIDES, TRACE METALS, AND HEAT. GROUP REPORT. Morgan, J.J.; Bach, W.; Eriksson, E. pp 291-311 of Global chemical cycles and their alterations by man. Stumm, W. (ed.). Berlin; Abakon Verlagsgesellschaft (1977).
From Workshop on global chemical cycles and their alterations by man; Berlin, F.R. Germany (15 Nov 1976).
See CCNF-761184--.
- Global chemical cycles involve a variety of sources, sinks, reservoirs, and fluxes of the chemical elements and their compounds. For global cycles, in principle, all natural and man-influenced sources and sinks for chemical substances and energy are of potential significance. Interactions of chemical and energy source functions in affecting global environment may be strong. Source functions of special interest are those which characterize man's alteration of global cycles, for example fluxes of carbon dioxide, radionuclides, fixed nitrogen, heat, toxic substances such as trace metals, and synthetic organics. Topics discussed include some aspects of the CO₂ problem, including CO₂ source functions and future CO₂ burdens in the atmosphere; climatic consequences; possible errors in measuring fossil fuel consumption; radionuclides from the nuclear fuel cycle (release, global distributions, and population exposure); global mobilization of metals; the solar constant; the albedo; and halocarbons.
- 267 (CONF-770689--) INDUCTIVE MODELLING OF POPULATION TIME SERIES. Rust, B.W.; Kirk, B.L. (Oak Ridge National Lab., TN (USA)). 1977. Contract W-7405-ENG-26. 52p. Dep. NTIS, PC A04/MF A01.
From SIMS conference on statistical analysis of ecological processes in time and space; Alta, UT, USA (27 Jun 1977).
A method for modeling time series is considered which is based on the iterative combination of statistical regression and spectral analysis techniques. The goal is to find a model which reduces the residuals to a white noise series. The use of the technique is illustrated by considering two examples: striped bass catch curves for the Atlantic coast fisheries, and the time series for the buildup of CO₂ in the atmosphere. Finally, the application of the technique to the 10-year wildlife cycle is briefly discussed. 12 figures, 4 tables.
- 268 (NP--22802) COAL AS AN ENERGY RESOURCE: CONFLICT AND CONSENSUS. ACADEMY FORUM, WASHINGTON, D.C., APRIL 4--6, 1977. (National Academy of Sciences, Washington, DC (USA)). 1977. 330p. National Academy of Sciences, Washington, DC.
- A national energy policy is considered ruled out not only by shifting public perceptions but also by the pervasiveness of energy. Energy is embodied in all goods and services. Formulating a supply policy toward energy is highly difficult, although possibly feasible. For demand it is considered simply impossible. The real problem is postulated to be that the public has not yet figured out what it wants. Implicit in the future is an array of social decisions. Important decisions include the fertility rate, desires about per capita income, and the work-leisure decision. Individual and social decisions on such issues are complicated, interdependent, and certain to change over time. A second major issue has to do with other sources of fuel: oil, natural gas, uranium, and so on. The third of the major points concerns risk. (LTN)
- 269 COMPARABILITY OF CO₂ MEASUREMENTS. Bischof, W. (Univ. of Stockholm). Tellus; 29: 435-444(1977).
In measuring the atmospheric CO₂ concentration, corrections for the carrier gas effect are required at present for each individual gas analyzer. It is shown that standard gases of CO₂/air composition offer less complication in the data comparison than CO₂/N₂ standards which are most commonly being used for calibration. CO₂/air standards which are used in Stockholm and related to the Scripps manometric calibration scale have remained stable over more than 10 years. Aircraft data from the upper troposphere and the lower stratosphere obtained in the Stockholm project are in fair agreement with data from the Mauna Loa and the South Pole stations. An accelerating increase over the period 1963 to 1975, i.e. about 0.5 ppm/yr at the beginning and about 1.3 ppm/yr at the end of the period, has been observed.
- 270 EFFECT OF HUMAN ACTIVITIES ON THE EARTH'S ATMOSPHERE AND FUTURE TRENDS. Junge, C. Universitas (Stuttgart); 32: No. 2, 165-173(1977).
Measurements showing the global increase in atmospheric carbon dioxide concentration are discussed in terms of estimates of the future increase in coal and oil consumption. The problems of predicting the scale of any warming of the earth's surface due to increasing atmospheric carbon dioxide are analysed. It is concluded that direct thermal energy input is of secondary importance, accounting for less than one tenth of that due to carbon dioxide. The problem of the increasing atmospheric concentrations of chlorofluoromethanes due to their continued use as cooling liquids and spray can propellants is outlined: stratospheric ozone depletion and its implications for the incidence of skin cancer. Other man-made trace gases are not considered hazardous. Basic research on natural climate is recommended.
- 271 ENERGY AND CLIMATE: OVERVIEW AND RECOMMENDATIONS. pp 1-31 of Energy and climate. Washington, DC; National Academy of Sciences (1977).
The nature and magnitude of the problem of the impacts on climate of energy production and consumption are reviewed briefly with recommendations made. Three by-products of energy production and use are heat, particulate matter, and gases. It now appears that direct

generation of heat from production and consumption of energy over the next few centuries will cause a rise of not more than 0.5°C in global average air temperature, although it may have substantial effects on local climates. If the correspondingly increased particulate emissions are properly controlled, there should be little global effect on climate from an increased atmospheric burden of aerosols. The climatic effects of CO₂ release may be the primary limiting factor on energy production from fossil fuels over the next few centuries. The prospect of damaging climatic changes may thus be the stimulus for greater efforts at conservation and a more rapid transition to alternate energy sources than is justified by economic considerations alone. The potential effect of CO₂ on climate could be exacerbated by fluorocarbons, NO_x, and other industrial gases. The natural variability of climate could increase or reduce the impact of such man-made effects. There are profound uncertainties regarding the carbon cycle, climate, and their interdependence. These uncertainties can be resolved only by a well-coordinated effort of extraordinarily interdisciplinary character. The focus for such an effort is not provided by any existing institutional mechanisms. 48 references.

272 IMPACT OF INDUSTRIAL GASES ON CLIMATE.

Keeling, C.D.; Bacastow, R.B. (Scripps Institution of Oceanography, San Diego, CA). pp 72-95 of Energy and climate. Washington, DC; National Academy of Sciences (1977).

Over 97 percent of the energy demand of the industrial world is met today by burning conventional fossil fuels. Even if conversion to other more costly forms of energy production is pursued vigorously, the annual consumption of fossil fuel is likely to double by A.D. 2000. If the world follows the widely respected economic policy of preferring at any one time the cheapest available fuel, the 4 percent per year growth in consumption of fossil fuel that prevailed for a quarter of a century before 1974 could resume and persist into the next century. A peak annual rate 10 or even 20 times today's rate may occur before depletion of fuel reserves forces a decline in consumption. Most of the by-products of fossil-fuel combustion are presently injected directly into the atmosphere. While still airborne, they interfere with natural radiative processes, and, if their removal from the air does not keep pace with their input, their accumulation in the air may result in climatic change. Both particles and gases are involved. The latter is discussed with major emphasis on the principal fuel by-product, carbon dioxide. The discussion emphasizes global-scale impacts.

273 CARBON DIOXIDE CYCLE AND THE BIOSPHERE.

Revelle, R.; Munk, W. (Scripps Institution of Oceanography, San Diego, CA). pp 140-158 of Energy and climate. Washington, DC; National Academy of Sciences (1977).

The industrial revolution and the accompanying rapid rise of human population have resulted in a flux of perhaps more than 200 Gt of carbon dioxide to the atmosphere. Two thirds of this quantity came from fossil-fuel combustion and one third from clearing of forests and other wildlands for agriculture. Only about 40 percent of the carbon dioxide produced in these ways remains in the atmosphere. Two models are developed that account for absorption of the remainder in the biosphere and the oceans. Both models depend on the assumptions that the increase in atmospheric carbon dioxide has caused net primary photosynthetic production to exceed

oxidation of organic matter by heterotrophic respiration and fires and that absorption of carbon dioxide by the oceans has been limited up to the present time to about 20 percent of the total carbon dioxide produced because of the buffer mechanism of seawater and the slow exchange of surface and deep ocean waters. In the preferred model, it is assumed that the biomass that carries out photosynthesis is constant in amount. The equilibrium partition of carbon among the atmosphere, the oceans, and the biosphere is then uniquely determined by the total quantity of carbon in the system. Computations using this model indicate that the atmospheric carbon dioxide content could rise to about 5 times the preindustrial value in the early part of the twenty-second century. 37 references.

274 PROJECTED WORLD ENERGY CONSUMPTION.

Perry, H.; Landsberg, H.H. (Resources for the Future, Inc., Washington, DC). pp 35-50 of Energy and climate. Washington, DC; National Academy of Sciences (1977).

Basic to any evaluation of the potential impact of man's use of energy resources on climate are estimates of how much energy will be consumed at various locations, which resources, and how much of each will be used to supply the demand, how much will be converted to other energy forms before use, and what pollutants and how much of each will be emitted as a result of use of the projected mix of fuel forms. Climatic effects from energy consumption may occur as the result of either heat that is released (over that incident upon the Earth from the Sun) or the effect that pollutants may have on both the amount of solar energy that reaches the Earth and the amount that is radiated from the Earth to space. Energy consumption and pollution emissions are estimated for eleven geographic regions and for four different years, the last year being 2025. Section 1.2 presents best estimates of energy resources for the world and for component parts, separately for nonrenewable and renewable sources, paying particular attention to the recoverability factor, i.e., how much of the resource in place can be mobilized for use. Section 1.3 presents estimates of energy demand, based upon projections of population and Gross National Product. A detailed exposition of the merits precedes the estimates. Section 1.4 gives estimates of the heat, carbon dioxide, and particulates that can be expected to be released by energy use.

275 GLOBAL INFLUENCES OF THE AEROSOL AND CO₂ CONTENTS OF THE AIR ON THE CLIMATE.

Mueller, W.A. pp 79-96 of Chemische und physikalische Umweltbelastungen. Tagung ueber Umweltforschung der Universitaet Hohenheim. Kunick, W.; Kutscher, G. (eds.). Stuttgart, Germany, F.R.G.; Univ. Hohenheim (1977). (In German)

Worldwide no impacts on account of the anthropogenic effects of increasing aerosol particles and CO₂ contents, which exceed natural deviations, can be detected at the moment. In the future it will depend on the superposed increase (or decrease) rate of aerosol and CO₂, whether there will be an increase or decrease in temperature. The extent of an aerosol particle and CO₂ increase by realistic amounts on the basis of model calculations made so far seems to be small, however there ought to be clearly visible effects, e.g. as they start to appear in town climates, and here in particular in connection with the radiation household.

276 WILL CLIMATIC CHANGES OCCUR IN THE NEXT DECADES DUE TO INCREASING COMBUSTION.

Hampicke, U. Umschau; 77: No. 18, 599-606(1977).

Doubling the atmospheric carbon dioxide content by burning fossil fuels and by vegetation destruction may lead to an increase in atmospheric temperature of 1.5 to 3°C. Permissible global warming seems to be 2°C at most, according to present knowledge from climatic history, of which 1°C should be reserved for warming mechanisms other than carbon dioxide. Hence anthropogenic rise of the atmospheric carbon dioxide content should not exceed 50% of the original level. Taking into account the carbon dioxide release from vegetation destruction and from noncommercial fuels, the total anthropogenic carbon dioxide production is higher than previously estimated. World ocean's capacity to absorb carbon dioxide must be equally higher, thus providing a relatively ample margin for utilizing fossil fuels in the future even if climatic risks are carefully avoided.

277 GREENHOUSE EFFECT. Munn, R.E. Mazingira; No. 2, 78-85(1977).

Cumulative carbon dioxide increase in the biosphere has been indicated as a possible cause for irreversible climate changes. The reliability of the more realistic predictive models of carbon dioxide concentrations, sources, sinks, and effects is discussed. The main sources are listed as fossil fuel combustion and vegetative decay with the oceans and land biospheres assigned as sinks. The author concludes that more observational data are needed for verification of forecasted environmental effects. (PCS)

278 CLIMATIC EFFECTS RELATED TO PRODUCTION AND USE OF FOSSIL FUELS. Williams, J. Lexenbourg, Austria; International Inst. for Applied Systems Analysis (1977). 45p.

Two aspects of the climatic effects of fossil fuel use are considered: firstly the local effects of release of waste heat, gases and particulates which are observable at the present time and secondly, the potential global climatic effects of carbon dioxide and waste heat. The many uncertainties involved in assessing possible impacts of energy strategies on global climate are emphasized.

279 EFFECTS OF HUMAN ACTIVITIES ON GLOBAL CLIMATE. Kellogg, W.W. Geneva; World Meteorological Organization (1977). 49p.

At present it is difficult to make any predictions for the natural course of climate in the next several decades. However by using climate models, predictions of the cause of climate changes as a result of anthropogenic influences can be made, other external factors remaining the same. Experiments with a number of different models have converged on approximately the same conclusions: the largest single effect of human activities on climate is due to an increase in atmospheric carbon dioxide concentration through fossil fuel combustion, i.e., air and thermal pollution, which contributes to a warming of the lower atmosphere; the best estimate of the warming of the mean surface temperature of the earth is about 1°C by 2000 AD and 3°C by 2050 AD with 3 to 5 times that increase in polar regions, and an uncertainty of roughly a factor of two. These conclusions assume a continued quasi exponential rate of release of carbon dioxide to the atmosphere. Absorption of the added carbon dioxide is expected to take between 1000 and 1500 years. If all economically recoverable

fossil fuel is burned in the next few centuries, the atmospheric concentration of carbon dioxide would increase by 5 to 8 times. An example of a natural warming on a similar scale to that expected in the middle of the next century occurred 4000 to 8000 years ago. Generally there was more rainfall especially over the present sub-tropical deserts, but some regions in middle and high latitudes were drier than now. The extent of Arctic and Antarctic sea ice would be influenced. The total volume of the major ice sheets would change, but a change in sea level cannot yet be predicted with any confidence.

280 GLOBAL ROLE OF THE ATMOSPHERE. Tarbo, A.M. (Inst. for Medical-Biological-Biological Problems, Moscow). Dokl. Biol. Sci. (Engl. Transl.); 237: No. 1/6, 469-471(1977). Translated from Dokl. Akad. Nauk USSR; 237: No. 1, 234-237(Nov 1977).

A model was constructed of the global carbon cycle in the atmosphere-plant-soil system. The model shows that the annual balance of carbon in the atmosphere determines the variation in CO₂ content leaving the atmosphere to form the mass of plants and entering the atmosphere as a result of disintegration of organic substances of the soil. The annual increment in the mass of plants increases with an increase in concentration of atmospheric CO₂ and increases or decreases with a change in temperature. The rate of disintegration of organic substances of the soil increases when the temperature increases. (HLW)

281 (AED-Conf--77-139-010) ENERGY - ENVIRONMENT - ECONOMY. ATTEMPT AT A CLASSIFICATION OF THE SYSTEM AND ITS PROBLEMS WITH REGARD TO THE DEVELOPMENT OF SCIENCE. Hoecker, K.H. (Stuttgart Univ. (TH) (Germany, F.R.). Inst. fuer Kernenergetik und Energiesysteme). (Stuttgart Univ. (TH) (Germany, F.R.). Inst. fuer Kernenergetik und Energiesysteme). 1977. 24p. (In German). (CONF-770592--5). Dep. NTIS (US Sales Only), PC A02/MF A01.

From Energy policies forum of the Landesregierung; Stuttgart, F.R. Germany (9 May 1977).

The paper places the controversy over nuclear power in the context of large systems and their interaction: Relevance of the systems with regard to the living conditions of the expanding world population and the behaviour of the public, risk and its importance (e.g. the CO₂ content in the air) as well as the freedom of action when it comes to power supply.

282 LAND'S RESPONSE TO MORE CARBON DIOXIDE. Lemon, E. pp 97-130 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977). From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

With a continued increase of fossil fuel carbon dioxide (CO₂) in the atmosphere there is cause for concern about future consequent climate change. Records indicate that about half the CO₂ input remains in the atmosphere and the other half is absorbed by the land and sea. No one knows the proportions or for sure the mechanisms of fixation. On the land the initial CO₂ fixation is by photosynthesis in plants. Short term experiments indicate that photosynthesis is speeded up by more atmospheric CO₂. However, other plant processes and environmental stress may negate this initial response. The life cycle of individual plants and whole forest ecosystems could be

shortened too, so that net carbon accretion in the end is little changed. A small change in net photosynthesis of the living biomass of the land might be quite significant however. This would depend upon the size and stability of both living and dead carbon pools. Man's influence on both is a recognized possibility yet both kind and magnitude are unknown. For example, forest cutting might be balanced by regrowth or managed agricultural production. Also soil humus losses from forest cutting or prairie plowing might be balanced by high technology agriculture where plant residues increase soil humus. Eutrophication of lakes and estuaries due to increased nutrient cycling also adds carbon to the detritus pool.

- 283 GLOBAL CARBON DIOXIDE PRODUCTION FROM FOSSIL FUELS AND CEMENT, A.D. 1950 TO A.D. 2000. Rotty, R.M. (Inst. for Energy Analysis, Oak Ridge, TN). pp 167-181 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Industrial production of carbon dioxide has been increasing at the exponential rate of 4.3 percent almost continuously since 1860. Based on latest revised fuel use and cement manufacture data from the United Nations Statistical Office, CO₂ production is calculated for each year, 1950 through 1974. The 1974 value is nearly 18×10^9 metric tons of CO₂/year (5×10^9 metric tons C), about 2 percent of which is a result of cement manufacture. Three scenarios for future energy demand and cement manufacture are developed and used to extrapolate the industrial carbon dioxide production to the year A.D. 2000. The selected scenarios suggest that annual CO₂ production will grow to a value between 30×10^9 and 53×10^9 metric tons by A.D. 2000, with a most probable value equivalent to 6 ppm of the atmosphere equivalent (approx. 46.5×10^9 metric tons) at that time.

- 284 FATE OF FOSSIL FUEL CO₂ IN THE OCEANS. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977). 761p. (CONF-760168--). \$54.50.

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

The question of whether the CO₂ content of the atmosphere is increasing at a catastrophic rate is a very timely question. Will the increase in the atmospheric CO₂ content affect our climate and environment. This question cannot be answered, however, without first defining the behavior and the history of CO₂ in our total environment. Carbon chemistry of the ocean must be closely related to the balance between the precipitation undersaturated deep waters. This in turn is related to the biosphere, both oceanic and terrestrial, and geological processing occurring in sediments. Apparent fluctuations in this balance, as observed in the sedimentary column, have stimulated efforts to clarify the controlling factors which are operating in the present oceans. As this understanding has improved, it has become appreciated not only how sensitive the dynamic CaCO₃ precipitation-dissolution cycle may be to the injection of fossil fuel CO₂ into the oceans, but also how serious the possible consequences of such an injection may be. These problems were addressed by the various papers presented at the meeting. The general structure of the meeting was comprised of three broad categories: the mobilization of

CO₂ and resulting injections into the oceans, including the ensuing processes which would occur in the water column; the phenomena which would occur at the sea-sediment interface as a consequence of such injections; and the geological implications created in the sedimentary column. Separate entries were made for the individual papers.

- 285 ¹³C VARIATIONS IN MARINE CARBONATE SEDIMENTS AS INDICATORS OF THE CO₂ BALANCE BETWEEN THE ATMOSPHERE AND OCEANS. Kröppnick, P.M. (Univ. of Hawaii, Honolulu); Margolis, S.V.; Wong, C.S. pp 295-321 of Fate of fossil fuel CO₂ in the ocean. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

A model is presented to explain the departures from equilibrium of the ocean-atmosphere CO₂-¹³C system with respect to temperature, latitude and water mass characteristics. Carbon isotope data suggests that invasion and evasion of CO₂ to and from the sea is at least partially controlled by the organic productivity of a water mass. Surface water delta values are determined by exchange with the atmosphere and by the amount of carbon removed versus that replenished. Deeper water delta ¹³C values are controlled by the relative rates of upwelling of deep water, by in situ respiration, and by the dissolution of settling particles. The record of delta ¹³C fluctuation for the last 75 million years in oceanic surface and bottom waters is recorded in the calcareous remains of benthic and planktonic foraminifera and in nanofossils. The assumption of equilibrium deposition of carbon isotopes by these organisms is shown to not always be the case. Nevertheless, the trend of delta ¹³C values derived from these three organisms are parallel for the majority of the Late Cretaceous and Cenozoic, perhaps indicating that they are responding to ocean-wide productivity variations. The exact nature of the processes responsible for delta ¹³C variations in fossil carbonate sediments, however, is still unknown, but increased understanding of delta ¹³C variations in the present-day oceans and atmosphere will eventually aid in understanding and interpreting the significance of past fluctuations in the CO₂-¹³C-CaCO₃ system.

- 286 CARBONATE CHEMISTRY OF NORTH ATLANTIC OCEAN DEEP-SEA SEDIMENT PORE WATER. Morse, J.W. (Univ. of Miami, FL). pp 323-343 of Fate of fossil fuel CO₂ in the ocean. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

The carbonate chemistry of twenty cores taken in the central North Atlantic Ocean has been studied in order to elucidate the processes controlling the diagenesis of calcium carbonate in deep-sea sediments. Two major problems make the interpretation of the results uncertain: lack of knowledge of the extent to which reactions take place between the calcium carbonate in the sediment and the pore water during recovery and short-term storage; and the large differences presently reported in values for the equilibrium ion product of calcite. If there is little reaction between the calcium carbonate in the sediment and the pore water during the core recovery and short-term storage, three important conclusions can be drawn from the data presented in this study. Sediments

below 3000 meters water depth are more undersaturated with respect to calcite than is the overlying water. Very little reaction takes place between the calcium carbonate in these sediments, and the pore waters in the upper meter of sediment, which could be due to rapid coating of the calcium carbonate grains after deposition at the sediment water interface. In sediments above 3000 meters water depth, small amounts of aragonite in the upper few centimeters of sediment exert a strong influence on the carbonate chemistry of the pore waters.

287 MODELLING THE INFLUENCE OF BIOTURBATION AND OTHER PROCESSES ON CALCIUM CARBONATE DISSOLUTION AT THE SEA FLOOR.

Schink, D.R.; Guinasso, Jr. (Texas A and M Univ., College Station). pp 375-399 of Fate of fossil fuel CO₂ in the ocean. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Profiles of dissolved and particulate carbonate in abyssal sediments have been calculated and the associated fluxes determined. The fractions of CaCO₃ in accumulating sediments were then evaluated. The calculations considered: effect of depth on solubility; rate of dissolution linearly decreasing as saturation approaches; rate of bioturbation; rate of supply of carbonate sediment; input rate of non-calcareous sediment; rate of bioturbation; and impedance of a non-turbulent boundary layer. These calculations indicate that the "carbonate compensation depth" would have a narrow depth range even if the dissolution rate increased only linearly with departure from saturation; that when carbonate accretion is nil, pore waters may still saturate with carbonate ion; that increases in the supply flux of carbonate by a factor of two will deepen the compensation level by more than a kilometer; that bioturbation has much less influence on the carbonate system than it has on interstitial silica; and that bottom currents or turbulence can have very significant influence on the calcium carbonate accretion patterns.

288 EQUILIBRIUM AND MECHANISM OF DISSOLUTION OF MG-CALCITES.

Wollast, R.; Reinhard-Derie, D. (Univ., Brussels). pp 479-493 of Fate of fossil fuel CO₂ in the ocean. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

The dissolution of Mg-calcite, the most abundant carbonate secreted by marine organisms, is discussed in terms of the thermodynamic implications concerning the dissolution of a solid solution. A method of theoretical interpretation of the experimental results is proposed. It is also shown that the composition of the equilibrium mixture of the final aqueous and solid solution depends on the initial ratio of solid to liquid used in the experiments. The mechanism of the dissolution is further considered on the basis of kinetic data and examination of the initial and final products of the reaction. It is concluded that the experimental study of the dissolution of natural Mg-calcites is much complicated by the fact that marine organisms are generally heterogeneous solid solutions, and that marine organisms are generally heterogeneous solid solutions, and that reprecipitation of a series of new solid solutions on the surface of the initial Mg-calcite lead to a multiphase system

which strongly prevents this system from reaching the equilibrium at the time scale used in laboratory experiments. It is thus difficult at this time to precisely quantify the influence of the composition of the Mg-calcite on its dissolution in the marine environment and further studies are indispensable to a better comprehension of an essential step of the cycle of CO₂ in the ocean.

289 CHALK FORMATION: EARLY DIAGENESIS.

Wise, S.W. Jr. (Florida State Univ., Tallahassee). pp 717-739 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Induration of chalk layers during the early diagenesis of deep sea carbonate oozes is effected primarily by processes of cementation superimposed on the normal depth dependent effects of gravitational compaction. Units having a high "diagenetic potential" due to the deposition of greater amounts of metastable particles are likely to become lithified earliest so that the induration of the sediment layers does not proceed uniformly. Calcium carbonate cement is derived from the in situ dissolution of metastable particles and is precipitated on more stable particles as low magnesium calcite overgrowths. This process may be inhibited by the presence of non-carbonate impurities such as clay minerals, volcanic ash or siliceous microfossils, but where effective, it allows lithification to proceed in a manner which conserves calcium carbonate within the sediment pile, thus allowing little carbonate or CO₂ to be recycled into the hydrosphere or atmosphere during diagenesis.

290 RECOMMENDATIONS OF THE WORKING GROUP ON CARBON IN THE ATMOSPHERE AND IN THE OCEAN.

Gieskes, J.M. (Scripps Institution of Oceanography, La Jolla, CA); Pytkowicz, R.M. pp 3-6 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Recommendations are made with regard to the following: man's input of carbon dioxide into the atmosphere; monitoring stations for atmospheric CO₂; importance of land and ocean biota for uptake and release to the atmosphere of CO₂; air sea exchange of CO₂; and mixed layer-deep ocean exchange of CO₂. (HLW)

291 FOSSIL FUEL PROBLEM AND CARBON DIOXIDE: AN OVERVIEW.

Pytkowicz, R.M.; Small, L.F. (Oregon State Univ., Corvallis). pp 7-31 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

An overview of the carbon dioxide system in nature and its perturbation by man is presented in this work. Emphasis is placed upon an understanding of the factors that control this system, and on needed research, as a basis for predicting the impact of the burning fossil fuel.

292 INFLUENCE OF THE SOUTHERN OSCILLATION ON ATMOSPHERIC CARBON DIOXIDE.

Bacastow, R. (Scripps Institution of Oceanography, La Jolla,

CA). pp 33-43 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

The atmospheric CO₂ record at the South Pole, after the seasonal effect is removed, reveals a small anomaly with a period of three to four years and an amplitude of about one part per million. The rate of change of this anomaly, and the corresponding anomaly at Mauna Loa, Hawaii, correlate well with the usual index of the Southern Oscillation. The Southern Oscillation is a large scale atmospheric and hydrospheric fluctuation involving wind strengths, ocean currents, and sea surface temperatures. Most directly, it is a fluctuation in the strength of the Pacific Trade winds, but the Southern Mid Latitude Westerlies also fluctuate in phase. The correlations indicate that CO₂ is removed from the atmosphere at times of stronger than average Trade winds and Mid Latitude Westerlies. It is suggested that CO₂ enters the Southern Mid Latitude oceans more rapidly during times of increased Westerlies. A more complete explanation of the relationship implied by the correlation should aid our understanding of how and where fossil fuel CO₂ enters the oceans.

- 293 HYDROGEN IONS AND THE THERMODYNAMIC STATE OF MARINE SYSTEMS. Bates, R.G.; Culbertson, C.H. (Univ. of Florida, Gainesville). pp 45-61 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

The influence of surface pH on the exchange of CO₂ between atmosphere and ocean is considered. Different acidity functions for seawater measurements are compared, and acidic dissociation constants in the carbonate system are critically examined as a function both of temperature and salinity.

- 294 MODELING THE OCEANS AND OCEAN SEDIMENTS AND THEIR RESPONSE TO FOSSIL FUEL CARBON DIOXIDE EMISSIONS. Bolin, B. (Univ. of Stockholm). pp 81-95 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

The continuity equation for the distribution of an arbitrary tracer in a water body is integrated with due regard to the basic characteristics of the ocean circulation to deduce a multiple reservoir model for the carbon cycle. Methods for evaluating the flux of carbon between the reservoirs are presented in some detail. Awaiting results from a series of model computations, some principle characteristics are pointed out, particularly the dependence of the downward flux of carbon into the sea on the sinking of detritus and thus, of the biological production in the surface layers of the ocean. The possible role of man's input of phosphorus into coastal waters (and possibly the open sea) is assessed.

- 295 ATMOSPHERIC CARBON DIOXIDE AND SOME INTERPRETATIONS. Machte, L.; Hanson, K.; Keeling, C.D. pp 131-144 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

The increasing amount of high quality benchmark carbon dioxide concentration data deserves critical analysis to improve our understanding of the entire carbon cycle. It is argued that the readily measured seasonal variation at benchmark stations outside of the Arctic Region can be accounted for by land photosynthesis and decay of vegetation, and that the best record at Mauna Loa shows no evidence of a changing land biosphere (although the technique is not especially sensitive). It is also argued that the time changes of the residual concentration left after long-term trend and seasonal variation have been removed could be related to sea surface temperature in the El Nino region of the eastern Pacific Ocean off South America.

- 296 NEUTRALIZATION OF FOSSIL FUEL CO₂ BY MARINE CALCIUM CARBONATE. Broecker, W.S.; Takahashi, T. pp 213-241 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

The CaCO₃ stored in marine sediments will ultimately neutralize the CO₂ generated by fossil fuel combustion. Details of this process are explored and a model of the early phases of this process in the western basin of the deep Atlantic Ocean is presented. The amount of CaCO₃ available for dissolution is derived from the calcite content of marine sediments and the extent to which these sediments are stirred by benthic organisms. The conclusion is that the available calcite is about equivalent to the CO₂ which would be released if our known resources of natural gas, oil and coal were burned. The rate at which this dissolution will proceed is estimated from the rate at which natural dissolution has proceeded during the Holocene. The conclusion is that if linear kinetics are followed, the time constant will be on the order of 1500 years. On the other hand, if the exponential kinetics found in the laboratory apply, then the time constant will be much shorter. It is possible that the dissolution process will become limited by the rate stirring of the mixed layer in deep sea sediments. The insoluble residue of clay minerals and opal built up in the upper few millimeters of the sediment as the result of dissolution must be mixed down into the underlying sediment if more than the upper few millimeters of sediment is to be attacked.

- 297 CARBONATE SATURATION; DISSOLUTION RATE RELATIONSHIP. Boyle, E.A.; Edmond, J.M. (Massachusetts Inst. of Tech., Cambridge). pp 261-268 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Although the re-cycling rate of calcium carbonate is usually presumed to be dependent on the degree of saturation of the deep ocean, the functionality of this relationship is not known. The saturation-dissolution relationship could be determined by measurements of recent carbonate sedimentation rates and separation of the effect of productivity variations from the effect of variations in the degree of saturation. Preliminary analysis suggests that the sediment dissolution rate is highly sensitive to small (i.e. 10%) shifts in the

near-bottom saturation value.

- 298 BIOGENIC CARBONATE PARTICLES IN THE OCEAN: DO THEY DISSOLVE IN THE WATER COLUMN. Honjo, S. (Woods Hole Oceanographic Institution, MA). pp 269-294 of Fate of fossil fuel CO₂ in the ocean. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Excess CO₂ on the earth should eventually be neutralized in the ocean by the skeletal remains of calcite and aragonite produced by planktonic organisms particularly foraminifera, coccolithophores and pteropods. The remineralization rates of biogenic carbonate, which controls the alkalinity adjustment of the ocean, is a function of their absolute dissolution rates. It is important to clarify the process and locality, how and where major remineralization occurs in the changing oceanic environment. The residence time of planktonic foraminiferan tests and pteropod shells is too short to undergo the significant dissolution while they are settling through the water column. On the other hand, the residence time and specific surface area of coccoliths is very large and their skeletons should be completely dissolved in the water column before arriving at the ocean floor. However, well preserved suspended coccoliths in undersaturated deep water have been collected. This paradox has been explained by invoking a two stage transportation hypothesis; first coccoliths descend with high speed within the fecal pellets of grazers; secondly discrete coccoliths sink very slowly after having been shed from the host fecal pellet in the deep sea. Carbonate in fecal pellets are protected from undersaturated seawater and their residence time in the water column is short through the process of fast sinking.

- 299 EFFECT OF BENTHIC BIOLOGICAL PROCESSES ON THE CO₂ CARBONATE SYSTEM. Paul, A.Z. (Columbia Univ., NY). pp 345-354 of Fate of fossil fuel CO₂ in the ocean. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Benthic organisms effect the dissolution of calcium carbonate tests and particles through the following activities: the production of CO₂ by respiration increases the solubility of calcium carbonate; digestive processes strip organic coatings from calcium carbonate tests and shells allowing the undersaturated water to reach their surfaces; and bioturbation keeps the upper layer of sediments mixed and thus prevents calcium carbonate from being buried rapidly and lost to the system. Bioturbation is probably the most important factor and includes the following processes: organisms moving over or through the sediment; benthos eating the sediment and egesting feces or pseudofeces, or rejecting certain size grains; tube or burrow building activities of infauna; and sediment filling open burrows. Although benthic populations are not high there may be adaptations that permit processing of large quantities of sediment allowing the organisms to obtain their required nutrition from low organic carbon deposits. The meiobenthos (organism smaller than 0.5mm) may play an important role in the upper 1-2cm in deep-sea sediments.

DETERMINED BY ¹⁴C DATING AND ITS IMPLICATIONS REGARDING CLIMATE STRATIGRAPHY AND THE FATE OF FOSSIL FUEL CO₂. Peng, T.H. (Columbia Univ., NY); Broecker, W.S.; Kipphut, G.; Shackleton, N. pp 355-373 of Fate of fossil fuel CO₂ in the ocean. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

A series of radiocarbon dates on Indian Ocean cor V19-188 reveals that this core was vertically mixed to a depth of 9 cm. Core top ¹⁴C dates from a number of other areas also indicate that the sediment has been mixed to a depth ranging from 6 to 18 cm. This mixing has important implications with regard to the fate of fossil fuel CO₂. A numerical model has been developed to study the effect of sediment mixing on radiocarbon dates, carbonate concentrations, oxygen isotopes and fauna abundances. This model indicates that the deviation of apparent ¹⁴C ages from the true age ranges from 530 years to 1800 years for core V19-188, with the maximum deviation at the climatic transition depth.

- 301 CARBON-13 IN UVIGERINA: TROPICAL RAINFOREST HISTORY AND THE EQUATORIAL PACIFIC CARBONATE DISSOLUTION CYCLES. Shackleton, N.J. pp 401-427 of Fate of fossil fuel CO₂ in the ocean. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Benthonic foraminifera in late Pleistocene deep-sea cores show significant variation in delta ¹³C with depth in sediment. This indicates that delta ¹³C in dissolved oceanic CO₂ undergoes a significant change in a few thousand years. This is in apparent contradiction to the estimated 300 ka residence time for carbon in the ocean. It suggested that this is a consequence of changes in the terrestrial plant biomass, which has a delta ¹³C of about -25‰/00. Postulated changes in world vegetation, particularly in tropical rainforests during the Late Pleistocene, were sufficient to produce a change of the magnitude observed. Rapid expansion of forests between 13 ka and 8 ka ago may have resulted in the striking accumulation of aragonite pteropods in Atlantic Ocean sediments of that age. Rapid deforestation during an interglacial-glacial transition probably caused the intense carbonate dissolution which is observed in Equatorial Pacific Ocean sediments deposited over this interval. The current rate of injection of fossil fuel CO₂ into the atmosphere is substantially greater than the rate at which it was added during post-interglacial aridification in the tropics.

- 302 SEDIMENT MIXING AND CARBONATE DISSOLUTION IN THE SOUTHEAST PACIFIC OCEAN. Sundquist, E.; Richardson, D.K.; Broecker, W.S.; Peng, T.H. pp 429-454 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Core descriptions of about 280 LDGO cores from the southeast Pacific Ocean indicate that a carbonate-rich top layer, noted by Broecker and Broecker (1974) in cores from the East Pacific Rise, is widespread at or near the calcite compensation depth. Sediment mixing is indicated in these cores by mottling and burrow structures and by discordance of C¹⁴ and

thorium sedimentation rates. A simple mathematical mixing model suggests that the high-carbonate layer may have accumulated during a low stand of the compensation level in the last glacial period. However, in many cores the carbonate layer is not repeated in down-core cycles, as would be expected. Previous glacial carbonate peaks may have been largely dissolved during succeeding interglacials, or stirred into the most recent glacial layer along with small accumulations of interglacial non-carbonates. Box core studies should help to clarify the important influences of bioturbation on these problems.

- 303 MECHANISMS FOR CALCITE DISSOLUTION ON THE SEA FLOOR. Takahashi, T.; Broecker, W.S. (Columbia Univ., NY). pp 455-477 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Arguments in support of the hypothesis that the major dissolution of CaCO₃ in the deep sea takes place within a few millimeters of the water-sediment interface are presented. Three models for the dissolution of CaCO₃ are considered: the stagnant boundary film model, and the constant variable resaturation time models. Assuming that the diffusive flux of CO₂ is equal to that of total CO₂ out of sediment, the validity of each model is tested using the CaCO₃ distribution in sediments observed in the Rio Grande Rise area. The stagnant boundary film model fails to adequately represent the data. The constant resaturation time model fits the data satisfactorily, and gives a characteristic calcite resaturation time consistent with the experimental value of 7 minutes. The variable resaturation time model when combined with the calcite solubility of Berner also fits the data satisfactorily, and predicts dissolution of calcite above the sedimentary lysocline. This prediction is consistent with the observation of Berger. However, the model requires that the rate of calcite dissolution increases with decreasing CO₂ concentrations at about one-fourth of the value obtained from the data of Berner and Morse.

- 304 RECOMMENDATIONS OF THE WORKING GROUP ON FATE OF FOSSIL FUEL CO₂ AND THE SEDIMENTARY RECORD. Berger, W.H. (Scripps Institution of Oceanography, La Jolla, CA). pp 497-503 of Fate of fossil fuel CO₂ in the ocean. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Recommendations are discussed with regard to the following; immediate response of the environment to increased carbon dioxide; long-term response of the environment; climatic effects of carbon dioxide increase; and possible remedial action to prevent excessive carbon dioxide levels. (HLW)

- 305 CARBON DIOXIDE EXCURSIONS AND THE DEEP-SEA RECORD: ASPECTS OF THE PROBLEM. Berger, W.H. (Scripps Institution of Oceanography, La Jolla, CA). pp 505-542 of Fate of fossil fuel CO₂ in the ocean. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Deep-sea sediments bear on the CO₂ problem

in three major ways: the sediment-ocean system is a powerful buffer for a geologically short-term CO₂ pulse like the present industrial input; deep-sea sediments provide a detailed record of the natural background fluctuation in climate against which a CO₂ induced change has to be measured; substantial CO₂ excursions may have occurred in the past, leaving a record in deep-sea sediment. The buffer action is mainly due to dissolution of calcareous sediments. Response is fastest in an ocean where dissolution effects are already widespread, such as the present one. The great extent of dissolution on the sea floor is evident from the shallowness of the R/sub o/-level, the level where foraminiferal species lists first change noticeably. The lysocline (the level of maximum change) is about halfway between R/sub o/-level and CCD. Climatic fluctuations are thought to be tied to a large extent to astronomical causes. To verify this hypothesis, the dissolution have to be determined. Excursions of the saturation level during the Pleistocene (taken as change in the compensation depth of Globigerina rubescens) exceed 1 km and interfere with the signal produced by productivity changes alone.

- 306 MODULATION OF MARINE SEDIMENTATION BY THE CONTINENTAL SHELVES. Hay, W.W.; Southam, J.R. (Univ. of Miami, FL). pp 569-604 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Estimates of the magnitudes of fluctuations in the mechanical and chemical loads of rivers through geological time are obtained by considering the relation between river loads and area, elevation, hypography, and climate of the present continental configuration. On long time scale it is shown that the continental shelves bypass material to deeper oceanic accumulation sites. However, for periods of rapidly rising sea level following glaciations, the sedimentation regime operates in such a way that continental margins consume a flux of CaCO₃ equal to or several times larger than the input from rivers. The initial effect on the ocean's sedimentation system due to the introduction of CO₂ by the burning of fossil fuels will be the dissolution of aragonite from shallow water tropical shelves.

- 307 ORGANIC CARBON IN DEEP-SEA SEDIMENTS. Heath, G.R.; Moore, T.C. Jr.; Dauphin, J.P. (Univ. of Rhode Island, Kingston). pp 605-625 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).

From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

The rate of accumulation of organic carbon in marine sediments is closely related to the bulk sediment accumulation rate and can be described by the equation: (Organic Carbon Accumulation Rate) = 0.01 (Sedimentation Rate) 1.4. Diagenetic reduction of the organic carbon content of older sediments appears to be exponential in both reduced and oxidized sediments, with half lives in the 15-55,000 year range. Pleistocene climate fluctuations have resulted in marked variations in the supply of organic carbon to the deep-sea, in part due to oceanographic changes, and in part due to the destruction of nearshore depositional environments by lowered sea level. Carbonate-rich deposits contain organic matter that is intimately associated with test

calcite. The climate and carbonate effects can mask the diagenetic pattern evident in uniformly deposited sediments, but they do not alter the basic relation between organic-carbon and total-sediment accumulation rates.

- 308 CARBONATE ACCUMULATION AND DISSOLUTION IN THE EQUATORIAL PACIFIC DURING THE PAST 45 MILLION YEARS. Heath, G.R.; Moore, T.C. Jr.; van Andel, T.H. (Univ. of Rhode Island, Kingston). pp 627-639 of Fate of fossil fuel CO₂ in the oceans. Andersen, N.R.; Malahoff, A. (eds.). New York; Plenum Press (1977).
From Symposium on the fate of fossil fuel CO₂ in the oceans; Honolulu, HI, USA (16 Jan 1976).

Cenozoic carbonate-bearing sediments deposited beneath both the biologically productive equatorial zone and the less productive waters more than 4° from the equator in the central Pacific show decreasing accumulation rates with increasing water depth due to dissolution of carbonate at the sea floor. Below 3.5 km, the rate of dissolution increases linearly with depth. The vertical gradient of the dissolution rate has varied by a factor of thirty during the Cenozoic, from 0.6gm/cm²/1000 yr/km during the Early Oligocene to probably reflect changes in bottom-water circulation due to tectonic and climatic changes during the past 45 million years. The calcite compensation depth beneath the equator dropped almost 2 km from the Late Eocene to the Early Oligocene, and rose about 500 m from the Middle to Late Miocene. Because of the higher vertical gradient of the Miocene dissolution rate, however, the Miocene rise represents about twice the reduction in carbonate supply as does the Eocene rise.

- 309 RADIOCARBON CONTENT VARIATIONS IN THE ATMOSPHERE IN THE YEARS 1950 TO 1975 AS SHOWN BY MEASUREMENTS OF GEORGIAN WINE SPIRIT RADIOACTIVITY. Burchuladze, A.A.; Gedevarishvili, D.D.; Pagava, S.V.; Togonidze, G.I. (Tbilisskij Gosudarstvennyj Univ. (USSR)). pp 261-263 of Low-radioactivity measurements and applications. Povinec, P.; Usacev, S. (eds.). Bratislava, Czechoslovakia; Slovenske Pedagogicke Nakladatelstvo (1977). (In Russian)

From International conference on low radioactivity measurements and applications; Tatranska Lomnica, Czechoslovakia (6 Oct 1975).

The usefulness of wine spirits for the determination of radiocarbon variations in the atmosphere is discussed. The methodology of sample preparation and counting using a liquid scintillation spectrometer with benzene scintillator is briefly described. The results for the period 1950 to 1975 are presented showing that the mean residence time of the CO₂ molecule in the atmosphere is 10.6±0.2 yr.

- 310 ENERGY AND THE ATMOSPHERE: A PHYSICAL-CHEMICAL APPROACH. Campbell, I.M. London, England; John Wiley and Sons Ltd. (1977). 406p.

An attempt was made to unify the bases of energy production and conversion on the one hand with atmospheric consequences and conversions on the other, using fundamental chemical and physical arguments, so interrelating the demands of the energy crisis and protection of the atmospheric environment. Aspects of biochemical science, fuel technology, and planetary dynamics are thus incorporated into the central core of chemical and physical knowledge. Chapter titles include: the earth as a planet; the natural energy balance of the earth; the gross structure of

the earth's atmosphere; the photosynthetic origin of fuels; combustion and fuels; the realization of energy; the major cycles of the atmosphere; photochemistry of the polluted troposphere; neutral chemistry of the upper atmosphere; and ionic species in the mesosphere and lower thermosphere. (JGB)

- 311 RECYCLING OF EXCESS CARBON DIOXIDE FROM FOSSIL ENERGY CONVERSION BY PLANTS. Wagener, K. (Kernforschungsanlage, Juelich, Ger.). pp 319-328 of Living systems as energy converters. Buvet, R.; Allen, M.J.; Massue, J.P. (eds.). New York, NY; Elsevier/North-Holland, Inc. (1977).

From European conference on living systems as energy converters; Pont-a-Mousson, France (18 Oct 1976).

The following topics are discussed: prediction of CO₂ levels in the atmosphere; exchange kinetics between the three major reservoirs of carbon: atmosphere, biosphere, and ocean; response of global primary productivity to rising CO₂ levels; stimulation of photosynthesis by CO₂; effect of higher temperature and rainfall on global primary productivity; consequences on the global standing biomass; and recycling of fossil energy potential by stimulated photosynthesis. (HLW)

- 312 (AED-Conf--77-002-003) WHAT IF MANKIND WARMS THE EARTH. Kellogg, W.W. (National Center for Atmospheric Research, Boulder, CO (USA)). 1977. 20p. (CONF-770223--2). Dep. NTIS (US Sales Only), PC A02/MF A01.

From ENVITEC congress; Dusseldorf, F.R. Germany (7 Feb 1977).

There are a variety of human activities that are being pursued on such a large scale that they may influence regional and global climate. Virtually all of these activities, including the addition of carbon dioxide and particles to the atmosphere, are expected on theoretical grounds to cause an increase in mean surface temperature in the decades ahead, and by 2000 AD the total warming effect will probably be larger than any of the natural climate fluctuations during the past 1,000 years or more. It is therefore pertinent to inquire what a warmer earth might be like; and to obtain a first rough answer we turn to our mathematical models of the atmosphere, and also to the conditions that have been deduced for the period about 4,000 to 8,000 years ago when the earth was apparently several degrees warmer than now. At that time some areas that are now subtropical deserts received more rainfall, and there were other areas in the middle latitudes that were drier. There are several important implications for society if mankind does succeed in warming the earth - and a number of still unanswered questions as well.

- 313 MONITORING THE GLOBAL CLIMATIC IMPACT OF DIRECT HEAT ADDITION ASSOCIATED WITH ESCALATING ENERGY USE. Penner, S.S. (Univ of Calif, San Diego). Energy (Oxford); 1: No. 4, 407-412 (Dec 1976).

Using M.I. Budyko's overall heat-balance equation, the author estimates that direct heat addition associated with worldwide energy use in the year 2050 will be responsible for a mean global temperature rise of 0.27°C at a 20 kw/sub t/ per capita energy consumption for a world population of ten billion people. The corresponding temperature rise between 15 and 60°N is estimated to be 0.44°C. A program for monitoring the global climatic impact of escalating energy use involves precise monitoring of the following quantities: (a) the

solar constant, (b) the effective earth-atmosphere albedo, and (c) the net (long-wavelength) radiant energy emitted from the earth-atmosphere system. Both the effective albedo and the (long-wavelength) radiant energy emitted from the earth-atmosphere system will depend on the nature and size of particulate concentrations in the atmosphere, on molecular emitters (especially CO_2 and H_2O), cloud cover, and on the radiative-convective circulation pattern. 6 refs.

- 314 DEVELOPMENT AND APPLICATIONS OF SPATIAL DATA RESOURCES IN ENERGY RELATED ASSESSMENT AND PLANNING. Olson, R.J.; Goff, F.G.; Gison, J.S. (Oak Ridge National Lab., TN). pp 12.1-12.7 of *Advancements in retrieval technology as related to information systems*. Neuilly sur Seine, France; Advisory Group For Aerospace and Development Research (Dec 1976).

From Proceedings of the advancements in retrieval technology as related to information systems; Arlington, VA, USA (20 Oct 1976). See CONF-761017--.

Research in energy-related assessment and planning at Oak Ridge National Laboratory involves investigating environmental themes at several levels requiring data at appropriate spatial and temporal scales. In the Environmental Sciences Division, a spatial database is being developed for the Eastern United States at the county--subcounty unit level of resolution. The database contains information on terrain, water resources, climate, land use, forest resources, agriculture, wildlife resources, critical natural areas, human population, and energy uses. A spatial hierarchy of metric, geodetic, and geopolitical scales was defined as a framework to organizing the data. Spatial units within a hierarchical level serve as building blocks that can be assembled or aggregated to satisfy analysis needs. Building blocks also allow accessing more detailed spatial data by using pointers to information not stored in the database. Uses of the database are related to the capability to cross-reference and integrate information in various subject sectors, utilizing spatial units and temporal periods commensurate with regional themes. An investigation of potential changes in vegetation patterns related to predicted temperature changes from increased atmospheric CO_2 is presented to illustrate an application of the data resources. Other themes include coal extraction in Appalachia, landscape patterns, habitat and population dynamics of selected biological species, and energy facility siting. 3 figure, 2 tables.

- 315 (NP--21727) METHANOL: ITS SYNTHESIS, USE AS A FUEL, ECONOMICS, AND HAZARDS. Hagen, D.L. (Minnesota Univ., Minneapolis (USA)); Energy Research and Development Administration, Washington, DC (USA)). Dec 1976. vp. NTIS, PC A09;MF A01.

Thesis.

The synthesis of methanol using existing and proposed means of production and sources of feedstocks is reviewed. Conventional methods of producing methanol are surveyed. Proposed methods of fermentation, electro-, and radiation-synthesis are discussed. Conventional production technology from synthesis gas is examined in detail. The range of possible sources of feedstocks from fossil fuels to biomass, atmospheric carbon dioxide, and carbonates are portrayed along with renewable and nonrenewable energy sources. A survey of recent studies and research on methanol is given within the historical context. Fuel related properties are reviewed and compared

with isooctane. Combustion emissions and their variation with temperature and fuel preparation are similarly compared. Uses of methanol as a combustion fuel and recent tests in boilers, turbines, conventional and stratified charge Otto engines, and diesel engines are discussed emphasizing comparative efficiencies. Current developments on the uses of methanol directly and indirectly in fuel cells and as a feedstock for single cell protein are examined. Historical prices of methanol are presented along with major causes for the fluctuations. The costs of synthesizing methanol are presented including overall production costs from organic feedstocks. Proposed costs of producing methanol from electrolytic hydrogen and carbon dioxide are also given. Fiscal and physical causes for inflation are discussed along with the costs of storage, transportation and conversion. The numerous biological, physical, and chemical hazards of using methanol as a fuel are discussed together with safety precautions and treatment. 609 references.

- 316 GREENHOUSE EFFECTS DUE TO MAN-MADE PERTURBATIONS OF TRACE GASES. Wang, W.C.; Yung, Y.L.; Lacis, A.A.; Mo, T.; Hansen, J.E. (Goddard Space Flight Center, Inst. for Space Studies, New York). Science; 194: No. 4266, 685-690(12 Nov 1976).

Nitrous oxide, methane, ammonia, and a number of other trace constituents in the earth's atmosphere have infrared absorption bands in the spectral region 7 to 14 μm and contribute to the atmospheric greenhouse effect. The concentrations of these trace gases may undergo substantial changes because of man's activities. Extensive use of chemical fertilizers and combustion of fossil fuels may perturb the nitrogen cycle, leading to increases in atmospheric N_2O , and the same perturbing processes may increase the amounts of atmospheric CH_4 and NH_3 . We use a one-dimensional radiative-convective model for the atmospheric thermal structure to compute the change in the surface temperature of the earth for large assumed increases in the trace gas concentrations; doubling the N_2O , CH_4 , and NH_3 concentrations is found to cause additive increases in the surface temperature of 0.7°, 0.3°, and 0.1°K, respectively. These systematic effects on the earth's radiation budget would have substantial climatic significance. It is therefore important that the abundances of these trace gases be accurately monitored to determine the actual trends of their concentrations.

- 317 WHAT CAN WE SAY ABOUT FUTURE TRENDS IN OUR CLIMATE. Mitchell, J.M. Jr. Environ. Data Serv.; 4-9(Nov 1976).

The author of this general article suggests that statistical relationships between climatic variations and plausible forcing phenomena such as volcanic eruptions, carbon dioxide trends, or sunspot numbers should be recognized as possible clues to climatic behavior, not as reliable bases for climate predictions. Important technological advances in climatology are mentioned including climate modeling and improved monitoring through use of remote sensing technology and a variety of new satellite observing systems. (MFB)

- 318 (ORAU/IEA(M)--75-3) ENERGY AND THE CLIMATE. Rotty, R.M. (Oak Ridge Associated Universities, Inc., TN (USA)). Sep 1976. Contract EY-76-C-05-0033. 33p. Dep. NTIS, PC A03;MF A01.

The total global energy picture is reviewed

and the consequences of man's energy use are postulated. It is pointed out that anthropogenic factors, and especially energy releases, can affect the world's climate. The release of energy to the atmosphere for eventual radiation to space causes a global warming. Per capita energy uses must be evaluated in making any projections as to the future global energy consumption rates, but any reasonable projection shows energy-use rates that cause concern with regard to effects on the climate. Localized energy releases give local and regional changes that will be apparent before the global changes. Cities have different climates than the nearby rural areas. Heat-flux density is an important consideration in evaluating meteorological changes resulting from large localized heat sources. Enhancement of convective cloud activity (including showers and thunderstorms) is possible if the heat-flux density is high. Aerosols released to the atmosphere can cause a warming or cooling effect depending on the nature of the aerosol and the albedo of the surface below. Changes in cloud cover are important in changing the radiation budget of the planet. Extensive irrigation, artificial reservoirs, and large cooling towers all add humidity to the atmosphere, but any resulting increase in cloudiness will tend toward overall cooling which will tend toward a reduction in cloudiness. Increases in atmospheric CO_2 (e.g., from the combustion of fossil fuels) add to the absorption of long wave radiation and the resulting greenhouse effect. The resulting planetary warming depends on the amount of CO_2 uptake by the biota and by the oceans.

- 319 (ORNL--5194) GLOBAL CARBON DIOXIDE PROBLEM. Baes, C.F. Jr.; Goeller, H.E.; Olson, J.S.; Rotty, R.M. (Oak Ridge National Lab., TN (USA)). Aug 1976. Contract W-7405-ENG-26. 84p. Dep. NTIS \$5.00.

This report strives to link important aspects of the global carbon dioxide problem which too commonly are treated only separately. The present section (1) outlines these aspects, (2) summarizes the main conclusions, and (3) recommends actions to improve on judgment of the risks and reduce the human costs of change.

- 320 CARBON ISOTOPES IN THE GEOSPHERE. A MATHEMATICAL MODEL DESCRIBING GLOBAL DEVELOPMENT AND CONCERNING REGIONAL PECULIARITIES. Weise, G.; Wetzel, K. (Akademie der Wissenschaften der DDR, Leipzig. Zentralinstitut fuer Isotopen- und Strahlenforschung). Isotopenpraxis; 12: No. 6, 219-226 (Jun 1976). (In German).

With growing industrialization an ever increasing amount of combustion products of fossil fuels (coal, petroleum, natural gas) is emitted into the geosphere and induces a global change of the isotopic composition of atmospheric CO_2 . The mathematical model to describe this development includes exchange processes between the atmosphere, the hydrosphere and the biosphere. For checking it the time-dependent development of the ^{13}C concentration will be more useful than that of the ^{14}C concentration because of the heavy disturbances caused by nuclear explosions since the fifties. After being checked in this manner the explained mathematical formalism of a two-box model is applied to particular areas of the earth's surface with pronounced regional peculiarities.

- 321 (PB--266764) ANALYSIS OF NONCOAL MINERALS ATMOSPHERES. FINAL REPORT. Rodgers, S.J. (MSA Research Corp., Evans City, PA (USA)).

21 May 1976. Contract S0231057. 121p. NTIS PC A06/MF A01.

The quantity and behavior of gases in metal and nonmetal mines were monitored to provide background information on feasibility of incipient fire detection systems. Monitoring was conducted during working and nonworking periods at intake air, return air, and working places. Gases generated during diesel operations and shot firing were of particular interest. Gases that were monitored were CO , CO_2 , NO , NO_2 , and SO_2 . Submicrometer particulate concentrations were also monitored. Commercially available instruments were used and included nondispersive infrared, electrochemical, and chemiluminescent types. The ratios of the various gases generated during diesel operations and shot firing were similar to those expected from an incipient fire, except for the CO_2/NO_x ratio, which was sufficiently different to be considered for early fire warning. Samples taken near leaking bulkheads showed high CO_2 levels, and low CO levels, the reverse of anticipated behavior in coal mines.

- 322 MAN'S IMPACT ON CLIMATE. Build. Syst. Des.; 73: No. 3, 1-10 (Apr 1976).

Human impact on weather and climate is reviewed. Combustion of fossil fuels is raising the carbon dioxide content by about 0.2% per year, but no parallel climatic trend is detectable. Humanly produced aerosols are measurable on a local and regional scale. Total nonsolar heat is so slight as to elevate the global mean temperature by only 0.01 C. Records of the past 15 years do not indicate any appreciable decreases in ozone except during the last three years. Only inhabitants of large urban areas and those living at short distances downwind of emission sources are feeling relatively mild climatic effects of pollution.

- 323 (PB--254834) SENSORS FOR CONTINUOUS MONITORING OF TOXIC IONS, NUTRIENTS, AND DISSOLVED GASES IN WATER. Shuman, M.S.; Fogleman, W.W. (North Carolina Water Resources Research Inst., Raleigh (USA)). Apr 1976. Contract DI-14-31-0001-4157. 137p. (UNC-WRRI--76-113). NTIS \$6.00.

Ion-selective electrodes and a new type of dissolved gas sensor based on piezoelectric crystals were assessed for use in continuous monitoring of water quality. Relevant stream and effluent water quality standards were reviewed in order to define the constraints on the use of these sensors. The use of sensors in continuous monitoring programs in the United States and other countries was also examined and reviewed. The state-of-the-art of ion-selective electrodes for toxic ions, nutrients and dissolved gases in water was reviewed. A tabular summary of electrode characteristics and an extensive bibliography were compiled. Recommendations for the use of these sensors were made with consideration of the practical problems encountered in continuous monitoring. A dissolved gas sensor for carbon dioxide utilizing a coated piezoelectric crystal was fabricated and evaluated. Didodecylamine and dioctadecylamine were useful coating materials but were also sensitive to water vapor and sulfur dioxide. A probe was designed with the crystal isolated from the aqueous sample by a film of polyvinyl chloride, cast Teflon or by a microporous Teflon filter.

- 324 (BNWL--2000(Pt.3), pp 253-288) CLIMATE AND WEATHER: NATURAL AND ANTHROPOGENIC PERTURBATIONS. Drake, R.L. Mar 1976. Pacific Northwest Laboratory Annual Report

for 1975 to the USERDA Division of Biomedical and Environmental Research. Part 3.

Human activity can change the average atmospheric temperature and humidity values, as well as the chemical composition of the air. These changes affect local and regional weather and climate, and may have a significant influence on global climate. Examples of human activity that produce these changes are the increase of CO₂ content of the atmosphere from the combustion of fossil fuel; the production of aerosols by industry, automobiles, home heating units and agricultural practices; the releases of large quantities of heat and water vapor from the cooling facilities of large fossil and nuclear power plants; and the modification of the earth's albedo due to urbanization, agriculture, deforestation, reservoirs and soil spills. Research activities have resulted in an overview of the important natural and anthropogenic perturbations of weather and climate, and the resulting need for further climatic research; a theoretical study that may contribute to a better understanding of atmospheric electricity; atmospheric turbidity data at the Hanford site and their relationships to changes in the aerosol size distribution; initial efforts in determining the optical properties of aerosols such that we can better understand the radiative properties of the atmosphere; and the characterization of large power plant cooling tower plumes through the use of long exposure photography and instrumented aircraft. (auth)

- 325 BIOSPHERE HAS UNDERGONE DRAMATIC CHANGES AND WILL CONTINUE TO DO SO. II. Hall, C.A. *Aware*; No. 66, 12-15 (Mar 1976).

The ways in which global industrialization can change global rates of primary productivity include the positive effects of carbon dioxide enhancement and local fertilization from smokestack nutrients and the negative effects of acid rain, potential climate changes, changes in sunlight intensity by increased aerial particulates and aerosols, destruction of oceanic fisheries by highly industrialized overfishing and coastal development, and destruction of the public service function of natural ecosystems either by urbanization or by replacement of natural biotic systems with intensively managed ones.

- 326 (AD-A--033654) ANALYSIS OF HIGH-ALTITUDE EFFECTS SIMULATION (HAES). REPORT FCR 16 APR 1974--15 APR 1975. Reidy, W.P.; Degges, T.C.; Neal, W. (Visidyne, Inc., Burlington, MA (USA)). 1 Feb 1976. Contract F19628-74-C-0177. 76p. (VI--311). NTIS, PC A05/MF A01.

Initial formulation of the analysis of the energy deposition and the electron density profiles in an EXCEDE-type experiment are presented. Altitude profiles are given for the night time zenith spectral radiance for CO₂ bands at 4.3 micrometers and 15 micrometers and for the ozone band at 9.6 micrometers. Model calculations of the vibrational population of the first excited level of the CO₂ v₃ vibrational mode are also presented.

- 327 CONCERNING POSSIBLE EFFECTS OF AIR POLLUTION ON CLIMATE. Landsberg, H.E.; Epstein, E.S. *Bull. Am. Meteorol. Soc.*; 57: No. 2, 213-218 (Feb 1976).

Some views on the problems of possible effects of air pollutants on climate are expressed. No climatic alterations have been attributed to anthropogenic stratospheric aerosols. The case of carbon dioxide is more ominous with potential to elevate the world's

temperature by 1-2 C. Concern is greater at the local scale than at the global level. Selected NOAA and international measurement and research activities that pertain to global and regional scales of climate and low level pollution are described.

- 328 CARBON DIOXIDE CONCENTRATION AND FLUX IN A LARGE AGRICULTURAL REGION OF THE GREAT PLAINS OF NORTH AMERICA. Verma, S.B.; Rosenberg, N.J. (Univ. of Nebraska, Lincoln). *J. Geophys. Res.*; 81: No. 3, 399-405 (20 Jan 1976).

Results of observations of CO₂ concentration [CO₂] and flux in an area of typical agricultural land use in the east central Great Plains of North America (Mead, Nebraska) are reported. The observations were made at sufficient heights to represent an integration of CO₂ fixation and release due to all types of land use in the region (pasture, alfalfa, annual crops). Minimum daytime [CO₂] ranges from about 295-300 ppm in late July to early August (the time of apparent maximum photosynthetic activity) to 328-332 ppm in winter. The shape of the annual CO₂ concentration cycle at Mead is described and compared with those for Mauna Loa, Hawaii, and Barrow, Alaska. Peak daytime flux of CO₂ (in g x 10⁻⁷ cm⁻²s⁻¹) from the atmosphere to the ground varied from about 0.5 in early June to 1.5-2.0 in late July to early August and 0.5 in late September. The net daily CO₂ flux (in grams per square meter), calculated from the downward daytime and upward nocturnal fluxes, is about 10-12 in early June, 18-20 in early August (maximum), 6-10 in September, and 1-5 in early October. (auth)

- 329 STATE OF THE ENVIRONMENT AND ITS IMPLICATIONS TO RESOURCE POLICY DEVELOPMENT. Biswas, A.K.; Biswas, M.R. (Dept. of Environment, Ottawa). *Bioscience*; 26: No. 1, 19-25 (Jan 1976).

Problems encountered in maintaining a high level of progress while protecting and conserving the environment are discussed. The following long-term potential environmental hazards associated with energy development and consumption are considered briefly: thermal pollution, the possibility of climatic changes due to the constantly increasing levels of heat fluxes, carbon dioxide and particulates, the problems of management of highly radioactive nuclear and other toxic wastes, and problems caused by rapid deforestation in countries that rely heavily upon wood as a source of fuel. (JTE)

- 330 SUN AS A MAKER OF WEATHER AND CLIMATE. Willett, H.C. *Technol. Rev.*; 78: No. 3, 46-54 (Jan 1976).

The theory that an increase of atmospheric carbon dioxide produced by the combustion of fossil fuels could best explain the warming trend observed from 1920 to 1940 has long stimulated popular concern and debate. An alternative explanation proposing that variations in solar activity best fit recent observed climatic fluctuations, and offering a very sketchy physical hypothesis is presented. Patterns of atmospheric circulation on earth reflect cyclic changes in the sun. By studying solar cycles, a "little ice age" bringing extremes of cold is predicted by the year 2200. However, the next age of widespread glaciation is still too distant to be seen.

- 331 (CONF-740921--), pp 112-135) INTERACTIONS OF ATMOSPHERIC CARBON DIOXIDE,

DIFFUSE LIGHT, PLANT PRODUCTIVITY AND CLIMATE PROCESSES MODEL PREDICTIONS. Lister, R.; Lerch, E. (Cornell Univ., Ithaca, NY). 1976.

From Atmosphere - surface exchange of particulate and gaseous pollutants symposium; Richland, WA, USA (4 Sep 1974).

We are concerned with predicting subtle interactions between land vegetation and changing atmospheric properties. We deal specifically with increased concentrations of CO₂ and increased diffuse sunlight due to scattering by assumed increases in particulate matter. Both increasing CO₂ and proportions of diffuse light enhance photosynthesis of plant communities up to a point, depending upon the type of plant. Thus, vegetation can damp long-term CO₂ perturbations caused by increasing fossil fuel use. However, concomitant increases in diffuse sunlight with atmospheric dust loading could also reduce total solar radiation input at the surface, thus affecting thermal fluxes from the vegetation. The altered thermal regime then influences plant processes as well as atmospheric processes. We have found with a highly sophisticated mechanistic model (SPAM) that efficient photosynthesis C₄ plants differ from less efficient C₃ plants in their responses to increasing CO₂ and diffuse light, thus complicating prediction even more. So far we have tried to bracket conditions which have been hypothesized to develop in the next 50 to 100 years.

- 332 (COO--2195-23) **ENERGETICS AND DYNAMICS OF THE STRATOSPHERE.** Newell, R.E.; Tahnk, W.R. (Massachusetts Inst. of Tech., Cambridge (USA). Dept. of Meteorology). 1976. Contract E(11-1)-2195. 78p. (CONF-760217--14). Dep. NTIS \$5.00.

From Annual meeting of American Association for the Advancement of Science; Boston, MA, USA (24 Feb 1976).

Current problems are outlined that emerge from diagnostic studies of the energy, momentum and mass budgets of the stratosphere: How is the temperature field maintained by radiative and dynamic processes. How is the wind field maintained. What causes large changes in the temperature and circulation in late winter. Why is an ozone maximum associated with these changes. How does energy supplied to the stratosphere from the troposphere compare with energy generated in situ. What is the structure, significance and origin of large-scale wave motions in the upper stratosphere. What is the influence of the stratosphere on the troposphere. What, in our view, are the priorities for future observational studies of the stratosphere.

- 333 **ACTUAL AND POTENTIAL EFFECTS OF POLLUTANTS ON CLIMATE.** Landsberg, H.E. (Univ. of Maryland, College Park). pp 32.1.1-32.1.4 of 1975 environmental sensing and assessment. New York, NY; Institute of Electrical and Electronics Engineers, Inc. (1976).

From IEEE international conference on environmental sensing and assessment; Las Vegas, NV, USA (15 Sep 1975).

On the local scale man-made atmospheric pollutants have obvious and subtle effects on climatic parameters. They affect sunshine, visibility and fog frequency. They lead to spectacular increases in condensation and freezing nuclei, yet their effect on precipitation is not yet fully elucidated. They redistribute low-level temperatures in metropolitan areas. On occasion plumes can apparently cause considerable cloud banks downwind. As urban areas grow these effects

begin to become measurable on a regional scale. On the global scale it appears that most anthropogenic sources of air contaminants are still very small compared with those of natural origin. Ocean spray, sand blowing, and volcanic eruptions remain among the major steady or sporadic sources. The only notable exception appears to be the continuous increase of CO₂ in the atmosphere resulting from the combination of fossil fuels. Although this should lead to a global temperature rise, up to this time such a trend is not yet discernible in the noise pattern of short term climatic oscillations and fluctuations. Stratospheric contamination by high-flying aircraft and from diffusion of fluorocarbons, with their possible effect on the ozone layer have become a major concern but at present only minor changes in the conventional elements of surface climate can be foreseen.

- 334 **TRENDS IN ATMOSPHERIC PROPERTIES.** Machta, L. (National Oceanic and Atmospheric Administration, Silver Springs, MD). pp 32.2.1-32.2.4 of 1975 environmental sensing and assessment. New York, NY; Institute of Electrical and Electronics Engineers, Inc. (1976).

From IEEE international conference on environmental sensing and assessment; Las Vegas, NV, USA (15 Sep 1975).

On a global scale, long-term (many years) trends in carbon dioxide, dust, and ozone are discussed. In the case of the first two quantities upward trends blamed on human activity but, up to this point, the changes in total ozone appear to be similar to those which have occurred in the past, presumably without man's help. It is argued that changing air composition remote from local sources can be a global scale, but the interpretation of the trends must be made with care.

- 335 **CO₂ - GREENHOUSE OR ATMOSPHERIC EFFECT.** Kanestrom, I. (Oslo, Universitetet, Oslo, Norway). Geophys. Norv.; 31: 1-5(1976).

The heating in a greenhouse is studied in a theoretical model with two different house covers: (1) the greenhouse is made of glass that absorbs the longwave radiation (2) the cover consists of a substance (for instance rock salt) transparent to longwave radiation. Also the turbulent transport of sensible heat is taken into account. With the assumptions made, the model shows that the ratio between the surface temperature inside these houses depends strongly on the shortwave radiation and the strength of the turbulent heat transfer (given by the Nusselt and Rayleigh numbers).

- 336 **EFFECTS OF ANTHROPOGENIC EMISSIONS ON CLIMATE: A REVIEW OF SELECTED TOPICS.** Barrie, L.A.; Whelpdale, D.M.; Munn, R.E. Ambio; 5: No. 5-6, 209-212(1976).

Trace substances have been cycling through the atmosphere/ocean/biosphere system since the beginning of time. However, traditional pathways are increasingly being short-circuited by human intervention, e.g., by the combustion of fossil fuels and by the use of chemical fertilizers. The evidence that climate may be changed inadvertently by some of these interventions is reviewed briefly. The main pollutants discussed are carbon dioxide, suspended particulates, heat, and substances such as supersonic aircraft emissions and chlorofluoromethanes that may affect the stratosphere.

- 337 **TRANSFER OF SO₂ AND OTHER REACTIVE GASES**

ACROSS THE AIR-SEA INTERFACE. Tellus; 28: No. 4, 349-353(1976).

Using results obtained from experimental studies of the atmospheric transport of sensible heat, water vapor and momentum over the sea, deposition velocities of soluble and reactive trace gases are evaluated. The deposition velocities that result vary with the height of observation; they are nearly linearly dependent upon wind speed and are a function of the prevailing stability regime. In near-neutral stratification, it appears best to take the deposition velocity to be about 0.13 percent of the wind speed when observations are made at 10 m height. When data are collected at 1 m height, this factor becomes about 0.2 percent. Although the evaluations are intended to apply particularly to the case of SO_2 transfer, consideration of the molecular diffusivities of other gases that are similarly reactive (e.g., NH_3 , HCl , NO_2 and SO_3) suggests that less than 10 percent error will result from adopting the present results for SO_2 for these gases as well. When the liquid phase resistance is important, as is the case for CO_2 for example, then the deposition velocities are decreased to a limiting lower value specific for each gas. The present model considers only the simpler case in which the liquid phase resistance is negligible.

338 COAL OR NUCLEAR: THE UNINTENDED CONSEQUENCES OF ELECTRICITY GENERATION. Lave, L.B. (Carnegie-Mellon Univ., Pittsburgh). pp 171-182 of California energy: the economic factors. San Francisco; Federal Reserve Bank of San Francisco (1976).

The paper complements the Boskin - Gilbert paper, The Economic Common Sense of Controlling Nuclear Power Development, in which social costs were considered. The "unintended consequences" refer to the external costs to individuals and to the environment of the production of coal and nuclear fuel. Lave reviews the problems caused by considering only direct or private costs of fuel production, and points up the need to make prices more reflective of social costs. If social costs are not assigned properly to prices, incentives to minimize such costs are absent. He discusses regulation not in the sense of public-utility price regulation, but rather in the sense of regulation of safety or pollution controls. In regard to the regulatory process, Lave advocates a greater reliance upon prices reflecting both social costs and private production costs. There is a role for direct regulation, especially where externalities have long-term consequences, such as disposal of nuclear wastes and control of carbon-dioxide emissions from coal burning. In his analysis, Lave argues that the external costs to society of coal production are greater than those of nuclear power. Although his estimates do not cover such crucial issues as nuclear waste disposal and nuclear accidents, he concludes that the large external costs associated with coal need to be considered carefully before choosing a policy that encourages coal production.

339 IS NUCLEAR ENERGY SAFE FOR WORKERS AND THE PUBLIC. I. Cohen, B. (Univ. of Pittsburgh). pp 58-68 of Nuclear energy and America's energy needs. Washington, DC; AFL-CIO Industrial Union Department (1976).
From Conference on nuclear energy and America's energy needs; Washington, DC, USA (18 Mar 1976).

See CONF-760381--.

Dr. Cohen first discusses wastes from coal-burning power plants, then those from nuclear

power plants. Coal-fired plants produce more wastes, but nuclear wastes are radioactive. Exposure to natural radiation is about 500 times as much as the public will receive from nuclear power plants. Safe handling of wastes from nuclear plants is reviewed, contrasting the handling to the careless way arsenic or chlorine gas is handled. The burying of radioactive wastes and the effects on ground water are followed. Dr. Cohen cites a substitution scenario: uranium is the source of radium, and radium has been causing some thousands of fatalities per year from time immemorial; therefore, uranium is burned completely up, the Earth will be cleansed of much of its radiation since "uranium is in the long-run a much more dangerous thing than the waste which it turns into when it is burned in a nuclear power plant." Lastly, the burden put upon future generations "to watch" the radioactive wastes is analyzed; calculations show that a thousand years' waste accumulation can be buried in a ten-mile square area, requiring one patrol person parttime to watch. Dr. Cohen sees the burden much greater of our consuming all of the minerals and not leaving any for future generations. The only way he sees to right ourselves with the progeny he feels, is to leave them with the technology that will allow them to live in reasonable comfort without all these resources we are consuming. . . . We owe future generations a source of cheap and abundant energy: since solar energy is almost impossible to develop as a cheap source, nuclear is the only source. (MCW)

340 NATURAL DUST AND ACID RAIN. Winkler, E.M. (Univ. of Notre Dame, IN). Water, Air, Soil Pollut.; 6: No. 2/3/4, 295-302(1976).

Atmospheric dust originates from three sources; terrestrial airborne matter, volcanic, and cosmic. Terrestrial natural dust makes up the main bulk reflecting the soil composition to 150 mi away. Soil erosion from flood plains, plowed fields and construction sites is the main source. Quartz, feldspar, the carbonates calcite and dolomite, and clay minerals are the components in decreasing order of frequency. Natural dust in the atmosphere interacts with rainwater converting the carbonates to benign gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). Naturally leached soils produce less calcite than unweathered sediments on flood plains and construction sites, and in granitic and crystalline rocks less than in limestone areas. Heavy industrialization associated with high emission of CO_2 and SO_2 on the one hand, and excess production of dust on the other appears to counteract man's interference with natural ecosystems in the opposite direction.

341 ATMOSPHERIC CARBON DIOXIDE VARIATIONS AT THE SOUTH POLE. Keeling, C.D.; Adams, J.A. Jr.; Ekdahl, C.A. Jr.; Guenther, P.R. (Univ. of California, San Diego, La Jolla). Tellus; 28: No. 6, 552-564(1976).

Duplicate measurements of 749 discrete samples of air collected at the South Pole indicate that the seasonally adjusted concentration of atmospheric carbon dioxide in the polar southern hemisphere rose 3.7 percent between 1957 and 1971. The rise, mostly attributable to the burning of fossil fuels, has not been steady. In the mid-1960's, possibly as a result of wide-spread cooling of surface ocean water, it slackened for several years; recently it has accelerated. Similar changes in rate have also been observed at Mauna Loa Observatory, Hawaii, in the northern hemisphere and are evidently a global phenomenon.

really the answer to the problem.

- 342 ATMOSPHERIC CARBON DIOXIDE VARIATIONS AT MAUNA LOA OBSERVATORY, HAWAII. Keeling, C.D.; Bacastow, R.E.; Bainbridge, A.E.; Ekdahl, C.A. Jr.; Guenther, F.R.; Waterman, L.S. (Univ. of California, San Diego, La Jolla). Tellus; 28: No. 6, 538-551(1976).

The concentration of atmospheric carbon dioxide at Mauna Loa Observatory, Hawaii is reported for eight years (1964 to 1971) of a long term program to document the effects of the combustion of coal, petroleum, and natural gas on the distribution of CO₂ in the atmosphere. The new data, when combined with earlier data, indicate that the annual average CO₂ concentration rose 3.4 percent between 1959 and 1971. The rate of rise, however, has not been steady. In the mid-1960's it declined. Recently it has accelerated. The long term trend of rising CO₂ appears to be in response to increasing amounts of industrial CO₂ in the air. Changes in rate have also been observed at the South Pole and are evidently a global phenomenon.

- 343 INADVERTENT WEATHER AND CLIMATE MODIFICATION. Barrett, E.W. (National Oceanic and Atmospheric Administration, Eouler, CO). CRC Crit. Rev. Environ. Control; 6: No. 1, 15-79(Dec 1975).

Although the possibility that human activities might affect weather and climate was suggested by scientists a century ago, it is only during the last two decades that concerted efforts have been made to detect and measure these influences and to develop models for prediction of the future magnitudes of these influences and to develop models for prediction of the future magnitudes of these influences. Review of all published information up to the beginning of 1975 reveals that the total mass of atmospheric carbon dioxide has increased about 3 percent since 1958 as a result of combustion of fossil fuels, that atmospheric dust loading has risen substantially downwind of large urban-industrial complexes in developed countries, and that waste heat from man's activities now amounts to 0.02 percent of the average solar-energy input to the planet. The effects of this pollution on global climate are, however, undetectable as yet against the background of natural fluctuations. Near cities, the local climate tends to be warmer, the diurnal range of temperature is lower, and the annual precipitation higher than if the cities were absent; the measurable effects are felt for only a few tens or hundreds of kilometers around the sources. It is concluded that, except for some possible subtle effects of man-made pollutants on the stratospheric ozone layer, present levels of human activity are not likely to perturb the global climate measurably. However, existing models of climatic change (which are still rather imperfect) predict significant effects in the relatively near future if current industrial and population growth rates persist. (auth)

- 344 DISPROPORTIONS IN THE DISCUSSION ON NUCLEAR ENERGY. Geschger, H. (Bern Univ. (Switzerland)). Electro-Rev.; 67: No. 47, 1354-1355(25 Nov 1975). (In French).

Problems associated with the safety of nuclear power stations and possible effects on the environment are discussed in comparison with long term effects of charging the atmosphere with CO₂ and dust in an excessive manner. The aim should be to conserve petroleum for petro-chemicals and to reduce consumption of fossil fuels. This can in part be achieved by using solar energy but nuclear energy is

- 345 MODELLING THE GLOBAL CARBON CYCLE.

Gowdy, C.M.; Mulholland, R.J.; Emanuel, W.R. (Howard Payne Coll, Brownwood, Tex). Int. J. Syst. Sci.; 6: No. 10, 965-976(Oct 1975).

This paper presents a mathematical model of the global biogeochemical carbon cycle. Through computer simulation of this model, the effect of the projected addition of carbon dioxide into the biosphere resulting from fossil fuel combustion is noted. In particular, the added amount of carbon dioxide in the atmosphere is predicted, and the concomitant increase in the atmospheric temperature due to this effect is projected. Validation of the model is discussed and a sensitivity analysis is performed to test its robustness.

- 346 CHEMICALLY ENHANCED CO₂ GAS EXCHANGE IN A EUTROPHIC LAKE: A GENERAL MODEL. Emerson, S. (Columbia Univ., Palisades, NY). Limnol. Oceanogr.; 20: No. 5, 743-753(Sep 1975).

The exchange of carbon dioxide between the atmosphere and water is governed by the kinetics of diffusion and reaction in the interfacial boundary layer. Previous derivations of the equations describing this process are not always applicable to lakes. A general model, developed to explain the CO₂ exchange rate in eutrophic Lake 227 of the Experimental Lakes Area, indicates that carbon dioxide invasion into this lake is five to ten times that predicted if there were no reaction. The model results conform with data from laboratory CO₂ invasion experiments. The large chemical enhancement in Lake 227 is caused by a strong CO₂ gradient resulting from an epilimnion depleted of carbon dioxide by eutrophication. These results indicate that calculations of the CO₂ gas exchange rate, especially in eutrophic lakes, must consider the possibility of a relatively large enhancement factor.

- 347 (PB--249684) THE STRATOSPHERE PERTURBED BY PROPULSION EFFLUENTS. CIAP MONOGRAPH 3. FINAL REPORT. (Institute for Defense Analyses, Arlington, VA (USA). Science and Technology Div.). Sep 1975. Contract DOT-OS-30057. 746p. NTIS \$18.75.

See also PE--249316.

The Climatic Impact Assessment Program (CIAP) of the U.S. Department of Transportation is charged with the assessment of the impact of future aircraft fleets and other vehicles operating in, or transiting through, the stratosphere. Monograph 3 considers the perturbations of the radiation fluxes, and therefore the composition of the stratosphere, that are produced by the emission of engine effluents from potential, large-scale operations of aircraft in the lower stratosphere (e.g., 29 to 69 kft or 9 to 21 km). The important engine emissions are the odd nitrogen oxides (NO_x or NO and NO₂), sulfur dioxide (SO₂), and water vapor (H₂O). Monograph 3 considers the significant perturbations in the composition of the radiative species in the stratosphere, which include ozone (O₃), nitrogen dioxide (NO₂), sulfuric acid aerosols (75 percent H₂SO₄), and water vapor. These considerations require an understanding of complex phenomena involving radiative, chemical, dynamic, and thermodynamic processes in the stratosphere. Since CIAP is concerned with predictions of effects that take place in the distant future, the methodology used for this purpose is based on models of atmospheric phenomena. (GRA)

- 348 (MTR--7004) QUANTITATIVE ENVIRONMENTAL COMPARISON OF COAL AND NUCLEAR GENERATION WORKSHOP SUMMARY. Bernardi, R.; Borko, B. (Mitre Corp., McLean, VA (USA)). Sep 1975. 54p. Mitre Corp., McLean, VA.

Some topics discussed are as follows: the economic and social costs of coal and nuclear electric generation; effects of emitted carbon dioxide, waste heat, and particulates on climate modification; estimation of public risks of commercial nuclear power plants; potential for diverting recycled plutonium from the nuclear fuel cycle for use in terrorism, sabotage, and political extortion; major sources of radiation releases and the effects of accidents of fuel reprocessing and recovery plants; accidents and risks from the transportation of radioactive materials; and evaluation of methods and risks for radioactive waste disposal. (HLW)

- 349 (RL0--2225-T20-12) RADIOCARBON IN THE SEA. FINAL REPORT. Fairhall, A.W. (Washington Univ., Seattle (USA)). 15 Aug 1975. Contract AT(45-1)-2225. 8p. Dep. NTIS \$3.50.

The project described in this final report began in 1963 with measurements of fallout ^{14}C in the atmosphere, with simultaneous collection of fission products. Studies in the oceans have included the collection and measurement of more than 1000 samples of sea water in vertical profiles between the surface and as deep as 5000 meters from many different ocean areas. Many of these samples include, in addition to ^{14}C measurement, the measurement of total dissolved inorganic carbon. The combination of the two measurements permits the determination of the absolute amount of ^{14}C in sea water (atoms per liter) which turns out to be a much more meaningful quantity than just the ^{14}C /total carbon ratio given by the ^{14}C measurement alone. One result of our studies on bomb ^{14}C has been a simple model which explains quantitatively the observed secular increase in the mixing ratio of atmospheric CO_2 due to the increasing utilization of fossil fuels. At the present time about half the annual emission of fossil CO_2 is removed from the atmosphere and it apparently is being taken up in certain unsaturated areas of the oceans. Since this results in an increase in total carbon in the mixed layer the gradients in total carbon will be altered and so will the eddy diffusion fluxes of dissolved carbon.

- 350 CLIMATIC CHANGE: ARE WE ON THE BRINK OF A PRONOUNCED GLOBAL WARMING. Broecker, W.S. (Columbia Univ., Palisades, NY). Science; 189: No. 4201, 460-463 (8 Aug 1975).
AIR; CARBON DIOXIDE; ABUNDANCE; TEMPERATURE EFFECTS; CLIMATES; WEATHER; DUSTS; EARTH PLANET

- 351 CHLORINATED HYDROCARBON POLLUTANTS AND PHOTOSYNTHESIS OF MARINE PHYTOPLANKTON: A REASSESSMENT. Fisher, N.S. (Woods Hole Oceanographic Inst., MA). Science; 189: No. 4201, 463-464 (8 Aug 1975).
CLIMATES; CARBON DIOXIDE; EARTH ATMOSPHERE; TEMPERATURE DEPENDENCE; HEATING; COOLING; FUELS; FUEL CONSUMPTION; AIR POLLUTION

- 352 BALLOON-BORNE LOW TEMPERATURE AIR SAMPLER. Lueb, R.A.; Ehhalt, D.H.; Heidt, L.E. (National Center for Atmospheric Research, Boulder, CO). Rev. Sci. Instrum.; 46: No. 6, 702-705 (Jun 1975).
Design, construction, and performance of a balloon-borne low-temperature stratospheric air

sampler are described. The sampler can collect 16 samples of 10-liter STP air at different stratospheric altitudes. The collected samples allow measurement of the trace gases H_2 , H_2O , CH_4 , CO , CO_2 , and N_2O .

- 353 (AD-A--621703) CLIMATIC CHANGE. Gates, W.L.; Imbrie, J. (RAND Corp., Santa Monica, CA (USA)). May 1975. 45p. (P--5437). NTIS \$5.00.

During the past four years interest in the problem of climatic change has greatly increased, due in part to growing recognition of its impact on human affairs. This has been matched by a surge of scientific research on nearly all aspects of the problem, especially the areas of climatic data analysis and climatic modeling for both present and past climates. During this period the large-scale distribution of global climate was successfully simulated by a variety of numerical models, and extensive efforts are underway to further improve their accuracy. Climate models have also been used in new diagnoses of the mechanisms of both past and possible future climatic changes, an activity which has underscored the need for more complete documentation of both recent instrumentally observed climatic changes and of those inferred from historical and paleoclimatic sources. (GRA)

- 354 CARBON-12/CARBON-13 ISOTOPE RATIO MEASUREMENT AS AN ENVIRONMENTAL POLLUTION INDICATOR. Genshiryoku Kogyo; 21: No. 5, 60 (May 1975). (In Japanese).

The carbon isotope ratio can be used as an index of air pollution, and atmospheric carbon dioxide can be used to determine the ratio. There are two methods of trapping gaseous carbon dioxide; a cold trap method with liquid nitrogen and a precipitation method with barium carbonate. The latter method tends to precipitate one kind of isotope more than the other; however, the former method traps carbon isotopes non-selectively and a 100 percent trapping of CO_2 can be expected. A typical delta C-13 value during daytime at residential areas is 8.35. Auto exhaust gas shows -30.5 as the delta C-13 value and the value ranges from -20.43 to -14.02 for areas with automobile traffic. The delta C-13 value for heavy oils and natural gases ranges from -47 to -21; therefore, the measurement of carbon isotope ratios of atmospheric CO_2 near industrial areas would give the degree of air pollution.

- 355 (NSF-RA-N--75-052) ENERGY USE AND CLIMATE. POSSIBLE EFFECTS OF USING SOLAR ENERGY INSTEAD OF "STORED" ENERGY. Greeley, R.S. (Mitre Corp., McLean, VA (USA)). Apr 1975. Contract C-938. 49p. (M--74-66(Rev.1)). GPO \$1.10.

The use of fossil, nuclear and, to a lesser extent, geothermal energy sources throughout the world at rates possible to be attained before the year 2100 could cause an increase in average global temperature. The size and effects of such a temperature increase have not yet been calculated with any degree of certainty. The use of solar energy instead of "stored" energy sources would avoid the problems of waste heat release and carbon dioxide emissions and thus avoid the possibility of such a global temperature increase. However, the large areas needed for solar energy collectors could pose a problem in land use and could affect climate through changes in solar absorption and energy distribution patterns. More extensive measurements and calculations of global climate

changes are needed in order to understand the causes of such changes, particularly from human activities, and to predict their impact on the earth and on human society.

- 356 FUTURE IMPACT OF FISSIL CO₂ ON THE SEA. Fairhall, A.W.; Erickson, J.L. (Univ. of Washington, Seattle). Nature (London); 254: No. 5497, 273-275(20 Mar 1975).

The Letters to the Editor section reported an objection and author rebuttal to several facets of a paper in which the chemical consequences of certain models used to predict the rate of fossil carbon dioxide accumulation in the oceanic mixed layer were presented.

- 357 IMMISSION MEASUREMENTS OF O₃ FOR DETERMINATION OF PHOTOCHEMICAL CONVERSION IN CLOSE TO GROUND AIR LAYERS. Birkle, M. Staub-Reinhalt. Luft; 35: No. 2, 41-45(Feb 1975). (In German).

Selective ozone measurements with a chemiluminescence analyzer were taken in Mannheim and Karlsruhe, Federal Republic of Germany, intermittently from 1972 to 1974. In addition, the concentrations of nitric oxide, nitrogen dioxide, total sulfur compounds, dust, carbon monoxide, carbon dioxide, and total hydrocarbon compounds were measured along with the barometric pressure and temperature. The results of the O₃ measurements were classified by diurnal fluctuations. Three different groups of diurnal fluctuations could be distinguished, bad weather diurnal fluctuations which could be observed on rainy days with strong winds, good weather diurnal variations occurring on sunny days with no winds, and all combinations of bad weather and good weather diurnal variations. The possibilities of smog prediction and warning are discussed.

- 358 EFFECT OF INCREASES IN THE ATMOSPHERIC CARBON DIOXIDE CONTENT ON THE CARBONATE ION CONCENTRATION OF SURFACE OCEAN WATER AT 25°C. Skirrow, G.; Whitfield, M. Limnol. Oceanogr.; 20: No. 1, 103-107(Jan 1975).

CARBON DIOXIDE;SURFACE WATERS;CARBONATES; IONS;SEAS;THERMODYNAMICS;CALCITE;FOSSIL FUELS; EARTH ATMOSPHERE;EQUATIONS;ENVIRONMENTAL EFFECTS;FOSSIL-FUEL POWER PLANTS

- 359 LOCAL, REGIONAL, AND GLOBAL IMPORTANCE OF AIR POLLUTANTS. Reed, L.E. (Central Unit on Environmental Pollution, London). Environ. Health (London); 83: No. 1, 21-23, 35(Jan 1975).

All pollutants produced by man discharged from an identifiable point or location. Their concentration is usually greatest at this stage, and therefore the potential to cause an effect is maximum. A systematic and rational approach to monitoring is presented, clearly identifying the separate requirements at local, national, and international levels. Pollution from motor traffic has increased enormously in recent years: Measurements of sulfur dioxide and smoke, traffic pollution, and industrial pollutants are discussed. Pollution affecting a region, a whole country, or even an area extending to several adjoining countries is considered. The individual importance of pollutants depends on the concentration prevailing, their toxicity, their persistence, and the rate at which they are scavenged from the atmosphere. Sulfur, carbon dioxide, and Pb are discussed as pollutants on the global scale.

- 360 EFFECTS OF DOUBLING THE CO₂ CONCENTRATION

ON THE CLIMATE OF A GENERAL CIRCULATION MODEL. Manabe, S.; Wetherald, R.T. J. Atmos. Sci.; 32: No. 1, 3-15(Jan 1975).

The climatic effects of doubling the carbon dioxide concentration in a highly simplified three-dimensional general circulation model were analyzed. The concentration of CO₂ may increase as much as 20 percent during the latter half of this century as a result of fossil fuel combustion. The model contains these simplifications: a limited computational domain, an idealized topography, no heat transport by ocean currents, and fixed cloudiness. The CO₂ increases the temperature of the model troposphere, but it lowers that of the model stratosphere. The tropospheric warming is somewhat larger than that expected from a radiative-convective equilibrium model. The increase of surface temperature in higher latitudes is magnified due to the recession of the snow boundary and thermal stability of the lower troposphere which limited convective heating to the lowest layer. The doubling of CO₂ significantly increases the intensity of the hydrologic cycle of the model.

- 361 ENERGY PROBLEM AND CLIMATE IN THE 21ST CENTURY. Flohn, H. (Bonn Univ. (F.R. Germany). Meteorologisches Inst.). At. Inf.; No. 5, 3-7(1975). (In German).

From Reactor conference; Nuernberg, F.R. Germany (8 Apr 1975).

EARTH ATMOSPHERE;CLIMATES;WEATHER; METEOROLOGY;SEAS;HUMAN POPULATIONS;ENVIRONMENT; FOSSIL FUELS;SOLAR ENERGY;NUCLEAR ENERGY;AIR POLLUTION;ABSORPTION;WASTE HEAT;CARBON DIOXIDE; ENVIRONMENTAL EFFECTS

- 362 METEOROLOGICAL ASPECTS OF ENERGY PRODUCTION. Schmidt, F.H. Ned. Tijdschr. Natuurkd.; 41: No. 12, 171-7(1975).

WIND POWER;VELOCITY;SOLAR ENERGY;REVIEWS; USES;NETHERLANDS;LEVELS;CARBON DIOXIDE;EARTH ATMOSPHERE

- 363 CARBON DIOXIDE PROBLEM. Jones, L.W. (Univ. of Michigan, Ann Arbor). pp 1177-1179 of Hydrogen energy. Part B. Veziroglu, T.N. (ed.). New York; Plenum Publishing Corp. (1975).

From Hydrogen economy Miami energy conference; Miami Beach, FL, USA (18 Mar 1974). See CONF-740306--PB.

It is shown that reliance on fossil fuels for our future energy needs will lead to a significant buildup in atmospheric carbon dioxide. As it is believed that CO₂ is a significant factor in regulating the earth's heat balance, such a buildup may be a cause for concern. (auth)

- 364 CLIMATIC BARRIERS TO LONG-TERM ENERGY GROWTH. Schneider, S.H.; Dennett, R.D. (National Center for Atmospheric Research, Boulder, CO). Ambio; 4: No. 2, 65-74(1975).

CLIMATES;THERMAL POLLUTION;ENERGY DEMAND; FOSSIL FUELS;NUCLEAR POWER;WASTE HEAT;CARBON DIOXIDE;GROWTH;FEEDBACK;EARTH ATMOSPHERE; DIFFUSION;WIND POWER;HYDROELECTRIC POWER;SOLAR ENERGY;DUSTS;TEMPERATURE EFFECTS;ENVIRONMENTAL EFFECTS

- 365 ENERGY CONVERSION: THE ATMOSPHERIC ENVIRONMENT AND CLIMATIC CHANGE. Pearman, G. (CSIRO, Aspendale, Australia). pp 71-96 of Solar energy. Messel, H.; Butler, S.T. (eds.). Elmsford, NY; Pergamon Press, Inc. (1975).

The energy resources that man has exploited

most during the energy demand increase are the fossil fuels. Their environmental consequences range from the more local health hazards and relatively intangible problems of aesthetics to problems of environmental conservation and global climatic change. Environmental consequences occur from extraction to final processing and utilization. This discussion is restricted to aspects of the global climatic consequences of the use of fossil fuels. After reviewing the quantities available from solar energy (originally), three instructive models are presented to introduce the relationships between atmospheric composition and climate: planetary energy budget, particles in the atmosphere, and simultaneous absorption and reflection by the particles. Evolution of the climatic change is reviewed. The possibility is discussed that two man-made substances, CO_2 and particulates, injected into the atmosphere, cause climatic change. It is concluded from the discussion that the potential involvement of atmospheric composition in the determination of climate is not complete and, even if a complete knowledge were possessed, there exists an inability to determine what effects man's activities might have on this composition and how, in a quantitative way, the composition interacts with the energy balance of the atmosphere and its circulation. (MCW)

- 366 (CONF-751027-- , pp 611-620) REVIEW OF DIFFERENT ATTEMPTS OF TRACING BACK THE INCREASING ATMOSPHERIC CO_2 LEVEL TO PRE-INDUSTRIAL TIMES. Freyer, H.D. (Inst. of Chemistry, Juelich, Ger.); Wiesberg, L. 1975.

From 2. international conference on stable isotopes; Oak Brook, IL, USA (20 Oct 1975).

For predictions on the future CO_2 increase, the present CO_2 excess above the equilibrium level has to be known. However, CO_2 concentrations in the atmosphere during the last century have been measured very imperfectly. The following possibilities for CO_2 determinations referring to the past decades have been investigated: (a) direct analysis of atmospheric CO_2 included in gas bubbles of glacier ice; (b) the stable carbon isotope record in lime and cement mortar samples and in the wood of tree rings, respectively. It turns out that only the isotope record in wood gives reliable data and the results of different authors indicate a world-wide trend. Nevertheless the shape of the ^{13}C curves found in modern wood cannot be completely interpreted on the basis of an increasing atmospheric CO_2 level. Possible factors influencing the stable carbon isotope record in biological material (such as different growth conditions of plants due to environmental changes: atmospheric CO_2 variations due to land cultivation and climatic influences) are pointed out.

- 367 (CONF-751027-- , pp 630-644) CARBON ISOTOPE DISCRIMINATION BY PHOTOSYNTHESIS: IMPLICATIONS FOR THE BIO- AND GEOSCIENCES. Lerman, J.C. (Univ. of Arizona, Tucson); Troughton, J.H. 1975.

From 2. international conference on stable isotopes; Oak Brook, IL, USA (20 Oct 1975).

Land plants are depleted in the heavy isotopes of natural carbon ^{14}C (radioactive) and ^{13}C (stable) compared with the isotope composition of atmospheric CO_2 . These depletions can be assayed on milligram quantities of organic matter converted to CO_2 and analyzed in a double inlet-double collector mass spectrometer, the ratio $^{13}\text{C}/^{12}\text{C}$ usually being expressed as delta ^{13}C vs. PDB, in per mil (‰). The delta value in higher plants ranges between +39 and -9 ‰. The variations

of this delta value are mainly determined by the type of carbon fixation reaction, e.g., the delta value allows us to distinguish between C_3 (Calvin-Benson) plants typically -28 ‰, and C_4 (Hatch-Slack) plants typically -13 ‰. These corrections are important for archaeological and groundwater dating. Since the carbon delta values persist in dead and ancient plant remains such as wood, pollen, peat, soil, coal and oil, it is possible to investigate previous environmental conditions, past climate, paleoecology, plant interaction with the environment and evolution of photosynthetic mechanisms. The delta value also tags the commercial products derived from plants and animals allowing their origin to be traced in investigations of fraud. Some of these naturally labeled products have medical applications.

- 368 THERMAL STRUCTURE AND DYNAMICS OF THE STRATOSPHERE. London, J. (Univ. of Colorado, Boulder). Int. J. Chem. Kinet.; 7: No. Suppl. 1, 85-99(1975).

From Symposium on chemical kinetics data for the upper and lower atmosphere; Warrenton, VA, USA (15 Sep 1974).

Chemical processes related to the thermal structure and dynamics of the stratosphere are discussed. The sink for thermal energy in the stratosphere is mainly through radiative emission by carbon dioxide in the 15 micron bands; thus, its concentration is of considerable interest particularly for the long term stratospheric energy budget. Ozone strongly absorbs near ultraviolet solar radiation and also plays a dominant role in determining the thermal structure of the stratosphere. Ozone variations are largest in the subpolar regions during the winter when the temperature and wind variations in the lower stratosphere are also the largest. There is little water vapor in the stratosphere, although occasional clouds are formed in the middle stratosphere at high altitudes during the winter. Water vapor in the stratosphere is reasonably well mixed, with a mixing ratio of about 4 to 5 ppm (by volume) at 15 km. Additional trace gases in the stratosphere which by themselves exert very little direct input to the radiative budget but either directly or indirectly influence the local concentrations of ozone, water vapor, and/or carbon dioxide include nitric oxide, nitrogen dioxide, atomic hydrogen, hydroxyl radical, and hydroperoxyl radical. The stratosphere also contains a relatively high concentration of aerosols at a height of about 20 km, and stratospheric aerosol is capable of affecting the backscattering of solar radiation by atmospheric particles and thereby changing the overall albedo of the earth-atmosphere system. Aerosols can also contribute slightly to the radiation budget of the lower stratosphere, depending on the refractive index of the aerosol particles.

- 369 RATE CONSTANT RATIO FOR THE REACTIONS OF OH WITH O_3 AND CO . Demore, W.B. (Jet Propulsion Lab., Pasadena, CA). Int. J. Chem. Kinet.; 7: No. Suppl. 1, 273-287(1975).

From Symposium on chemical kinetics data for the upper and lower atmosphere; Warrenton, VA, USA (15 Sep 1974).

Mixtures containing O_2 , CO_2 , and H_2O were irradiated at 1849 Å. Ozone and carbon monoxide were produced, and eventually reached steady-state concentrations. It is shown that the ratio of steady-state concentrations depends only on the relative rates of light absorption by CO_2 and O_2 and the relative rate constants for the $\text{OH} + \text{CO}$ and $\text{OH} + \text{O}_3$ reactions.

Experiments in the range 271 to 333°K gave results which yield an Arrhenius expression for the ratio of rate constants for the reaction of OH with O₃(k₆) and CO(k₇).

- 370 (CONF-7510172--P1, pp 333-335) OPTICAL METHOD FOR DETERMINATION OF CO₂ TOTAL ABUNDANCE IN A VERTICAL COLUMN OF THE ATMOSPHERE. Brounshtein, A.M.; Frolov, A.D.; Shashkov, A.A. (Hydrometeorological Service of the USSR, Leningrad). 1975.

From 10. international symposium on remote sensing of environment; Ann Arbor, MI, USA (6 Oct 1975).

Despite the relatively small CO₂ concentration in the earth's atmosphere (about 330 ppm--millionth parts by volume), the gas is an important climate-forming factor. The estimation of CO₂ influence on the Earth's climate was made using comparatively crude numerical models, however they show the importance of controlling the CO₂ concentration averaged over height (or the total CO₂ content in the atmospheric vertical column) with the aim of detecting concentration changes with time (the trend). The trend being small (0.5 to 1.2 ppm per year), highly accurate measurements are required. At present the magnitude of CO₂ trend is determined from local ground-level concentration measurements having been carried out at US baseline stations for a number of years. However considerable difficulties arise in selecting the site of a baseline station and observation conditions if one wants to use these data as mean over height CO₂ concentration because of the necessity to avoid the influence of local CO₂ sources. The method for determination of the total CO₂ abundance from solar radiation absorption spectra developed in the Main Geophysical Observatory (Leningrad, USSR) is based on using the ratio R of transmittances in the neighboring spectral intervals of the 4ν₂ + ν₃ (2.06 μm) CO₂ Band as a characteristic of the absorbing gas amount over the radiation path. Optimal photo-metering conditions for the usual optical paths in the atmosphere are provided in the selected band. Besides the band is comparatively clear, being overlapped only by weak water vapor lines.

- 371 (DHEW-(NIH)--77-1065) ATMOSPHERE: ENDANGERED AND ENDANGERING. FOGARTY INTERNATIONAL CENTER PROCEEDINGS NO. 39. Kellogg, W.W.; Mead, M. (eds.). (Department of Health, Education, and Welfare, Washington, DC (USA)). 1975. 178p. (CONF-7510192--). GPO.

From The atmosphere: endangered and endangering; Washington, DC, USA (26 Oct 1975).

Topics of panel discussions held at the conference centered around the pertinent facts about the atmosphere, definition of the main factors that determine the climate, and some of the things that mankind can do to affect it. Five individual presentations are entitled: the carbon cycle and the paleo-climatic record; the interaction of the atmosphere and the biosphere; some thoughts on control of aerospace; international structures for atmospheric problems; some comments on technology and the atmosphere. (JGB)

- 372 NONCONDENSABLE GAS EFFLUENTS FROM GEOTHERMAL POWER PLANTS. Axtmann, R.C. (Princeton Univ., NJ). Am. Chem. Soc., Div. Environ. Chem., Prepr.; 15: No. 1, 188-150(1975).

From 169. ACS national meeting; Philadelphia, PA, USA (6 Apr 1975).

Noncondensable gas effluents from geothermal

powerplants vary widely and depend intimately on the geochemistry of the underground reservoir. Carbon dioxide, however, is always the main component (78 to 95%). The gas fraction declines with exploitation in a complicated fashion. Geothermal plants at Cerro Prieto, Mex.; Monte Amiata, Italy; Lardarello, Italy; Geysers, U.S.; and Wairakei, N.Z.; produce 0.73, 0.19, 0.13, 0.054, and 0.012 ton/Mw/day of sulfur, respectively, and 4.2, 62.0, 11.0, 1.4, and 0.32 tons/Mw/day of carbon dioxide, respectively, compared with 0.27 and 25.0 tons/Mw/day for a conventional plant burning 3.5% sulfur coal and 0.077 and 25.0 tons/Mw/day for a plant burning 1% sulfur coal. Direct-contact condensers are more economical for geothermal steam than indirect-contact (surface) heat exchangers. The effect of the various pollutants on the environment and the equipment employed at the various plants are discussed. Table and 12 references.

- 373 ASPECTS OF GAS ANALYSIS BY ABSORPTION SPECTROSCOPY. Schinkmann, M. Draegerheft; 300: 28-36(1975). (In German).

Following a review of the fundamentals of absorption spectroscopic gas analysis, the three main spectroscopic methods, dispersive, nondispersive, and laser spectroscopy are discussed. Analyzers operating according to the dispersive method require a dispersion medium (prism, diffraction screen, interference filter). Non-dispersive spectroscopy compares the spectrum of the gas to be examined with that of a reference gas of pre-determined concentration. Laser operation spectroscopy is characterized by high selectivity. Carbon dioxide (CO₂), water (H₂O), nitric oxide (NO), nitrogen dioxide (NO₂), formaldehyde (H₂CO), acetone (CH₃)₂CO, and acetaldehyde (CH₃)HCO can be determined with the CO laser, benzene (C₆H₆), ethylene (C₂H₄), hydrogen fluoride (H₂S) and ozone (O₃) with the CO₂ laser. Ammonia can be determined with either the CO, the CO₂, or N₂O laser, or by sulfur dioxide with the CO₂ or xenon laser.

- 374 ATMOSPHERIC CHEMICAL REACTION. PART I. GLOBAL FORMATION AND EXTINCTION OF ATMOSPHERIC COMPONENTS. Suzuki, S. Sekiyu Gakkaishi; 17: No. 12, 1053-1062(Dec 1974). (In Japanese).

The formation and extinction processes of atmospheric components are reviewed. Various pollutants are continuously emitted into the atmosphere and these pollutants become extinct with or without undergoing various changes. The formation and extinction mechanisms, environmental cycle, and mass rate balance of sulfur compounds (sulfur dioxide, hydrogen sulfide), nitrogen compounds (ammonia, nitrous oxide, nitric oxide, nitrogen dioxide), carbon dioxide, carbon monoxide, hydrocarbons (total HC, methane), and aerosols (liquid or solid and organic or inorganic particulates in the particle size range of 0.01 to 1000 micron) are reviewed.

- 375 (PB--238075) CHANGES IN THE GLOBAL ENERGY BALANCE. FINAL REPORT, 15 JUNE--15 OCTOBER 1974. McLellan, A. IV. (Kellogg (M.W.) Co., Houston, TX (USA)). Oct 1974. Contract EPA-68-02-1308. 26p. NTIS \$3.75. ENERGY BALANCE;HEAT;CLIMATES;SOLAR RADIATION; PARTICLES;EARTH ATMOSPHERE;CARBON DIOXIDE;AIR POLLUTION;ENERGY SOURCES

- 376 ¹³C DECREASE IN WOOD FROM ANNUAL RINGS OF TREES. A STUDY ON THE ANTHROPOGENIC EFFECTS ON THE CO₂ BALANCE OF THE ATMOSPHERE. Wiesberg, L. Aachen, Germany; Technische Hochschule (26

Jun 1974). 121p. (In German).

Thesis.

Fossil carbon, i.e. coal, natural oil, and natural gas, generally has a deficit in ^{13}C of about 18% as compared to atmospheric CO_2 . It has therefore been tried to follow the path of the fossil CO_2 released into the atmosphere as a result of increasing energy consumption. An increased fraction in the air would mean a reduction of ^{13}C in CO_2 . With this in mind, the author examined annual rings in trees dating back through the past 65 years. A reduction of about 0.3% was the most probable reduction up to 1970. The amount of fossil CO_2 produced during this period is known, and a comparison of the data suggests a fast exchange between atmosphere and ocean with mean dwell time in the atmosphere of only about 3 years for CO_2 molecules. Using a simple model assumption, it is estimated that about 30% of the anthropogenic CO_2 are still to be found in the atmosphere.

- 377 SOME CONSEQUENCES OF THE PRESENT ENERGY POLICY. pp 15-27 of *Electrochemistry for ecologists*. Bockris, J.O'M.; Nagy, Z. New York; Plenum Publishing Corp. (1974).

FOSSIL FUELS;ENERGY SHORTAGES;ENVIRONMENTAL EFFECTS;ENVIRONMENT;HEALTH HAZARDS;COMBUSTION; ECOSYSTEMS;AIR POLLUTION;CARBON DIOXIDE; METEOROLOGY;CARBON MONOXIDE;HYDROCARBONS;SULFUR DIOXIDE;NITROGEN OXIDES;REMOVAL;ELECTRIC POWER; PLANTS;TEMPERATURE DEPENDENCE;EARTH ATMOSPHERE; ENERGY POLICY;ENERGY SOURCES;NATURAL GAS; PETROLEUM;SOLAR ENERGY;ENERGY DEMAND; RADIOACTIVITY;SEAS;POLLUTION;ECOLOGY

- 378 MAN-MADE DISRUPTIONS OF THE CARBON DIOXIDE AND OXYGEN CONCENTRATION IN THE ATMOSPHERE AND THE ROLE OF PLANTS. Gerakis, P.A. (Univ. of Thessaloniki, Greece). J. Environ. Qual.; 3: No. 4, 299-304(1974).

CARBON DIOXIDE;OXYGEN;AIR;PLANTS;QUANTITY RATIO;FOSSIL FUELS;HUMAN POPULATIONS;COMBUSTION; TURBIDITY;TEMPERATURE DEPENDENCE;CLIMATES; CHEMICAL EFFLUENTS;ENVIRONMENTAL EFFECTS

- 379 INVESTIGATING TRENDS IN BACKGROUND POLLUTION OF THE ATMOSPHERE. Waller, C.C. pp Paper 2.1-11, 18p. of 9th world energy conference. London; World Energy Conference (1974).

From 9. world energy conference; Detroit, MI, USA (22 Sep 1974).

See CONF-740910--P2.

AIR POLLUTION;CARBON DIOXIDE;SULFUR DIOXIDE; NITROGEN OXIDES;NATURAL OCCURRENCE;FOSSIL FUELS; MONITORING;CLIMATES;EARTH ATMOSPHERE;PARTICLES; AUTOMOBILES;AIRCRAFT;GLOBAL ASPECTS

- 380 ENERGY CRISIS AND NUCLEAR ENERGY. Oye, O.G.W. Fra Fys. Verden; 36: No. 2, 31-38(1974). (In Norwegian).

General environmental problems of energy generation in fossil fuel-fired and nuclear power plants are discussed with respect to the recent energy crisis. The increasing exhaustion of the fossil fuel sources as a result of stepped-up energy production in the world has created a necessity for balanced energy production with respect to the availability of energy carriers, and for restraint in energy use. Fossil fuel-fired power plants generate environmental hazards due to thermal pollution, and the emission of carbon dioxide, sulfur dioxide, nitrogen oxides, and particulate matter. The increasing CO_2 concentration in the atmosphere may lead to an increase in the overall temperature. When combined with industrial smoke, nitrogen oxides may produce

photochemical smog. Nitrogen oxides are also believed to destroy the ozone belt in the stratosphere. Weighing the environmental hazards and availability of resources of fossil and nuclear energy indicates that nuclear energy is a feasible and necessary alternate energy source.

- 381 ACCUMULATION OF FOSSIL CO_2 IN THE ATMOSPHERE AND THE SEA. Fairhall, A.W. (Inst. of Nuclear Sciences, Lower Hutt, New Zealand). Nature (London); 245: No. 5419, 20-23(7 Sep 1973).

A model is presented which accounts quantitatively for the buildup of fossil CO_2 in the atmosphere. The model also predicts something not previously recognized: a significant uptake of fossil CO_2 by the sea. The sea is presently supersaturated with respect to aragonite and calcite, which calcareous organisms form in building their shells. Should the sea become unsaturated in CaCO_3 , the shells of these organisms would tend to dissolve, as would the ocean's coral reefs. One test of the model would be afforded by careful monitoring of total CO_2 levels in the mixed layer over the next few years. The model predicts an increase in the mixed layer of about 1.4 per cent in the next decade. Because this is about double the accuracy of the present methods for measuring total CO_2 in seawater, this trend, if present, should be detectable within 3 to 5 years. (MFB)

- 382 GLOBAL BLUNDER. Vogel, J.C. Nucl. Act.; 10-13(Jul 1973).

Effects of increased CO_2 release from fossil fuels on global basis. ENERGY CONSUMPTION; ENVIRONMENT;FOSSIL FUELS;NUCLEAR POWER;ELECTRIC POWER;AIR POLLUTION;ENERGY CONSERVATION;NUCLEAR FUELS;COMBUSTION;ENVIRONMENTAL EFFECTS; BIOLOGICAL EFFECTS;CLIMATES;CARBON DIOXIDE

- 383 LAWS OF VARIATION IN PH IN ATMOSPHERIC PRECIPITATIONS. Lavrinenko, R.F. pp 195-202 of Air pollution and atmospheric diffusion. Berlyand, M.E. (ed.). New York; John Wiley and Sons, Inc. (1973).

PH VALUE;ATMOSPHERIC PRECIPITATIONS;URBAN AREAS;INDUSTRY;AIR POLLUTION;FUELS;COMBUSTION; SULFUR DIOXIDE;COAL;CARBON DIOXIDE; ENVIRONMENTAL EFFECTS

- 384 GLOBAL PRODUCTION OF CO_2 FROM FOSSIL FUELS AND POSSIBLE CHANGES IN THE WORLD'S CLIMATE. Rotty, R.M. New York; American Society of Mechanical Engineers (1973). 12p.

The current consumption of fossil fuels is adding carbon dioxide to the atmosphere at rates which will affect the global climate to only a small degree unless the consumption continues for a very long period of time. The rate of increase of demand for energy, and fossil fuel energy in particular, leads to projections of atmospheric carbon dioxide levels which can begin to have noticeable effects on the global climate by the end of this century and substantial effects during the first half of the next century.

- 385 GLOBAL EFFECTS OF CONTAMINANTS IN THE UPPER ATMOSPHERE. Machta, L. (NOAA, Silver Springs, MD). pp 1-9 of Pollution: engineering and scientific solutions. Barrekette, E.S. (ed.). New York; Plenum Publishing Corp. (1973).

From 1. international meeting on pollution; Tel Aviv, Israel (12 Jun 1972).

See CONF-720673--.

In summary, there is little doubt that jet aircraft have increased the amount of high clouds; all of us can attest to persistent contrails in the sky. But whether the increase is significant or negligible is not yet resolved. The weather station records consistently indicate more high clouds in the post jet period but natural variability precludes identifying the increase from 1965-69 as necessarily due to aircraft operations rather than due to natural causes. There are a variety of weather and climate effects which might follow from an increase in high clouds but further research will be required to make a case for or against a weather change.

- 386 VIEW FROM THE MOON (ENVIRONMENTAL POLLUTION CAUSED BY PETROLEUM). Dole, H.M. pp 186-189 of Proceedings of the fourth symposium on the development of petroleum resources of Asia and the Far East. New York; United Nations (1973).

From 4. symposium on the development of petroleum resources of Asia and the Far East; Canberra, Australia (27 Oct 1969).

See CONF-691079--P3.

Pollution caused by petroleum and petroleum combustion is examined. Consumption of petroleum in the U.S. is noted and the hazards of petroleum production such as blowouts are assessed. Other hazards including tanker accidents and refinery pollution are discussed along with increased concentrations of Co and CO₂ in the atmosphere. (JRD)

- 387 (ORNL-tr--4346) EFFECT OF CARBON DIOXIDE GAS ON THE THERMAL BALANCE OF THE ATMOSPHERE. Rakipova, L.R.; Vishnyakova, O.N. Translated by S.D. Blalock, Jr. from Tr. Gl. Geofiz. Obs.; No. 315, 39-45(1973). 9p. Dep. NTIS, PC A02/MF A02.

The theoretical problem of estimating the effect of variations in the content of carbon dioxide gas in the atmosphere on its temperature consists of two independent parts: (1) calculation of changes in radiation fluxes and influxes caused by variations in the concentration of carbon dioxide gas, (2) calculation of changes in temperature caused by changes in the radiation influxes. These calculations are elaborated upon. (GHT)

- 388 INFLUENCE OF CARBONIC ACID GAS CONCENTRATIONS ON THE ATMOSPHERIC THERMAL REGIME. Rakipova, L.P.; Vishnyakova, O.N. Meteorol. Gidrol.; No. 5, 23-31(1973). (In Russian).

The influence of carbon dioxide concentration on atmospheric temperature is considered in terms of radiative heat influx, macroturbulent heat exchange (horizontal and vertical), condensation and evaporation, and heat exchange with the lower atmospheric layers and the ocean surface. Carbon dioxide concentrations were varied from zero to more than five times the modern volume concentration. The CO₂ heating effect for modern conditions was 6.7 K for the warm hemisphere and 6.9 K for the cold hemisphere. A change in temperature of 0.3 K conforms to a 20 percent increase in CO₂ concentrations and a temperature change of 1.3 K conforms to a 100 percent increase relative to the modern volume concentration. High CO₂ concentrations cause a saturation effect.

- 389 EFFECT OF CHANGING CO₂ CONCENTRATION ON RADIATIVE HEATING RATES: FURTHER COMMENTS. Newell, R.E.; Herman, G.F.; Dopplick, T.G.; Boer, G.J. (Massachusetts Inst. of Tech.,

Cambridge). J. Appl. Meteorol.; 11: No. 5, 864-867(Aug 1972).

Changes in radiative heating and cooling rates due to both the near infrared and 15 μ bands of CO₂ are computed for changes in CO₂ concentration from 320 to 600 and 1000 ppMv. An increase in CO₂ concentration leads to a smaller net cooling rate in the troposphere, little net change at the tropopause, and increased cooling in the stratosphere. The 15 μ and near infrared effects act in the same sense in the tropopause but tend to compensate in the stratosphere, although the near infrared contribution is generally small when compared with that due to the 15 μ band. Possible effects of the changes on the generation of zonal available potential energy are suggested.

- 390 GLOBAL CIRCULATION OF ATMOSPHERIC POLLUTANTS. Newell, R.E. (Massachusetts Inst. of Tech., Cambridge). Sci. Am.; 224: No. 1, 32-42(Jan 1971).

Pollution is more than a plume of smoke rising above a factory or a yellowish haze hanging over a city. The foreign substances man introduces into the air spread all over the globe and rise into the upper atmosphere. It is therefore important to learn how each of the major pollutants enters the atmosphere, the speed and extent of its spread and the ways in which it may alter the atmosphere and thus affect temperature and precipitation both locally and worldwide. This article is a discussion of the movement of the various pollutants and a review of what is known about the effect on temperature of foreign substances in the atmosphere. The pollutants considered are carbon dioxide, carbon monoxide, ozone, sulfur compounds, particles and water vapor.

- 391 ELECTRIC POWER GENERATION: OPTIONS FOR ENVIRONMENTAL IMPROVEMENT. Crenhall, W.A. (Consolidated Edison Co. of New York, Inc.). pp 557-63 of Man's impact on the climate. Matthews, W.H.; Kellogg, W.W.; Robinson, G.D. (eds.). Cambridge, MA; MIT Press (1971). ENVIRONMENTAL EFFECTS; POWER PLANTS; CARBON DIOXIDE; SULFUR OXIDES; NITROGEN OXIDES; RADIOACTIVE WASTES; AIR POLLUTION

- 392 EFFECT OF CHANGING CO₂ CONCENTRATION ON RADIATIVE HEATING RATES. Newell, R.E.; Dopplick, T.G. (Massachusetts Inst. of Tech., Cambridge). J. Appl. Meteorol.; 9: No. 6, 958-959(Dec 1970).

Carbon dioxide is the largest global pollutant by mass and atmospheric concentrations are increasing at about 0.7 ppM v per year. The influence of this change on the atmospheric temperature structure is unknown. One method for investigating this is to compute the radiative heating rate as the local imbalance of radiative fluxes, for each altitude and for different CO₂ mixing ratios, keeping other factors constant. This manuscript is a discussion of the application of this approach. Data of the local rate of temperature change produced by infrared radiative divergence due to CO₂, H₂O, and O₃ are presented. At lower levels the net cooling rate was slightly diminished while at upper levels it was significantly increased by a change in CO₂ from 320 to 400 ppMv. The physical reasons for the two changes differ and are discussed. To place the CO₂ contribution to temperature in perspective it was compared with other radiative components (H₂O and O₃) at two levels (5 to 10 mb and 850 to 1000 mb). Clear skies were assumed. Carbon dioxide was secondary to water vapor in the troposphere and dominant in the lower stratosphere. When searching for a

potential influence of global pollution on the tropospheric temperature the author suggested it would be wise to pay careful attention to the water cycle and its possible modification, particularly as it enters also through the effect of latent heat.

- 393 (PB=193835) LONG-TERM EFFECTS OF AIR POLLUTION: A SURVEY. Robinson, G.D. (Center for the Environment and Man, Inc., Hartford, CT (USA)). Jun 1970. 44p. NTIS. AIR POLLUTION;HEALTH HAZARDS;BIOLOGICAL EFFECTS;ENVIRONMENTAL EFFECTS;METEOROLOGY; CLIMATES;MONITORING;ALBEDO;CARBON DIOXIDE; AEROSOLS;CARBON MONOXIDE;SULFUR DIOXIDE; NITROGEN OXIDES;OZONE;GEOPHYSICS

- 394 ANNUAL AND BIENNIAL MODULATIONS IN THE TROPICAL HADLEY CELL CIRCULATION. Newell, R.E.; Kidson, J.W.; Vincent, D.G. (Massachusetts Inst. of Tech., Cambridge). Nature (London); 222: No. 5588, 76-78(5 Apr 1969).

A study of temperature and wind variations in the tropics has recently been completed based on data for the period 1957 to 1964 from almost 300 sounding balloon stations between 40°N and 30°S. Monthly zonal average results, based on objective map analysis from the surface up to 100 mbar (about 16 km) and on

latitude band means above, are used in this communication. Plots of the temperature at 50 mbar at 10°N and 10°S and 100 mbar at 10°N and 10°S show the same phase. Highest temperature at all four points occur in August of each year and in addition there is a marked biennial variation at 50 mbar with highest temperatures in August of odd numbered years. These variations occurring simultaneously in both hemispheres, obviously cannot be the result of solar zenith angle changes. Neither can they be the result of changes in the principal infrared absorber common to 100 and 50 mbar, namely carbon dioxide; an increase in its concentration would lead to an enhanced heating rate at the tropopause and an enhanced cooling rate at 50 mbar, thus producing an out of phase temperature variation. The temperature changes thus seem to be a result of a modification of the rising motion in the tropical Hadley cells and consequent changes in the adiabatic cooling. With the annual cycle removed, the biennial variation shows clearly at all levels with the highest temperatures occurring toward the end of the even years. The biennial variation in tropospheric temperature is consequently in the opposite sense to that observed in the tropical lower stratosphere and is associated with a higher tropical tropopause. The ultimate source of the Hadley cell modulation is not known but sea surface temperature changes may be responsible.

CORPORATE INDEX

In the Corporate Index, report literature is indexed using the name of the organization or institution responsible for issuing the report. Headings are provided for all report literature and for published literature for which a corporate approach is especially desirable, e.g., symposium and conference proceedings.

Each entry under a corporate heading gives the report title and the volume and abstract numbers. Report numbers, if applicable, are given in parentheses at the end of the entry.

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Proceedings of the US Department of Energy environmental control symposium. Volume 1. Plenary session and fossil fuels, 44 (DOE/EV--0046(Vol.1))
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